Ohio River Pools 1, 2, and 3
Riverbank Geology, Conditions, and Access Reports

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Abstract

The intent of the 3R2N terrestrial study is to describe and document conditions of riverbank geology, accessibility, preservation and restoration potential along the Ohio River in Pools 1, 2, and 3, Allegheny County, Pennsylvania. Data collected during the 2003 field season includes bank and berm slopes, heights, material types and grain sizes, material conditions, accessibility potential, and floodplain identification. Data was collected along $1/10^{th}$ mile sections of each bank, which were identified in the field with a Global Positioning Receiver (GPS). This data was entered into a database for later GIS and ARCINFO analysis. Riverbank access was graded into three categories and mapped with ARCVIEW computer software. Preservation data was also graded into three categories and mapped. The data from the access and preservation maps was filtered through a Boolean truth chart, and riverbank sections worthy of restoration were identified, graded, and mapped. Riverbank grain sizes and materials distribution were plotted for each pool and the resulting trends discussed.

Table of Contents

I. Geological Context

Geological Time

In order to present a geological history of the Ohio River, the rocks through which it flows, and the ages of the materials transported by the river, a discussion of the amount of time is presented, using the geological time scale used today (figure 1). This time scale is divided into *Eras* and *Periods*. The bedrock layers exposed in the Ohio River valley from Leetsdale, Pennsylvania (Pool 3) to downtown Pittsburgh (Pool 1) are from the Pennsylvanian Period, in Paleozoic Era (meaning "old life") dating from about 310 million (ma) years ago. If one were to drill a hole in Pittsburgh down through 16,000 feet of sedimentary layers, much older rocks will be found from the Precambrian Era, about 1,200 ma (million years ago). These ancient crystalline rocks (non-sedimentary) are exposed on the surface about 150 miles north of Toronto, Ontario, Canada, and in the Philadelphia area in Pennsylvania. The simplified geological time scale (figure 1) illustrates the Eras and Periods. The sedimentary beds exposed in the Ohio River valley are shown in the local stratigraphic rock column, which shows an expanded portion of the Pennsylvanian Period (figure 2), and range from the lower Conemaugh Group (all of the Glenshaw Formation and a small part of the Casselman Formation) and the uppermost portions of the Allegheny Group.

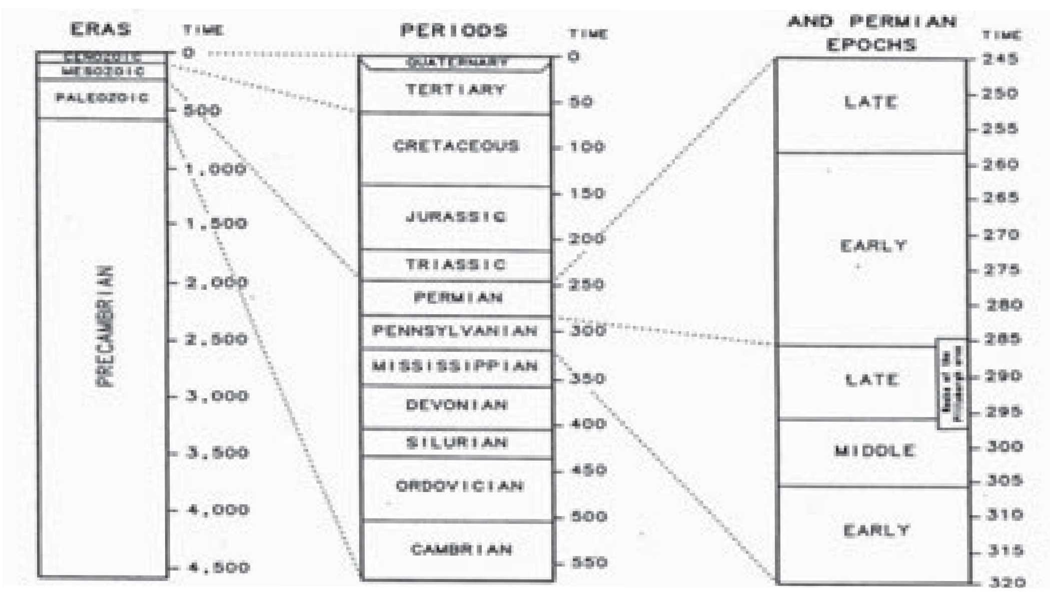


Figure 1.

