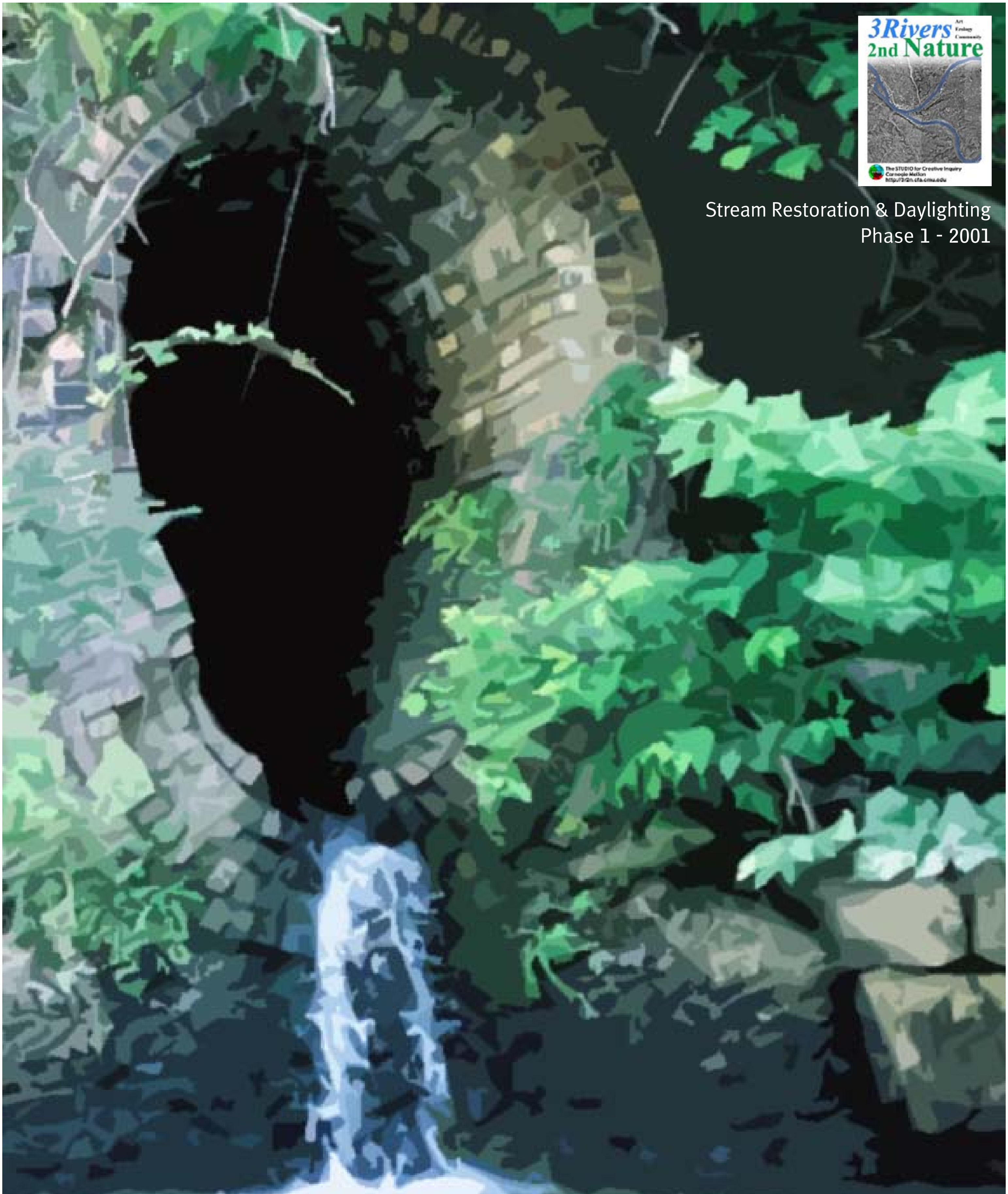

Stream Restoration & Daylighting

Phase 1 - 2001

STREAM RESTORATION AND DAYLIGHTING:

Opportunities in the Pittsburgh Region

Presented by:

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Carnegie Mellon University

For more information on the 3 Rivers – 2nd Nature Project, see http://3r2n.cfa.cmu.edu

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EXECUTIVE SUMMARY

Scope and Goals

The 3 Rivers – 2nd Nature stream restoration and daylighting program addresses stream restoration within cities. We maintain that living streams represent a core value relevant to a successful new economy city. We use the phrase "living streams" to emphasize that our local streams are ecosystems, not merely urban infrastructure. Living streams provide for a wide range of essential urban needs: water quality improvement, runoff management, recreational and educational opportunities, beautiful landscapes, and wildlife habitat. They support property values and generate other economic benefits.

Our efforts in this program include analysis by experts in infrastructure, water policy, stream biology, landscape architecture, art, urban planning, geographic information systems, and other disciplines, *integrated* with public dialogues—all addressing current stream conditions, opportunities to protect and restore streams, and the broad benefits that can be generated through stream restoration. A particular 3 Rivers – 2nd Nature focus is stream "daylighting." Daylighting is the act of removing streams from underground pipes and culverts, restoring some of the form and function of historic streams. Daylighting is the most profound form of stream restoration, recreating a surface waterway where "nothing" exists now.

We aim to identify daylighting opportunities in Allegheny County and encourage development of daylighting demonstration sites. Our program takes a strategic, conceptual approach. Our interest is in framing issues, communicating opportunities, and building constituencies. The effort is structured to be iterative and replicable, both within sub-areas of the county and as a model that can be applied beyond. Our goals are:

> *Short Term:* Develop efficient and effective expert and public processes to identify high-potential daylighting sites and encourage initiation of appropriate projects.
>
> *Long Term:* Change expert and public consciousness about the benefits of open waterways and functioning urban aquatic ecosystems, and effect the protection and restoration of those ecosystems in order to realize their ecological, economic, infrastructure, social and other values.

Daylighting can provide multiple benefits—tangible and intangible—for every dollar expended. These include improvements to the functional values of waterways and urban stormwater systems through increased hydraulic capacity for flood control, lowering of water velocities to reduce downstream erosion, removal of water from combined sewers, improvements to water quality, and more. Daylighting can improve aquatic habitat and provide "new" riparian corridors for wildlife. It can revitalize neighborhoods, increase property values, and benefit nearby businesses. It can be more cost effective than the expense of repairing a failing culverts. Daylighting projects help educate children and adults alike about the workings and values of stream corridors and wetlands. In doing so, they foster stewardship of natural resources and energize people with a sense of "setting things right." What more powerful restoration project is there than recovering a buried, out-of-sight and out-of-mind waterway that seemed lost forever?

METHODS

The first year study area focused on tributaries to the Pittsburgh Pool. There were five main tasks:

- *Characterize watershed and stream conditions in the study area.* Assess the general ecological health of streams in the study area and set the context for selection of potential daylighting sites for further study.
- *Identify potential daylighting sites.* Cast a wide net for identification of potential daylighting sites.
- *Select and study example daylighting sites.* Select a few appropriate sites to put forward for community discussion as examples of daylighting opportunities. Develop the necessary background information and materials.
- *Engage the community.* Create community dialogue about daylighting and perhaps generate a level of interest such that local community groups and individuals might pursue daylighting projects at the selected location(s) or other locations.
- *Develop a concept study and resource analysis.* Compile the results of the year's activities and discuss daylighting opportunities in the region in both general and specific terms. (This report is the product of this task)

WATERSHED AND STREAM FINDINGS

Streams that flow into the Pittsburgh Pool—excepting the rivers themselves—drain a total of 168,965 acres, or 264 square miles, of Allegheny County. The Washington County portion of Chartiers Creek adds another 132 square miles to the area that drains to the Pittsburgh Pool, for a total Pool "watershed" of 396 square miles (approximately 253,000 acres) in Allegheny and Washington Counties.

Remarkably little good data is available about the physical status of Allegheny County streams—even the simple metric of how many miles of our pre-development stream network remains open, and how miles have been culverted or otherwise "disappeared" has heretofore been unavailable. We combined existing stream data from the Allegheny County Geographic Information System with an original analysis of digital elevation model data to construct a comprehensive open/buried stream map of the year one study area. While the data is still somewhat rough (future studies will refine it), we now have a good "first cut" estimate of the open/buried status of streams in watersheds flowing into the Pittsburgh Pool (Allegheny county portion only):

	Miles	Percent
Currently Open Streams	564.2	59.0%
Culverted Streams	389.9	40.8%
Uncoded	1.4	0.1%
Total	955.5	100%

We identified 21 key watersheds in the year one study area. These are watersheds approximately one square mile or larger in size. For each of these watersheds we gathered and reviewed available data concerning a variety of measures of stream and watershed ecological health. This allowed us to categorize the watersheds into various classes of ecological integrity. We did not use a "formula" to determine the categories, but rather assessed the overall trend of a variety of indicators. We relied most heavily on recent macroinvertebrate bioassessments, and to some extent on the Pennsylvania DEP's stream assessment data, supplemented by review of land use data and patterns. The classifications follow:

Highest integrity streams/watersheds

- Guyasuta Run
- Pine Creek
- Chartiers Creek

This class includes those streams whose benthic macroinvertebrate communities were classified as only "slightly impaired." All three watersheds are heavily forested and have low proportions of their land in built environment land uses and impervious surfaces, and each has many headwater areas with limited to no development.

Moderate integrity streams/watersheds

- West Run
- Sipes Run
- Becks Run
- Girtys Run
- Homestead Run
- Jacks Run
- Spruce Run

Streams with macroinvertebrate communities rated "moderately impaired" are included in this class, plus a few other streams. In general, these watersheds are more developed than those in the previous class, but are not as highly urbanized as the next class.

Low integrity streams/watersheds

- Streets Run
- Saw Mill Run
- Nine Mile Run
- Tassey Hollow
- Woods Run
- Four Mile Run

These are all highly urbanized watersheds. Tassey Hollow, Woods Run, and Four Mile Run are different from the other three streams in that each no longer has a connection to a main river. Each has been captured by combined sewers; only wet weather overflows now reach the rivers from these watersheds. However, we do not "drop" these watersheds to the lowest ecological integrity class because each has remnant streams in substantial blocks of forest in an upper portion of its watershed.

Extremely altered streams/watersheds

- Spring Garden
- Allegheny Cemetery

- Heths Run
- Corliss Street
- 32nd Street Culvert

Each of these watersheds is very heavily urbanized and has no connection to a river, its stream system having been replaced by combined sewers. Each contains few to no remnant stream segments.

Care should be taken in interpreting and using these classifications. The classes are based on overall watershed/stream conditions. They take some note of some important watershed subareas and stream reaches but cannot encompass all the important variations in ecological integrity within each watershed and stream system. Nonetheless, the stream classifications above can be useful in selecting sites for stream restoration and daylighting projects. All things being equal, it can be argued that restoration projects in higher integrity watersheds will have greater chances for success and higher value.

It is clear that many local streams have significantly improved in biological terms over the last 20 years with the demise of industry. Stream bugs, fish and wildlife are returning to our streams. Many streams have incredible potential for a range of human uses from fishing, to wading, bird-watching and exploring. For each mile of river in the year one Allegheny County study area of we have 21 miles of currently open streams, so streams are critical to public access to aquatic ecosystems. One question we have to address is, can we resolve our bacteriological water quality problems to make it safe to use our streams? If we can, we have good reason to believe that protecting and restoring our currently open streams, and daylighting buried streams in appropriate locations, will yield exciting results.

THE AGENDA FOR LIVING STREAMS

Data on culverting permits from the Pennsylvania DEP show that Pittsburgh-area streams are still being buried. It is also clear that development threatens the ecological integrity of many local watersheds. The available data on stream conditions and consideration of the historical and current factors leading to degradation and outright loss of streams suggest that a multi-faceted agenda, outlined in this report, is required to establish an ethic—and real results—for living streams in Allegheny County:

- *Protect* currently open streams from further degradation.
- *Improve* the condition of open but degraded streams.
- *Daylight* buried streams in appropriate locations.

ABOUT DAYLIGHTING

Daylighting is possible in a wide range of pre-existing land use conditions. Of course, not every buried stream can or should be daylighted. And not every daylighting project can or should create a completely natural stream. The full spectrum of daylighting projects includes:

> *Natural restoration:* A project that restores the characteristics of natural streams. These include a stream bottom and stream banks that are permeable to water and are vegetated. The degree of “naturalness” can vary: in appropriate locations the result can be quite a wild stream, in others the channel may be reinforced

through the strategic use of natural materials and the stream and its corridor may be otherwise sensitively manipulated.

Architectural restoration: A restoration of the flowing water to the open air, but in a carefully designed and entirely contained channel. Such projects are typically done in dense urban areas or other locations where flow must be well-controlled. The result could be a babbling, rock-lined channel through a city square, or a larger waterway with walls and bottom made of stone blocks or concrete, running along a street or through a park or downtown area.

Cultural restoration: A project that celebrates a buried stream but does not "raise" it. Though the stream remains buried, a variety of markers and public art inform people of the stream's current condition, its historical route and uses, and other physical and cultural information.

An additional variable, for natural and architectural restoration projects, is whether some or all of the available flow is restored to the open air. We can consider both *full flow* and *partial flow* options for daylighting. For instance, a project might restore the dry weather "base flow" to the surface, but divert high stormwater flows into an existing or new culvert.

Costs of daylighting projects across the U.S. have ranged from $15 to $5,000 per linear foot. It is difficult to get an exact handle on "typical" daylighting costs, because projects are so varied. However, natural restoration projects with appropriate use of volunteer labor typically run about $15 to $250 per linear foot. Complicated architectural restorations can run from $1,500 per linear foot in highly structured urban parks to $5,000 per linear foot in a central business district.

A variety of challenges must be met if a daylighting project is to be successful. These include:

Community issues. Often the prospect of restoring flowing water to the surface raises concerns over safety, public access, water quality and health, and differing expectations of project purposes and results. These issues must be fully articulated and each must be responsibly addressed.

Institutional issues. Daylighting projects can raise various questions relating to stream ownership, maintenance, and liability. They may also present difficulties in coordinating multiple agencies and in permitting. Some of these issues may be "showstoppers," but a can-do approach often resolves them.

Technical issues. The more urban a project's location, the more technical issues will come up. And the more constrained the potential project corridor, the more difficult it will be to solve the problems. One can't usually expect to duplicate pre-development conditions, and techniques appropriate in rural stream restoration projects may not be appropriate in the city. It's important that the project designers include a wide range of technical experts: engineers, biologists, landscape architects, and others.

SITE IDENTIFICATION ,SELECTION, AND CONSIDERATION

In the first year of the 3 Rivers – 2nd Nature program, we were assisted by ALCOSAN in identification of potential daylighting sites. ALCOSAN had previously identified 20 locations where direct stream inflows to municipal combined sewers might occur. Its engineering consultant, CDM, determined that 11 of these sites are direct inflows of perennial streams. ALCOSAN is interested in developing stream/sewer separation projects at these locations to remove dry and wet weather flows, and attendant sediment contributions, from the sewer system. These flows and sediments take up valuable capacity in the system and impose treatment and maintenance costs. Daylighting is an alternative to conventional stream separation projects that can produce additional benefits.

The 3R2N daylighting team, with feedback and approval from the 3R2N Advisory Committee, chose two of the ALCOSAN stream inflow sites for further investigation—one in Sheraden Park in Pittsburgh's West End, and another in Pittsburgh's Schenley Park and Junction Hollow. The following reasons contributed to our interest in these sites:

- Both are valley bottom sites with manageable stream slopes. This avoids water velocity and erosion problems that could occur on steeper sites.
- Both sites have significant natural land in their contributing watersheds, which raises the potential for restoration success. At the same time, both present opportunities for demonstrating better stormwater management within their watersheds.
- Both are substantially on public land. This avoids the difficulties and expense of obtaining property or easements.
- Both offer the possibility of completing a daylighting project all the way to a natural waterway. This would be a significant challenge for the Junction Hollow site, and comparatively easy at the Sheraden Park site.
- Junction Hollow offers a very high visibility location. Sheraden Park is less regionally notable, but as a public park will still obtain notice.

3 Rivers – 2nd Nature researched each of the sites and their watersheds in some detail. We hosted public outreach events on each site in late September of 2001. Participants in the Schenley Park/Junction Hollow event mostly indicated enthusiastic support for further study of the daylighting option there. Participants in the Sheraden Park event were neither enthusiastic nor dismissive of daylighting at that location. Rather, they were skeptical the city would ever invest in a significant restoration project in Sheraden Park, which they believe has been neglected by the city for over 30 years.

This report concludes with a review of key steps that daylighting project proponents must undertake to develop successful projects. It also presents a list of useful resources—technical references, helpful organizations, and project funding ideas.

3 Rivers – 2nd Nature stands ready to provide conceptual assistance to Allegheny County daylighting proponents that pursue these or other projects, insofar as our resources allow. Our approach remains identification of opportunities, followed by strategic public intervention to spark discussion and consideration of the opportunities. Specific projects must by taken up and driven by local communities if they are to succeed. Future efforts of the 3R2N stream restoration and daylighting program will include further development and refinement of tools for characterization of stream and watershed conditions, extension of our methods to other parts of the county, and analysis and development of policy options to advance the living streams agenda.

INTRODUCTION

The 3 Rivers – 2nd Nature stream restoration and daylighting program addresses stream restoration within cities. We maintain that living streams represent a core value relevant to a successful new economy city. We use the phrase "living streams" to emphasize that our local streams are ecosystems, not merely urban infrastructure. Living streams provide for a wide range of essential urban needs: water quality improvement, runoff management, recreational and educational opportunities, beautiful landscapes, and wildlife habitat. They support property values and generate other economic benefits. To obtain these many benefits, Allegheny County cities and communities must protect existing stream ecosystems and restore compromised ones.

Our efforts take place within the larger context of integrated ecosystem restoration, which embraces the complex goal of nature in the context of contemporary urban culture. This is an emerging paradigm for ecological and social change. Creating this change requires integrating experts with communities. Thus, our efforts in this program include analysis by experts in infrastructure, water policy, stream biology, landscape architecture, art, urban planning, geographic information systems, and other disciplines, *integrated* with public dialogues—all addressing current stream conditions, opportunities to protect and restore streams, and the broad benefits that can be generated through stream restoration.

Stream restoration has been defined in various ways by various authors and agencies. We follow the broad definition of the Federal Interagency Stream Restoration Working Group (1998, p. I-3):

> Restoration, as defined in this document, includes a broad range of actions designed to enable stream corridors to recover dynamic equilibrium and function at a self-sustaining level. The first and most critical step in implementing restoration is to, where possible, halt disturbance activities causing degradation or preventing recovery of the ecosystem. Restoration actions may range from passive approaches that involve removal or attenuation of chronic disturbance activities to active restoration that involves intervention and installation of measures to repair damages to the structure of stream corridors.

The National Research Council (1992, p. 18) defines aquatic system restoration as "the return of an ecosystem to a close approximation of its condition prior to disturbance." This is rarely possible in urban situations. Our concept of stream restoration, therefore, also encompasses less expansive notions such as "rehabilitation," the recovery of ecosystem functions and processes in a degraded habitat; and "reclamation," action intended to change the biophysical capacity of an ecosystem, as defined by the Federal Interagency Stream Restoration Working Group (1998, following Dunster and Dunster 1996).

A particular 3 Rivers – 2nd Nature focus in addressing stream restoration in Allegheny County is stream "daylighting." Daylighting is the act of removing streams from underground pipes and culverts, restoring some of the form and function of historic streams. Daylighting is the most profound form of stream restoration, recreating a surface waterway where "nothing" exists now (Pinkham 2000).

The 3 Rivers – 2nd Nature daylighting program seeks to identify daylighting opportunities in Allegheny County and encourage development of daylighting demonstration sites. The effort is structured to be iterative and replicable, both within sub-areas of the county, and as a model that can be applied beyond. Our goals are as follows:

Short Term: Develop efficient and effective expert and public processes to identify high-potential daylighting sites and encourage initiation of appropriate projects.

Long Term: Change expert and public consciousness about the benefits of open waterways and functioning urban aquatic ecosystems and effect the protection and restoration of those ecosystems in order to realize their ecological, economic, infrastructure, social and other values.

Our program takes a strategic, conceptual approach. We are not undertaking design efforts. Rather, our interest is in framing issues, communicating opportunities, and building constituencies. We aim to assist local citizens and organizations interested in stream restoration and daylighting by developing information on stream conditions in Allegheny County, outlining the range of restoration possibilities, identifying key challenges that projects must address, and providing models and tools to assist local stakeholders in implementing projects they wish to pursue. We combine a “top-down” approach that screens the region for opportunities with a “bottom-up” approach that encourages local communities to take responsibility for developing specific projects. Our work is based on an asset-analysis framework, in which we emphasis how stream restoration and daylighting can increase the base of natural and built environmental and infrastructure assets of the region.

Rationale and Context

A recent review of implemented and proposed daylighting projects across the country and abroad shows that daylighting projects can provide multiple benefits—tangible and intangible—for every dollar expended (Pinkham 2000). These include improvements to the functional values of waterways and urban stormwater systems through increased hydraulic capacity for flood control, lowering of water velocities to reduce downstream erosion, removal of water from combined sewers, improvements to water quality, and more. Daylighting can improve aquatic habitat and provide “new” riparian corridors for wildlife. It can revitalize neighborhoods, increase property values, and benefit nearby businesses. It can be cost effective compared to the expense of repairing a failing culvert. Daylighting projects help educate children and adults alike about the workings and values of stream corridors and wetlands. In doing so, they foster stewardship of natural resources and energize people with a sense of “setting things right.” What more powerful restoration project is there than recovering a buried, out-of-sight and out-of-mind waterway that seemed lost forever?

Many of these benefits could be realized in Allegheny County daylighting projects. The infrastructure connection receives special attention in our program. For instance, we know that ALCOSAN presently treats a significant amount of creek water. Removal of these streams from the system (sewer-separation) would mitigate treatment costs at the plant and maintenance costs (e.g. sediment removal) for the conveyance system. ALCOSAN has already identified 20 locations where sewer separation could help reduce combined sewer overflows and support the objectives of its Long Term Control Plan. Daylighting is an alternative to conventional sewer separation. It would provide the additional values of improved water quality and flood mitigation complimented by urban habitat and aesthetic benefits. It combines environmental restoration and infrastructure rehabilitation, producing multiple benefits from dollars spent on “gray infrastructure” by increasing the amount of “green infrastructure” that integrates green space into the urban landscape. ALCOSAN has expressed considerable interest in fostering daylighting projects in local municipalities.

To date, few U.S. daylighting projects have removed streams from combined sewer systems. Proposed projects in Portland, Oregon, and Seattle, Washington were to do so, but these projects did not proceed because of a variety of technical and political difficulties. Both projects involved routing a daylighted stream through for long distances through heavily built-up areas. The technical difficulties and financial costs were great.[1]

However, there is nothing inherently unachievable about daylighting streams as part of a sewer separation program. Indeed, in Switzerland a 1991 law mandated removal of clean water inputs to combined sewer systems. The city of Zürich has to date removed an average flow of 4.5 million gallons per day, water that no longer burdens the city's two treatment plants (where dry weather inputs total 71 mgd). The Zürich experience is particularly instructive given the hilly topography of the city.

While separating stream flows and sanitary sewage is a key concern at the present time, we wish to cast the net even more broadly. We are also addressing streams that have been put into storm culverts, seeking places where restoration of those streams to the surface could benefit ecosystems and local communities. By examining all types of culverted streams, we hope to facilitate a wide range of planning and decision making processes that impact stream and riparian ecosystems and attendant human values, such as open space and greenway corridors. Further, discussion of daylighting raises the question of whether currently open streams have adequate protection, and whether and where channelized or badly degraded stream channels should be renaturalized. We believe our focus on "radical stream restoration"—daylighting—will engender broad dialogue on stream protection and restoration.

We also make linkages to watershed issues and progressive stormwater management as appropriate. For instance, a daylighting site cannot be developed without consideration of the upstream watershed. Feasibility will increase and results improve when the quantity, velocity, and sediment load of runoff reaching a daylighting site is reduced by applying stormwater infiltration and bioretention methods in the watershed.

Limited precedents for this effort exist, though no U.S. communities have attempted the comprehensive review for daylighting opportunities that 3 Rivers – 2nd Nature has initiated for Allegheny County. Several dozen daylighting projects have taken place in the U.S. since the late 1970s. Most American daylighting projects emerge organically, as efforts driven by neighborhoods, parks groups, conservation organizations, or city public works officials with a particular problem or opportunity at hand. Few "top-down" efforts to identify the best opportunities within a geographic region have taken place. A few localities—Portland, Oregon; several eastern San Francisco Bay Area communities; and Washington, D.C. have prepared maps of "disappeared" streams. Only Washington, D.C. appears to have done so as a tool for selecting possible daylighting locations, and that

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[1] In the case of Seattle (the Ravenna Creek project), project proponents claim they adequately addressed all the issues—including funding by securing substantial federal assistance—only to have the project stalled and killed by one obstinate city staff member who convinced a subcommittee of city council of his view. Despite impressive success lobbying other officials, the project faced this one insurmountable obstacle in a largely non-accountable public official. The truth of this claim could not be independently verified, but this story does point out that the political pitfalls in major daylighting projects, which represent a substantial change from business as usual, can be significant.

effort did not use geographic information system (GIS) tools extensively, as our program does. The U.S. EPA sponsored an effort to identify and prioritize potential daylighting demonstration locations in the Charles River watershed in and near Boston, Massachusetts in 1998 and 1999. This effort also did not utilize GIS and other tools our project employs.

RELATION TO OTHER 3 RIVERS – 2ND NATURE PROGRAMS

The daylighting program both builds on and supports the other programs of the 3 Rivers – 2nd Nature project:

Urban Water Quality: Daylit streams typically increase dissolved oxygen relative to culverted waterways, and their sediments and vegetation can remove metals and nutrients and bacterial contaminants. Such results benefit both the tributary streams themselves and the mainstem rivers. Some daylighting projects remove water from combined sewers, potentially reducing the number and severity of combined sewer overflows.

> *Urban Riverbank Bio-diversity:* Daylighting increases green infrastructure in the urban environment. It increases the number and quality of micro-habitats, and can link riverside and tributary areas for ecological restorations that realize habitat and biodiversity values.
>
> *Post-industrial Urban River Access and Public Use:* This program's efforts assist in the identification of culverted streams. In return, the daylighting program will support public access by helping to clarify opportunities and rationales for linking park and greenway areas from the riverbanks up into the tributaries. Together these two programs will improve our understanding of the historical context of access to the rivers and streams; the development of the region's gray infrastructure; and the historic, current, and potential relations between access and infrastructure.