Simplified geologic time scales, showing the relationships between eras, periods, and epochs. The rock of the Pittsburgh area were deposited mainly during the Late Pennsylvanian. Time is shown in millions of years

Geological History of the Ohio River

The present-day Ohio River flows southward from Pittsburgh, Pennsylvania, to its confluence with the Mississippi River, at Cairo, Illinois. The Ohio River is formed by the confluence of the Monongahela and Allegheny Rivers and shares characteristics of both. It is slowly eroding and downcutting the flat-lying sedimentary beds of shale, sandstone, limestone, claystone, and coal that were originally deposited during the Pennsylvanian Period of geological time (about 310 million years ago). These bedrock layers can be seen from certain points along the Allegheny

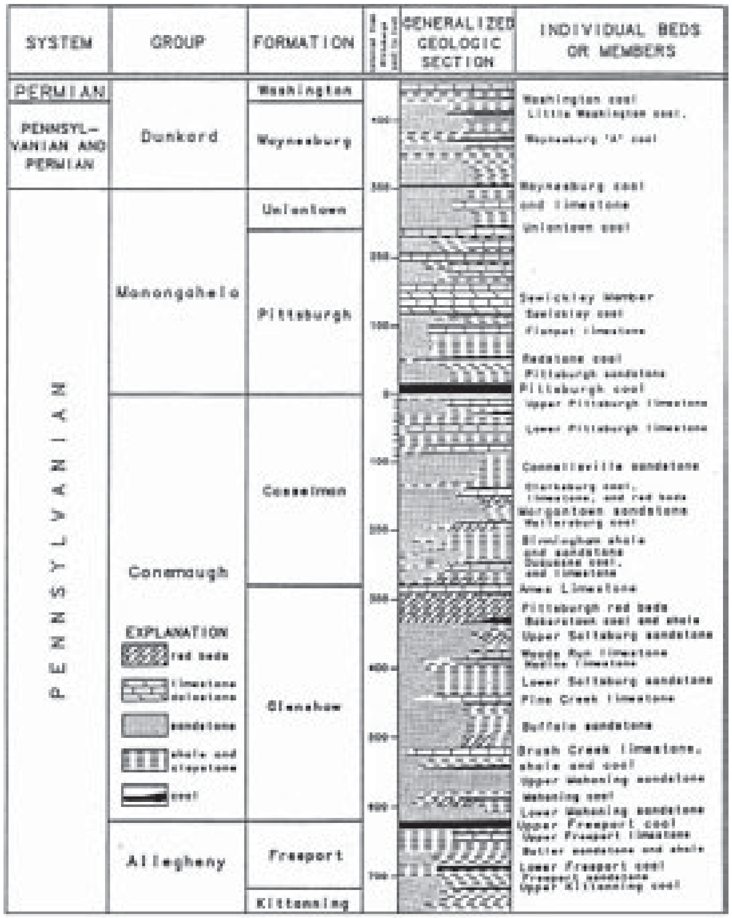


figure 1.

River today (figures 3 and 4). During this time of rock formation, the river drainage system and topography were totally different from that seen today; the ancestral rivers flowed west into a shallow sea that covered Western Pennsylvania and Eastern Ohio. The climate was tropical, as the equator was very close to the Pittsburgh area due to continental drift. Figure 5 is a paleogeographic map of Pennsylvania, as of about 300 million years ago. The climatic environment at this time in Pennsylvania's history was similar to that of the Amazon River delta in Brazil; very hot and steamy, with high amounts of rainfall. This was due to its proximity to the earth's equator; processes of continental drift have moved the North American continent northward about 45° latitude. Plants grew quickly in this environment; then decayed and formed thick layers of organic matter that was later compressed and changed to coal. Huge insects lived in this environment, with some dragonfly species having a wingspan of over 30 inches. The rivers that drained this ancestral landscape flowed from east to west, into the shallow sea that covered much of Western Pennsylvania and Ohio at that time; the beds and channels of these old rivers have no relationship to those of the rivers now seen in the region. The sources for these ancestral rivers were in the mountains to the east, which predated the Appalachians.

Figure 3.

Figure 4.

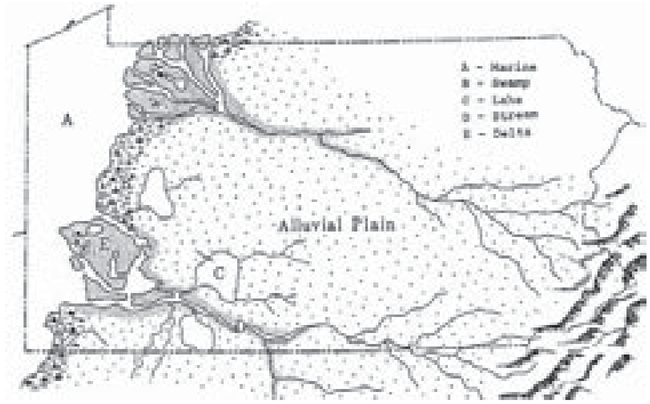


Figure 5.

The history of the Ohio River as we know it today probably began back at the beginning of the Cenozoic Era, about 60 million years ago (Wagner, 1970). During this time, Western Pennsylvania was a broad, flat plain similar to those now seen in the mid-western United States. There was probably very little topographic relief, and there was little elevation difference between the tops of any hills and the water levels of the Ohio. The topographic relief in Pittsburgh is now nearly 700 feet, as the level of the water in the Ohio at the Point is 710 feet above sea level, and the tops of the highest hills are almost 1400 feet above sea level.

Figure 6.

During the late Cenozoic era (about 5 million years ago) geological processes slowly uplifted the Pittsburgh area, increasing the slope of the Ohio River, allowing it to start downcutting erosion. The erosional style during the early Cenozoic Era was one of sidecutting, with large river meander loops. As the Ohio flowed faster due to uplifted land and a greater downslope river gradient (with a larger resulting erosive capability), the river's course straightened out somewhat and sideways erosion was abandoned to greater downward erosion. Deep valleys were then cut, about 400 feet below the elevation of the plain formed during the early Cenozoic Era. If one looks out at the Pittsburgh landscape from a high point (such as the USX Tower downtown) one can see that all the hilltops are level, and represent the remnants of this old plain (figure 6). The downcutting action of the Ohio continued until the river's water level was about 200 above that seen today.

Figure 7.

There was a temporary hiatus of the downward erosion of the Allegheny, and this was affected by the advance of the great ice sheets that covered Northwestern Pennsylvania during the "ice ages." There were four ice sheet advances during this time period, but the next to the last ice advance radically changed the courses of some of our rivers.

The Ohio River has not always flowed south, emptying into the Mississippi River. Before the third ice advance, the Ohio River originally flowed north into Lake Erie, in the valley of the present-day Beaver River. The original headwaters of the Ohio River were near present-day Mew Martinsville, West Virginia; the river flowed northwards to present-day Rochester, Pennsylvania, and then up the Beaver River and French Creek valleys to Lake Erie. The ice sheet advance dammed the north-flowing Ohio River, and water impounded behind it forming a large valley-fill lake. This lake, called "Lake Monongahela," probably formed between 750,000 and 970,000 years ago (Marine and Donahue, 2000). Thick deposits of sand, mud, gravel, and cobbles can be seen in certain places within Pittsburgh at about 920 feet above sea level; this deposit is known as the "Carmichaels Formation" or the "Parker Strath" (Wagner, 1970). These unconsolidated sediments represent material deposited by the Allegheny and Monongahela Rivers when they were impounded by glacial ice to the north. Figure 7 represents these terrace deposits and abandoned loops in the Pittsburgh area, and figure 8 shows these deposits in Allegheny County. Marine and Donahue (2000) have found evidence for this lake as far south as present-day West Virginia. The Cathedral of Learning (University of Pittsburgh) and the Carnegie Museum of Natural History both rest on the Carmichaels Formation deposits. Sometime during this high water event, the southern portion of the Ohio River eroded through its divide in West Virginia, and started to flow southward. Figure 9 is a pre-glacial river drainage pattern map of Western Pennsylvania, also showing the furthest advance of the glacial ice.

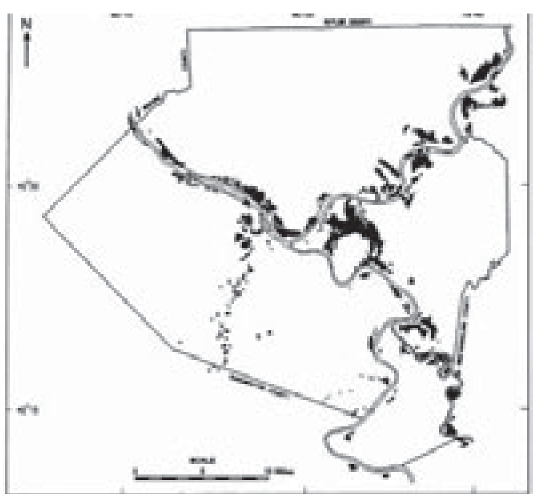


Figure 8.