ORGANIZATION OF THIS REPORT

The next chapter of this report describes the methods of the 3R2N daylighting program in general terms. This is followed by key findings on the current conditions of the study area's streams and watersheds. Several subsequent chapters present general background relevant to consideration of daylighting projects: historical reasons for culverting of streams, a proposed agenda for local stream restoration and daylighting activities, a review of different general types of daylighting projects, costs and benefits of daylighting, and a discussion of the social, institutional, and technical challenges daylighting projects can present. We then turn to identification of potential daylighting sites in the study area, and selection of two sites for further investigation. The sites are described in detail. The report concludes with a brief guide to the daylighting project process and a list of useful resources.

METHODS SUMMARY

The 3 Rivers – 2nd Nature stream restoration and daylighting program is scheduled as a four-year effort. The first three years (2001-2003) will sequentially focus on sub-areas of Allegheny county, developing stream condition characterizations, highlighting opportunities, and working with stakeholders within each sub-area. The expert and public processes developed in the first year will be refined and reapplied to additional sub-areas in the second and third years. The fourth year will pull together the results and lessons of the first three years to develop a comprehensive rationale and "game-plan" for long-term stream protection, restoration, and daylighting in the region.

YEAR 2001 ACTIVITIES – PROGRAM INITIATION

The first year study area focused on tributaries to the Pittsburgh Pool. There were five main tasks:

- *Characterize watershed and stream conditions in the study area.* Assess the general ecological health of streams in the study area and set the context for selection of potential daylighting sites for further study.
- *Identify potential daylighting sites.* Cast a wide net for identification of potential daylighting sites.
- *Select and study example daylighting sites.* Select a few appropriate sites to put forward for community discussion as examples of daylighting opportunities. Develop the necessary background information and materials.
- *Engage the community.* Create community dialogue about daylighting and perhaps generate a level of interest such that local community groups and individuals might pursue daylighting projects at the selected location(s) or other locations.
- *Develop a concept study and resource analysis.* Compile the results of the year's activities and discuss daylighting opportunities in the region in both general and specific terms. This report is the product of this task.

Each task is summarized below. Detailed methodologies are presented in later sections of this paper.

Task 1 – Characterize watershed and stream conditions

The initial step was to understand the condition of watersheds and streams in the study area. This required gathering and summarizing currently available data, and generating additional data.

We first used digital watershed boundaries from the U.S. Geological Survey (USGS) and digital topographic data from the Allegheny County Geographic Information System (AGIS) to identify all land that drains by local streams (not including the mainstem rivers) to the Pittsburgh Pool. We delineated the major local stream watersheds within this year one study area. We also examined maps and made field visits to note key stream and watershed features, such as the physical status of tributary junctions with the rivers (open or culverted).

Second, given our emphasis on the daylighting subset of stream restoration opportunities, a key need was to understand how much of the original hydrologic endowment of the region—its free-flowing stream system—has been lost to stream culverts and combined sewers since development began several centuries ago. This analysis requires a complete map of the drainage network in the county. The map must include both currently open streams and streams now buried in culverts. Most available maps do not show locations of culverted streams, so the primary challenge was to locate all culverted streams. The map should be digitized and compatible with a geographic information system (GIS), to allow for statistical analysis of open/culverted stream conditions, and for queries using various screening criteria to identify potential daylighting sites. Further, we wished to use data sources and methods for developing the map that could be readily replicated in other counties and regions. We took several approaches to developing a complete stream map:

Approach 1 – *USGS map features*

Topographic maps from the USGS include streams. We examined whether these maps include stream culverts.

Result: A few stream culverts are shown, but most culverts are not. The maps must be scanned for input into a GIS.

Approach 2 — *County GIS hidden streams coverage*

Drainage data from the Allegheny County Geographic Information System (AGIS) includes categories for open streams and for "hidden" (i.e., culverted) streams. We examined the extent of the coverage.

Result: The AGIS drainage data is incomplete. For substantial portions of the county, particularly in the older urbanized areas, neither open nor culverted streams are shown.

Approach 3 – *Pennsylvania DEP stream culverting permits*

Since 1995 the Pennsylvania Department of Environmental Protection has been documenting permits it issues for construction of stream culverts (defined by DEP as anything less than 100 feet in length) and stream enclosures (anything 100 feet or more in length) by means of USGS Quads and page coordinates. We obtained and examined the DEP lists for Allegheny County.

Result: The data is limited to very recent years. It only indicates locations of issued permits, not whether a project was actually built. The data had to be converted to GIS format.

Approach 4 – *ALCOSAN stream inflow sites*

An ALCOSAN maintenance engineer has developed from memory a list of streams that he knows are flowing into the existing combined sewer systems. ALCOSAN has mapped these points. Sewer maps show the location of the combined sewer culvert running from the inflow point to the ALCOSAN interceptor at a river. The combined sewer culvert indicates the approximate path of the historic stream.

Result: While useful for identification of potential stream daylighting sites, this information is far from a complete map of the locations of all historic streams that have been replaced by combined sewers. Also, local knowledge of sewer system engineers will vary considerably beyond the ALCOSAN service area.

Approach 5 – *Sewer maps*

Sewer maps should be a good source of information on the location of culverted streams. Large combined sewer culverts typically convey historic streams as well as sewage. We assessed the usefulness of available sewer maps.

Result: The quality of sewer maps varies markedly from municipality to municipality. Also, not all streams are entirely plumbed into combined sewer lines. (A good example is the stream in Fern Hollow in

Pittsburgh's Frick Park. It and a combined sewer run parallel.) Sewer maps may be a useful tool for analyzing conditions at small numbers of potential daylighting sites, but are of questionable value for region-wide identification of culverted streams.

Approach 6 – *Digital elevation model analysis*

We used GIS modeling techniques and digital elevation data to identify the topographic low points of all watersheds in the county. Lines connecting the low points indicate where we would expect streams to be. We then overlaid the DEM-generated drainage network with the current AGIS stream coverage. Locations where there is a DEM-generated stream line but no AGIS stream information probably indicate culverted streams.

Result: A map combining the DEM drainage data and AGIS stream data has been created, edited and proofed for the year one study area. Combining the data sets required more manual manipulation than we had expected. The combined data represents a reasonable "first cut" approximation of the open/culverted status of the entire, historic, pre-development stream network. It allows for development of summary statistics on culverted and open stream miles in the study area. While this data is a good start, in the process of developing it we discovered that the AGIS stream coverage is not entirely accurate (e.g. some currently open streams are not included), and the DEM-generated data may have locational inaccuracies because generations of landforming (cut and fill) activity have altered the topography of many valley bottoms. Thus we have identified and recently begun two additional steps to help revise and refine the complete open/buried stream map.

Approach 7 – *"Connect the lines" analysis of USGS maps*

The USGS Quadrangle (graphic.tiff) maps have been scanned for use in GIS. These maps identify surface streams, fill, and culverts where highway or roadway impediments occur. We must first digitize this existing information, then use that as a base map which can be compared to the AGIS stream coverage (and in turn to the digital elevation model drainage network). The goal is to highlight isolated surface stream segments. The underlying USGS topography will allow us determine how the isolated segments connect with other segments, and land cover analysis will determine if it's likely the missing segment is culverted.

Result: This is a tedious and time intensive process, which began in December.

Approach 8 – *Historic maps*

The combined DEM/AGIS map and "connect the lines" approaches ought to be comprehensive, but so much landforming (cut and fill) has been done in Pittsburgh that there will be inconsistencies. Examination of historic maps (analog data) should help refine the location of historic stream paths. This information could be digitized and incorporated into the GIS.

Result: We have identified a number of appropriate historic maps. Reviewing and digitizing them is a significant effort that will require strategic funding.

While we developed the complete open/culverted stream map, we also gathered and compiled watershed data available from AGIS. This data included watershed development indicators such as land use and the percentage of impervious surfaces. These measures give us a general indication of the degree to which human development activities have compromised the ecological integrity of local watersheds.

We also reviewed a number of existing and ongoing stream studies for useful descriptive data. These included:

- A study of physical/chemical water quality and bacteriological conditions at the mouths of major tributaries to the Pittsburgh Pool, prepared by 3R2N researchers Kathleen Knauer and Tim Collins (2001).
- A study of macroinvertebrates (stream "bugs") at stream mouths carried out in cooperation with 3 Rivers – 2nd Nature by U.S. Army Corps of Engineers staff Michael Koryak and Linda Stafford (2001).
- Stream assessments prepared by the Pennsylvania Department of Environmental Protection (2001) for its "Unassessed Waters Program."

Together, these various data allowed us to make reach some general conclusions about stream health in the study area, and provided a context for selecting potential daylighting sites for further study.

Task 2 – Identify potential daylighting sites

The long-term intent of the 3R2N daylighting program is to develop a mapping and site identification tool for stream preservation and ultimately restoration and daylighting. Over the last year, we began to develop methods to synthesize new knowledge about stream quality developed by the 3R2N field teams with existing GIS data and current knowledge of sewer and stormwater infrastructure possessed by local engineers, public officials, and citizens. The information collected to date has been transferred into GIS for analysis.

As described above, the team found a surprising lack of applicable and good-quality GIS-compatible stream and infrastructure data in the Allegheny County region. Existing data sets were incomplete or poorly digitized (for our needs), requiring extensive editing and oversight. As a result, GIS analysis completed in the first year study did not allow for identification of potential daylighting sites. Methods for doing so will be developed in later studies.

We also sought out local knowledge that could help identify potential daylighting sites. We did not have the time to locate and contact appropriate sources in each municipality, so we searched for compilations of local knowledge. These could include lists of stream inflows to combined sewers, and inventories of drainage problems that might derive from inadequate culverts. Such locations could be examined to determine if daylighting is a possible solution to an infrastructure problem. We investigated the following potentially relevant information sources:

Approach 1 – Allegheny County Emergency Management

Localized flooding problems sometimes stem from under-capacity stream culverts. We asked the county Emergency Management Agency if they had flood hazard maps or lists that would indicate such sites.

Result: They do not have any data on this problem that we could easily sort through and use for identification of such sites across a large area.

Approach 2 – Allegheny County Health Department

ACHD often gets complaints on flooding and related drainage issues. We asked if they had flood hazard maps or lists that could help identify under-capacity stream culverts.

Result: ACHD does not document complaints by subject matter, and after two years, all complaint files go into storage.

Approach 3 – ALCOSAN stream inflow list

As noted above, an ALCOSAN engineer has identified from memory locations of stream inflows into combined sewers. We worked with ALCOSAN to understand and review this list.

Result: The list included 20 sites where direct inflows of streams to municipal combined sewers could be occurring. ALCOSAN developed this list as part of its Pennsylvania Act 537 Sewage Facilities Plan and its Long Term Control Plan for combined sewer overflows. The ALCOSAN engineer knew of these sites from years of experience working in the field with the municipal combined sewer systems. Camp Dresser & McKee (CDM), ALCOSAN's engineering consultant, studied these sites during 2001. Eleven sites were determined to have direct connections of perennial streams to municipal combined sewers. Such sites are potential candidates for sewer separation projects. Conventional separation projects create a separate storm sewer for stream and stormwater flows, and do not recreate surface streams. Separation could include daylighting, though the feasibility of daylighting at each site varies substantially. We review the daylighting potential of the eleven sites later in this report.

Task 3 – Select and study example daylighting sites

A number of factors can make daylighting a culverted stream difficult or impossible:

- extensive infrastructure and buildings over the culvert or areas of possible stream relocation;
- "capture" of streams by combined sewers (daylighting projects must divert stream water above inflows to combined sewers);
- high land values that preclude open space uses;
- steep slopes that would result in overly erosive stream velocities;
- high discharge rates, due to upstream conditions (e.g. imperviousness), that cannot be managed given stream corridor constraints imposed by surrounding urban land uses;
- sunk costs in recently culverted streams.

In addition to these "negative" screening criteria, selection of daylighting sites should be guided by the following "positive" criteria:

- *Local support.* Are neighbors, local citizen groups, and local agencies likely to actively support a project? Are any likely to oppose it?
- *Funding opportunities.* Are one or many angles to grants or other potential funding programs likely? Could a daylighting project at this site be an adjunct to some other existing or likely project by public or private parties with interests in development, parks, transportation, water management, or other areas?
- *Technical feasibility.* Are the potential technical challenges at this site likely to be manageable? Is a project here likely to be robust (unlikely to impair other values or otherwise fail)? Does a project here seem "doable?"

- *Demonstration value.* Is the potential project in a high-visibility location? Will the before/after change be significant and apparent? Is the project likely to have demonstrable positive benefits for habitat creation, water quality improvement, amenity development, flood control, or other public goals?

Of the 20 sites on the original ALCOSAN stream inflow list, eleven were determined by CDM to have perennial stream water. Others were ephemeral stream inflows or simply wet weather inflows to combined sewers through storm drains or deteriorated sewer lines. Two of the perennial stream inflow sites were under study for separation projects by the spring of 2001. In June of 2001, the 3R2N daylighting team visited several sites determined by CDM to be potentially suitability for stream daylighting.

The 3R2N daylighting team chose, with feedback and approval from the 3R2N Advisory Committee, two sites for further investigation and public engagement. One site is in the Four Mile Run watershed of the eastern portion of Pittsburgh. Another is in Pittsburgh's West End, in Sheraden Park, which drains to Chartiers Creek. (These sites and the specific reasons for their selection are described in considerable detail later in this report)

We researched the selected sites in some detail. Our efforts included multiple visits to inventory and photograph key features at each site, map and ground reconnaissance of each site's watershed, personal and phone meetings with responsible local agencies and other key informants, and preparation of appropriate maps. The team notated base maps provided by CDM for the area around each site. The maps showed spatial relationships between daylighting opportunities and other culverted streams; downstream outfalls for combined sewer overflows (CSOs); local parks, amenities, and natural areas; streets and building footprints; watershed boundaries; and other relevant features for each site and its watershed.

Task 4 – Engage the community

Case studies of daylighting projects show that few happen without extensive community involvement and participation (Pinkham 2000). It is necessary to engage project neighbors and the wider public to develop support for projects, and to address the many concerns and challenges that can arise from daylighting proposals. Moreover, since 3 Rivers – 2nd Nature has a strategic focus—identifying opportunities and providing information and tools, rather than directly pursuing and leading projects—our approach is to educate the public and key stakeholder groups about specific opportunities, and then step back to let projects "sink or swim" based on the needs and interests of the affected communities. Our community engagement methods included:

Publicity. We established dates for public meetings on daylighting and the opportunities for each sites, then notified the public through a variety of means. Brean Associates sent email notices and mailed fliers to hundreds of individuals on mailing lists developed for the overall 3 Rivers – 2nd Nature effort. They also contacted representatives of key watershed and community groups and asked those individuals to spread the word about the public meetings.

Public meetings. We held a public meeting and site tour for the Four Mile Run site on Saturday, September 29th, and for the Sheraden Park site on Sunday, September 30th. These events lasted six and four hours, respectively. (The Four Mile Run site tour was longer, required bus shuttles, and necessitated serving lunch.) Approximately 52 people (not counting the 3R2N team) attended the Four Mile Run event, and 17 attended the Sheraden Park event. We presented information in plenary on daylighting generally and the selected watersheds and sites. We toured each site on foot with the attendees, and pointed out where a daylighted stream could run, as well as the challenges and potential benefits at each site. The site tours included participation and commentary from experts in stream ecology, landscape architecture, city planning, and other disciplines. After the tours, participants took part in roughly one-hour discussions sessions facilitated by the 3 Rivers – 2nd Nature team. Points made and questions raised in the discussions were captured by recorders in each discussion group.

Website development. The daylighting team made use of the 3 Rivers – 2nd Nature website to begin posting information on daylighting. We posted a basic description of the daylighting concept, some before/after images of daylighting projects from other cities, and three maps showing the physical status (open vs. culverted) of streams in Allegheny County.

Task 5 – Develop a concept study and resource analysis

The final report for year one (this document) is meant to:

- Articulate the rationale and discuss implementation considerations for daylighting projects in the region.
- Report the watershed and stream characterization results.
- Discuss the historical and current cultural contexts for the loss of open streams and opportunities for their restoration.
- Discuss the opportunities and challenges of stream daylighting—in general terms and specifically for the two sites examined in detail.
- Provide information and identify additional resources that can be used by local stakeholders interested in pursuing daylighting projects.

WATERSHED AND STREAM CONDITIONS

The 3 Rivers – 2nd Nature Year 1 study area consists of watersheds of all streams that flow into the Pittsburgh Pool. These streams vary in significance from Chartiers Creek, a major stream system that extends well beyond Allegheny County, to small perennial and ephemeral streams that drain the plains and hills immediately above the river banks. Chartiers Creek has a watershed that encompasses 227 square miles, while smaller perennial streams may have watersheds of less than a hundred acres, often much less where streams arise from seeps and springs created by local geologic conditions.

Stream conditions can be profiled in many ways. Streams can be evaluated for the physical configuration and conditions of the stream channel, the physical and chemical quality of the water flowing in them, the presence of pathogenic organisms, the nature and conditions of the biotic communities they contain, and for their overall condition as a combined function of a variety of measures. Most stream evaluations require significant time and often significant amounts of money. Rarely are all or even a large sample of the streams in a given region inventoried and assessed vis-à-vis comprehensive or even limited criteria. However, a variety of information on stream conditions in Allegheny County is available.

This chapter characterizes the physical and ecological conditions of the study area's major streams and their corresponding watersheds. We begin with basic physical descriptions of the streams, then examine land use in their watersheds. Land use is an important general predictor of the ecological health of watersheds and streams. After these general characterizations, we report the results of several recent studies of local streams. These studies address physical and chemical water quality, bacteriological water quality, stream fauna (macroinvertebrates), and overall stream health. The chapter concludes with a discussion of the implications of the various findings, vis-à-vis stream/watershed ecological health and restoration potential.

STUDY AREA WATERSHED DELINEATIONS

Streams that flow into the Pittsburgh Pool—excepting the rivers themselves—drain a total of 168,965 acres, or 264 square miles, of Allegheny County. The Washington County portion of Chartiers Creek adds another 132 square miles to the area that drains to the Pittsburgh Pool, for a total Pool "watershed" of 396 square miles (approximately 253,000 acres) in Allegheny and Washington Counties.

As the region has developed over the last several centuries, some local watersheds have been so heavily developed that their streams have been entirely lost to culverts and combined sewer systems. Simple topographic analysis reveals watersheds of many hundreds of acres that once must have maintained flowing streams, but now reveal no surface streams whatsoever. Because this study addresses these losses—and opportunities to recreate some surface streams that now lie buried—we include these watersheds in our data, along with watersheds still graced by open streams. We identified 21 key watersheds in the year one study area. These are watersheds approximately one square mile or larger in size. (One square mile is 640 acres; a few of the selected watersheds are just under that size.) In addition, we added Tassey Hollow, a tributary to the Monongahela from Braddock Hills through Rankin and Braddock, because this 524 acre watershed is the known site of a significant stream inflow into municipal combined sewers. Figure 1, "Study Area and Key Watersheds," shows the study area boundary (within Allegheny County) and the locations of the 21 key watersheds. Table 1 provides the names, location, and size of these watersheds in descending order.

Note that in the case of the Spring Garden, Allegheny Cemetery, Corliss Street, and 32nd Street Culvert watersheds, we were unable to determine the name of the stream that once ran through the watershed. Thus we named these watersheds after prominent features or streets.

Appendix A

Table 1 – Key Watersheds in the Year One Study Area, Ranked by Size

Watershed	Tributary to (descending bank):	Total Acres
Chartiers Creek*	Ohio; Left Bank	60,707
Pine Creek	Allegheny; Right Bank	43,028
Saw Mill Run	Ohio; Left Bank	12,431
Girtys Run	Allegheny; Right Bank	8,565
Streets Run	Monongahela; Left Bank	6,437
Nine Mile Run	Monongahela; Right Bank	3,887
Spring Garden	Allegheny; Right Bank	2,302
Four Mile Run	Monongahela; Right Bank	2,290
32nd Street Culvert	Allegheny; Left Bank	2,002
Becks Run	Monongahela; Left Bank	1,627
Homestead Run	Monongahela; Left Bank	1,494
Jacks Run	Ohio; Right Bank	1,433
Spruce Run	Ohio; Right Bank	1,330
Woods Run	Ohio; Right Bank	1,280
West Run	Monongahela; Left Bank	977
Allegheny Cemetery	Allegheny; Left Bank	975
Sipes Run	Allegheny; Right Bank	932
Corliss St	Ohio; Left Bank	665
Heths Run	Allegheny; Left Bank	632
Guyasuta Run	Allegheny; Right Bank	625
Tassey Hollow	Monongahela; Right Bank	524
Key Watersheds Totals		154,143
Allegheny County Year One Study Area Totals		168,965

*Only the Allegheny County portion of Chartiers Creek is described here. The watershed extends beyond Allegheny County, totalling approximately145,000 acres.

PHYSICAL STATUS OF STUDY AREA STREAMS

Table 2 organizes the watersheds according to the rivers and banks to which they are tributaries, and adds basic observations on the status of streams in the watershed. This includes whether the stream mouth is currently open, culverted, or no longer existing due to capture of the stream by combined sewers. The table also notes whether the stream has built a sand bar at its river junction. Sand bars are typical of streams meeting rivers in this region, and are a physical form that provides ecological function such as varied habitat for fish and other aquatic creatures.

Table 2 – Key Watersheds by Location, with Stream and Watershed Conditions

River / Watershed	Total Acres	Stream Mouth Status*	Presence of Sand Bar**	Key stream and watershed cor
Allegheny River, left bank, descending order				
Heths Run	632	No stream; combined sewer	N.A.	Watershed is entirely culverted.
Allegheny Cemetery	975	No stream; combined sewer	N.A.	Watershed is almost entirely culverted.
32nd Street Culvert	2,002	No stream; combined sewer	N.A.	Watershed is entirely culverted.
Allegheny River, right bank, descending order				
Guyasuta Run	625	Short culvert	Yes	
Sipes Run	932	Short culvert	Yes	
Pine Creek	43,028	Open	Yes	This watershed supports a cold water (trout) fishery: Pine Creek is classified as " and Boat Commission.
Girtys Run	8,565	Short culvert	Yes	
Spring Garden	2,302	No stream; combined sewer	N.A.	Watershed is almost entirely culverted.
Monongahela River, left bank, descending order				
West Run	977	Long culvert	Yes	Watershed is almost entirely culverted.
Homestead Run	1,494	Long culvert	Yes	Dry weather flows leak from the stream culvert into sewer lines underneath. As a stream mouth.
Streets Run	6,437	Long culvert	Yes	Channelization of main stem under consideration.
Becks Run	1,627	Short culvert	Yes	Stream is channelized for a considerable distance up from the stream mouth.
Monongahela River, right bank, descending order				
Tassey Hollow	524	No stream; combined sewer	N.A.	
Nine Mile Run	3,887	Open	Yes	Upper portions of the watershed are heavily developed, with only a few tiny stre river in the lower watershed—Frick Park, Fern Hollow, and the Nine Mile Run Gre under residential development. A habitat restoration project on open reaches in/
Four Mile Run	2,290	No stream; combined sewer	N.A.	Watershed is almost entirely culverted, with the notable exception of Schenley P
Ohio River, left bank, descending order				
Saw Mill Run	12,431	Short culvert	No	Stream is partially channelized upstream from its mouth. Additional channelizatic
Corliss St	665	No stream; combined sewer	N.A.	Watershed is entirely culverted.
Chartiers Creek***	60,707	Open	No	
Ohio River, right bank, descending order				
Woods Run	[illegible]	No stream; combined sewer	N.A.	Watershed is almost entirely culverted, with the notable exception of Riverside P

N.A. = Not applicable

Note that Table 2 shows that 9 of the 21 key watersheds no longer have streams that reach the main stem rivers. These stream system have been captured by combined sewers. Only it wet weather, during combined sewer overflow events, does stream water from these watersheds reach the river, mixed with sanitary sewage. Undoubtedly many additional streams in smaller watersheds have been similarly captured. Also note that 7 of these 9 watersheds are entirely or almost entirely culverted. That is, they have now or only few remnant streams flowing on the surface.

A simple, but key, physical characterization of a stream system is to note the degree to which humans have culverted or otherwise directly manipulated the stream channel. Most simply, is the channel:

- open and "natural," meaning the channel is largely able to establish its own path (for instance, by eroding the stream bank) and flows over a natural bottom reflecting local soils and geology; or
- open but highly constrained by man—"channelized"—with a bottom and/or sides that are reinforced with concrete, gabions, rip-rap, or other hardening; or
- "culverted"—buried in a pipe or other culvert, covered by decking, or otherwise "disappeared."

Remarkably, no complete inventory of Allegheny streams classified in this simple manner has been made. Many of the region's stream were put underground in culverts or channelized long before environmental agencies started tracking or carefully regulating such activity. 3 Rivers – 2nd Nature investigated a number of sources to determine whether data were available that could be compiled to provide such an inventory. That data does not exist.

Understanding how many streams have been channelized and culverted, and where, would establish a current baseline for stream restoration efforts. Therefore, we determined we would build the necessary database, starting with the best currently available GIS data and using GIS tools to "fill in the gaps."

The Allegheny County Geographic Information System database, or AGIS, is maintained by the Allegheny County Division of Computer Services. Its drainage coverage is a line/point coverage that was digitized from aerial photography flown in the spring of 1992 for the eastern half of the county, and the spring of 1993 for the western half of the county. The attributes of the coverage are:

Code	Attribute
510	Rivers
520	Streams (open and "natural" streams)
530	Drainage Canals (open but channelized streams)
540	Hidden Streams (culverted streams)
550	Lock
560	Dams
570	Mooring Cells (Point)

580 Hidden River

590 Hidden Drainage Canal or Culvert

The following definitional notes from the AGIS data dictionary (Allegheny County Division of Computer Services, undated) are useful to understanding the differences between the attributes that are key to this study:

> A drainage canal is a man-made or channelized hydrologic feature. It is differentiated from streams in that drainage canals have had the sides and/or bottom stabilized to prevent erosion for the predominant length of the feature. Streams may have had some stabilization done, but are primarily in a "natural" state. Hidden streams are those areas that have been covered by man-made facilities.

The data dictionary does not define "hidden river" or "hidden drainage canal or culvert," but we determined that very little (almost none) of the drainage data for the county was assigned to these codes, so they were ignored, as were locks, dams, and mooring cells.