As the glacial ice finally retreated, the old Ohio River divide was eroded through and all the water from the Allegheny and Monongahela (forming the Ohio River) flowed southward to the Mississippi River, at Cairo, Illinois, as it does presently. Lake Monongahela drained, and the river started again on its downcutting action. There was a fourth ice advance that deposited a blanket of unconsolidated glacial till in the northern portions of the Allegheny River drainage basin and much of this material was deposited in the Allegheny riverbed, due to outwashing from the surrounding hills. Much of this glacial material has been washed into the Ohio River, mixing with more locally derived sediments from the Monongahela River. One of the major differences between the Allegheny and Monongahela riverbank and bottom materials is the introduction of glacial alluvium, which the Monongahela lacks. Downcutting remains the major erosional style of the Ohio River, even though there is still some meandering and sidecutting. The water level of the Ohio has dropped about 200 feet since the third ice advance; this may give an idea of how slow erosional processes are on a major waterway. Figure 10 is a map of the present drainage patterns in Western Pennsylvania.

Figure 9.

The portion of the Ohio River observed during the Phase IV portion of the 3R/2N Study (pools 1, 2, and 3) flow in a fairly straight line in a northwest direction from downtown Pittsburgh, in a zone of weakness in the bedrock. The sedimentary layers in the Pittsburgh area suffered mild deformation when the Appalachian Mountains were raised about 250 million years ago; this resulted from a collision between North America and North Africa, sometimes named the "Allegheny Orogeny" (an orogeny being a mountain-building geological event). This orogeny did not happen suddenly, or catastrophically, but over a long period of time, probably tens of millions of years. The final result was a high (estimated at about 40,000 feet!) range of

Figure 10.

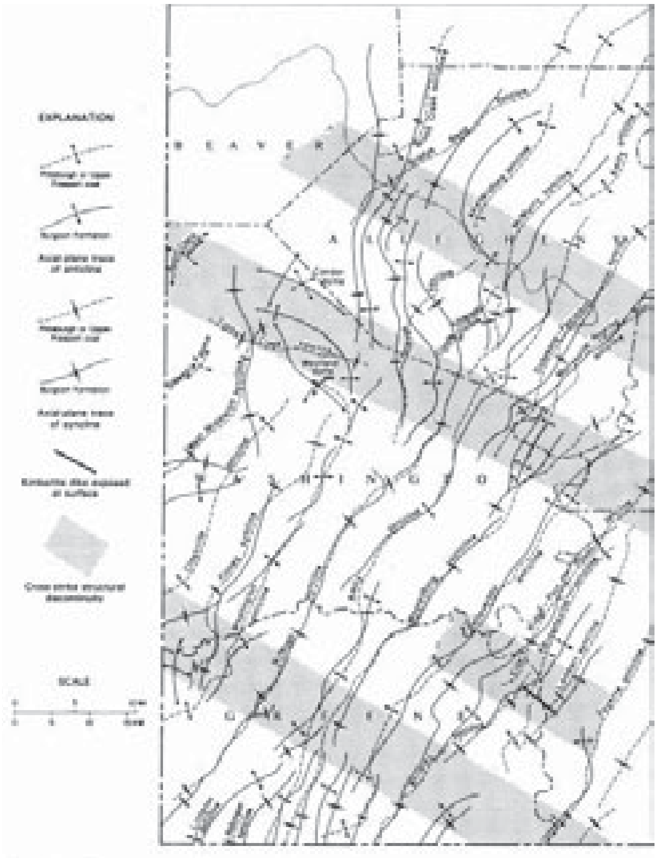


Figure 11.

Structure axes and cross-strike structural discontinuities in southwestern Pennsylvania (structure axes on Pittsburgh or Upper Freeport coal modified from Berg and others, 1980).

mountains (the Appalachians) in present-day central and eastern Pennsylvania and very minor rock folding in the Pittsburgh area, due to its longer distance from the continental collision point. The greater the distance from the collision zone (or the suture line), the less deformation one observes in the effected bedrock. The sides of the folds in the Pittsburgh region have a slope of only about 2 degrees; Chestnut Ridge and Laurel Hill both have fold slopes of about 15 degrees, since these folds (or anticlines) are closer to the suture (or collision line), that is, close to present-day Philadelphia, Pennsylvania. Some bedrock in central Pennsylvania has been tilted and folded so the beds are vertical, or turned over.

The axes, or "ridges" of the rock folds in the Pittsburgh region have a direction that trends northeast; see figure 11, a rock structure map of Southwestern Pennsylvania (Harper and Laughrey, 1987). From this map, the northeastern trends of the folds can be seen, along with four fracture zones that are at right angles, or normal to the regional folds. These are areas of bedrock fracturing that formed during the Appalachian Orogeny, along with the folding. Note that the Ohio River (in Allegheny County) and a portion of the Monongahela River flow along the trend of these fracture zones. The rivers preferentially downcut in these fracture zones, as the bedrock is weaker, and more easily eroded. The fracture zones are caused by very deep bedrock movement during the folding events. Figure 12 (Harper and Laughrey, 1987) shows four geological bedrock block diagrams illustrating some of the processes that lead to the formation of cross-structural fracture zones. One of these fracture zones is over 85 miles deep and temporarily penetrated liquid magma under the Earth's crust (Prellwitz, 1994). The resulting cross-structure fracture was intruded by igneous rock about 150 million years ago.

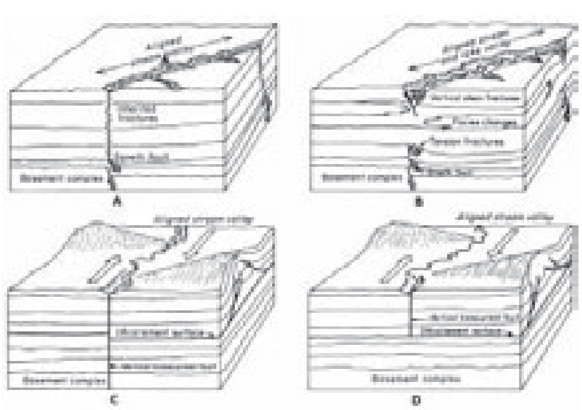


Figure 12.

II. Data Aquistion and Analysis

Field Methods

The fieldwork for Year 4 of the project was confined to Pools 1, 2, and 3 of the Ohio River, from Leetsdale, Pennsylvania, to the point at Pittsburgh, Pennsylvania. Pool 1 of the Ohio River starts at Pittsburgh, and ends at the lock and dam at Emsworth; pool 2 starts at the Emsworth dam, and ends at the Dashields lock and dam below Sewickley, PA. Pool 3 starts below the Dashields lock and dam and extends to the Montgomery lock and dam at Ohioview, PA. The portion of the Ohio River pool 3 included in the Phase IV study area is from Dashields lock and dam downriver to below Leetsdale, PA at the Allegheny County boundary line.

Both banks of the Ohio River (and the banks of the islands) were divided into 1/10th mile sections. These section's start and stop points were programmed in to a GPS (Global Positioning System) receiver unit as latitude and longitude points. This GPS receiver was used aboard the field vessel to determine each section's starting and ending point.

The geology and geometry of the riverbank and/or berm was described for each 1/10th Mile section. If a berm was present in a section, its slope was reported (in degrees) and the average grain size distribution data was recorded. A modified version of the Wentworth-Udden scale of grain sizes was used to report data for this study (Boggs, 1987), which is:

Boulder Size	› 256 mm.
Cobble Size	64 mm. — 256 mm.
Pebble Size	4 mm. — 64 mm.
Coarse Sand Size	1 mm. — 4 mm.
Sand Size	1/16 mm. — 1 mm.
Silt Size	1/256 mm. — 1/16 mm.
Clay Size	‹ 1/256 mm.

Along with the grain size distribution data and the berm slope in degrees, the percentages of natural and manmade materials were recorded for each section. Manmade materials include slag, cement, steel, wooden bulkheads, gabion, stone block, rubble, and "other."

Natural materials (if not moved and deposited by human operations) were classified as bedrock, boulders, cobbles, gravel, sand, mud, and "other." Driftwood piles and other garbage that were deposited or dumped on the berm were not included in any of the geological descriptions.

The riverbanks were described using the same procedure as the berm; the bank slope was reported in degrees, the grain size distribution of the bank materials was determined, and the percentages of the natural and manmade materials were recorded for each 1/10th mile bank section. The height of the bank above water level was also recorded.

The condition of the berm and bank materials was reported as "consolidated" or "unconsolidated." An example of a consolidated bank would be a steel bulkhead, or a stone block wall. Unconsolidated natural bank and berm materials include sand, gravel, cobbles, silt, and mud. Manmade materials can also be unconsolidated, including slag piles, and coal mine waste dumps.

Along with the berm and bank slope steepness number (in degrees), four categories of steepness were recorded. The first, "vertical," implies a 90° "slope." A "steep" bank or berm is one that has a slope greater than 45°, but is not vertical. A "moderate" slope is less than 45°, but greater than 22° and a "slight" bank or berm slope is less than or equal to 22°.

The bank and berm slopes were measured using a wooden Jacob's Staff and a geological compass that has a built-in clinometer. The Jacob's Staff was placed parallel with the slope to be measured, the compass was placed on the staff, and an angle in degrees was then recorded. Most berm slopes were less than 25°, and bank slopes usually were greater than 45°. The bank height measurements were determined by line-of-sight from the opposite bank, or the middle of the river, using an object with a known height (such as a building, or a railroad freight car) for comparison. Bank heights were also determined by climbing the bank, noting its slope, and estimating height using simple trigonometric relationships.