Figure 2, "Stream Status 1992/1993," shows rivers, open streams, channelized streams, and culverted streams as coded in the AGIS database. The most notable feature of this map and its underlying data is the lack of almost *any* stream lines for the core of the county, in the city of Pittsburgh and surrounding older communities. One would expect here, given the rather uniform topography and geology of the county, that a density of stream lines similar to that shown for sparsely developed portions of the county should exist. Further, we know from historic stream maps that many streams did exist within Pittsburgh's current city limits in the early years of European settlement, including the downtown area. Closer examination of Figure 2 shows similar "holes" in stream coverage for many other older communities in the county. Clearly, the amount of culverted streams in the county is much greater than shown by the AGIS data.

Where then, did the missing streams run before they were buried? In order to approximate those locations, we used a U.S. Geological Survey "digital elevation model" (DEM). A DEM is comprised of small cells containing elevation data that represent a continuous 3 dimensional surface in 2 dimensions. The cells in the USGS DEM each represented the average elevation of an area measuring 30 meters by 30 meters (98 feet by 98 feet). We applied to the DEM a hydrologic network function available in the spatial analysis tools of the GIS software (Arc Info) to create lines that follow the low points of each watershed in the county. Each of the DEM-based lines indicates where a stream would be expected to run. The criteria for this analysis required that for a DEM cell to be considered a "low point" and therefore a point on a stream path, it must have a minimum of 100 cells "draining" into it. This is equivalent to 22.2 acres. This criteria produced a stream density in rural portions of the county that was very similar to the density of streams in the AGIS drainage coverage of the same areas, indicating that our DEM-generated drainage coverage approximates perennial streams, like the AGIS coverage. Thus, the DEM-generated stream lines for built-up areas are a good approximation of the lengths and locations of streams prior to development.

To compose the most accurate comprehensive stream database possible with the two data sets, we then compared the drainage network created using the DEM data with the AGIS drainage coverage. Wherever AGIS lines and DEM-derived lines overlapped or ran in close parallel, we threw out the DEM-derived lines in favor of the AGIS lines. Wherever only an AGIS line or a DEM-derived line were present, we kept that line in the database. Where AGIS and DEM-derived lines in the same watershed did not connect, we "drew in" connections. Most of these manually added stream lines were very short in length. Eliminating some of the smaller duplications or anomalies in combining the data sets required visual inspection of the stream lines at a very detailed scale, a time-consuming process. To-date, we have completed this "desktop" inspection and subsequent corrections for only the year one (Pittsburgh Pool) tributary watersheds. The resulting complete stream coverage is shown in Figure 3, "Revised Stream Status 1992/1993."

This map and database is currently the most complete stream map available for any area of Allegheny County. It is a reasonable approximation of the current open, channelized, or culverted status of the streams in the year one study area. However, it has some limitations:

- We have assumed that all of the DEM-derived lines in locations where AGIS lines did not exist represent culverted streams. It is possible that some of these lines should in fact be coded as channelized streams or open streams in "natural" condition. This is because some channelized or natural streams may have been missed during the aerial photoanalysis for the AGIS database, due to vegetative cover or other photo interpretation difficulties or errors.[2] However, we believe these omissions were probably few, and thus our retained DEM-derived lines are probably, with few exceptions, culverted streams.
- While those omissions in the AGIS database are probably few, we are somewhat more suspect of the AGIS data's accuracy in noting whether currently open streams are "natural" or channelized. We know from familiarity with local streams that some channelized streams were coded as natural streams in the AGIS database. Thus the open and natural stream category in the AGIS database (and by extension in our comprehensive database) probably over-represents actual conditions in the field, and the channelized stream category under-represents actual field conditions.
- Also, any streams that have been channelized or culverted since 1992/93 are no longer correctly coded in the AGIS database. We know that the Pennsylvania DEP issued permits allowing culverting of 12,190 feet (2.3 miles) of streams from 1994–2000.
- Finally, and germane to all the points above, we have not field-verified any of this data. A complete field check would require a substantial effort. Over the next several years, we hope to field-check randomly selected stream reaches to determine the error rate in our data, or to enlist the help of local authorities or volunteers to thoroughly check the map against actual field conditions.

Bearing in mind the limitations noted above, our comprehensive stream status database does allow some indicative statistics. Table 3 presents the stream data for the 21 major watersheds in the study area, ranked by the percentage of historic stream miles that remain open.

The data show that for the Allegheny county portions of watersheds tributary to the Pittsburgh Pool, 41 percent of the historic streams are now culverted or otherwise disappeared (e.g. by combined sewer systems). It is

[2] For instance, we know that the AGIS data set did not correctly identify portions of West Run as currently open stream. This omission was corrected in our revised stream status data and map.

remarkable how significantly many of the key watersheds have been altered by culverting. Of the 21 key watersheds, 13 are now over 50% culverted, 6 are over 90% culverted, and 3 are 100% culverted.

It is also interesting to note that the 21 key watersheds include all but about five miles of the study area's open "natural" streams. This is because the remaining portion of the study area consists largely of very small watersheds draining the hillsides and plains adjacent to the rivers. The hillsides, while often not developed due to steep slopes, usually do not have enough drainage area to generate perennial streams. Streams that pick up hillside drainage and cross the plains to the rivers have largely been culverted due to development of this flat, prime land.

None of the key watersheds are substantially unaffected by culverting. The most open stream systems remain in the watersheds of Guyasuta Run (21% culverted), Pine Creek (23% culverted), and Chartiers Creek (29% culverted). These most open streams also scored some of the highest biological integrity ratings in recent studies (reviewed later in this report). In general, the higher the percentage of open streams in a watershed, the better the biological conditions. Our analysis of overall watershed/stream ecological integrity, shown later in Table 10, reflects the open/culverted status of streams.

Table 3 – Stream Status in the Year One Study Area, Ranked by Percent Open

Watershed	"Natural"	Channelized	Culverted	Uncoded*	Stream Miles	% Stil	
Guyasuta Run	3.37	0.00	0.91	0.00	4.28		
Pine Creek	211.04	0.00	63.40	0.00	274.44		
Chartiers Creek*	256.30	0.00	106.14	1.08	363.52		
Spruce Run	5.45	0.00	2.94	0.00	8.39		
Streets Run	21.05	0.00	13.35	0.00	34.40		
Jacks Run	4.41	0.00	3.10	0.00	7.51		
Sipes Run	3.01	0.00	2.33	0.00	5.34		
Girtys Run	25.20	0.00	21.97	0.00	47.17		
West Run	2.38	0.00	2.90	0.00	5.28		
Becks Run	2.74	0.00	4.84	0.00	7.58		
Homestead Run	2.52	0.00	5.08	0.00	7.60		
Woods Run	1.84	0.00	6.07	0.00	7.91		
Tassey Hollow	0.60	0.00	2.02	0.00	2.62		
Saw Mill Run	13.42	0.00	47.88	0.31	61.61		
Nine Mile Run	4.04	0.33	15.73	0.00	20.10		
Four Mile Run	1.15	0.00	10.78	0.00	11.93		
Spring Garden	0.50	0.00	9.61	0.00	10.11		
Allegheny Cemetery	0.14	0.00	4.83	0.00	4.97		
32nd Street Culvert	0.00	0.00	9.46	0.00	9.46		
Corliss St	0.00	0.00	3.09	0.00	3.09		
Heths Run	0.00	0.00	3.50	0.00	3.50		
Key Watersheds Totals	559.16	0.33	339.93	1.39	900.81		
Allegheny County Totals	563.84	0.33	389.92	1.39	955.48		

*Streams not coded in the AGIS database

WATERSHED LAND USE

The Allegheny County Geographic Information System (AGIS) includes land use data, based on analysis of 1992 and 1993 aerial photography. This data helps us differentiate more natural from more modified landscapes. AGIS assigns all land to one of 14 land use categories; for this study, we classified those land use categories noted below in italics as "built environment.":

- Hydrologic Feature (rivers, streams, ponds, reservoirs)
- *Transportation (all streets, roads, highways)*
- Forest
- Grassland/Open Space
- Agriculture/Pasture
- *Low Density Residential*
- *Medium Density Residential*
- *High Density Residential*
- *Identified Malls*
- *Commercial*
- *Industrial*
- *Heavy Industrial*
- *Strip Mine (also includes major steel slag dumps)*
- *Non Vegetated (typically this is land under development)*

Built environment land uses are the landscapes that are most disturbed by human activity. By disturbance, we mean deviation from the ecological and hydrological state that is expected for this region: forested landscape. Virtually all lands in Allegheny County, including those now forested, have been "disturbed." For instance, most forested land is "second growth." The original native forest was cleared for lumber, firewood, and agricultural uses centuries ago, and in many places has grown back and been cut again many times.

Second-hand forest provides many of the ecological functions of the original forest. Among those functions are the absorption of rainfall by the forest canopy and the infiltration of a high percentage of annual precipitation into the duff of the forest floor and the soil and subsoil underneath. Grassland and well-managed pasture similarly infiltrate much of the annual precipitation. Properly plowed agricultural fields also allow for infiltration.

Infiltration is ecologically important because it attenuates runoff and recharges the ground water. It evens out the hydrologic regime by reducing peak runoff and allowing ground water to seep back into streams as "base flow" even in dry months.

In the built environment, impervious surfaces such as pavements and rooftops prevent precipitation from infiltrating into the soil. This results in increased runoff, which can erode stream channels and increase flooding problems. It also reduces groundwater recharge, which often means that the base flow of streams is reduced. The overall hydrologic result can be unnaturally higher flows during and just after storms, and unnaturally low flows during dry months. The ecological result is often destruction of aquatic habitat as stream channels are eroded, and higher water temperatures and reduced oxygenation of water as dry month stream flows drop. Impervious surfaces also increase the ambient air temperature (the "urban heat island effect") which in turn often raises stream water temperatures. Development usually exposes streams to runoff of automotive oils, gasoline, brake lining dust, lawn chemicals, pet feces and other pollutants. Increased pollutant loads have been directly correlated with increased imperviousness (Schueler 2000).

The intensity of the hydrologic and ecological disturbance caused by the built environment ranges from slight for those low density residential developments that retain substantial portions of land in forested condition and keep impervious surfaces to a minimum, to extreme for high density urban and industrial areas where impervious surfaces are a high proportion of the total landscape.[3] A number of studies have shown that when the proportion of impervious surfaces within a watershed reaches 10%, stream channel instability and declines in aquatic biodiversity generally result. When imperviousness exceeds 25%, impacts are typically severe (Schueler 2000, Caraco et al. 1998).

The relationship of imperviousness to stream health is not entirely linear, and recent work has shown that "not all imperviousness is created equal." That is, impacts can occur at lower levels of imperviousness, and be avoided at somewhat higher levels, depending on the storage capacity of soils in the watershed, the connectivity of impervious surfaces to each other and to streams (e.g., direct piping to streams of large surfaces such as parking lots increase impacts, as does lack of streamside buffers to intercept flows from impervious surfaces), stream type (e.g. flat or steep, straight or meandering, normal or steeply incised channel cross section), and other watershed and stream-specific factors (Bledsoe and Watson 2001). Nonetheless, the percentage of watershed imperviousness provides an initial indication of the degree of hydrologic and ecological disruption human activities have visited upon a stream.

Data in the Allegheny County Geographic Information System allows partial calculation of impervious surfaces in a watershed. The data is partial because some parking lots, most sidewalks, and some other features such as patios and plazas are not included in the database. The data also requires some time-consuming manual manipulation in order to derive impervious areas. Thus, we calculated impervious surfaces for some but not all watersheds in the study area.

A functionally similar measure to imperviousness is the percentage of a watershed in the built environment land use categories noted above. The higher the percentage of built environment, the higher the percentage of impervious surfaces is likely to be. We derived the percentage of built environment for all watersheds in the year one study area.

Table 4 shows acreages and percentages for all land uses for the 21 watersheds delineated for the year one study area. It also provides total built environment acres and percentage built environment for each watershed.

Table 5 shows the 21 key watersheds of the study area ranked by percentage of watershed area in built environment land uses, from lowest to highest. In other words, watersheds at the top of the list are likely to be least impacted by development, and those at the bottom are likely to be most impacted. Table 5 also provides

[3] Strip mines can also increase runoff and reduce base flow. Notably, runoff from strip mines also has chemical properties that are extremely disruptive to stream life. A few of the study area watersheds, noted in later tables and discussions, have significant amounts of strip mine land use.

the top 3 land use classes for each watershed and comments on land use patterns within each watershed. Together these columns give a good idea of the nature of the built environment in the watershed. Further, Table 5 provides the percentage of impervious surfaces for selected watersheds. For comparison with physical stream status, the table also provides the percentage of the historic stream network that is now culverted.

Table 4 - Land Use in Key Watersheds of the Year One Study Area, by Acres and Percentage

Land Use in Acres

Land Use		Hydrologic Feature	Transportation	Forest	Grassland / Open Space	Agriculture / Pasture	Low Density Residential	Med Density Residential	High Density Residential	Identified Malls	Commercial	Industrial	Heavy Industrial	Strip Mine	Non-vegeta		
Sum of ACRES	GRID_CODE																
LARGE_SHED	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Grand Total	
32nd Street Culv	0	2	63	105	14	0	321	301	1,014	0	128	37	12	0	5	2,002	1,882
Allegheny Cemetery	0	2	0	285	58	0	168	138	254	0	5	9	51	0	6	975	630
Becks Run	0	0	0	659	81	0	305	316	258	0	2	4	0	0	3	1,627	887
Chartiers Creek**	18	8	1,682	25,644	1,802	13,047	11,482	2,627	1,029	333	137	1,027	13	568	1,293	60,707	20,189
Corliss St	0	2	5	204	19	0	201	125	57	0	1	50	0	0	1	665	439
Four Mile Run	0	2	37	338	112	0	516	493	631	0	53	70	5	0	34	2,290	1,838
Girtys Run	0	17	28	3,522	647	0	3,154	569	219	166	92	46	0	0	106	8,565	4,379
Guyasuta Run	0	0	12	481	43	0	68	3	4	0	3	7	0	0	4	625	101
Heths Run	0	13	2	105	15	0	105	91	268	0	5	18	0	0	9	632	499
Homestead Run	0	0	3	307	86	0	617	411	50	0	2	2	11	0	5	1,494	1,101
Jacks Run	0	0	61	585	52	0	373	214	132	0	0	5	0	0	10	1,433	796
Nine Mile Run	0	0	113	1,056	153	0	611	774	965	55	16	30	0	99	15	3,887	2,677
Pine Creek	0	91	743	25,490	1,818	3,584	9,462	364	101	143	37	465	0	27	704	43,028	12,046
Saw Mill Run	0	0	366	2,826	665	0	3,789	2,641	1,876	82	55	42	0	0	90	12,431	8,940
Sipes Creek	0	0	6	468	125	0	276	8	27	0	1	2	0	0	20	932	339
Spring Garden	0	6	187	865	176	0	499	254	209	0	64	18	0	0	23	2,302	1,255
Spruce Run	0	0	0	566	101	34	268	201	134	0	0	6	0	0	19	1,330	628
Streets Run	0	1	190	2,902	530	0	1,770	472	237	0	17	104	2	169	43	6,437	3,003
Tassey Hollow	0	1	3	163	53	0	183	38	54	0	1	2	19	2	5	524	307
West Run	0	0	5	266	25	0	360	253	54	0	1	1	7	0	5	977	686
Woods Run	0	0	3	577	41	0	205	222	189	0	28	5	0	0	9	1,280	662
Grand Total	18	146	3,510	67,412	6,617	16,665	34,732	10,514	7,764	778	648	1,948	120	864	2,408	154,143	63,286

Land Use by Percentage

Sum of ACRES	GRID_CODE																
LARGE_SHED	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Grand Total	
32nd Street Culv	0.0%	0.1%	3.1%	5.2%	0.7%	0.0%	16.1%	15.0%	50.7%	0.0%	6.4%	1.8%	0.6%	0.0%	0.2%	100.0%	94
Allegheny Cemetery	0.0%	0.2%	0.0%	29.2%	6.0%	0.0%	17.2%	14.2%	26.0%	0.0%	0.5%	0.9%	5.2%	0.0%	0.6%	100.0%	65
Becks Run	0.0%	0.0%	0.0%	40.5%	5.0%	0.0%	18.7%	19.4%	15.9%	0.0%	0.1%	0.2%	0.0%	0.0%	0.2%	100.0%	55
Chartiers Creek**	0.0%	0.0%	2.8%	42.2%	3.0%	21.5%	18.9%	4.3%	1.7%	0.5%	0.2%	1.7%	0.0%	0.9%	2.1%	100.0%	33
Corliss St	0.0%	0.3%	0.8%	30.6%	2.9%	0.0%	30.2%	18.9%	8.6%	0.0%	0.1%	7.5%	0.0%	0.0%	0.1%	100.0%	66
Four Mile Run	0.0%	0.1%	1.6%	14.8%	4.9%	0.0%	22.5%	21.5%	27.6%	0.0%	2.3%	3.1%	0.2%	0.0%	1.5%	100.0%	80
Girtys Run	0.0%	0.2%	0.3%	41.1%	7.5%	0.0%	36.8%	6.6%	2.6%	1.9%	1.1%	0.5%	0.0%	0.0%	1.2%	100.0%	51
Guyasuta Run	0.0%	0.0%	1.9%	77.0%	6.9%	0.0%	10.9%	0.5%	0.7%	0.0%	0.5%	1.1%	0.0%	0.0%	0.6%	100.0%	16
Heths Run	0.0%	2.0%	0.3%	16.6%	2.4%	0.0%	16.6%	14.4%	42.5%	0.0%	0.8%	2.9%	0.0%	0.0%	1.4%	100.0%	79
Homestead Run	0.0%	0.0%	0.2%	20.5%	5.7%	0.0%	41.3%	27.5%	3.3%	0.0%	0.1%	0.2%	0.8%	0.0%	0.3%	100.0%	74
Jacks Run	0.0%	0.0%	4.3%	40.8%	3.7%	0.0%	26.0%	14.9%	9.2%	0.0%	0.0%	0.4%	0.0%	0.0%	0.7%	100.0%	56
Nine Mile Run	0.0%	0.0%	2.9%	27.2%	3.9%	0.0%	15.7%	19.9%	24.8%	1.4%	0.4%	0.8%	0.0%	2.5%	0.4%	100.0%	69
Pine Creek	0.0%	0.2%	1.7%	59.2%	4.2%	8.3%	22.0%	0.8%	0.2%	0.3%	0.1%	1.1%	0.0%	0.1%	1.6%	100.0%	28
Saw Mill Run	0.0%	0.0%	2.9%	22.7%	5.4%	0.0%	30.5%	21.2%	15.1%	0.7%	0.4%	0.3%	0.0%	0.0%	0.7%	100.0%	72
Sipes Creek	0.0%	0.0%	0.6%	50.2%	13.4%	0.0%	29.6%	0.8%	2.8%	0.0%	0.1%	0.2%	0.0%	0.0%	2.1%	100.0%	36
Spring Garden	0.0%	0.3%	8.1%	37.6%	7.7%	0.0%	21.7%	11.0%	9.1%	0.0%	2.8%	0.8%	0.0%	0.0%	1.0%	100.0%	55
Spruce Run	0.0%	0.0%	0.0%	42.6%	7.6%	2.6%	20.2%	15.1%	10.1%	0.0%	0.0%	0.4%	0.0%	0.0%	1.4%	100.0%	47
Streets Run	0.0%	0.0%	3.0%	45.1%	8.2%	0.0%	27.5%	7.3%	3.7%	0.0%	0.3%	1.6%	0.0%	2.6%	0.7%	100.0%	47
Tassey Hollow	0.0%	0.1%	0.7%	31.1%	10.1%	0.0%	35.0%	7.3%	10.3%	0.0%	0.2%	0.4%	3.6%	0.3%	0.9%	100.0%	59
West Run	0.0%	0.0%	0.5%	27.2%	2.6%	0.0%	36.9%	25.9%	5.5%	0.0%	0.1%	0.1%	0.7%	0.0%	0.6%	100.0%	70
Woods Run	0.0%	0.0%	0.2%	45.1%	3.2%	0.0%	16.0%	17.3%	14.8%	0.0%	2.2%	0.4%	0.0%	0.0%	0.7%	100.0%	52
Grand Total	0.0%	0.1%	2.3%	43.7%	4.3%	10.8%	22.5%	6.8%	5.0%	0.5%	0.4%	1.3%	0.1%	0.6%	1.6%	100.0%	41

*Built environment categories are in italics

**Only the Allegheny County portion of Chartiers Creek is described here.

Table 5 – Land Use in Key Watersheds of the Year One Study Area
Ranked by ascending percentage of watershed area in built environment land uses

Watershed	Total Acres	Built Environment**	Impervious Surfaces***	Original Streams Still Open	1st Dominant Land Use	2nd Dominant Land Use	3rd Dominant Land Use	Comments
Guyasuta Run	625	16%	8%	79%	Forest - 77%	Low Density Residential - 11%	Grassland/ Open Space - 7%	Very high proportion forested. Little development in headwaters. The only substantial urban land uses are far downstream, near the river.
Pine Creek	43,028	28%	9%	77%	Forest - 59%	Low Density Residential - 22%	Agriculture/ Pasture - 8%	High proportion—67%—in forest or agriculture. Headwaters are sparsely developed, for the most part. Some significant connected impervious surfaces in mall, commercial, and industrial areas located along the main stem. Plus a few such areas along tributaries or in headwater areas.
Chartiers Creek*	60,707	33%	11%	71%	Forest - 42%	Agriculture/ Pasture - 22%	Low Density Residential - 19%	Overall, a high proportion—64%—is in forest or agriculture. Much of the land along the main stem and in sub-watersheds along the eastern side is densely developed with urban/suburban land uses, and exhibits many locations with substantial connected impervious surfaces. West side sub-watersheds are much more sparsely developed. But some include substantial strip-mined areas (totalling 568 acres, or 0.9% of the Allegheny County portion of the watershed).
Sipes Run	932	36%	10%	56%	Forest - 50%	Low Density Residential - 30%	Grassland/ Open Space - 13%	High proportion—63%—in forest or grassland/open space. Much of this area is broken up by low density residential development.
Streets Run	6,437	47%	12%	61%	Forest - 45%	Low Density Residential - 28%	Grassland/ Open Space - 8%	Slopes leading down to the main stem and some of the tributaries are forested. But many of the headwaters areas are densely developed. East side of the watershed includes some strip-mined area (169 acres, or 2.6%).
Spruce Run	1,330	47%	N.C.	65%	Forest - 43%	Low Density Residential - 20%	Medium Density Residential - 15%	2 of 3 top land uses are built environmnent. Lower portions of the watershed are more developed, while upper portions are fairly sparsely developed.
Girtys Run	8,565	51%	18%	53%	Forest - 41%	Low Density Residential - 37%	Grassland/ Open Space - 8%	Nearly 50% in forest or grassland/open space, but high proportion of low density residential (37%). Major connected impervious surfaces occur along one tributary due to intense mall/commercial strip development (McKnight Road). Another headwaters area—in/around West View and Laurel Gardens—is heavily developed with medium and high-density residential land uses.
Woods Run	1,280	52%	N.C.	23%	Forest - 45%	Medium Density Residential - 17%	Low Density Residential - 16%	Lower portions of the watershed and some headwaters areas are heavily developed and culverted. However, a substantial portion of the headwaters, largely in Riverview Park, remains forested and features remnant streams.
Spring Garden	2,302	55%	N.C.	5%	Forest - 38%	Low Density Residential - 22%	Medium Density Residential - 11%	Some forested areas remain in the headwaters, but most of the watershed is heavily developed, including 8% in transportation land use (I-279). Watershed is almost entirely culverted.
Becks Run	1,627	55%	17%	36%	Forest - 40%	Medium Density Residential - 20%	Low Density Residential - 19%	Slopes leading down to the main stem and some of the tributaries are forested. But many of the headwaters areas are very densely developed. High density residential makes up another 16% of the watershed.
Jacks Run	1,433	56%	N.C.	59%	Forest - 41%	Low Density Residential - 26%	Medium Density Residential - 15%	Upper portions of the watershed are fairly sparsely developed. Lower portions are more developed, though active land use in the lower stream valley itself is limited.
Tassey Hollow	524	59%	N.C.	23%	Low Density Residential - 35%	Forest - 31%	High Density Residential - 10%	First occurrence of high density residential in the top 3 land uses. This occurs in the lower watershed, near the river. The upper watershed is less intensely developed and has some substantial contiguous forested areas.
Allegheny Cemetery	975	65%	N.C.	3%	Forest - 29%	High Density Residential - 26%	Low Density Residential - 17%	This and all following watersheds are ⇢65% built environment. This watershed has a substantial contiguous expanse of forest in the Allegheny Cemetery, where a few remnant streams occur.
Corliss St	665	66%	N.C.	0%	Forest - 31%	Low Density Residential - 30%	Medium Density Residential - 19%	Watershed is entirely culverted. Some small forested areas remain due to steep slopes.
Nine Mile Run	3,887	69%	27%	22%	Forest - 27%	High Density Residential - 25%	Medium Density Residential - 20%	Upper watershed is heavily developed with a full range of urban land uses. 27% forest reflects Frick Park and Fern Hollow, which form a highly notable contiguous expanse of forested land. Former steel slag dump dominates the stream valley below Frick Park. The slag dump is now under residential and greenway development.
West Run	977	70%	20%	45%	Low Density Residential - 37%	Forest - 27%	Medium Density Residential - 26%	A few blocks of forested land remain in headwaters along the west side of the watershed. Balance of watershed has a few small forested pockets, but is predominantly developed—low, medium, and some high density residential.
Saw Mill Run	12,431	72%	23%	22%	Low Density Residential - 30%	Forest - 23%	Medium Density Residential - 21%	Forested areas are substantially broken up and largely limited to slopes above main stem and some tributaries. Watershed is widely developed with low, medium, and high density (another 15%) residential land uses.

Homestead Run	1,494	74%	20%	33%	Low Density Residential - 41%	Medium Density Residential - 28%	Forest - 20%	Watershed is widely developed with residential areas at low, medium, and high density. Remaining forested areas are small and widely scattered.
Heths Run	632	79%	30%	0%	High Density Residential - 42%	Forest - 17%	Low Density Residential - 17%	Watershed is heavily developed with urban uses, with a few small blocks of forested land located in Highland Park. Watershed is entirely culverted.
Four Mile Run	2,290	80%	31%	10%	High Density Residential - 28%	Low Density Residential - 22%	Medium Density Residential - 22%	All 3 top land uses are all built environment. However, 15% of the watershed is in forest, most of which occurs in a nearly contiguous block in Schenley Park, where tributary streams are still open and naturalized.
32nd Street Culvert	2,002	94%	45%	0%	High Density Residential - 51%	Low Density Residential - 16%	Medium Density Residential - 15%	All 3 top land uses are built environment. Virtually all urban land use is highly urban. Watershed is entirely culverted.
Key Watersheds Totals	105,292	41%	N.C.	62%	Forest - 44%	Low Density Residential - 22%	Agriculture/ Pasture – 11%	Ag/pasture as a top 3 land use is due to large amounts of this land use in Chartiers Creek watershed. Medium density land use is the fourth dominant land use, at 7%.
Allegheny County Totals	168,965	44%	N.C.	59%	Forest – 41%	Low Density Residential – 22%	Agriculture/ Pasture – 10%	Ag/pasture as a top 3 land use is due to large amounts of this land use in Chartiers Creek watershed. Medium density land use is the fourth dominant land use.