Bank and berm accessibility was reported as "easy," "moderate," and "no access." Easy access (from the water side of the bank and/or berm) usually had a berm with a slope of less than 22°, and a material grain size distribution that allowed easy landing from a boat. Large boulders inhibit access, as thick soft deposits of mud and silt. The berms that had the easiest access had a large amount of sand, coarse sand, and pebble sized material, and a small amount of cobble sized grains. Steep banks with no berms (and bank slopes greater than 45°) generally had more difficult access, and a vertical wall or bulkhead was classified "no access."

Grain size distributions for the bank and berm materials were measured by picking one spot of the bank or berm (about 1 meter square) if the rest of the 1/10th mile section had similar material characteristics. If the grain size of the bank and/or berm material changed significantly in one section, then an overall size distribution average was reported. Banks that were covered by dense vegetation were sampled with a shovel to determine materials and grain size ranges. Berm and bank areas that appeared to be in a natural state were sampled and the material was sieved to determine grain size distribution ranges.

III. Access Descriptions

Figures 13 and 14 show riverbanks that are vertical and have consolidated materials that are manmade. These banks are classified under the "no access" category. Figure 13 is a high steel dock, now inactive, that was once used by Pittsburgh Demoines Steel Company on Neville Island. This wall is over 25 feet high. Figure 14 is a steel bulkhead used as a dock for Army Corps of Engineers repair facility on Neville Island. These walls are over 20 feet high. Many industrial sites along the Ohio River utilized an unsaleable waste product as a building aggregate, increasing the amount of level land above high flood stage. Other areas of "no access" include the riverfront adjacent to lock and dam structures and portions of the bank blocked by shipping activity. (Figures 15 and 16)

Figure 13.

Figure 14.

Figure 15.

Figure 16.

Figures 17, 18, and 19 are areas that have difficult but possible access. Figure 17 is a photograph of a shoreline that has a fairly steep bank, giving somewhat difficult access from a small boat. An abandoned lock wall (figure 18) is low enough to permit access from larger boats. Landing here in a small boat or canoe would be difficult, due to the wall height of 5 feet. Some shorelines along the Ohio River have possible but difficult access because the property is private, and trespassers would be vigorously ejected by the authorities. An example is shown in figure 19, the large launching facilities of the U.S. Army Corps of Engineers, on Neville Island.

Figure 17.

Figure 18.

Figure 19.

Figure 20.

Figures 20,21,22, 23, and 24 all show bank and berm conditions along the Ohio River that have “easy” access conditions. Figure 20 is a gently sloping sandy berm with a very low bank. A trailer park and campground are on the flat floodplain above this bank, and this locality has ideal access from any small boat. A similar but less developed setting is shown in figure 21, where a sandy berm with some gravel provides an ideal landing point. The most ideal access for most boaters is a paved public launching ramp (figure 22). A berm that consists of gravel only provides easy access (figure 23), and the private boat docks at the end of the old abandoned wall of Lock 2 allow the landowners there ideal access to the river, even though there is a vertical structure present.

Figure 21.

Figure 22.

Figure 23.

Figure 24.

Figure 25.

Figure 26.

Figure 27.

Figure 28.

Bank and Berm Materials: Man-made

Man-made bank and berm conditions were observed during the 2003 field season on the Ohio River. Unconsolidated man-made bank and berm materials include steel mill slag, coal mine refuse piles, cement plant waste material, boulders dumped along the bank to stabilize erosion, and rubble material dumped as fill for railroad and highway rights-of-way. Consolidated man-made materials include cement docks and bulkheads, stone and brick walls, structures at water level, steel and wood retaining walls, dumped cement, and solidified slag. Other man-made materials that do not fall into the above categories include odd trash dumped along the riverbank, and occasional wrecks (figure 30). Examples of consolidated man-made bank materials are cement walls, steel piling walls, and cement block walls. Figure 25 is a cement wall built as a foundation for a power plant. In some bank areas, large boulders (known as "rip-rap") are placed along the riverbank to control erosion. Figures 26 and 28 (a health club and commercial barge docking area) both have non-natural rip-rap bank materials. A large scrap yard at Neville Island has utilized several old barges as a docking area (figure 27), and nearby,

Figure 29.

someone has dumped waste cement and slag, which have both solidified to form a man-made riverbank (figure 29).