N.C. = Not calculated

*Only the Allegheny County portion of Chartiers Creek is described here. The watershed extends beyond Allegheny County, totalling approximately 145,000 acres.

**Built Environment consists of the following italicized land uses:

Hydrologic Feature
Transportation
Forest
Grassland/Openspace
Agriculture/Pasture
Low Density Residential
Med Density Residential
High Density Residential
Identified Malls
Commercial
Industrial
Heavy Industrial
Strip Mine
Non Vegetated

***Impervious surfaces may be slightly underestimated. Sidewalks, some parking lots, and some plazas/patios are not included.

These tables show that land use patterns in the 21 key watersheds of the year one study area are highly varied. We will consider these patterns further in a section below that develops classifications of the overall ecological integrity of each watershed.

STREAM STUDIES

Water quality – physical/chemical assessments

Measurements of physical parameters (e.g. temperature, conductivity, total dissolved solids) and chemical parameters (e.g. pH, dissolved oxygen, ammonia, hardness, alkalinity, iron, aluminum, copper, zinc) are common metrics for judging water quality. Any number of local, state, and federal agencies, volunteer groups, school classes, and other groups and individuals take many such water quality measurements on the region's streams. However, coordinated efforts to take such measurements across many streams, using consistent protocols and labs of assured quality, are rare.

3 Rivers – 2nd Nature undertook one such effort in 2000. Its water quality team took measurements of the 3 physical and 9 chemical parameters listed above for 14 tributaries to the Pittsburgh Pool—the study area of this report. The samples were taken on several dates at one standard location near the mouth of each tributary, at the first riffle upstream from the main stem river to assure no backflow from the river affected the samples. The 3R2N year 2000 water quality report summarizes the findings (Knauer and Collins 2001, p. 21, 27, 33). The measurements were all taken in dry weather conditions, and were compared with the Pennsylvania DEP water quality criteria for the designated use of each stream, which is warm water fisheries for all the streams but Pine Creek, which is designated for trout stocking (25 PA Code § 93.9). All the samples were within the designated use criteria with the following exceptions:

- Nine Mile Run (Monongahela tributary) had an average pH of 10, above the permissible range of 6-9. This is probably due to runoff from the large slag piles that sit astride the lower portions of the stream.
- Dissolved oxygen was low for Homestead Run (Monongahela tributary), which had very low flow (no flow in one sampling event).
- Street's Run (Monongahela tributary) had one dissolved oxygen measurement below the minimum allowable concentration of 4.0 mg/L.
- Total dissolved solids concentrations for Chartiers Creek (Ohio tributary) had several readings above the maximum allowable concentration of 750 mg/L.
- Total dissolved solids concentrations for Saw Mill Run (Ohio tributary) had several readings above the maximum allowable concentration of 750 mg/L.

A second survey of multiple study area streams was carried out in the late spring and early summer of 2001 by U.S. Army Corps of Engineers staff, as part of a biological study for 3 Rivers – 2nd Nature (Koryak and Stafford 2001). In 33 streams tributary to the Pittsburgh Pool and the pools of Monongahela dams 2 and 3, the study team took field measurements of four physical/chemical water quality parameters, and lab measurements for 20 metals, 4 tests of nutrient concentrations, and 10 other values. Data tables in the report provide full results for these tests. The report text notes the following findings as most significant for Pittsburgh Pool tributaries:

- Nine Mile Run had the highest field pH reading of all the streams, at 10.43, versus an average of 7.79. It also had zero total acidity, while the other streams averaged 8.9 mg/l as $CaCO_3$. Both findings are consistent with a stream influenced by steel slag leachate.
- Pine Creek had the lowest hardness of all the streams (207.8 mg/l total hardness as $CaCO_3$ compared to an average value of 390.8 mg/l).
- Total aluminum measurements were significantly elevated in Streets Run (1,600 ug/l) and Homestead Run (1300 ug/l).
- Total iron measurements were significantly elevated in Street's Run, at 3400 ug/l.

While we could no doubt report here on many other water quality measurements taken by other organizations, we turn instead to other types of assessments that are more germane to this study's emphasis on physical and biological stream health. Water quality measurements are "snapshots" in time, and often change from day to day or hour to hour. Physical and biological measurements integrate events and conditions occurring in streams over long periods of time. We also will consider below a recent bacteriological assessment, because of the importance of bacteriological water quality to human water contact.

Bacteriological assessments

Bacteriological assessments indicate the presence of bacteria that are potentially harmful to humans. Typical tests measure the presence of fecal coliforms, bacteria that live in the intestines of many animals. This bacteria could come from human sewage or the fecal matter of mammals such as dogs or raccoons and birds such as ducks or geese. Currently affordable tests do not tell us which type of defecation is in the water, only that fecal indicators are present. Fecal coliforms are not themselves harmful to people, but they indicate that other, pathogenic bacteria are likely to be present.

3 Rivers-2nd Nature sampled bacteriological quality in 14 tributaries to the Pittsburgh Pool in 2000 (Knauer and Collins 2001). As for the physical/chemical water quality measurements discussed above, these measurements were taken in dry weather, at points near the mouth of each tributary but above the backwater influence of the main stem rivers.[4] Many streams showed high levels of bacteriological indicators. Overall, the averages were significantly above standards for human water contact (Table 6).

[4] Some of these tributary mouths (Heths Run, 32nd Street Culvert, and Four Mile Run) are now located in combined sewer outfall structures, and it is unclear whether flows emanating from them are meant to be clean, or represent a problem with the regulator structure.

Table 6: Fecal Coliform Measurements for Pittsburgh Pool Tributaries, Compared to Pennsylvania DEP Standard.

Source*	Geometric Mean CFU/100ml**
6 tributaries to the Allegheny River	821
6 tributaries to the Monongahela River	1799
2 tributaries to the Ohio River	992
PA DEP standard for human water contact	200

*Dry weather samples, taken after at least 3 days without rain or known CSOs.

**Geometric means are calculated from fecal coliform results from all sampling locations on each river (approximately 48 samples per river).

Source: Knauer and Collins 2001, Table 6, p. 38.

The 3R2N team classified the tributaries as most and least impacted by bacteriological contamination as follows:

Allegheny River tributaries:

Most impacted:	Sipes Run
	Pine Creek
	Girtys Run
Least impacted:	Guyasuta Run
	Heths Run
Culverted:	32nd Street Culvert

Monongahela River tributaries:

Most impacted:	West Run
	Streets Run
	Becks Run
Least impacted:	Nine Mile Run
Little Flow:	Homestead Run
Culverted:	Four Mile Run

Ohio River tributaries:

Most impacted:	Saw Mill Run
Least impacted:	Chartiers Creek

We return briefly to these assessments in the summary section of this chapter.

Biological assessments

In the later spring and early summer of 2001, U.S. Army Corps of Engineers staff Michael Koryak and Linda Stafford carried out a benthic macroinvertebrate bioassessment of 33 Allegheny County streams for 3 Rivers – 2nd Nature. Benthic macroinvertebrates are stream “bugs” that spend part or all of their lives in or on the bottom of streams. They include insects such as mayflies (order Ephemeroptera), stone flies (Plecoptera), caddis flies (Trichoptera), and midges (family Chironomidae, in the order Diptera); aquatic worms (phylum Anelida); crustaceans such as scuds (genus Gammerus); and other invertebrates.

Bioassessments are a very useful indication of overall stream health because biological communities integrate the effects of a variety of conditions—chemical, physical, hydrologic, ecological—and do so over time, in response to fluctuating conditions. Rather than the "snapshot" view of specific conditions offered by water quality and bacteriological tests, bioassessments provide a holistic view of multiple conditions and stresses over and between the life cycles of stream organisms. Because different taxa (e.g. different families of organisms) respond differently to different stresses, the presence, diversity, and relative abundance of different taxa can reveal a great deal about overall conditions and even about specific problems, such as acid mine drainage, present in particular streams.

Benthic macroinvertebrates are particularly good subjects for bioassessments because they are usually present in all water bodies, from rivers to the smallest headwaters that do not have the necessary habitat and flow for fish and other vertebrates. They also are limited in their mobility, so they indicate conditions in fairly small reaches of a stream, thus allowing, for instance, studies of stream health above and below potential sources of stress, such as point sources of pollution or tributaries characterized by significant nonpoint runoff pollution. Further, these organisms are relatively easy, quick, and inexpensive to study. Many environmental agencies routinely use a variety of established protocols for benthic invertebrate bioassessments as a tool for evaluating stream health.

The Koryak and Stafford study sampled benthic macroinvertebrate communities in the first riffle reach above the confluence of each stream with a main stem river. Because many Allegheny County streams are culverted at their mouths, this sometimes meant the researchers pulled their samples considerably inland from the rivers. This study, then, addressed stream health at the downstream-most point of each major tributary in the study area, an approach that reveals integrated and conditions and stresses throughout the watershed, which may include alike major problems far upstream and significant disturbances immediately above the sample site. The researchers did not attempt to systematically identify reasons for any observed impairment of stream health.

This study is particularly notable because it developed new biological community evaluation metrics oriented toward the multiple sources of stress in the urban and suburban streams of the greater Pittsburgh region. Most standard metrics (e.g. the Hilsenhoff Family Biotic Index) are oriented toward evaluating the impacts on stream health of sewage pollution and agricultural nutrient enrichment. Streams in this region face additional stresses such as acid mine drainage, mineralized and highly alkaline urban and industrial (e.g. steel slag) leachate, and runoff of road deicing salts. Previous research by Koryak, Stafford and others has shown that each of these stresses have characteristic signatures on benthic macroinvertebrate communities.

The study also used a local stream as its "reference station" for several metrics that compare a study station's biological conditions to a general standard. The team stated that ". . . in order to generate reasonable standards and realistic goals, rather than holding up a pristine stream of the unglaciated Appalachian Plateau as a standard, it would be appropriate to consider the urban/suburban environment of the Allegheny County portion of the upper Ohio drainage basin as a distinct ecoregion, and to utilize a stream of this ecoregion as a reference" (Koryak and Stafford 2001). Because Pine Creek is noted as a relatively healthy regional stream—consider, for instance, its designation as "approved trout waters" by the Pennsylvania Fish and Boat Commission—results from the study's sample on Pine Creek were used as the reference station for the overall study.

The study incorporated several standard and new metrics of the benthic macroinvertebrate communities into a formula for a "condition score" for each stream sample. Condition scores greater than 80% were considered to indicate non-impaired streams, 60-79% slightly impaired, 40-59% moderately impaired, and less than 40% severely impaired. Table 7 presents the results for the year one study area streams.

Table 7 – Degree of Stream Health Impairment, and Condition Scores, for Year One Study Area Streams, Per 2001 U.S. Army Corps of Engineers Benthic Macroinvertebrate Study

Degree of Impairment / Stream	Condition Score
Non-impaired	
None	
Slightly impaired	
Pine Creek	71.3
West Run	62.0
Chartiers Creek	61.3
Guyasuta Run	60.0
Moderately impaired	
Becks Run	58.6
Homestead Run	55.9
Sipes Run	50.9
Girtys Run	47.3
Severely impaired	
Four Mile Run (at Panther Hollow)	39.1
Saw Mill Run	37.6
Streets Run	36.6
Tassey Hollow	34.2
Nine Mile Run	31.3

Source: Koryak and Stafford 2001, Table 4.

It is interesting to note that a stream that has good biological conditions can have poor bacteriological water quality. For instance, as shown in the previous section, Pine Creek and West Run are both considered "most impacted" by bacteriological contamination, yet these streams are the two least impacted within the study area vis-à-vis benthic macroinvertebrate communities.

While no streams in the study area (indeed, none of the 33 streams in the year one *and* year two 3 Rivers – 2nd Nature study areas) are non-impaired, the researchers considered the number of slightly impaired and moderately impaired streams very encouraging. Further, they made a number of other biotic observations of significance; for instance, presence of salamanders and fish at a number of sampling stations. While little data is available to allow for analysis of trends in stream health, residents along some of the streams also indicated that they believe conditions have improved. Also, the researchers themselves noted marked improvement in aquatic biodiversity in one stream they had previously studied, in the 1980s (Thompson Run in the Turtle Creek watershed, in the year two study area). Overall, the team concluded, "The diversity of aquatic life found in these streams during the first phase of the 3R-2N bioassessment exceeds what might have been expected from historical memories and impressions of these urban waterways as industrial waste conduits and/or open sewers."

These results give us hope that appropriate actions—sewer infrastructure rehabilitation, improved stormwater management, stream channel protection and restoration, and other measures and programs—can and will make a positive difference to the biodiversity and overall stream health of many of the region's watersheds.

Overall assessments

Since 1997, the Pennsylvania Department of Environmental Protection has been surveying wadeable streams in the state, with the goal of completing a statewide assessment of Pennsylvania's water quality within 10 years. The "Unassessed Waters Program" is designed to fulfill the state's responsibilities under the federal Clean Water Act to report the status of water resources, including section 305(b) water quality inventory reports, and section 303(d) impaired waterways lists, and to provide a summary of areas with non-point source (NPS) pollution problems (section 319).

This assessment program combines biological and physical evaluations. DEP's field surveys begin by identifying discrete stream reaches, then verifying land use patterns and point sources of pollution compiled from available databases. The assessment biologist then samples benthic invertebrates using a procedure similar to the EPA Rapid Bioassessment Protocol. He or she compares the relative abundance and known tolerances to pollution of invertebrate families collected with biological criteria that indicate whether the stream is biologically healthy or impaired. The biologist also conducts a stream habitat evaluation to examine water velocities and depths, sediment deposition, stream bank erosion, vegetative cover, and other physical characteristics of the stream. The combined biological and habitat scores determine whether the stream attains—or not—the criteria set for it.

The state's water quality standards designate uses for each water body in the state. These designations are codified in the Pennsylvania Code, Title 25, Chapter 93. The standards for Allegheny County water bodies are in §93.4(a) and §93.9(u) to 93.9(w). Relevant aquatic life use designations for Allegheny County and the study area are:

Warm Water Fishes—"Maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat." All streams and rivers in Allegheny County are designated for this use unless otherwise designated for one of the following uses.

Cold Water Fishes—"Maintenance or propagation, or both, of fish species including the family Salmonidae [trout and salmon] and additional flora and fauna which are indigenous to a cold water habitat." Pine Creek, from its main stem and tributary headwaters to the North Park Lake Dam, is the only Allegheny County stream so designated. It is located in the year one study area.

Trout Stocking—"Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat." Within the year one study area, three streams are so designated: Pine Creek and its tributaries from the North Park Lake Dam to the Allegheny River, Nine Mile Run, and Thoms Run, a tributary to Chartiers Creek. Nine additional streams in Allegheny County but outside of the year one study are designated for trout stocking.

Streams can additionally be designated as *High Quality*, or of *Exceptional Value*. These designations provide special protection against degradation of water quality. There are no waters designated of exceptional value within Allegheny. Five streams are designated as high quality waters: Guyasuta Run upstream of Route 28 (a "warm water fishes" stream within the year one study area), and four "trout stocking" streams outside of the year one study area.

For stream reaches that do not attain their criteria according to assessments completed under the "Unassessed Waters Program", the evaluator notes likely sources of impairment. For Allegheny County streams studied to date, the following sources of impairment have been noted:

- Abandoned Mine Drainage
- Agriculture
- Bank Modifications
- Combined Sewer Overflow
- Construction
- Golf Courses
- Habitat Modification
- Hydromodification
- Industrial Point Source
- Land Development
- Municipal Point Source
- Natural Sources
- On site Wastewater
- Petroleum Activities
- Removal of Vegetation
- Road Runoff
- Small Residential Runoff
- Subsurface Mining
- Urban Runoff/Storm Sewers
- Other
- Unknown

Abandoned mine drainage and urban runoff/storm sewers are the most frequently noted sources of impairment for all the Allegheny County streams studied to date. Construction, removal of vegetation, and habitat modification are other common impairment sources.

Likely causes of impairment are also identified by the assessment biologist. These causes have included:

- Flow Alterations
- Metals
- Nonpriority Organics
- Nutrients
- Oil and Grease
- Organic Enrichment/Low Dissolved Oxygen
- Other Habitat Alterations
- Other Inorganics
- Pesticides
- pH
- Priority Organics
- Salinity/TDS/Chlorides
- Siltation
- Suspended Solids
- Turbidity
- Water/Flow Variability
- Unknown

Siltation and the associated indicators of suspended solids and turbidity are the most frequently noted causes of impairment. Nutrients, organic enrichment/low dissolved oxygen, and metals are other common causes of impairment.

Roughly half of Allegheny County has been surveyed for this program (Pennsylvania Department of Environmental Protection 2001). Figure 4, "Pennsylvania Department of Environmental Protection Stream Assessment," shows the results to date. In short, given the DEP criteria, the overall health of local streams is mixed. Of the streams surveyed so far, many are impaired—they do not attain criteria set for them—especially in watersheds tributary to the south side of the Ohio River (Sawmill Run, Chartiers Creek, and Montour Run watersheds). Tributaries to the Allegheny River are in generally better shape, though the Girtys Run watershed, substantial portions of the Plum Creek watershed, and the main stems of Pine Creek and Deer Creek are impaired.

Caution should be used in interpreting the results of this survey of stream conditions. It is not clear how frequently (e.g. how many times per mile of stream) the DEP carried out these assessments, how far up into stream headwaters the assessment teams went, and how the results were extrapolated between stations and above and below the highest and lowest stations tested on a stream. Streams that do not meet criteria at one location may meet criteria at other locations. Nonetheless, the DEP survey provides another useful general indication of stream health in the region.

For all of Allegheny County, the results to date are provided in Table 8.

Table 8: Attaining and Nonattaining Allegheny County Streams, as Determined by the Pennsylvania Department of Environmental Protection

	Stream Miles	Percentage of All Streams	Percentage of Assessed Streams
Unassessed streams	677	48%	-

Nonattaining streams	434	31%	60%
Attaining streams	291	21%	40%
Totals	1,402	100%	100%

Source: Pennsylvania Department of Environmental Protection 2001

For the 3R2N key watersheds of the year one study area, the DEP results to date are summarized in Table 9 below.

Table 9: Attainment Status of Allegheny County Year One Study Area Streams, as Determined by the Pennsylvania Department of Environmental Protection, Ranked by Percent Attainment

Watershed	Percentage of Stream Miles Assessed	Attainment Status of Studied Stream Reaches
Guyasuta Run	100%	100% attainment
Sipes Run	100%	100% attainment
Pine Creek	100%	Approx. 50–60% attainment. The main stem of Pine Creek from the river all the way to the northwest corner of the watershed, including the Fish Run and Wexford Run tributaries, is impaired. Crouse Run in the northeast portion of the watershed is impaired, as are some additional, minor tributaries. Major tributaries that do attain their criteria include Little Pine Creek (east), Little Pine Creek (west), and the northern tributaries Willow Run, Montour Run, North Fork Pine Creek, and Rinaman Run.
Chartiers Creek	⇢95%	⇠10% attainment. Only a few minor tributaries attain their criteria.
Girtys Run	100%	0% attainment
Saw Mill Run	Approx. 90%	0% attainment
Streets Run	⇠10%	0% attainment. But note that only a small portion of the watershed has been studied.

Source: Pennsylvania Department of Environmental Protection 2001

SUMMARY AND IMPLICATIONS

Table 10 summarizes much of the information presented in previous pages, and provides some general judgements about the overall state of each watershed and stream system. This table classifies the year one watersheds/streams into four categories. The classification scheme is not based on a quantitative formula, but rather represents professional judgments about the relative ecological integrity of each of the studied watersheds, taking into account the wide variety of issues and findings discussed in previous pages.

Table 10 – Summary and Classification of Key Streams/Watersheds of the Year One Study Area

Class / Watershed	Built Envir.**	Imperv. Surf.***	Original Streams Still Open	Stream Miles Attaining DEP Stream Criteria (Penn DEP 2001)	Degree of Benthic Macroinvertebrate Community Impairment (Koryak and Stafford 2001)	Biological Contamination (Knauer and Collins 2001)	Notable Water Quality Findings	
Highest Integrity								
Guyasuta Run	16%	8%	79%	100%	Slightly impaired	Least impacted		Most he
Pine Creek	28%	9%	77%	50–60%	Slightly impaired	Most impacted	Lowest total hardness of all streams studied (Koryak and Stafford 2001).	Hea Pennsyl
Chartiers Creek*	33%	11%	71%	⟵10%	Slightly impaired	Least impacted	Several high total dissolved solids readings (Knauer and Collins 2001).	High p watersh
Moderate integrity								
West Run	70%	20%	45%	Not assessed	Slightly impaired	Most impacted		Wa
Sipes Run	36%	10%	56%	100%	Moderately impaired	Most impacted		Low in
Becks Run	55%	17%	36%	Not assessed	Moderately impaired	Most impacted		Str
Girtys Run	51%	18%	53%	0%	Moderately impaired	Most impacted		dev
Homestead Run	74%	20%	33%	Not assessed	Moderately impaired	Insufficiently studied	Low dissolved oxygen (Knauer and Collins 2001). Elevated aluminum (Koryak and Stafford 2001).	Dry wea weathe
Spruce Run	47%	N.C.	65%	Not assessed	Not studied	Not studied		
Jacks Run	56%	N.C.	59%	Not assessed	Not studied	Not studied		T stream
Low Integrity								
Streets Run	47%	12%	61%	Insufficiently	Severely impaired	Most impacted	One low dissolved oxygen reading (Knauer	Many c

Woods Run	52%	N.C.	23%	Not assessed	Not studied	Not studied
Four Mile Run	80%	31%	10%	Not assessed	Severely impaired	Not studied
Extremely Altered						
Spring Garden	55%	N.C.	5%	No stream	No stream	No stream
Allegheny Cemetery	65%	N.C.	3%	No stream	No stream	No stream
Heths Run	79%	30%	0%	No stream	No stream	Least impacted
Corliss St	66%	N.C.	0%	No stream	No stream	No stream
32nd Street Culvert	94%	45%	0%	No stream	No stream	No stream

N.C. = Not calculated

*Only the Allegheny County portion of Chartiers Creek is described here. The watershed extends beyond Allegheny County, totalling approximately 145,000 acres.

**Built Environment consists of the following italicized land uses:
Hydrologic Feature
Transportation
Forest
Grassland/Openspace
Agriculture/Pasture
Low Density Residential
Med Density Residential
High Density Residential
Identified Malls
Commercial
Industrial
Heavy Industrial
Strip Mine
Non Vegetated

***Impervious surfaces may be slightly underestimated. Sidewalks, some parking lots, and some plazas/patios are not included.

In making these judgments, 3R2N relied most heavily on the macroinvertebrate bioassessments prepared by Koryak and Stafford, and to some extent the DEP's overall stream assessments, supplemented by review of land use data and patterns. The measures made in the Koryak and DEP studies are more holistic and integrative measures of stream health than the "snapshot" views of physical/chemical and bacteriological water quality. Further, the region has embarked on a long-term program of infrastructure rehabilitation to address bacteriological contamination. Given that our watershed/stream classifications are made here with an eye toward identifying watersheds that might be most interesting for near and long-term stream protection and restoration efforts, we chose to largely disregard bacteriological contamination, in the belief that this source of ecological impairment will be addressed over time.

Land use is also a key evaluative measure, in part because it tends to have a "uni-directional" nature: it typically increases in intensity, and rarely gets "better" from an ecological point of view, with a few notable exceptions (such as the current status of former industrial areas along the banks of the main rivers). In the context of protecting and restoring the ecological integrity and potential of watersheds, those watersheds that are less densely developed, and those with more substantial "chunks" of relatively natural land, are arguably of greater interest than more densely developed watersheds and those where naturalized land is scattered and disconnected. [5] Readers may wish to cross-reference Table 5, "Land Use in Key Watersheds of the Year One Study Area, Ranked by Ascending Percentage of Watershed Area in Built Environment Land Uses" while reviewing the following watershed/stream classifications.

The "bottom" of the list was determined by figures on the percentage of original streams that now are culverted. It consists of most of the watersheds with few remnant streams and no stream mouth at the relevant river.

Care should be taken in interpreting and using these classifications. The classes are based on overall watershed/stream conditions. They take some note of important watershed subareas and stream reaches but cannot encompass all the important variations in ecological integrity within each watershed and stream system. For instance, some low-rated systems may include stream reaches that are highly worth protecting or restoring.

The classification scheme and a discussion of the results follows:

Highest integrity streams/watersheds

- Guyasuta Run
- Pine Creek
- Chartiers Creek

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[5] This by no means is meant to down-play the mitigative and restorative value of many redevelopment and retrofit measures that can "soften" the urban landscape and provide multi-functional benefit, including improved hydrologic functions. 3 Rivers – 2nd Nature strongly supports such efforts. See *Re-Evaluating Stormwater: The Nine Mile Run Model for Restorative Redevelopment* (Ferguson, Pinkham, and Collins 1999) for further information.

This class includes those streams whose benthic macroinvertebrate communities were classified as only "slightly impaired" by Koryak and Stafford. Guyasuta Run and Pine Creek also faired well in the DEP stream assessment. All three watersheds are heavily forested have low proportions of their land in built environment land uses, and impervious surfaces. Each has many headwater areas with limited to no development. Chartiers Creek ranks lowest on the list because portions of its watershed are heavily developed, and strip mines have compromised some tributaries. Note that "highest integrity" is used here as a relative term. It describes these watersheds relative to other watersheds in the study area, not necessarily in relation to pristine watersheds of the larger ecoregion. Nonetheless, it is clear that Chartiers Run and Pine Creek are widely considered highly valuable and important throughout and beyond Allegheny County. Guyasuta Run, though a much smaller watershed, is clearly deserving of local protection and probably wider recognition as well.