Bank and Berm Materials: Natural

Some of the banks and berms along the Ohio River consist of natural materials. These materials are all unconsolidated, except for one exposure of natural bedrock in pool 3 near Leetsdale, PA. (figure 31). Natural materials include boulders, cobbles, pebbles, sand, Silt, and mud. The boulders, cobbles, and pebbles are from local sources, as a product of normal weathering, or introduced, from the outwash of glacial materials transported by ice. Some of the introduced materials have been brought in from sources over 1000 kilometers to the north, from Canada.

Figure 30.

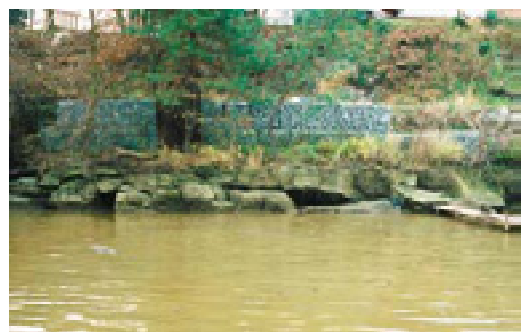


Figure 31.

Local natural bank and berm materials are similar to those found in the Monongahela and Allegheny Rivers; the parent rocks which they have weathered from consist of sandstone, shale, limestone, and a small amount of coal. The local bedrock in the Ohio River basin is similar to that of the Monongahela and Allegheny River watersheds, except for a lesser amount of coal.

Figure 32 is a photograph of a large gravel bank on the northeast side of Neville Island. This bank is about 20 feet high and consists mostly of cobble and pebble sized material, with a lesser amount of sand sized grains. Much of this material has been introduced to the area from transport by glacial ice. Much of the exotic material is from the Canadian Shield, which is made up of pre-Cambrian rock ranging in age from 1.2 to 2.6 billion years old. A 1 meter square was imposed on a flat portion of this gravel bank and a cobble count performed; the results are as follows:

- 77% Local sedimentary material (sandstone, shale, etc.)
- 5%Exotic sedimentary material (sandstone, limestone, etc.)
- 17% Exotic metamorphic material (gneiss, quartzite, etc.)
- 1% Exotic igneous material (granite, gabbro, etc.)

The exotic sedimentary cobbles were identified by fossil content and species; this percentage could be higher if ambiguities in field identification were eliminated. Most fossils collected from introduced sedimentary rocks were of Silurian age (figure 1, Geological Time Scale) and these rocks are exposed on the surface in the Buffalo, New York area, but deeply buried in the Pittsburgh region. Since there are no surface exposures of metamorphic or igneous rocks within the Allegheny River drainage basin, these cobbles are definitely of exotic origin, even though they were transported and deposited by natural processes. Metamorphic rocks occur about 16,000 feet deep in the Pittsburgh area.

A riverbank with natural materials of a smaller grain size is shown in figure 33. This low Bank (about 12 feet high) consists mostly of sand, with some gravel nearer to the berm. This is a good example of a low floodplain deposit, where the materials are eroded and transported more frequently than higher more competent bank materials during flood stages. Figure 34 shows the southernmost tip of Neville Island; most of the material here is mud, with some intermixed sand.

Figure 32.

Figure 33.

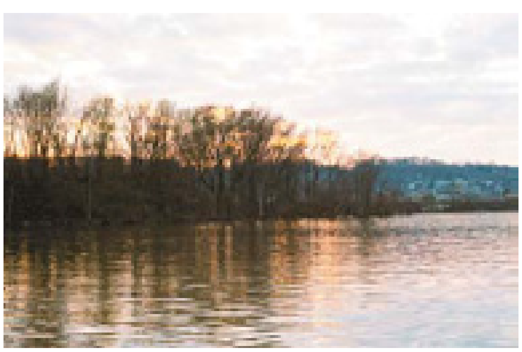


Figure 34.