Moderate integrity streams/watersheds

- West Run
- Sipes Run
- Becks Run
- Girtys Run
- Homestead Run
- Jacks Run
- Spruce Run

Streams with macroinvertebrate communities rated "moderately impaired" are included in this class, plus a few other streams. In general, these watersheds are more developed than those in the previous class, but are not as highly urbanized as the next class. West Run is somewhat of an anomaly in this list. It heads the list because of an excellent "slightly impaired" macroinvertebrate bioassessment rating, yet it is a highly urbanized watershed. So too is Homestead Run, though that stream was rate "moderately impaired" for macroinvertebrate communities. The Sipes Run watershed has a low proportion of built environment land uses and impervious surfaces. It probably does not make the "highest integrity" macroinvertebrate class because much of its natural landscape (forest and grassland/pasture) is broken up by residential development. Becks Run makes the moderate integrity class in spite of the channelization of much of its stream channel in the lower watershed. The Becks Run watershed has some substantial blocks of forest land, but heavy development in its headwaters. Spruce Run does not have bioassessment or stream assessment ratings, but is included because its proportion of built environment land uses is commensurate with other watersheds in this class. Jacks Run is included for similar reasons. Jacks Run is the only stream in this class that does not have at least some dry weather flow to its river (Homestead Run is intermittently dry and flowing in dry periods). However, the culverted lower stream valley of Jacks Run is only sparsely developed and a trunk sewer improvement project is underway there that will probably restore continual flow to the stream mouth, thereby improving the ecological value of that river/stream embayment.

Low integrity streams/watersheds

- Streets Run
- Saw Mill Run
- Nine Mile Run
- Tassey Hollow
- Woods Run
- Four Mile Run

These are all highly urbanized watersheds. Streets Run has a fairly low proportion of land in built environment and impervious surface. However, many of its headwaters areas are very densely developed, and some are impacted by strip mining. Probably as a result, its bioassessment rating is “severely impaired,” as for the other streams in this class (excepting Woods Run, which did not have a macroinvertebrate study). Saw Mill Run and Nine Mile Run are both heavily urbanized, though their development patterns differ sharply. Remaining forested land in Saw Mill Run occurs in small, poorly connected blocks. Most of the forested land in Nine Mile Run occurs in one block in Frick Park and Fern Hollow. This area is now the site of a major stream habitat restoration project. Tassey Hollow, Woods Run, and Four Mile Run are different from the other three streams in that each no longer has a connection to a main river. Each has been captured by combined sewers; only wet weather overflows now reach the rivers from these watersheds. However, we do not “drop” these watersheds to the lowest ecological integrity class because each has remnant streams in substantial blocks of forest in an upper portion of its watershed. In the case of Woods Run and Four Mile Run, these blocks are in large city parks—Pittsburgh’s Riverview and Schenley Parks, respectively.

Extremely altered streams/watersheds

- Spring Garden
- Allegheny Cemetery
- Heths Run
- Corliss Street
- 32nd Street Culvert

Each of these watersheds is very heavily urbanized and has no connection to a river, its stream system having been replaced by combined sewers. Each contains few to no remnant streams. AGIS data shows tiny remnant streams in Spring Garden and Allegheny Cemetery, but no stream remnants in the remaining watersheds. 3R2N found a barely running seep in Heths Run, and did not investigate the headwaters of the other streams because their extensive urbanization did not seem to warrant further effort at this time.

Implications

The stream classifications above can be useful in selecting sites for stream restoration and daylighting projects. All things being equal, it can be argued that restoration projects in higher integrity watersheds will have greater chances for success and higher value.

However, all things are rarely equal. Again, one should take care in using these classifications. They are a general indication of watershed and stream conditions and not the specific value of particular sub-watersheds and stream reaches. For instance, Nine Mile Run rates low in very many categories of the summary table and its overall classification. Yet its large amount of open space in and around Frick Park offers significant opportunities for ecological restoration. Due to recent intense interest in improving conditions of the stream and its riparian corridor, a multi-million dollar restoration project is now underway in Nine Mile Run. We will return to this question of relative value of projects in different watersheds in subsequent sections of this report: including the chapter titled “The Agenda For Living Streams,” and the chapter on site identification and selection.

It is clear that many local streams have significantly improved, in biological terms, over the last 20 years with the demise of industry. Stream bugs, fish and wildlife are returning to our streams. Many streams have incredible potential for a range of human uses from fishing, to wading, bird-watching and exploring. For each mile of river in the year one study area we have 21 miles of currently open streams, so streams are critical to public access to aquatic ecosystems. One question we have to address is, can we resolve our bacteriological water quality problems to make it safe to use our streams? If we can, we have good reason to believe that protecting and restoring our currently open streams, and daylighting buried streams in appropriate locations, will yield exciting results.

WHY ARE SO MANY STREAMS BURIED?

Having reviewed the conditions of watersheds and streams in the study area, we now turn to further enriching the background for later identification, selections, and discussion of candidate daylighting sites by considering the historical and current context for the loss of open streams. Following chapters will address the general stream protection and restoration agenda; describe the types, benefits, costs, and challenges of daylighting; and review local daylighting precedents, before we turn to daylighting site identification and selection.

There are many reasons why so many streams in Allegheny County are buried. Most of the culverting happened decades ago, driven by several historical factors:

- As Pittsburgh was settled, open streams were a convenient way to dispose of sewage and stormwater, and early plumbing systems were simply routed to streams. Culverting streams became an attractive solution that minimized the potential for human access to this dirty water, at the same time hiding the filth streams carried.
- In the late 1800s, as the sewer network rapidly expanded, Pittsburgh opted to construct combined sewers—large pipes that carry both stormwater and sanitary sewage—rather than separate storm and sanitary sewers (Tarr 1989). That decision, considered state-of-the-art engineering at the time and into the middle of the 20th century (Tarr 1979), has enormous implications today. We know well the problem of combined sewer overflows into our rivers and some larger streams during wet weather. In addition, had Pittsburgh and other older municipalities opted for separate storm and sanitary sewers, it would have been more economical to keep some now-buried streams on the surface. Further, more daylighting opportunities would exist today had streams and sewage not been mixed in so many places.
- Pittsburgh's topography and industry also contributed to the loss of open streams. Given the many steep slopes of our landscape, flat, buildable land was at a premium. Cutting of hillsides and hilltops, and filling of valley bottoms, created more land for development—and streams were culverted and buried to make way.
- In the older communities, the land-forming was augmented by deposits of spoils from coal-mining in some high stream valleys, and by dumping of steel slag along the rivers to cut handling costs and raise land up out of the floodplains.

Pittsburgh-area streams are still being buried. While there are now many large tracts of flat land along the rivers, where steel mills and related facilities once stood, most of the growth is in away from the rivers in the suburban hill country or along headwater streams. Flat land here is very valuable, and streams are sometimes in the way of proposed building footprints, parking lots, and other facilities. Sometimes the streams are re-routed; sometimes they are culverted underneath the new land uses. Cut and fill is still a common development practice, one that can lead to burying of streams. While we are no longer building combined sewers, new storm sewers are being installed in the growing suburbs, and sometimes perennial streams are put into those pipes to speed drainage of newly developed land.

Since 1994, Pennsylvania DEP has kept a database of all new culverts on large streams (those draining over one square mile). Figure 5, "Pennsylvania DEP Stream Enclosure Permits, 1994-2000," shows all the location of all culverts over 100 feet in length—classified as "stream enclosures" by DEP—that DEP issued permits for from 1994 to 2000. The total lengths of streams permitted to be buried (it is not known if all of these culverts were in fact built) comes to 7,283 feet.

Besides these longer culverts, we should keep in mind two other important ways in which streams are still being "disappeared" in Allegheny County. First, new roads and driveways often cross streams, often at frequent intervals. While the culverts they require are short, and streams may remain open in between, this new "automobile habitat" chops up the integrity of natural streams. This is detrimental to stream health and, as well, years later these compromised streams are more likely to be considered for channelization or complete culverting, particularly if growth in upstream areas has increased storm runoff and led to erosion or flooding problems. Figure 6, "Pennsylvania DEP Stream Enclosure and Stream Culvert Permits, 1994-2000," adds to the previous stream enclosure figure all the culverts under 100 feet permitted by DEP in the same time period. This brings the total length of large streams culverted in this period to 12,190 feet, or 2.3 miles. These culverts are all in addition to the culverted stream estimates in Table 3, which is based on 1992/93 data on open streams in Allegheny County. For this 2.3 mile addition to the culverted stream total in Table 3, a corresponding subtraction of 2.3 miles in the open stream category is also required.[6] The actual length of stream culverting activity since 1994 could be substantially greater, because these DEP figures only include projects where the upstream watershed is one square mile or greater. Projects on streams draining less than 100 acres don't require any DEP permit, and projects on streams draining between 100 acres and one square mile are allowed under "General Permit 7." Data on those projects is not yet computerized by DEP. Thus, the data presented above does not reflect culverting activity on many headwater streams in Allegheny.

Second, streams can disappear without being culverted, through a variety of processes that result in de-watering. While the channel remains, habitat for fish and other aquatic creatures is lost as once-perennial streams go dry for much of the year, flowing only in large storms. For instance, in some places sewer lines that were placed along or underneath streams have deteriorated to the point where water infiltrates into the pipes. Surface flows may disappear directly into holes in sewers. This is known to have occurred in Nine Mile Run, a tributary to the Monongahela in Pittsburgh's east end. Deteriorated sewer lines can behave like giant French drains, drawing water out of the soil or alluvium. As the stream substrate loses saturation, surface flows sink in, and water disappears from the surface. This problem occurs in many places. Jack's Run, a tributary to the north side of the Ohio at the edge of Pittsburgh, and Homestead Run on the Monongahela are good examples of this type of de-watering. A sewer rehabilitation and stream restoration project to address this problem on Jack's Run is now planned by ALCOSAN, Pittsburgh, Bellevue, and Ross. Finally, streams often lose water, to the point of going dry, as watersheds are developed. Increased impervious surfaces—roads, parking lots, buildings, sidewalks, etc.—mean that less precipitation soaks into the soil to recharge the ground water. Ground water, not surface runoff, is the source of stream base flow, the water that runs in streams in the summer and other dry periods. If groundwater recharge is reduced by development of large portions of a watershed, the local stream will run lower or not at all.

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[6] We did not revise Table 3 in this manner because we do not know if all the permitted culverting projects were actually constructed.

THE AGENDA FOR LIVING STREAMS

The available data on stream conditions and consideration of the historical and current factors leading to degradation and outright loss of streams suggest that a multi-faceted agenda is required to establish an ethic—and real results—for living streams in Allegheny County.

- *Protect* currently open streams from further degradation.
- *Improve* the condition of open but degraded streams.
- *Daylight* buried streams in appropriate locations.

PROTECT CURRENTLY OPEN STREAMS FROM FURTHER DEGRADATION

Given the many values of natural streams, and with the stream base of the county already so compromised — 41% of our historic streams now buried, and an unknown but important portion effectively killed by channelization—it's critical that we stop the losses. We must enact policies and seek development patterns and design solutions for the built environment that minimize or eliminate channelization and culverting.

Destroying urban streams is an expensive public policy failure. As urban streams are impacted by development they go through stages of infrastructure development, followed by problem resolution activities focused on the effect of a problem rather than its cause. First, as land is logged, paved, and developed, erosion and flooding increase. Then there is a response such as stream bank revetment (hard structural reinforcement) or channelization. The stream becomes an eyesore and a hazard. Pollution increases as development continues, or as hidden infrastructure deteriorates. Local desire to see these systems "disappeared" increases and often "wins." This is the process that has resulted in the situation we are in today, trying to identify urban streams that are now in sewer systems, and transported to ALCOSAN, where we pay to treat them. In one case, a stream that enters a sewer collection system on the North Side has resulted in an expensive ongoing maintenance program for sediment removal. Wouldn't it have been more sensible to protect the stream in the first place? Many similar and additional maintenance problems exist. ALCOSAN has only just begun to figure the costs (to all of us) of streams that were captured by sewer systems and transported to its plant for treatment.

It's important to note that protecting open streams not only serves ecological and infrastructure values, but also may, over the long term, preserve the integrity of the built environment and avoid all manner of economic problems for communities. The problems are most easily understood in California, where earthquakes have led to fracturing of buried stream culverts, resulting in water damage to surrounding building foundations (Pinkham 2000, p. 17). Similar but often subtler problems arise in eastern cities as well. Research by Ann Spirn (1998, p. 91-92) in Boston and Philadelphia has shown the key role that location along buried stream routes plays in abandonment of buildings, and how vacant lots are disproportionately located in valley bottoms. Unnoticed or unremarked, patterns begin: water flows downhill to the valley bottoms, culverts fail physically or fail to fully address drainage problems, basements flood, pavements heave, land subsides, building maintenance and insurance costs rise, owners move out and low-rate rentals begin, re-investments aren't made, neighborhoods decline. This doesn't happen everywhere, all the time, but planners are beginning to notice the patterns, and communities should carefully consider the long term potential economic and social implications and viability of each step along the continuum from developing along stream corridors to having flood problems to channelizing streams to culverting. Decision makers in the communities and agencies concerned with Streets Run and Sawmill Run are now considering channelization of portions of those streams. This “easy” solution to the problems experienced in those stream systems could cost more in the long run than may be commonly realized.

These days, good master plans and zoning attempt to preserve stream corridors and buffer zones around them. Setting in place and then sticking to such plans and zoning maps is critical for stream protection. Sometimes more is needed. A number of communities around the county have enacted stream protection ordinances that disallow or discourage culverting, channelization, and development and land use activities along streams that can damage banks and channels. Some have enacted culverting moratoriums to allow time for consideration and development of locally appropriate stream protection ordinances. Such a moratorium in Berkeley, California prevented culverting of a rare still-open stretch of Strawberry Creek immediately below the Strawberry Creek daylighting project, one of the country’s most-admired daylighting projects (Pinkham 2000, p. 6).

Besides stemming the obvious losses of channelization and culverting, we must also address the impacts often brought on by activities outside of the stream channel. As noted before, development brings increased impervious surfaces, which can harm streams physically by changing flow regimes. Imperviousness increases peak flows and reduces base flows—stream flows have “higher highs and lower lows.” The result in the first case is increased stream channel erosion (and deposition of the released soils and sediments at some downstream point), usually bringing loss of prime habitat for many aquatic creatures. In the second case, stream temperatures rise and aquatic habitat further declines as water levels recede in dry periods. Further, runoff from impervious surfaces often carries pollutants that compromise stream health.

These impacts can be mitigated or avoided with good planning and innovative development design. A host of design techniques and stormwater management measures, sometimes referred to as “better site design” principles (Center for Watershed Protection 1998) and “low impact development”(Prince George’s County Maryland 2000), can substantially reduce the harmful effects of development.

IMPROVE THE CONDITION OF OPEN BUT DEGRADED STREAMS

Given the fact that citizens of Allegheny County have significantly higher access to streams than rivers, it is important to address the sources of bacteriological contamination of our streams. The poor condition of much of our sewer infrastructures has to be a large part of this problem. ALCOSAN, the Three Rivers Wet Weather Demonstration Program, municipalities, citizen groups, and the public at large must all be involved in the search for solutions.

Further, the physical damages and water pollution caused by runoff from impervious surfaces must be addressed. Sometimes this means rehabilitating and restoring the stream channels themselves. The tools section of this paper lists a number of technical resources on stream restoration techniques. In addition, stream recovery can be aided by and may often depend on taking actions outside the stream channel. Many of the techniques of better site design and low impact development can be applied in the retrofit and redevelopment contexts as well as in new development settings. Work in Nine Mile Run has set out a vision and the principles for doing so in our region (Ferguson, Pinkham, and Collins 1999).

DAYLIGHT BURIED STREAMS IN APPROPRIATE LOCATIONS

This part of the agenda is the focus of this report. As we'll see below, daylighting can generate many benefits. Many of our streams have been lost forever, but some can be brought back. It is appropriate, perhaps even essential to the living streams idea that citizens and agencies in Allegheny County consider daylighting possibilities and implement projects that provide high economic, ecological, aesthetic, recreational, and other returns.

THE RELATIVE VALUE OF URBAN STREAM RESTORATION AND DAYLIGHTING

Many of our friends will argue, "Wait a minute, you are talking about spending a lot of money on streams in cities, which would be better spent on preserving and conserving high quality streams in more rural areas." The preservation, conservation, restoration and daylighting of streams needs to be an integrated and proactive policy in all regions of Western Pennsylvania. If the dominant development model in the cities features the wholesale destruction of streams to achieve density, tax revenues, and other goals, then it will be emulated outside the city as well. We need to understand that a clean living stream system is an indication of a successful policy of protecting our state's waters throughout the region.

The issue of relative value is often comes up for daylighting projects in particular. Daylighting can be expensive. Some people ask: wouldn't the money contemplated for a daylighting project be better spent elsewhere? Couldn't we get "more bang for the buck" restoring open but degraded channels in Allegheny County? Or remediating stormwater and other non-point source pollution problems? Or addressing the ravages of acid mine drainage?

This "bang for the buck" question is a natural one. We have several responses:

- The first response is to challenge the premise that daylighting provides lower returns than other types of restoration. Daylighting can provide significant hydraulic, water quality, and habitat returns, among other benefits. Some daylighting projects may be more expensive on a unit cost basis than other possible projects, but may provide higher returns per dollar spent. The "numbers" will depend on the specific project costs and benefits.
- The question reflects a concern for maximizing cost effectiveness in the spending of public funds. Fair enough, but we must be very careful how cost effectiveness is defined. For instance, if only economic returns or measurable improvements to water quality are considered, we may miss "counting" important intangible benefits like the amenity value of flowing water or the social and spiritual value of "bringing back" something that once seemed lost forever to the local community.
- This raises a related point: we must carefully articulate the goals we are trying to achieve. In some cases, the goals may not be fundamentally related to water, but instead flow from concerns for landscape quality, amenity development, or other urban priorities. What are the key decision criteria for the specific projects being considered, and for particular funding sources?
- The argument favoring other projects fails by geographic extension. Wouldn't we get more bang for the buck on projects way up Chartiers Creek, outside of Allegheny County? Or in West Virginia? Or the Amazon basin?

- The key point of these rhetorical replies is that post-industrial urban ecosystem restoration requires that we do all sorts of projects, wherever we can. No single metric provides an ultimate yardstick by which to measure project appropriateness. And we must do things where people live. Serving ecosystem values in the city is just as important, if not more so, than serving ecosystem values in the suburbs or the rural fringe.
- Finally, we should probably not accept another premise of the question—that stream restoration is a zero sum game; a project here takes funds away from a project there. The zero sum premise is a static view. Dynamism and change over time is what we all hope for, and often novel concepts produce it. Its very possible that investing in "expensive" but highly visible daylighting projects can increase public consciousness about streams in ways that lead to more stream care activity along still-open streams. Daylighting could even spark higher funding of traditional restoration programs, or new eligibility for stream projects from other sources and programs that come to see how stream restoration serves their values.

THE RANGE OF DAYLIGHTING POSSIBILITIES

Daylighting is possible in a range of pre-existing land use conditions. In recent decades, various communities have restored streams to the surface from underneath:

- vacant land;
- former railyards;
- school properties;
- open space and playing fields at parks;
- farm fields;
- golf courses;
- parking lots;
- extended "bridges" and parking decks;
- brownfield sites;
- former and active lumber mills;
- residential backyards; and
- commercial properties in downtowns.

Not every buried stream can or should be daylighted. And not every daylighting project can or should create a completely natural stream. The full spectrum of daylighting projects includes:

> *Natural restoration:* A project that restores the characteristics of natural streams. These include a stream bottom and stream banks that are permeable to water, and stream bank vegetation. Typically the geometry of the stream—its bends, the shape of the channel cross-section, and other features—is designed to match the expected flows so neither excessive erosion or sedimentation of the channel occurs. The degree of "naturalness" can vary: in appropriate locations the result can be quite a wild stream, in others the channel may be reinforced through the strategic use of natural materials and the stream and its corridor may be otherwise manipulated (within the limits of what running water will allow!).
>
> *Architectural restoration:* A restoration of the flowing water to the open air, but in a carefully designed and entirely contained channel. Such projects are typically done in dense urban areas or other locations where flow must be well-controlled. The result could be a babbling, rock-lined channel through a city square, or a larger waterway with walls and bottom made of stone blocks, running along a street or through a park or downtown area. Such projects restore some of the aesthetic values of flowing water, but do not incorporate the natural features of a streamside landscape or "riparian corridor."
>
> *Cultural restoration:* A project that celebrates a buried stream, but does not "raise" it. While the stream remains buried, a variety of markers and public art inform people of the stream's current condition, its historical route and uses, and other physical and cultural information. Such projects can also draw attention to needs and reasons for preserving or restoring other streams.

In short, a cultural restoration restores the stream to human consciousness, an architectural restoration restores some of its form, and a natural restoration restores both form and function.

An additional variable, for natural and architectural restoration projects, is whether some or all of the available flow is restored to the open air. We can consider both *full flow* and *partial flow* options for daylighting. For instance, a project might restore the dry weather "base flow" to the surface, but divert high stormwater flows into an existing or new culvert.

COSTS AND BENEFITS OF DAYLIGHTING

COSTS

Daylighting projects involve many potentially pricey activities and materials: technical studies and design work, acquisition of properties or easements, excavation and rough grading, hauling of fill, materials for the streambed and in-channel structures, landscaping materials, hand labor for final grading and revegetation, and more. Designers of daylighting projects say $1,000 per linear foot is a good, conservative rule of thumb for the full costs of substantial projects at market rates; that is, when all work is paid for in cash.

Actual costs for most projects often come out less. Lack of full funding fosters such inventions as use of volunteer labor, in-kind contributions, and donations of services and materials. Many daylighting have been done on a shoestring. However, it takes lots of public-spirited people and extremely competent coordination to pull this off.

It’s worthwhile to brainstorm potential sources of support: a local heavy equipment firm owned by an angler, a design firm that might reduce its fees to work on a novel project, nurseries that might give plant stock in return for publicity, highway or construction projects that could provide or accept fill, donate woody plant cuttings, or salvage root wads bound for a fire or dump. Potential volunteer or low-cost labor sources are also many: local conservation corps, schools, community organizations, and project neighbors. A project in Roscoe, New York even made use of prison inmate work crews.

A recent study of daylighting projects across the country (Pinkham 2000) reveals that 23 projects ranged in cost from $15 to $5,000 per linear foot. It’s difficult to get an exact handle on “typical” daylighting costs, because no project is typical. Each varies considerably in the amount of excavation required, technical difficulties encountered, economies of scale in construction, type of landscaping, additional non-stream amenities, use of volunteer labor, etc. A bit more specifically, the following costs are indicative of the range of project types that have occurred in the U.S.:

Table** 11 **– The Range of Daylighting Project Costs

Cost per Linear Foot	Type of Project
$15 to $250	Simple natural restoration daylighting projects, with considerable volunteer labor and in-kind donations.
$1,500	A large architectural restoration project in Kansas. The concrete stream channel was 10 feet wide and 30 inches deep. The project required considerable excavation. This price included development of substantial associated park amenities: concrete block paver path, grassy amphitheater, stage, substantial landscaping, fountains, other water play features.
$5,000	A major downtown daylighting project in Michigan. Architectural restoration: a concrete channel 20 feet wide and 12 feet deep. Costs included significant pre-construction surface and subsurface environmental assessments and public involvement processes, shoring up

	of foundations due to proximity to the stream channel construction zone, excavation and replacement of contaminated soils in locations, capping of contaminated soils in other locations, construction of multiple city street bridges, etc.

Source: Pinkham 2000.

BENEFITS

Stream restoration and daylighting projects completed across the country and throughout Europe show that daylighting can provide real benefits—tangible and intangible—for every dollar expended. A U.S. Environmental Protection Agency sponsored review of completed projects in the U.S. and abroad (Pinkham 2000) has shown that daylighting can:

- relieve choke points and flooding problems caused by under-capacity culverts;
- increase hydraulic capacity over that provided by a culvert, by recreating a floodplain;
- reduce runoff velocities—thus helping prevent erosion—as a result of natural channel meandering and the roughness of the stream bottom and banks;
- replace deteriorating culverts with an open drainage system that can be more easily monitored and repaired;
- cost less, or only marginally more, than replacing a culvert;
- divert urban runoff from combined sewer systems before it mixes with sewage, reducing combined sewer overflows and burdens on treatment plants;
- improve water quality by exposing water to air, sunlight, vegetation, and soil, all of which help transform, bind up, or otherwise neutralize pollutants;
- recreate aquatic habitat and improve fish passage;
- recreate valuable riparian habitat and corridors for wildlife movement;
- provide recreational amenities, such as a challenging new water hazard on a golf course, a place for children to play, or a streamside bench for people to relax upon;
- create or link urban greenways and paths for pedestrians and bicyclists;
- serve as an “outdoor laboratory” for local schools;
- beautify neighborhoods, perhaps serving as a focal point of a new park or neighborhood revitalization project;
- allow businesses to cut costs and increase profits while benefiting neighborhoods and the environment;
- increase property values;
- benefit nearby businesses by creating a new amenity that attracts people to the area;
- create jobs or job-training opportunities in building and maintaining the stream or park;
- build civic spirit and relationships as local residents, businesses, and governments come together to create the project;
- reconnect people to nature through the look, feel, and smell of open water and riparian vegetation, and through contact with aquatic and streamside creatures;
- give people a sense of “setting right something we messed up.”

Places like Phoenix, Arizona and Providence, Rhode Island have taken on very large and difficult river restoration programs in the very heart of the city. Each of these project have provided the centerpiece for renewed growth and interest in life downtown. In Aachen, a small city in Germany, a tiny steam flows from a park next to a school. Children float paper boats down the channel which runs through a commercial district which was beginning to fail. New cafes have emerged and citizens relish the sound of the “Paubach,” a stream which was once just a memory. How many of us played near a stream as children? How many of our childhood streams are lost? The intangible benefits of bringing back some of these streams are surely great.

In the Pittsburgh region, where much of our storm and sanitary sewer infrastructure is in poor condition or poorly configured, daylighting can combine environmental restoration and infrastructure rehabilitation. The historic co-mingling of streams and sanitary sewage presents continuing operation and maintenance costs to ALCOSAN. Stream water adds to wet weather capacity needs at the treatment plant, increases total treatment costs due to increased input, and carries sediments and other debris that settle in sewer lines and regulator structures, requiring periodic removal. For instance, costs associated with cleaning the Lower Northern Allegheny Interceptor of sediments contributed by the direct stream connection behind the Millvale Industrial Park included a contract cleaning for $197,000 in 1991, another contract cleaning in 1998 for $306,000, and prior unaccounted-for cleaning jobs performed by ALCOSAN in-house staff (memo by Jan Oliver of ALCOSAN to Kathy Knauer of ALCOSAN, August 14th, 2000). Other cleanings of stream-contributed sediments have reportedly involved similar costs, and on at least one occasion sediments had built back up to pre-cleaning levels within a month. Accumulation of sediments also imposes costs by taking up valuable capacity in the system—possibly exacerbating sewer overflow problems and perhaps ultimately forcing construction of additional wet weather management capacity.

Separating stream flows from sewers is a key aspect of ALCOSAN’s Long Term Control Plan for wet weather management. As ALCOSAN staff noted in an August 2000 3 Rivers – 2nd Nature meeting, incorporating daylighting into the sewer separation projects would increase the value of these separations to the community, and also help the agency educate the public on the necessity and value of the overall wet weather management program. Also, conventional separation of stream flows into a storm sewer might simply relocate a sediment problem, while a daylighting project could create streams that can be easily monitored and have the potential to be self-sustaining by equilibrating sediment transport with sediment deposition, as natural, meandering streams do.

Daylighting Challenges

3 Rivers – 2nd Nature recognizes that a variety of challenges must be met if a daylighting project is to be successful. These include:

Community issues. Often the prospect of restoring flowing water to the surface raises concerns over safety, public access, water quality and health, and differing expectations of project purposes and results. These issues must be fully articulated and each must be responsibly addressed.

Institutional issues. Daylighting projects can raise various questions relating to stream ownership, maintenance, and liability. They may also present difficulties in coordinating multiple agencies and in permitting. Some of these issues may be "showstoppers," but a can-do approach often resolves them.

Technical issues. The more urban a project's location, the more technical issues will come up. And the more constrained the potential project corridor, the more difficult it will be to solve the problems. One can't usually expect to duplicate pre-development conditions, and techniques appropriate in rural stream restoration projects may not be appropriate in the city. It's important that the project designers include a wide range of technical experts: engineers, biologists, landscape architects, and others.

Social challenges

Many challenges are social and psychological in nature. These issues can arise from project conception through project implementation and follow-up stages. Fear is a key concern to address. Water in pipes doesn't seem to scare people; water in open channels often does. Contributing to fear, but sometimes separate from it, is unfamiliarity.

- Local public works departments may worry about hydraulic performance, or object to real or imagined maintenance needs.
- Neighbors may believe the new channel could be a hazard to their children.
- Nearby residents and businesses may express concerns that the project will attract homeless people or drug dealers, become a trash-filled eyesore, support rats or mosquitoes, or otherwise impact the quality of the neighborhood.
- Expectations in the community may conflict. For instance, affected and adjacent property owners may have different desires for access and security than other potential users.
- Construction may be locally disruptive.
- Users and viewers of the new creek may expect instant, exotic landscaping. The values of native vegetation are not familiar to many, nor are the successional stages that newly established vegetation must go through. Early years will present a scruffy look that some may object to.

Institutional challenges

Daylighting projects can raise various issues relating to ownership, maintenance, and liability. They may also present difficulties in coordinating multiple agencies and in permitting.

- Who will own the new waterway is sometimes an issue. Where private property is involved, should a public agency buy the affected property outright, or secure a right-of-way? What will the property owner accept?
- Who will be responsible for maintaining the project? A buried pipe is typically the responsibility of the relevant public works agency. When something is opened, responsibility may revert to the adjoining owners, as would be the case for an open stream.
- An open channel may raise liability issues. Increased exposure to damage claims for water problems or to personal injury claims is possible. This may result in increased insurance premiums for owners of the site and those adjacent to it.

- Creating a surface waterway may also expose owners of the site or adjacent properties to additional environmental regulations and planning procedures (wetlands regulations, setback requirements, etc.), reducing their ability to develop their properties further.
- It can be challenging to work with multiple private organizations and public agencies that may not understand daylighting, and may not be responsive to public desires.
- In Allegheny County, given the large number of local governments, inter-municipal cooperation may be necessary for many daylighting projects. Liability, allocation of capital and O&M costs, and other upstream/downstream issues that cross municipal boundaries will certainly be scrutinized. Also, where streams define municipal boundaries, at least two communities are involved by definition. A particular concern in this situation is that any movement of the stream channel as part of the restoration project could lead to turf struggles.
- These projects need leaders, including governmental ones. Daylighting is often driven by a local citizens' group, but frequently sponsorship by a public agency that will take on the project as its own is essential. Establishing a lead agency is sometimes difficult. Should it be a public property owner like the city parks department or a school district? The sanitation authority? A regional planning commission?
- All relevant agencies need to be on board. Reluctance from key local agencies can harm the prospects for securing grants and permits.
- Multiple permits will probably be necessary, perhaps from all levels of government: federal, state, and local. The U.S. Army Corps of Engineers regulates almost any alteration to surface waters. Most states have one or more environmental programs that must examine the project. Local planning, construction, or hydraulic modification permits may be required as well.
- In Pennsylvania, a Department of Environmental Protection "dams and encroachment permit" must be obtained for most projects that impact the geometry of stream channels.
- Pennsylvania's Stormwater Management Act 167requires stormwater management plans for each basin. About ten of these plans have been done within Allegheny County; some remain to be done. A daylighting project in a basin where a plan has been completed would probably have to comply with the plan.
- Any project that intersects a river will have to be reviewed and approved by the U.S. Army Corps of Engineers under its responsibilities to regulate activities affecting navigable waters. Daylighting projects that reach one of Allegheny County's rivers would be subject to these regulations.
- An example of local regulation comes from the City of Pittsburgh. Any project that will excavate over 32,000 cubic feet of earth requires a conditional use approval. This requires that the city planning commission make a recommendation to city council. There are public hearings at both forums. The process typically applies a set of conditions; the onus is on the proponent to show that the conditions are not violated. This ordinance was put in place to stop large projects investing significant effort before approvals are granted, and thus having some leverage toward approval because the project is already physically moving along. Because daylighting projects often involve significant excavation, this regulation may often apply.

TECHNICAL CHALLENGES

Daylighting projects can present a number of technical challenges. The more urban the project's location, the more issues will come up. And the more constrained the potential project corridor, the more difficult it will be to solve problems. This should not discourage project proponents unduly. But one must have open eyes and realistic expectations. Also, designers and the public must realize that a solution to one challenge may conflict with solutions for another. Compromises are often necessary.

Site and situation

- What's underneath the site? Will buried utilities have to be avoided or moved? Might the project compromise access to utilities? Will the utilities compromise the project?

- What kinds of soils are there? Are soils contaminated from previous land uses or dumping? These are particularly relevant questions in Allegheny County, given our many brownfield sites.
- Where is the water table? Will the channel lose or gain water? Is either a problem? Is the ground water clean or contaminated? Is impervious lining of the channel necessary?
- Does the project require usurping other valuable land uses, such as parking spaces or recreation fields? Can these uses be moved or replaced elsewhere?
- Can the loss of existing desirable features of the site—mature trees, for instance—be minimized?
- What safety features are necessary? Fences, railings, shallow slopes? Grates over culvert outfalls and inlets?
- Will streamside paths be part of the project? What route should they take? Are picnic areas, bridges, or other features desired, and where should they be placed?
- Is disabled access required or desired, and how can it be provided?

Inputs from the watershed

- Will sedimentation be a problem? Can and should some sediments be trapped and periodically removed? Can the channel be designed to flush sediments downstream, and is that OK? All streams move sediment. The design objective is usually to achieve equilibrium—the condition in which the amount of sediment leaving the stream reach in question equals the amount entering it.
- What other pollutants will the new stream have to handle? Urban streams typically receive considerable amounts of nutrients and many kinds of organic and inorganic pollutants in stormwater. In the Pittsburgh region a particular problem can be runoff of road salt, used liberally in this “ice belt” region because of hilly terrain and frequent, repeated freeze/thaw cycles. Are biofiltration strategies upslope of the channel necessary to produce suitable water quality in the channel for supporting fish or other objectives? Can riparian vegetation remove enough of the pollutants?
- A key pollution concern in Allegheny County is bacterial contamination from leaking and overflowing sewers. On the one hand pathogens are attenuated in open streams, so daylighting an upper section of stream decreases the hazard downstream. But daylighting can also increase the public’s exposure as a site goes from no access to potentially contaminated water to partial or full access. Whether this is a problem will depend on the whether sewage contamination is a problem for a particular stream reach, how bad it is, and whether the problem can be resolved.
- Will the new stream carry or collect trash? What strategies can minimize this problem?

Channel design

- Can the original meanders be re-established? Can they be found or approximated from aerial photos, measures of the stream sinuosity upstream or down, or by examining soil types along the likely path of the old stream?
- What should the channel geometry be? Relationships between gradient and discharge (flow volume per unit time) must be carefully examined to determine the appropriate channel cross sections and sinuosity. Often these parameters are substantially different for current watershed conditions than before development. How should this affect placement of the channel? In short, what is the “urban equilibrium” condition given current or projected development?
- What fixed points will constrain channel design? For instance, culverts or bridges for roads and driveways may have to be accepted.
- What additional demands will be placed on design of the channel? Fish habitat requirements are a common consideration.
- Will in-channel structures be used to adjust depth, direction, or velocity? It’s necessary to work with the flow rather than against it.
- How will structures be anchored in the streambed?

Stream bank and floodplain

- How much of a floodplain is needed? What is feasible given surrounding land uses?
- What techniques will be used to stabilize the stream banks? Can bioengineering measures be appropriately anchored in the banks?
- Which native species will be best for revegetation? Can cuttings or saplings harvested from other sites be used to cut costs?
- What kinds of plantings are compatible with the site circumstances? For instance, narrow corridors may not allow for tree species that form a large diameter canopy at maturity.

Project logistics

- What is the appropriate season for construction and revegetation? How can the project logistics be arranged so that all essential operations are carried out within the available window of opportunity (including time to handle surprises)?
- Will temporary diversion of water flows be necessary? How will it be accomplished?
- How much excavation is required? Will demolition of parking lots or other structures be necessary? Can fill and spoils be used onsite to reduce hauling costs?
- How long will the restoration take to stabilize? What follow-up work will be necessary as the site matures? Establishing the new channel hydraulics happens quickly, but full ecological function requires time for slopes to stabilize and a canopy to develop.
- What routine maintenance tasks must be handled?

Local Daylighting Precedents

Urban stream restoration activity in the United States is varied, vibrant, and expanding, as shown in the books listed in the resources section of this report. Daylighting is a small but burgeoning subset of the field. It is just beginning to "take off" in the United States. A recent report (Pinkham 2000) identified 23 projects that have been completed across the country since daylighting began in the mid-1970s, and another 23 that were in various stages of consideration by early 2000.

Now, Allegheny County can add two projects to this growing list of daylighting activity nationwide. Projects have just begun on Nine Mile Run in Frick Park and Jack's Run in the North Side of Pittsburgh that include daylighting components.

Nine Mile Run

The Nine Mile Run stream restoration project is currently underway in Frick Park. It has been developed and funded through the U.S. Army Corp of Engineers. The City of Pittsburgh Department of City Planning, 3 Rivers Wet Weather, the Pittsburgh Parks Conservancy, and the new Nine Mile Run Watershed Association are also working together to help establish this first Pittsburgh restoration model. The restoration program was conceptualized by local citizens working with the support of the STUDIO for Creative Inquiry and the Pittsburgh Department of City Planning. The Heinz Endowments provided significant funding for the conceptualization and planning efforts. The final construction design was developed by Biohabitats, Inc., a nationally recognized ecological restoration firm from Timonium, Maryland. [7]

The $7.7 million project, the largest single urban ecological restoration effort in the state, will address over a mile of stream, from Braddock Avenue in Swissvale to the Monongahela River. The first phase, which began construction in December 2001, focuses on the Frick Park section upstream of Commercial Avenue in Pittsburgh. It will reconfigure and stabilize the stream channel by creating meanders, riffle/pool sequences, and step pools (pools created by small waterfalls); create and expand wetlands to help control and filter stormwater flows from developed areas above the park; recreate and restore a floodplain adjacent to the stream; and revegetate the

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[7] U.S. Army Corp of Engineers Nine Mile Run restoration plan: http://www.lrp.usace.army.mil/pm/ninemile/electrnc/index.htm.

City of Pittsburgh Department of City Planning: http://www.city.pittsburgh.pa.us/cp/.

3 Rivers Wet Weather: http://www.3riverswetweather.org/.

Pittsburgh Parks Conservancy: http://www.pittsburghparks.org/.

Nine Mile Run Watershed Association: c/o Pennsylvania Environmental Council, 412-481-9400.

STUDIO for Creative Inquiry, Nine Mile Run Greenway Project: http://Slaggarden.cfa.cmu.edu/.

The Heinz Endowments: http://trfn.clpgh.org/swissvale/.

Biohabitats, Inc.: http://www.biohabitats.com/.

area with native plants. The project will daylight 200 feet of the Falls Ravine stream, reconnecting it via a surface channel and wetland with the stream running through Fern Hollow, a major tributary to Nine Mile Run.

Major work is also being done on the sewer infrastructure at Nine Mile Run. ALCOSAN and the Pittsburgh Water and Sewer Authority have worked together in partnership with the municipalities of Swissvale, Edgewood and Wilkinsburg to resolve a 100 year old problem with sewage in Frick Park.[8]

JACK'S RUN

Jack's Run drains portions of Ross Township, Bellevue Borough, and the North Side of Pittsburgh. A sewer reconfiguration and rehabilitation project under design here will likely include the second stream daylighting project in Allegheny County.

Unlike Nine Mile Run, the Jack's Run project is a concept instigated by ALCOSAN because of a direct stream connection to the regional sewer network. Jack's Run drops into the ALCOSAN system via an inflow point to a municipal combined sewer trunk line. The diversion structure is located in the Jack's Run valley bottom about a half-mile inland from the Ohio River. The watershed above this point is the largest watershed of any stream flowing into the ALCOSAN system. Jack's Run contributes dry weather flows, high-volume wet weather flows, and large amounts of sediment and debris to the sewers. The inflow point requires dangerous manual raking to clear it of debris during some storms. During dry weather, the stream often disappears into the streambed alluvium several to many hundreds of yards upstream of the point where the stream directly enters the combined sewer. It is likely that the stream percolates through the alluvium and into cracked or disjointed sections of the sewer line that runs underneath.

The stream is entirely culverted below the direct inflow point, down to a combined sewer overflow structure located a few hundred yards inland from the river. Below this point, a remnant channel of Jack's Run receives wet weather overflows from the CSO structure. The channel is badly "blown out" by heavy storm flows, and receives no dry weather flow.

ALCOSAN is developing a major sewer improvement and stream restoration project in cooperation with the Pittsburgh Water and Sewer Authority, Bellevue, and Ross. Biohabitats is also involved, and the Pennsylvania Department of Environmental Protection has provided funding from their Growing Greener grants program. The project is in the final design stage.[9]

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[8] ALCOSAN: http://www.alcosan.org/.

Pittsburgh Water and Sewer Authority: http://www.pgh2o.com/.

Borough of Swissvale: http://trfn.clpgh.org/swissvale/.

Edgewood Borough: http://www.edgewood.pgh.pa.us/.

Borough of Wilkinsburg: 412-244-2900.

[9] Ross Township: http://www.ross.pa.us/.

The project is intended to remove all dry weather and most wet weather flows from the sewer system. It will do so by reconfiguring the diversion structure, installing some new sewer pipe, and utilizing existing sewer pipes in a different manner. It will also rehabilitate sanitary sewer lines to prevent infiltration of stream and ground water. This should restore surface flows to currently de-watered sections of the stream channel upstream of the sewer inflow point.

From this point down, the old combined sewer will have been converted into a storm culvert carrying only clean stream flow in both dry and wet weather. At the downstream end of the storm culvert approximately 250 feet of the culvert will be removed and the flow brought back to the surface from that point to the mouth of Jack's Run at the Ohio River, a distance of about 1500 feet. The existing stream channel will be restored utilizing bioengineering technologies. Also, the existing CSO structure will be relocated downstream near the mouth of Jack's Run at the Ohio River. It will still overflow in some wet weather events. The long term goal, however, is that the reduced infiltration and inflow into separate sanitary sewers will increase conveyance of the combined flows thereby minimizing the discharge.

While this is not “classic” daylighting, in the sense of digging up a culvert and replacing it with a stream channel, it can be considered daylighting because flows that were underground will once again run on the surface. A de-watered stream channel will be “re-watered.” Affected portions of the stream channel will be reconfigured to improve their aquatic habitat value and reduce erosion of the stream banks. It is also notable that by restoring flow to the mouth of Jack’s Run at the Ohio river, the project should increase the ecological value of that embayment.

Bellevue Borough: http://www.borough.bellevue.pa.us/.

Pennsylvania Department of Environmental Protection: http://www.dep.state.pa.us/.

Other organizations are noted in the previous footnote.

Identification and Selection of Potential Daylighting Sites

The long-term intent of the 3R2N daylighting program is to develop methods to marry the "bottom-up" knowledge of stream and sewer conditions possessed by local engineers, public officials, and citizens, with "top-down" methods for site identification and selection available through GIS-based analyses. In year one, we relied primarily on the first approach, and began building data sets and methods for the second.

Site Identification

The first year study used local knowledge to identify potential daylighting sites. Specifically, we considered a list developed by ALCOSAN of 20 sites where direct inflows of streams to municipal combined sewers might be occurring. ALCOSAN developed this list as part of its Pennsylvania Act 537 Sewage Facilities Plan and its Long Term Control Plan for combined sewer overflows. ALCOSAN engineers knew of these sites from years of experience working in the field with the municipal combined sewer systems. Camp Dresser & McKee (CDM), ALCOSAN's engineering consultant, studied these sites during 2001. Eleven sites were determined to have direct connections of perennial streams to municipal combined sewers. Such sites are all potential candidates for sewer separation projects. Conventional separation projects create a separate storm sewer for stream and stormwater flows, and do not recreate surface streams. Separation could include daylighting, though the feasibility of daylighting at each site varies substantially. Table 12 presents the ALCOSAN sites by watershed, with key features and issues at each site noted

Table 12 – Known Sites of Direct Stream Inflows to Municipal Combined Sewers

Watershed	Stream/Site Name	ALCOSAN LTCP Map #	Affected Municipalities	Distance to Open Stream or River (feet)	Approx. Drainage Area (acres)	Field Measured Stream Base Flow (gpd)	
Chartiers Creek	Sheraden Park	5	City of Pittsburgh	2,400	57	65,000	Perennial inflow located in major roads or buildings lie drainages in this small valle
Chartiers Creek	Forest Grove	6	Kennedy Township, Stowe Township	8,400	298	297,000	Large area between the infl
Chartiers Creek	St. Mary's Cemetery	7	Kennedy Township, McKees Rocks Boro	6,600	64	172,000	Large area between the infl
Four Mile Run	Four Mile Run (2 inflow sites)	15	City of Pittsburgh	5,300 and 4,500	294	35,000	One inflow site is located in through Junction Hollow for fill lies between Junction Ho streets intervene. The secor considerable buildings and
Jacks Run	Jack's Run	10	Belleview Borough, City of Pittsburgh, Ross Township	3,000	1,050	270,000	The stream valley below th Above the inflow structure, probably seeping into crack improvement project is und daylighted through the enti some dry weather base flov upstream from the Ohio Riv
Spring Garden	Spring Garden	14	City of Pittsburgh, Reserve Township, Ross Township	11,500	520	240,000	Large area between the infl
Tassey Hollow	Tassey Hollow	16	Braddock Hills Boro, Rankin Borough, Swissvale Boro	3,500	356	24,000	Large area between the infl
Unnamed small watershed	Ravine Street	1	O'Hara Township, Shaler Township, Sharpsburgh Boro	1,500	49	150,000	Sewer separation is planne improvements.
Unnamed small watershed	Fried & Reineman	2	Millvale Borough, Reserve Township	400	38	260,000	Sewer separation is planne improvements.
Unnamed small watershed	Orr Street	9	Stowe Township	1,800	26	129,000	Large area between the infl

Analysis of spatial data with a geographic information system should be able to help identify potential daylighting sites. Work completed by the 3R2N daylighting team revealed a number of ways that GIS could be used to help identify sites. A key starting point is to reveal the likely paths of historic streams. The digital elevation model analysis described earlier in this report is one way to identify the approximate location and extent of the pre-development stream drainage network. This network could then be intersected with sewer lines to identify points of potential connections that could be further investigated to determine if stream inflows actually exist. The analyst would start from the highest point of intersection in each sub-watershed and proceed downslope with further desktop analysis or field studies until actual inflow points are located. The analysis might take different approaches depending on whether the watershed is served by combined or separated sewers, and depending on the reliability of available sewer maps and the accuracy of the DEM-generated historic stream network.

Of course, not all inflow points make good daylighting sites. GIS could be used to carry out an initial screening by analyzing land uses lying between a culvert inflow point and downslope open streams or rivers, or culvert re-entry points. GIS could also allow one to overlap culverted stream reaches with public lands, valley slope classes, and other positive or negative screening parameters. For instance, one could identify all culverted stream reaches on public land with a shallow valley slope. Such locations are likely to be institutionally and technically easiest to daylight.

As this report went to press, a separate effort from the 3 Rivers – 2nd Nature daylighting program had received funding from the Heinz Endowments to develop methods and selection criteria for identifying and prioritizing potential sewer separation sites. That effort will build on some of the 3R2N analysis to date. However, it will focus on stream inflows to combined sewers and will not seek to identify significant opportunities to daylight streams buried in ordinary storm and stream culverts. In coming years, 3R2N hopes to continue the work begun in the year one study area to comprehensively survey the region for daylighting opportunities of all types.

SITE SELECTION

A number of factors can make daylighting a culverted stream difficult or impossible:

- extensive infrastructure and buildings over the culvert or areas of possible stream relocation;
- “capture” of streams by combined sewers (daylighting projects must divert stream water above inflows to combined sewers);
- high land values that preclude open space uses;
- steep slopes that would result in overly erosive stream velocities;
- high discharge rates, due to upstream conditions (e.g. imperviousness), that cannot be managed given stream corridor constraints imposed by surrounding urban land uses;
- sunk costs in recently culverted streams.

GIS could be used to further screen and rank identified sites on these and other “negative” or eliminating criteria. These issues can also be addressed “manually,” through map and field inspection of potential sites and their watersheds. This latter approach was taken by the 3R2N team in the year one site selection phase.

In addition to these negative screening criteria, selection of daylighting sites should be guided by the following “positive” criteria:

- *Local support.* Are neighbors, local citizen groups, and local agencies likely to actively support a project? Are any likely to oppose it?
- *Funding opportunities.* Are one or many angles to grants or other potential funding programs likely? Could a daylighting project at this site be an adjunct to some other existing or likely project by public or private parties with interests in development, parks, transportation, water management, or other areas?
- *Technical feasibility.* Are the potential technical challenges at this site likely to be manageable? Is a project here likely to be robust (unlikely to impair other values or otherwise fail)? Does a project here seem "doable?"
- *Demonstration value.* Is the potential project in a high-visibility location? Will the before/after change be significant and apparent? Is the project likely to have demonstrable positive benefits for habitat creation, water quality improvement, amenity development, flood control, or other public goals?

These criteria are primarily questions of judgment. Qualitative evaluation of sites vis-à-vis these considerations is required.

The 3R2N team evaluated the 11 sites on the ALCOSAN stream inflow list against the negative and positive criteria discussed above. Further, we took into consideration efforts that were already underway at several of the 11 sites. We classified the daylighting potential of these sites as follows:

Sites already planned for other projects

- *Ravine Street.* Conventional piped stream separation project.
- *Fried & Reineman.* Conventional piped stream separation project.
- *Jacks Run.* Partial daylighting project.

Currently infeasible for daylighting due to heavily built up land

- *Forest Grove*
- *St. Mary's Cemetery*
- *Orr Street*
- *Verner Avenue*
- *Spring Garden*
- *Tassey Hollow*
- *Four Mile Run – Saline Street*

High potential daylighting sites

- *Sheraden Park*
- *Four Mile Run – Junction Hollow*

The 3R2N daylighting team, with feedback and approval from the 3R2N Advisory Committee, chose both the Sheraden Park site and the Junction Hollow site for further investigation and public engagement. The following reasons contributed to our interest in these sites:

- Both are valley bottom sites with manageable stream slopes. This avoids water velocity and erosion problems that could occur on steeper sites.
- Both sites have significant natural land in their contributing watersheds, which raises the potential for restoration success. At the same time, both present opportunities for demonstrating better stormwater management within their watersheds.

- Both are substantially on public land. This avoids the difficulties and expense of obtaining property or easements.
- Both offer the possibility of completing a daylighting project all the way to a natural waterway. This would be a significant challenge for the Junction Hollow site, and comparatively easy at the Sheraden Park site.
- Junction Hollow offers a very high visibility location. Sheraden Park is less regionally notable, but as a public park will still obtain notice.

It's also of interest that these two sites are located in watersheds at the "top" and the "bottom" of the watershed ecological classification scheme presented earlier in this report (Table 10). Sheraden Park is located in the Chartiers Creek watershed, one of the higher quality watersheds of the year one study area. As such, daylighting here would contribute to heightened ecological integrity in an ecologically valuable watershed. Junction Hollow, on the other hand, is located in the Four Mile Run watershed, the most altered watershed within the study area that still has residual streams of any significance. While the ecological values of daylighting here might not be as high in an absolute sense as in less disturbed watersheds, restoring a stream to the surface here could make (depending on the final project design) a huge incremental difference in ecological values within this particular watershed, and certainly would have high amenity and educational value for the residents of this densely populated watershed.

TWO DAYLIGHTING STUDY SITES

The two sites chosen for this year's 3 Rivers – 2nd Nature study are each interesting in their own right as daylighting possibilities. Further, examining the opportunities at each site and engaging the public in consideration of each site helps reveal some of the benefits that other Allegheny County daylighting projects might provide, and some of the concerns and challenges that may arise for other projects in this region.

In the following pages, we describe each site and outline the daylighting opportunities there in detail. We discuss how daylighting could fit with other significant plans and proposals affecting each site. And we report key themes and ideas that emerged in the public outreach event at each site in September 2001.

FOUR MILE RUN/JUNCTION HOLLOW

The site and its daylighting opportunities

This site is located roughly two and one-half miles east of downtown Pittsburgh. Four Mile Run is a watershed that encompasses all of Schenley Park and all or parts of the Pittsburgh neighborhoods of Oakland, Schenley Heights, Shadyside, Bellefield, Squirrel Hill, and Greenfield. Most of the streams in the watershed, including the main stem of Four Mile Run all the way to the Monongahela River, have been long-since buried in combined sewer lines. However, two small streams still exist in Schenley Park—Panther Hollow Run and Phipps Run. Historically, the two streams met near the bottom of Panther Hollow, then flowed into Junction Hollow and joined a main branch of Four Mile Run.

Today, the streams meet and flow into Panther Hollow Lake, a man-made water body. High storm flows in the combined stream are diverted around Panther Hollow Lake via a concrete ditch. The combined stream no longer flows on the surface into Junction Hollow. No surface stream remains in Junction Hollow or any point between Panther Hollow Lake and the Monongahela River. Instead, both the lake overflow and the diversion ditch flows drop into a Pittsburgh Water and Sewer Authority trunk line that flows underground through Junction Hollow.

(see Appendix B, Schenley Park for a map of Schenley Park, Junction Hollow, and the Four Mile Run valley down to the Monongahela River. Notable features of the landscape are keyed in the photographs)

Stream water from Schenley Park could be kept on the surface, in a variety of possible stream channel configurations, on city-owned land through much of Junction Hollow. Given current land uses (railroad, recreation path, and vacant land), it would be relatively straightforward to carry a daylighted stream from Panther Hollow Lake down Junction Hollow for roughly 1,900 feet to the upper end of the newly built soccer field. There is currently enough open land in Junction Hollow to allow creation of a fairly "natural" looking stream in this area.

Such a project could add an important stream amenity to Junction Hollow. It would also help attenuate wet weather flows, delaying their delivery to the combined sewer lines and the ALCOSAN system, especially if wetlands and other stormwater management measures were incorporated into the project. The stream could be dropped back into the sewer lines at the upper end of the soccer field. This may be the practical strategy at this time. The technical challenges for daylighting increase rapidly between here and the Monongahela River.

However, if sufficient will and funding exists, it would be possible to daylight the stream further down the valley. The route would cross the following land uses (lengths are approximate) from the soccer field to the Monongahela River:

- Soccer field complex—350 feet. The soccer field takes up most of the valley bottom, but a stream could be “squeezed” around one side, probably in an architectural channel.
- Parking lot, road, and railroad bed—450 feet. In addition to navigating past the infrastructure in this section, the stream would descend a slope. An architectural channel, probably with step features, would be required.
- Boundary Street neighborhood, to the Swinburne Street bridge—850 feet. Streets, underground utilities, a playground area, and bridge piers for the Parkway East and Swinburne Street bridges would have to be negotiated. An architectural channel would be necessary through most or all of this section.
- Commercial properties, railroad beds, and Second Avenue—1000 feet. From the Swinburne Street bridge, the land *rises*. Fill under the railroad beds and commercial properties has created a mound that blocks the low end of the Four Mile Run valley where it reaches the banks of the Monongahela River. A surface stream could not be carried through this area without significant excavation and reforming of the landscape. A stream could be carried in a pipe through this area and re-daylighted on the west side of Second Avenue.
- Former LTV Steel site—400 feet. This now-vacant land on the banks of the river could allow a variety of daylighted stream treatments. The current surface of the land is roughly 25 feet above the normal level of the Monongahela River. The former river floodplain has been filled. A stream could run on the surface across the current level, and drop off in a waterfall feature to the river. Alternatively, a portion of the LTV site could be excavated down to the river level, creating an ecologically valuable embayment—a slack water area where flow from the stream and backwater from the river combine.

Few embayments remain along our mainstem rivers, so the opportunity to recreate one at Four Mile Run is worth serious consideration. Doing so requires that clean stream water remains separated from combined sewer lines from Panther Hollow Lake to the river. This is why it is important to consider ways to carry this water through the land uses noted above. If the stream cannot be carried on the surface through any of these areas, it could be carried in a pipe through those sections. Besides the possibility of creating an embayment, creating a daylighted channel/clean water pipe all the way to the river creates another key benefit by removing significant amounts of clean water from the sewer system.

If it is impractical at the current time to continue daylighting past the upper end of the Junction Hollow soccer field and the stream is dropped back into the sewer at that point, city planners, policy makers, and citizens could make efforts to set in place policies that open up possibilities for further daylighting in the future. For instance, much of the infrastructure between the soccer field and the river is in fair to poor condition, and will need replacement in coming decades. Rebuilt bridges, roads, and underground utilities could be configured in ways that would make daylighting the stream all the way to the river much more practical at some future point. Further, any redevelopment proposals in the Boundary Street neighborhood and for the commercial properties on the mound of fill blocking the mouth of Four Mile Run could be evaluated with an eye toward incorporating land use changes and land level manipulations that would ease the challenges of daylighting a stream in these areas.

While the obstacles are considerable, restoring Four Mile Run from Schenley Park to the river is a bold vision for the future of this part of Pittsburgh. The ecological, amenity, and economic development values of connecting Schenley Park to the river via a stream corridor should not be dismissed, but carefully considered before new activities preclude this opportunity for generations to come.

Relation to other plans and proposals

The best way for citizens to act upon their interests in stream restoration and daylighting is to become vociferous participants in the planning processes, organizations and private firms that have a vested interest in the planning and design of the areas in question.

Recently, the Pittsburgh Department of City Planning in partnership with the Pittsburgh Parks Conservancy released the Pittsburgh Parks Master Plan (LaQuatra Bonci Associates et al. undated).[10] The plan does not address daylighting, but it puts considerable emphasis on several actions in Schenley Park and Junction Hollow that would be mutually synergistic with daylighting: restoring the Panther Hollow watershed, trails and bridges; softening and naturalizing the edge of Panther Hollow Lake, and establishing connectivity from the lake area to Junction Hollow and beyond to the Monongahela River trails. These actions would improve the viability of daylighting a stream from the lake, and daylighting would in turn extend this scheme into Junction Hollow, providing additional value to the Junction Hollow access to the park.

The 3 Rivers – 2nd Nature team noted significant stormwater management problems in the watersheds upstream of Panther Hollow Lake. We found a number of broken stormwater pipes. Some of these are causing considerable erosion and sediment generation. The extent and functionality of the drainage network throughout the watershed is unknown, but it is likely that these conduits convey water that would otherwise be absorbed into soils to become part of the watershed's groundwater (conveying surface runoff before it is absorbed, or draining water out of wet soils). Thus these conduits reduce the base flow in Panther Hollow and perhaps also in Phipps Run. Runoff is also increased, and groundwater recharge decreased, by surface conditions within the watershed: 1) impervious surfaces, which are not a large percentage; 2) turf areas, which are substantial, and typically do not infiltrate as much rainwater as forested areas; 3) poor soil conditions in some forested areas, due to loss of soil from pre-park clearing of the land, and perhaps also from foot and bike traffic to this day in some locations. Also, below the first pedestrian/work road bridge over Panther Hollow upstream from Panther Hollow Lake, maintenance crews have placed cinders(crushed stone) to fill in eroded places in the work road, rather than fixing the sources of the runoff or its routing. These cinders create an

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[10] City of Pittsburgh Department of City Planning: 412 255-2200, http://www.city.pittsburgh.pa.us/cp/. Plan available at: http://www.city.pittsburgh.pa.us/cp/html/parks_plan.html.

Pittsburgh Parks Conservancy: http://www.pittsburghparks.org/.

LaQuatra Bonci Associates: 412-488-8822.

additional sediment load washing into the stream, filling the nooks and crannies around rocks and thus significantly reducing salamander and macroinvertebrate habitat.

The parks master plan calls for development of a hydrologic plan for the Panther Hollow watershed to achieve the following goals (p. 113):

a) Restore baseflow in the creeks to maintain perennial streams

b) Improve water quality and maintain source water flows to wetlands and Panther Hollow Lake

c) Improve visual quality. Elements of the plan should include removal of excessive drainage structures, reforestation and erosion control.

These efforts would improve the health of the watershed and its stream, which would in turn improve the ecological and hydrologic value of a daylighting project downstream of Panther Hollow Lake.

According to the parks master plan, the lake was constructed in 1909 as an enlargement of "an already existing small body of water" (p. 99). It was altered in 1957, though the plan document is not clear on whether the stepped concrete edge was installed then, or in the 1970s around the time the historic boathouse is believed to have been removed. The plan calls for several actions at this location (p. 113): "Renovate Panther Hollow Lake. Remove the concrete edge and channel to achieve a more naturalistic character. Reinforce the new "soft edge" treatment with native aquatic plant species."

The presence of the lake in any form will serve as a "stilling pool" for storm flows from the upper watershed, evening out the flows that would enter a new stream channel downstream from the lake. This will likely reduce stream flow velocities and lengthen the rise time of stream levels in a daylit channel, which will increase the chances for success of a naturalized stream channel design in Junction Hollow. Softening the lake edge would further increase the buffering effect of the lake.

The parks master plan clearly sets out an objective of creating greater connectivity of Schenley Park with the rest of the city, included a new access from Junction Hollow to the lake (across the existing railroad tracks) and connectivity through Junction Hollow to the riverfront trails network. The plan also calls for development of an overall landscape plan for Junction Hollow as a new portion of Schenley Park and a "destination in itself" (p 114). Daylighting a stream from Panther Hollow Lake down Junction Hollow will increase the visual, psychological, and ecological (riparian habitat) connectivity between these locations. And the stream should provide an additional amenity that will help make Junction Hollow a destination.

In addition to seeking synergies with improvements to Schenley Park, daylighting proposals for Junction Hollow and Four Mile Run must be considered in the context of changes that will take place as this area between Oakland and Hazelwood is transformed in coming years. The City of Pittsburgh Department of City Planning, in collaboration with the Hazelwood Initiative and the Oakland Community Council, sponsored in 2001 a master planning process for the former LTV Coke Works in Hazelwood. This plan also examines redevelopment in

Hazelwood itself, opportunities to improve connectivity between Hazelwood and Oakland, and ways to integrate development of the LTV site and Junction Hollow (Saratoga Associates 2001).[11]

The master plan, developed in part through a community involvement process, proposes mixed use development of the LTV site. Daylighting on the LTV site could fit well with a variety of land uses there. The plan also highlights the desire of the affected communities that any transportation systems developed through Junction Hollow be sensitive to the natural quiet and green space in Junction Hollow. A busway or light rail system are suggested as compatible options. Daylighting in Junction Hollow could certainly fit with, and even bolster, the values associated with Junction Hollow held by the community participants in the master plan development. The report itself does not make these characterizations of daylighting, but it does indicate that 3 Rivers – 2nd Nature has raised daylighting as a possibility for Junction Hollow (p. 67).

The master plan report also notes that institutions at the north end of Junction Hollow have in mind development possibilities within the Hollow. The master planning process "produced no clear consensus on the role of institutional development in Junction Hollow" (p. 21), though compatibility with the residential qualities associated with the Hollow will probably be key. Clearly, significant development in Junction Hollow would affect whether and how a daylighting project could be carried out there. Daylighting would be most straightforward without extensive building along the potential stream path. However, as several projects around the country have shown (Pinkham 2000), daylit channels can be developed in manners compatible with and supportive of intensive surrounding land uses.

Public comments

On the 29th of September, 2001, 3 Rivers – 2nd Nature hosted a six-hour public outreach event focused on daylighting possibilities for Junction Hollow and Four Mile Run. The event also addressed stream and lake rehabilitation in Schenley Park. Over 52 people attended, not counting the event organizers. We took participants on a foot and bus tour of water's path from the top of Panther Hollow at the east edge of Schenley Park all the way to the Monongahela River. After the tour, participants discussed what they had seen, and what they thought of daylighting both generally and specifically for this site. A separate 3 Rivers – 2nd Nature report presents notes from the various discussion groups. Following is a brief summary of some of the key themes of the discussions.

The tenor of the discussions made it clear most people present were intrigued by the daylighting idea and supportive of some type of daylighting in Junction Hollow and if possible, to the river. Some alternative views

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[11]City of Pittsburgh Department of City Planning: 412 255-2200, (ask for Wanda Wilson), http://www.city.pittsburgh.pa.us/cp/. Plan available at: http://www.city.pittsburgh.pa.us/cp/html/master_development.html.

Hazelwood Initiative: 412-421-7234, http://www.hazelwoodhomepage.com/.

Oakland Community Council:412-687-8568.

were also expressed. For instance, some people wondered if money might be better spent on existing open streams. Some preferred the hard edge of Panther Hollow Lake to the parks master plan idea of naturalizing the lake edge. But most discussions gravitated toward the potential benefits of daylighting; how daylighting fits with planning, education and other community needs and agendas; and how to move forward and advocate for daylighting and other urban ecosystem restoration values:

- A number of people saw great value in daylighting Four Mile Run all the way to the river. They noted the biological value, recreational value and how that brings economic value, and the social value of making connectivity between Pittsburgh neighborhoods more tangible. Some noted that properties adjacent to water are valuable, including housing along streams.
- Integration of daylighting with revitalization efforts for Hazelwood was a desire of several participants. In the 1800's Hazelwood was a retreat area for Pittsburgh. This history could be re-awakened in the minds of Pittsburghers. Development of tourist attractions, including flowing streams, would be good for business.
- Some noted how Hazelwood feels "trapped" by its current social image and physical disconnection from the rest of Pittsburgh. Creating environmental values on the LTV site could add value to the site and help reform Hazelwood's image.

The lack of old growth, new vegetation, and shade for well formed streams in Junction Hollow and on the LTV site was mentioned. Participants discussed how Pittsburgh in general must soften the city-scape and allow for more green space. The current openness of both areas allows the possibility of significant reforestation. Some participants put forward forested Fern Hollow in Nine Mile Run as an ideal to be considered for Junction Hollow. Others noted that there is little significant urban infrastructure in Junction Hollow now, but more is likely, and a key question is how to integrate urban uses and infrastructure with nature:

- Participants said that more information needs to be generated and made available about the various local areas along the potential daylighting route. A comparison should be made of natural daylighting, architectural daylighting, and no daylighting.
- Further, someone must gather and address concerns of local residents. Are the streams flowing through our parks less than clean? Safe? How does that factor into daylighting decisions?
- Many people talked about the variety of development pressures and ideas that have been put forward for Junction Hollow and the LTV site. There will be significant pressures from advocates of particular ideas over the next 5 years. This period will be crucial to planning and achieving good results. There is a need for much more dialogue to create many integrated solutions.

Considerable discussion of master planning took place:

- The current Hazelwood to Oakland city planning effort was described. Some people felt that a "true" master plan is still needed, one that addresses all issues. Water, other than the Monongahela River itself, did not receive much attention in the master plan community dialogues. The relationship of opening streams to *all* other issues should be explored.
- Connectivity, a key theme in the Hazelwood to Oakland master plan, was also a significant topic in the daylighting discussions. Many participants felt that daylighting could significantly enhance connectivity between neighborhoods. Some suggested water as motif for master planning for Junction Hollow.
- Participants noted that there are many projects going on—for instance, the recent creation of the soccer field and trail in Junction Hollow—that should all be fit into a greater, integrated plan. A key question is, who should be responsible for organizing this? There lots of organizations involved, and lots of pieces: the Department of City Planning, 3 Rivers – 2nd Nature, Pittsburgh Parks Conservancy, Southwest Pennsylvania Commission, etc. Organizations working in opposite directions gain nothing, said one participant.

There was a feeling that much greater effort to obtain public input into local idea generation and planning is needed. Educating the public is also a key need, so citizens will more actively seek to influence decision makers. However, some people noted that workshops to educate public, like the 3 Rivers – 2nd Nature public outreach event, often end up “preaching to the choir.” This led to considerable discussion of how to increase public involvement and generate greater advocacy for stream restoration and daylighting:

- Participants suggested it is essential to really get into the communities, to get directly to the local people. There is a considerable need for information that neighborhood people can link to their own lives. We will never solve water quality problems, for instance, without getting people to be more hands-on with the issue.
- It will be important to get more people on the site, with information on daylighting in hand. They can then relate their experiences on the physical landscape to advocacy in the political landscape.
- Another key tool involves updating information and resources—including those that help people understand and navigate the politic landscapes. Who is planning? How are ideas and proposals being advanced?
- The problem of the often parochial, compartmentalized nature of Pittsburgh-area communities came up. But often, streams (open or buried) run through several communities. Streams, then, could be used as connection and focal point to get communities involved in decision making.

Discussion group facilitators explored whether there was interest in forming a group or committee around daylighting advocacy:

- Participants said some kind of group is needed to gain recognition for the ideas, and to establish leadership for consistency of representation and effort. Such a group could help promote information generation and access, perhaps with a website as one of the tools.
- The question of whether society should allow continued culverting of streams could be addressed by this group, and the answers taken to those with political decision making power.
- A key point is that a daylighting advocacy group must address the bigger picture in order to be successful. That bigger picture is appreciation of streams generally. And stream experiences must be linked to the bigger picture of appreciation for living rivers.

A useful advocacy strategy is to focus on kids as our future. What are we teaching them? And what environmental legacy are we creating for them? Accordingly, education was an important topic of the discussions. Participants felt that daylighting could create significant teaching opportunities. However, many teachers are not supported by the school system to take advantage of the opportunities. Local and states standards are often not helpful. There is a strong need and opportunity for daylighting or watershed advocacy groups to help schools and teacher find local resources for teaching environmental science and other subjects using streams.

The need to also educate adults was discussed as well. Adults must have a greater understanding of the impacts of streams on communities. Ideas about creating this understanding were considered:

- Importantly, education does not just involve “telling,” but can also be “doing.” There are tremendous opportunities to get people involved as volunteers in stream restoration programs and projects. These experiences will evoke deeper feelings and help get more people involved in planning and political processes that involve streams.
- Information should be generated to help people think about stream conditions and issues. Maps of buried streams, like the one produced this year by 3 Rivers – 2nd Nature, should be made available, and overlaid

on current land uses and other thematic maps. Further, relevant histories should be developed. For instance, it's useful for people to know that in the 1800's Pittsburgh was the country's "typhoid capital." People cleaned up the water after they came to understand basic germ theory and the connection of water to disease.

- Interpretation of local prehistory and industrial history would advance the stream restoration agenda. People should have a greater understanding of why streams were put underground, and what that legacy means to us today.
- Placards along streams or buried streams to explain problems, opportunities, and projects to passers-by would be valuable. A map and brochure of interesting locations along walking tour routes, and numbered interpretive trails, are related possibilities. Watershed border signs, as seen in other places—e.g., "Welcome to the Chesapeake Bay Watershed"—would also raise public awareness.
- A key education target should be the media. Make the environment part of the news.

Sheraden Park

The site and its daylighting opportunities

Sheraden Park is located in the Sheraden neighborhood of Pittsburgh's West End, roughly three and one-half miles west of downtown Pittsburgh. The park lies in the bottom of a valley that drains north to Chartiers Creek, just opposite from downtown McKees Rocks. The hilltops above the park are heavily built-up with homes and other buildings. The side slopes of the park are wooded, and the valley floor is occupied by an upper general ball play field and a lower section with a playground and a softball field. A swimming pool is located in one of the side valleys, and another playground is located at the upper end of the park, near the Surban Street entrance.

The ball field, pool, playgrounds, and upper trails are heavily used by residents of the surrounding neighborhood. Local community members perform many clean-up and maintenance functions, in part because the park is not well-maintained by the Pittsburgh City Parks Department, according to community members.

Below the lower ball field, the valley bottom is narrow and weedy. A high, earthen railroad causeway blocks the lower valley at its opening to the Chartiers Creek floodplain, but a fairly wide and high arch tunnel allows access out to the floodplain. The flat area out toward Chartiers Creek is quite large, mostly non-forested, and not developed. Its greatest current use is by local youths for motorized dirt bike riding.

(see Appendix C, Sheradan Park for a map of Sheraden Park, the surrounding neighborhoods, and Chartiers Creek and its undeveloped floodplain. Key features are indicated, along with photographs)

A remnant perennial stream exists in the area above the upper field. The stream is fed by water—apparently ground water—that emerges in several seeps from a hillside just below Adon Street and Arletta Way.[12] It disappears after a short run of perhaps 300 feet into a catch basin, as do several drainage ditches and channels of ephemeral side streams throughout the park. These inlets drop into combined sewer lines that meet an ALCOSAN interceptor just below the park in the floodplain of Chartiers Creek. In addition to wet weather flow, some of the side valleys contribute significant amounts of sediment and other debris into the sewer system. The side valleys are highly eroded and the catch basins inadequate and poorly maintained. There is presently no surface stream from the catch basin that captures the remnant stream, all the way to Chartiers Creek.

The existing stream could easily be carried another 500 feet through the upper valley to the edge of the upper playing field. This section of the valley is often wet, creating difficult conditions for maintaining the grass here. Giving this area over to a stream, possibly with an associated wetland complex, would enhance the natural environment of this area. The existing trail could be retained and enhanced.

[12] This area of Pittsburgh appears to have geologic and soil conditions conducive to emergence of seeps and springs. The 3R2N team noted a number of other seeps on side slopes of the Sheraden Park valley, and we were told there are also seeps in the developed area above the park, along Chartiers Avenue. It is possible that some of these seeps are due to leaking water pipes.

From the up-valley end of the upper ball field, the challenges for routing a daylit stream channel increase. The route would cross or pass alongside the following land uses through the developed section of the park (lengths are approximate):

- Upper ball field—400 feet. This field takes up the entire breadth of the valley. The hillside slopes have been cut into in places to allow for a wider field. If one edge of the field could be “released” for an alternate use, the stream could be carried past. This might require using an architectural channel, so as to minimize the area taken up by the stream. Whether there is *any* room for a stream channel will depend on community desires for the size of this ball field and use of the space generally.
- Playground and picnic area—400 feet. This area also takes up the breadth of the valley. It is located below a steep drop created by the fill that forms the terrace on which the upper ball field is located. Getting a stream down this drop would clearly require engineered channel containment. A waterfall feature could be created. Another solution would be to run a highly structured step-pool architectural channel down the moderate slope created by a work road that now traverses the south side-slope of the valley from the upper ball field to the lower end of the playground area.
- Lower (softball) field, tennis courts, and parking area—450 feet. Again, the entire breadth of the valley bottom is taken up. This ball field is more developed than the upper ball field. It would be difficult to squeeze a stream channel—even an architectural channel—around it.

Given the land constraints and current community use of these spaces, daylighting through the developed portion of the park would be difficult. If daylighting through this section was determined to be desirable, it would probably require an architectural channel in order to maintain current uses. Such a project would be expensive.

A more likely scenario is to carry stream water in a pipe from the edge of the upper ball field to the valley just below the lower ball field. From this point down to Chartiers Creek, there are no significant competing land uses. The options for piping stream water from the upper daylighting section to the point at which it could daylight again are probably two:

- Install a new pipe to carry the stream water, keeping it out of the sewer system.
- Install a new pipe for sanitary and combined sewage coming from the developed area above the park, and convert the existing combined sewer line underneath the ball fields and facilities to carry clean dry weather stream flow and wet weather runoff from the side valleys.

Determining which option makes the most sense will require further study of the hydrology of the watershed and the depth and hydraulics of the existing sewer lines. For instance, one issue with converting the existing sewer line is the depth of that line below the lower ball field. If the pipe is too deep, it will not be possible to bring stream water back to the surface for a daylit channel down-valley of the lower ball field.

Assuming that maintaining separation of the stream from the sanitary sewers through the core of the park is technically and economically feasible, daylighting the stream below the lower ball field offers exciting possibilities. This lower part of the Sheraden Park valley is in disturbed but relatively natural condition. It should be feasible to recreate a stream channel in the 400 feet from the ball field to the railroad causeway, and to revegetate the valley bottom and associated side-slopes to create an ecologically viable stream corridor.

A recreated stream will have to cross over a buried natural gas pipeline that crosses the valley just south of the railroad. The depth of this pipeline is not known, and could affect the feasibility and expense (e.g. for protective linings or lowering of the pipeline) of stream channel construction. The railroad causeway also presents a challenge. Fortunately, the causeway bridges the valley bottom with a large arch tunnel. Perhaps a road once crosses underneath the railroad and ran up into the Sheraden Park valley. The arch is wide enough and short enough that routing both a trail and a stream channel (perhaps architectural) through it should be possible. Additional challenges may include working out rights of way and liability issue with the companies that own the gas pipeline and the railroad.

From the north side of the railroad causeway, a new stream would have a “clear shot” the rest of the way to Chartiers Creek. Local sources believe the large expanse of floodplain here is owned by Duquesne Light. A high-voltage power line traverses the area high overhead. The power line towers are very widely spaced and should not create obstacles to daylighting. ALCOSAN interceptors also cross underneath the area, but again there is ample space, and probably ample soil depth, to avoid these utilities.

The floodplain area is remarkable for its size (roughly 20 acres) and potential ecological and cultural significance. Assuming the land or appropriate easements can be acquired by public authorities, the public realm opportunities are substantial:

- A daylit stream channel could meander out across the floodplain to Chartiers Creek. The straight-line distance is about 800 feet from the railroad arch. Reestablishing a tributary link to Chartiers Creek would be of ecological value to this land and Chartiers Creek itself, especially because the Sheraden tributary is the closest tributary on Chartiers Creek to the Ohio River that could feasibly be restored. Restorationists could also create an associated wetland complex here, potentially a large one. The stream and/or wetlands would provide significant refuge habitat for Chartiers Creek fish and other aquatic creatures and riparian corridor wildlife.
- A bicycle and pedestrian trail along Chartiers Creek has been proposed to run through this area. A stream or wetland would add to the amenity value of this portion of the trail. In return, the trail will provide public access to the daylighting project and increase its visibility and appreciation by the public
- A canoe launch onto Chartiers Creek at or near the stream/wetland complex could be an additional, related amenity and point of access to the river/stream system.
- There is ample room on this floodplain to develop both a stream/wetland complex and additional passive and active recreational opportunities. The long, lancehead-shaped area is bounded by Chartiers Creek on the north and steep hillsides on the south, making it an “island” of potential natural and recreational value within the heavily developed areas that surround it. The area could be entirely devoted to a restored natural zone for quiet enjoyment, or a combination of natural areas and active zones for ball fields or other features.

Relation to other plans and proposals

With sponsorship from the Community Design Center, Hanson Associates in July of 1999 prepared a site analysis of Sheraden Park for the Sheraden Community Council, followed in October by a master plan (Hanson Associates 1999a, 1999b).[13] Previously, a team from the University of Pittsburgh carried out an environmental and recreational assessment (Beratan et al. undated).

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[13] Hanson Associates: 412-488-8840.

Sheraden Community Council: PO Box 4385, Pittsburgh, PA 15204.

The master plan provides a concise overview of the range of issues that should be addressed in Sheraden Park (p. 1):

> Identified issues included deficiencies in park management, safety and maintenance; poor park identification and signage; lack of a comprehensive and effective storm water management plan; unsafe and damaged recreational equipment; a damaged northern park area, extending from low ball field to Chartiers Creek; poor accessibility throughout the park; and the lack of habitat development.

Apparently as a result of the master plan, playgrounds have been since added and upgraded in the park, parking areas improved, and some facilities improved. A number of issues, including storm water management and habitat development, remain to be addressed.

Both the University of Pittsburgh assessment and the Hanson Associates documents note problems with the drainage system in the park. These include infrastructure problems such as poorly sited storm drains and lack of maintenance of catch basin grates and settling chambers. In addition, paved surfaces on designated trails, and creation and compacting of informal trails by dirt bike and pedestrian traffic create unnecessary runoff and soil erosion. The Hanson site analysis notes that poor drainage prevents establishment of grass in the upper valley.

The Hanson site analysis makes specific recommendations on stormwater management (p. 8):

- Eliminate impervious surfaces in parking areas by reconfiguring and identifying parking spaces.
- Changing path paving from asphalt to crushed stone, cinder, or mulch.
- Reconfigure paths to reduce runoff on steep slopes.
- Plan for water detention areas on site.
- Change playground surfaces to pervious surfaces.
- Promote planting that assists with retention of water on site.
- Use plant material to stabilize areas prone to erosion.
- Prevent the use of dirt bikes in the park, particularly on the steep slopes.
- Schedule frequent maintenance of runoff infrastructure.

Actions such as these, if carried out, would contribute to the success of a daylighting project in Sheraden Park. Daylighting should be carried out in conjunction with a comprehensive plan for managing runoff and erosion in the park.

While none of these documents mention daylighting, the master plan suggests, “Solutions include a series of retention ponds and/or creek beds” (p. 3). One of the two proposed site plans in the document does show extension of the creek in the upper valley from its current origin all the way to the edge of the upper ball field. The other shows retention ponds located above the upper ball field and below the lower ball field. Further, the Hanson Associates site analysis briefly discusses the sewer infrastructure in the park (p. 3):

Community Design Center: 412-391-4144, http://www.cdcp.org/.

> In the event improvements are made to the system in the park it is recommended that the systems be segregated so that storm runoff from the park does not burden the sanitary treatment. Because of the drainage recommendations, it is anticipated that a significant reduction in effluent is feasible.

Hanson Associates also notes (as did the 3R2N team) that the area under and just north of the railroad causeway tunnel is cluttered with graffiti, burnt-out cars, and other trash. Because of the current lack of access to the area, it is difficult to monitor and police. The master plan recommends, “An improved trail network will increase traffic in this area, and in turn, help to displace unwanted activity” (p. 4).

Further, the plan recommends that invasive, non-native plant species be removed wherever possible and native species substituted. It specifically notes the need to remove invasive exotics (they include extensive stands of Japanese Knotweed) in the floodplain area. Such a step would be necessary for a daylighting project in this area to be ecologically successful.

Public comments

On the 30th of September, 2001, 3 Rivers – 2nd Nature hosted a four-hour public outreach event focused on daylighting opportunities in Sheraden Park. Seventeen people attended, not counting the event organizers. Most were residents of the Sheraden neighborhood. Attendees included the president and several members of the Sheraden Community Council. We took participants on a foot tour of the park, from the top of the valley, to the remnant stream, down the valley, and out to Chartiers Creek. Afterwards, participants discussed what they’d seen and heard, their experiences living in the neighborhood, the community’s care for the park, and what they thought of the daylighting idea. A separate 3R2N report presents notes from the discussion. Following is a summary of some of the key themes that arose.

Many of the local residents at the event offered perspectives on the history of the park and their community’s experience of it. Some have lived in the area for six or more decades. Their comments included the following:

- The Chartiers Creek floodplain was a farm a long time ago. McKees Rocks was settled in the 1700s, and was a major center of activity for 100-200 years. The floodplain was probably farmed much of that time.
- About 50 years ago, McKees Rocks was a good place for young people to go for fun. People from the Sheraden neighborhood would walk down through the park and across the floodplain and a bridge to go to the theater , restaurants, shops, events and jobs in McKees Rocks. The downtown there is now not what it used to be.
- The park used to have more and greener grass. It was well maintained. Now there are more erosion problems.
- For some time a full-time caretaker lived onsite, in the building by the upper ball field and the playground.
- During the Great Depression, the Works Progress Administration made walking paths and installed the park’s stone walls.
- The lower ball field was a fairly recent addition. The upper ball field has been present, at its current size, for as long as anyone could remember.
- The pool used to be where playground is now. Its present location is not a good one. There are bad drainage problems in that side valley. Mud slides sometimes come into the pool, ruining the water.

Some participants noted on the tour that they were reminded of what a lovely place the park is, “a good place for picnicking.” Several children came along on the tour, and they remarked that they liked learning about the history of the park, and that they enjoyed learning about stream insects (when we stopped at the remnant stream, we collected and showed several species).

At the same time, some participants expressed concerns about personal safety in the park. They felt the park was safe when they were growing up, but their perception of it has changed. Many community residents apparently are reluctant to use the park alone because it feels isolated and has become somewhat of a hangout for teenagers.

Park maintenance was a significant topic of discussion:

- According to several residents, the city hasn’t taken much interest in the park in the last 30-35 years. The feeling was that the city doesn’t consider Sheraden Park big enough to be worth much effort.
- 30 years ago, the Parks Department would regularly clean out the sewers and clogged catch basins. Since the city has stopped managing the drainage system, they can’t manage the park very well, as drainage affects so much.
- Just this year the city has started maintaining the park more. But the park needs someone to take really take responsibility for oversight and management . Maintenance requires consistency.
- Volunteers from the community have done a lot of the maintenance over the years. For example, United Way / America Cares once had a park clean-up day twice a year. Participants removed fallen trees, old tires and other trash, and cleaned paths and steps and repaired walls.
- Residents felt that volunteers have done most of the work in the park for many years—more than their share. They seemed proud that the community cares about the park, but also felt that only so much should be expected of volunteers. Taxes should pay for most of the park maintenance.
- Asked if a daylighting project would help to get more people involved in caring for the park, participants thought it might generate some interest. But they also noted that “this is not a yuppie neighborhood where people can contribute a lot.”
- Participants also remarked about the burned-out cars and other debris near the railroad causeway. Some were surprised to see this, and wondered what it meant for the park and the community generally. One person remarked that “it seems that an area has to go way down before people start to pay attention to it.”

The Sheraden neighborhood residents were neither enthusiastic nor dismissive of the daylighting idea for Sheraden Park. Given their experience of the city’s minimal interest in the park, they generally skeptical that the city would ever invest the time and money in a stream restoration project here, or would construct and maintain it well.

Some expressed concerns that many streams are effectively open sewers. They would hesitate to let their kids play in a stream here unless they could be confident the water was safe.

One participant suggested that it might be better to put in a separate storm sewer all the way to Chartiers Creek. Other participants responded that that would not produce important benefits. Creation of additional wildlife habitat was mentioned as a benefit. So too was the notion of a stream providing water to the floodplain area, making it moister and lush with plants and trees.

The group discussed costs and benefits further. The point that were mentioned included:

- Fixing the infrastructure has to demonstrate financial savings. Sewer construction is typically $60/foot in greenfield situations, which when compared to typical daylighting costs mentioned in the presentation before the tour would indicate that installing new pipes to carry the stream would be much less expensive than daylighting.
- But simply separating stream and sewer water does not solve the water quality problem. It's not just a matter of sewage contamination. Metals and petroleum products are also problems. In normal, healthy streams, bugs will eat bacteria and the ecosystem deals with other contaminants. Piping the water will move these problems to Chartiers Creek.
- Legislated storm water regulation will take effect within 36 months. This will impose large costs on many communities. Could daylighting help address some of the issues?
- We need to take into account *all* aspects and consequences of action. What are the disadvantages? What other projects would be foregone by pursuing this project? Will this project help as much as another project with key issues; for example, Chartiers Creek water quality and compliance with the Clean Water Act? Politicians need to weigh these things. We have limited resources.
- On the other hand, daylighting could bring many non-quantifiable aspects. We should consider the broader significance of how it affects people's perception of place, of local government, of protecting and renewing the environment.
- Daylighting here could be a demonstration project that would attract more funding from federal agencies.

This discussion brought up the larger meaning and challenge of cleaning up the region's streams and rivers, and how daylighting fits. Comments included:

- We need to clean up the streams and rivers, just like we cleaned up the air. People wouldn't mind paying a higher ALCOSAN bill if they knew it was cleaning up the streams.
- ALCOSAN should do a better publicity job. If they got behind cleaning up streams, it would help to raise public awareness.
- ALCOSAN has been supportive with wet weather improvement projects. They supply lots of information, and are open about the state of streams and rivers.
- The problem is that it's not a 'sexy' issue, that people can <u>see</u>. It's out of sight, out of mind. It's not like a ball park, airport, or a road. The Mayor thinks that ballparks are more important than sewers.
- We have to do *something* to bring/keep people in Pittsburgh. Stadiums won't do it. Water quality is vital for economic growth of the city. "Our bread is buttered on sewers and on the water system."
- We keep hearing that streams going into sewers is a bad thing. It costs money. So should we separate sewers? Or is daylighting an answer?
- Daylighting is appealing because it increases green infrastructure. It integrate into the fabric of the community that it benefits. Improved quality of life is more important than money. Money will be spent, whether on repairing old infrastructure or looking ahead to new solutions.
- We are going to spend enormous amount of money on fixing sewers. Stream restoration gives something good directly back to the public, more than just a pipe.

The group also talked about advocacy for daylighting projects:

- To get results you have to increase visibility. Which institution would do that?
- One type of organized effort would be to connect existing institutions.
- The Parks Department has shown initiative in other areas of the city. Maybe getting political support would spur them to activity.
- A design competition would get attention.
- Private fundraising groups and regional corporations could help.

- City Councilman Alan Hertzberg, who represents the Sheraden neighborhood and the West End, is on the Public Works committee. He supports the idea but wants input from the community.
- "The squeaky wheel gets the grease, so sit on the politicians." Get media attention. Sewer news is buried. Write to newspapers.

TOOLS AND RESOURCES FOR STREAM RESTORATION AND DAYLIGHTING

THE DAYLIGHTING PROJECT PROCESS

Here are some pointers about the daylighting project process, offered as a rough "road map" to those who wish to advocate for and develop specific day projects. This advice on project implementation is drawn from discussions with dozens of people experienced with daylighting projects around the country.

Initiate

- Start small. Small projects give a community a feel for the value created and can generate support for doing more later.
- Begin to pursue funding early on. Try to leverage small grants into more funding.
- Do a thorough historical analysis of the site. What's underneath will affect project costs from excavation effort to soil amendments.

Reach out

- Get the community involved right away. Make sure residents understand what is involved, and be sure this is something they want. Outreach is very important. How it is done can determine the community reaction. Make the process very inclusive. Most of the neighbors can, and must, buy in. Design and construction get a lot of emphasis, but working with the community is a big part of the total effort involved. Carole Schemmerling, a daylighting project coordinator with the California Urban Creek Council advises, "Get as much information out there as possible in whatever ways you can do it. Tell people: here are the benefits, here are problems people perceive might occur, and here is the reality of other, completed projects. They have to have the pros and cons, and every situation is different."
- Work hard to develop a constituency for the project. Fostering supportive neighbors and users pays off politically and economically (in the form of volunteer labor and site stewards).
- Get schools involved. Schemmerling again: "Kids will be in the creek right away anyway, and involving them creates an incentive to do it right." Get lots of press coverage. Organize tours, host receptions, and so on. Get the word out and solicit ideas and concerns. Handle the concerns early.
- Enlist community help in planning and maintaining the project. Hold a community design "charrette"—an intensive workshop to develop objectives and design ideas. Organize planting and clean-up days. To stem vandalism, seek to involve kids and youths: they are less likely to pull the new willows for sword fights if they planted them.

Collaborate

- Work diligently with affected landowners. Note their concerns and adjust designs to allay fears and produce value for them.
- Link the project into a larger-area development scheme or master plan. This is especially helpful in more urban areas, where the expense and politics of right-of-way acquisition necessitate broad support. Also, a larger project with multiple benefits may be easier to fund than a more narrowly-focused one.
- Take a watershed approach. Look upstream and downstream for potential allies, like people affected by flooding or erosion problems that daylighting may help address. Don't take no for an answer. Work with local agencies and politicians to help them recognize the value being created.
- Obtain the enthusiastic support of one or more influential politicians. This can make everything else come much more easily.

Seek assistance

- Design the channel carefully, with competent technical help. The last thing daylighting proponents need is to have a project blow out, so it's imperative to get the hydraulics right.

- Look for solutions that reduce technical or construction complexities. For example, find ways to do appropriate parts of the restoration work using volunteers and the local conservation corps. This cuts costs, creates jobs, and connects local people to the local environment.
- Use technical and construction contractors who understand stream restoration well. Engineers who haven't done this sort of work may not fully appreciate the differences between the hydraulics of rigid channels and living streams, or the biologic and aesthetic issues. Earthmoving contractors must have a feel for what the designers want, and an ability to make field adjustments as required by the supervising engineer or designer.
- Pull together a competent team. It takes many types of expertise to pull off projects like these.
- Find a qualified generalist to pull it all together—someone with broad enough training or experience to understand the approaches, language, and data of all the various experts participating in the project, and with the requisite intuition to envision the desired outcome and steer the project toward it. Plan the logistics of construction carefully, especially if the seasonal window for earthmoving and planting is narrow due to wet weather or other conditions. Have everyone lined up to go.

Follow-up

- Prepare for strong follow-up. Most daylighting projects need continued planting and maintenance in their early years. It may be necessary to try many different plantings to see which work best with the site's soils, hydrology, etc. Plant and replant what can survive until a vegetative canopy gets established.
- Develop a budget for the first two to three years of follow-up. Ideally this should be incorporated into the overall project budget and funded before construction begins. This budget should include monitoring and evaluation of channel and bank stability and revegetation dynamics; training and supervision of volunteers and any paid maintenance personnel; tools; and an allowance for additional plants and other materials.
- Educate neighbors and users about the beauty and value of native species. People often expect more conventional landscaping.
- Educate them as well about the successional stages of the restoration. Landscape architect Gary Mason notes that a naturalized daylighting project will go from infancy to adolescence to maturity, with a different look and feel at each stage. The project will look like a mess as it's being done, then in the first years, shrubs and weeds will predominate. These are necessary for stabilizing the soil, and are part of the evolution toward a vegetative canopy, but they may prevent people from seeing or accessing the creek for a time.
- Document everything! Says Carole Schemmerling, "There is nothing so powerful as pictures of the culvert coming out, of the first fish, the first crayfish, the first bird's nest along the new stream."
- Take plenty of time. Be in it for the long haul. Successful daylighting projects are an incremental learning process.

PUBLISHED INFORMATION

The following publications and videos are helpful references for information on the whats, whys, and hows of stream restoration. These materials will help orient newcomers to the stream restoration field, allowing them to understand the key issues, technical concepts and language, restoration techniques, and much more. Please note that no book is a substitute for competent, experienced assistance. Restoration and daylighting proponents should seek technical assistance to assure project success.

***Applied River Morpholog**y*. By Dave Rosgen. 1996. Wildland Hydrology, 1481 Stevens Lake Rd., Pagosa Springs, CO 81147. A richly illustrated manual presenting a classification system for different stream types. Discusses the importance of understanding stream morphology and the principles that affect stream stability before intervening in channels and floodplains.

Biotechnical and Soil Bioengineering Slope Stabilization: A Practical Guide for Erosion Control. By Donald H. Gray and Robbin B. Sotir. 1996. New York: John Wiley & Sons, Inc. Presents a comprehensive and detailed review of soil erosion processes, the role of vegetation in slope stabilization, and the techniques of biotechnical and bioengineering approaches to slope stabilization, including the conjunctive use of plants with earth-retaining structures, revetments, and reinforced ground cover systems.

Daylighting: New Life for Buried Streams. By Richard Pinkham. 2000. Snowmass, Colorado: Rocky Mountain Institute. Available for download at http://www.rmi.org/sitepages/pid172.asp. Presents case studies of daylighting projects from around the U.S. and abroad, and synthesizes lessons learned from these projects.

Field Manual of Urban Stream Restoration. By Robert Newbury, Marc Gaboury, Chester Watson, and staff of the Nonpoint Pollution Control Program of the Illinois State Water Survey, Illinois Department of Natural Resources. Undated. Available from the Conservation Technology Information Center, 1220 Potter Dr., Room 170, West Lafayette, IN 47906, 765-494-9955, Fax: 765-494-5969, ctic@ctic.purdue.edu, http://ctic.purdue.edu. Describes and illustrates basic principles of fluvial geomorphology and selected techniques of pool/riffle reconstruction and biotechnical stream bank stabilization.

Restoring Streams in Cities: A Guide for Planners, Policy Makers, and Citizens. By Ann L. Riley. 1998. Washington, DC: Island Press. A comprehensive overview of urban stream restoration. Describes and illustrates basic principles of fluvial geomorphology and stream restoration methods. Reviews the roles of citizens and a host of agencies and professionals. Discusses many examples of stream restoration and the evolution of stream alteration and stream restoration activities in the United States.

Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group. October 1998. Available online at www.usda.gov/stream_restoration/. Printed version or CD-ROM with search capabilities available from National Technical Information Service, 5285 Port Royal Rd., Springfield, VA 22161, 800-553-6847, Fax: 703-605-6900, orders@ntis.fedworld.gov. A voluminous treatment of stream restoration, from analysis to planning, design, implementation, and monitoring. Useful for professionals, but also very accessible to the lay reader seeking a comprehensive reference.

Urban Stream Restoration: A Video Tour of Ecological Restoration Techniques, with Ann Riley. 1998. Nolte Media, 405-A West College Ave., Santa Rosa, CA 95401, 707-544-0499, Fax: 707-579-3902, www.noltemedia.com. Provides a one-hour introduction to stream restoration and a tour of six restoration sites, including three San Francisco Bay area daylighting projects described in this report: Strawberry Creek, Blackberry Creek, and Baxter Creek.

Urban Stream Restoration Practices: An Initial Assessment. 2000. By the Center for Watershed Protection, 8391 Main Street, Ellicott City, MD 21043-4605, 410-461-8323, Fax: 410-461-8324, www.cwp.org. Reports on a field assessment of stream restoration projects in the Mid-Atlantic and Midwest that examined 22 different types of stream restoration practices from the standpoint of their structural integrity, longevity, and ability to provided desired restoration function and habitat value.

A View of the River. By Luna B. Leopold. 1994. Cambridge, MA: Harvard University Press. A presentation of the fundamental principles of river action and behavior by a pre-eminent fluvial geomorphologist. A rigorous treatment, but accessible to a broad audience.

RESOURCE ORGANIZATIONS

The following nonprofit organizations and government agencies can assist with publications, seminars, consulting services, referrals to professionals, grant identification, and networking with other people and organizations interested in sharing experiences and advice. For a list of private consultants doing stream restoration work, see the references section of *Daylighting: New Life for Buried Streams* (publication information above).

Center for Watershed Protection. 8391 Main Street, Ellicott City, MD 21043-4605, 410-461-8323, Fax: 410-461-8324, www.cwp.org. Provides publications, information, and technical assistance on watershed planning, site design, stormwater management, and stream restoration.

Coalition to Restore Urban Waters. A network of urban stream restorationists: contact them through the Save Our Streams program of the Izaak Walton League.

Natural Resources Conservation Service, U.S. Department of Agriculture. See the USDA-hosted Federal Interagency Stream Corridor Restoration Working Group web site: www.usda.gov/ stream_restoration/. Local office covering Allegheny County is at 1000 Third St., #203, Beaver, PA 15009, 724-775-6231, extension 108. Provides technical assistance on stream restoration and soil conservation projects.

Pennsylvania Department of Conservation and Natural Resources. For information on DCNR programs related to streams, rivers, and watersheds, see: http://www.dcnr.state.pa.us/rivers/. Southwest Pennsylvania Regional office, Bureau of Recreation and Conservation: 1405 State Office Building, 300 Liberty Avenue, Pittsburgh, PA 15222, 412-880-0486 (ask for the regional advisor concerning river programs). DCNR is particularly notable as a source for stream and river-related funding information from state and some federal sources.

Pennsylvania Department of Environmental Protection. For watershed-related information, see: http://www.dep.state.pa.us/dep/deputate/watermgt/WC/Subjects/NonPoint.htm. For stream engineering, see: http://www.dep.state.pa.us/dep/deputate/watermgt/WE/We.htm. Local office: 400 Waterfront Drive, Pittsburgh, PA 15222, 412-442-4000 (ask for the Watershed Coordinator for Allegheny County). DEP has a regulatory function and is thereby a key player in any projects affecting waterways. Its watershed programs also help link people, projects, programs, and resources.

River Network, 520 SW 6th Ave. #1130, Portland, OR 97204, 503-241-3506, 800-423-6747, Fax 503-241-9256, info@rivernetwork.org, www.rivernetwork.org. A national organization of river and stream advocacy groups.

Rivers, Trails, and Conservation Assistance Program, National Park Service, U.S. Department of the Interior. See http://www.ncrc.nps.gov/PROGRAMS/RTCA/index.html. Local office (as of May 2002): 623 E 8th Avenue, Homestead, PA 15120, 412-464-4459. Provides technical, facilitation, and other services.

Save Our Streams, Izaak Walton League of America, 707 Conservation Lane, Gaithersburg, MD 20878, 301-548-0150, 800-284-4952, Fax: 301-548-0146, sos@iwla.org, www.iwla.org/SOS/index.html. This program is good entry into the world of citizen-based water quality monitoring.

Society for Ecological Restoration, 1955 West Grant Rd. #150, Tucson, AZ 85745, 520-622-5485, Fax: 520-622-5491, info@ser.org, www.ser.org. An organization of professionals active in ecological restoration.

3 **Rivers Wet Weather Inc.** Clack Health Center-Bldg 3, 3901 Penn Avenue, Pittsburgh, PA 15224, 412-578-8375. A federally funded demonstration program that funds innovative technical approaches, institutional models, and financial arrangements related to wet weather and sewer infrastructure in Allegheny County.

Trout Unlimited, 1500 Wilson Blvd. #310, Arlington, VA 22209-2404, 703-522-0200, 800-834-2419, Fax: 703-284-9400, www.tu.org. Particularly concerned with preservation and restoration of cold water fisheries.

U.S. Environmental Protection Agency. See the EPA's River Corridor and Wetlands Restoration web site: www.epa.gov/owow/wetlands/restore/. Regional office: Region 3, Office of Watersheds, 1650 Arch Street, Philadelphia, PA, 215-814-2310. A key regulatory agency, EPA also has some programs that provide a variety of assistance to citizens, community organizations, and municipal governments interested in environmental projects. EPA also administers a number of federal funding programs for environmental projects.

The Waterfront Center, 1622 Wisconsin Ave. NW, Washington, DC 20007, 203-337-0356, Fax: 203-625-1654, www.waterfrontcenter.org. A nonprofit organization particularly focused on the interface between cities and large water bodies such as rivers.

Watershed Assistance Center, Western Pennsylvania Conservancy. PO Box R, Route 381 South, Mill Run, PA 15464, 724-329-0531. http://www.wpconline.org/watershed/index.htm. A regionally funded program that assists communities and citizen organizations in identifying and prioritizing projects, finding funding, running the regulatory maze, securing competent design assistance, etc.

FUNDING SOURCES

Stream restoration and daylighting proponents can secure cash funding in a number of ways. Case studies and discussions with experienced practitioners indicate that potential funding sources are many, including those below. Some of these sources can also provide in-kind assistance.

- City parks budgets.
- School districts (for projects on school property).
- Redevelopment authorities, special districts, or economic development projects. A large project in Kalamazoo, Michigan, implemented daylighting and other downtown revitalization through an authority funded by bonds based on tax-increment financing.
- Public works budgets. Daylighting may be rolled into larger projects to improve stormwater management, roads, sewers, or other public services. If daylighting displaces some other action, like replacing an old storm drain, funds that would have gone to the conventional action may be applied instead to daylighting.
- Stormwater utilities funded by specific fees for water management. For example, the Jenkins Creek project outside of Seattle was funded by revenues from a "surface water charge" collected by the King County Surface Water Management Division.
- Other infrastructure agencies. State highway departments may support projects that involve improvements to bridges, reduce road flooding, or provide other transportation benefits. Several projects have tapped funds established by the federal Intermodal Surface Transportation Efficiency Act.
- Gifts from individuals. These can be secured in many ways. In Port Angeles, Washington, restorationists are paying for amenities around a daylighting site by asking citizens to sponsor benches, lamp posts, and even individual bricks in a path. People can have names put on the features they "buy."
- Nearby local businesses. They may believe the project will bring people to the area, or may simply support it as good neighbors.
- Businesses may also be property owners on daylighting sites. They may find daylighting is cheaper than replacing a deteriorating culvert, or governments can require them to daylight and restore a stream as a condition of approval for rezoning, redevelopment, or other actions that trigger government review.
- Local or national fishing and other sporting organizations, equipment manufacturers, and magazines.
- Foundations and philanthropists, ranging from local sources to large national organizations like the National Fish and Wildlife Foundation. Often a funder will be interested in a particular angle of a project, such as fishery restoration or urban park creation.
- State environmental programs. California's Department of Water Resources has an Urban Stream Restoration Program. Such a focused program is no doubt rare, but other states have programs on habitat, water quality, riverways, wetlands, fish and game, or other concerns that could include daylighting projects within their scope. Besides programs paid from a state's general fund, many states have funds for land acquisition or special projects from dedicated bond issues, vanity license plate fees, and lotteries. In Pennsylvania, the Department of Conservation and Natural Resources administers a number of programs that can help fund planning, technical assistance, land acquisition, and development related to stream protection and restoration.
- Clean Water Act funds; e.g., Section 319 grants.
- The U.S. Fish and Wildlife Service Challenge Cost-Share program and Partners for Wildlife program.
- Community Development Block Grants.
- Funds from the Federal Emergency Management Agency for flood relief and for flood prevention measures such as removal of choke points at undersized culverts.
- Many other sources. Daylighting proponents should think of every benefit a project offers, and then brainstorm lists of every possible agency, foundation, business, and community group that might have an interest in supporting each benefit.

For help identifying possible funding sources, we suggest Pittsburgh-area stream restoration and daylighting proponents first contact the local offices noted above for the following organizations:

- Pennsylvania Department of Conservation and Natural Resources
- Pennsylvania Department of Environmental Protection

- Watershed Assistance Center, Western Pennsylvania Conservancy

These organizations each have people on staff whose responsibilities include linking up worthy projects with requisite funding. They know the federal and state programs that are applicable to particular types of projects, and can probably help brainstorm additional sources such as foundation grants and local agency programs.

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