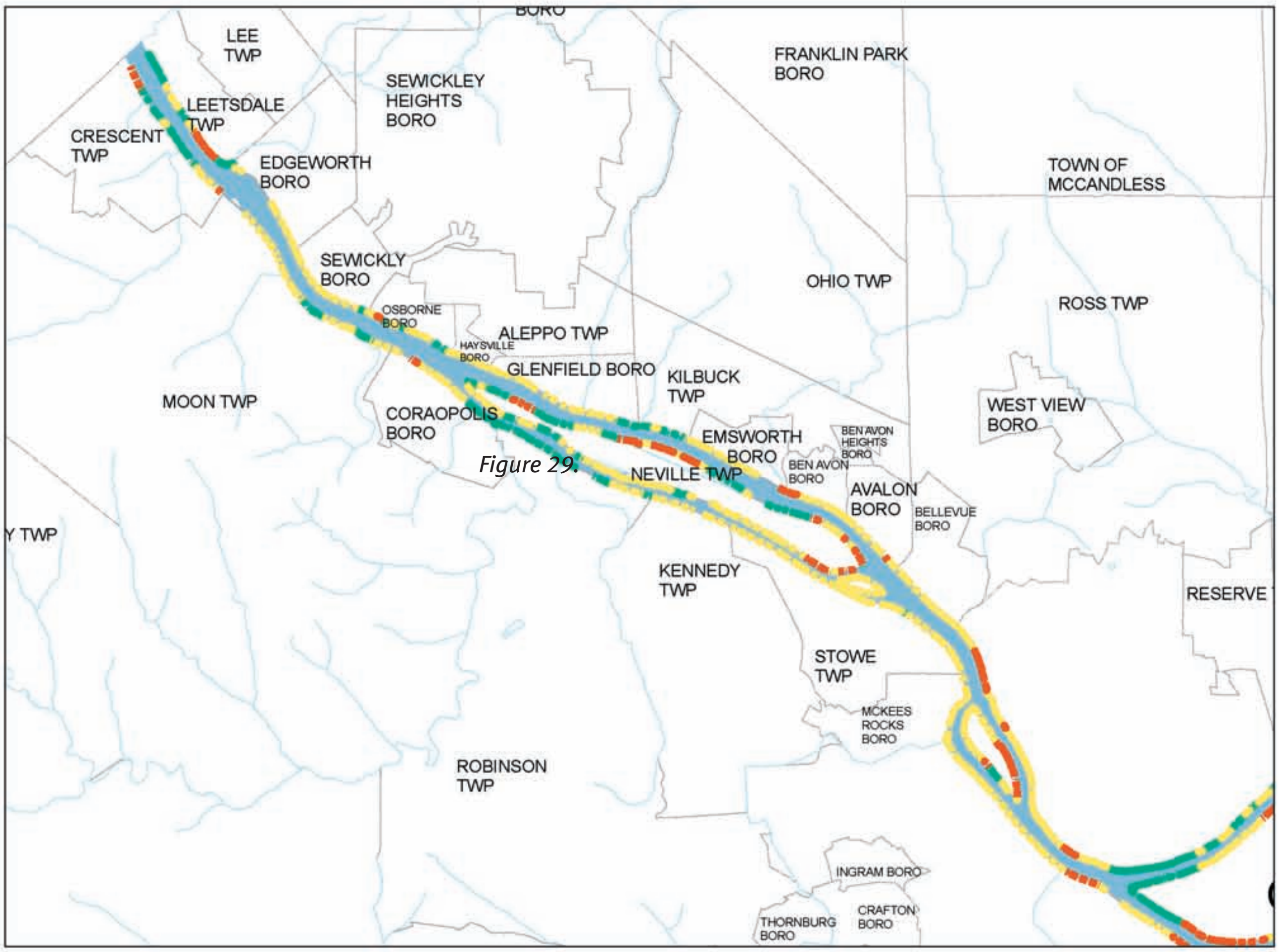
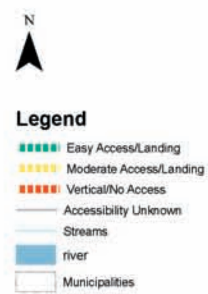

BORO
LEE TWP
SEWICKLEY HEIGHTS BORO
FRANKLIN PARK BORO
LEETSDALE TWP
CRESCENT TWP
EDGEWORTH BORO
TOWN OF MCCANDLESS
SEWICKLY BORO
OHIO TWP
ROSS TWP
OSBORNE BORO
ALEPPO TWP
HAYSVILLE BORO
GLENFIELD BORO
KILBUCK TWP
MOON TWP
WEST VIEW BORO
CORAOPOLIS BORO
EMSWORTH BORO
BEN AVON HEIGHTS BORO
Figure 29.
BEN AVON BORO
NEVILLE TWP
AVALON BORO
BELLEVUE BORO
Y TWP
KENNEDY TWP
RESERVE
STOWE TWP
MCKEES ROCKS BORO
ROBINSON TWP
INGRAM BORO
CRAFTON BORO
THORNBURG BORO

Figure 35.


N
Legend
Easy Access/Landing
Moderate Access/Landing
Vertical/No Access
Accessibility Unknown
Streams
river
Municipalities

IV. Results and Discussion

Data Analysis

The data from each 1/10th mile section of pools 1, 2, and 3 of the Ohio River was entered into a computer database, to be used in conjunction with the GIS and ARCINFO mapping programs. The three major areas of inquiry using the geological dataset and the computer mapping programs are:

1. Describing which sections of the riverbank have easy, moderate, and no **access**
2. Determining which riverbank sections are the best **preserved**, or which are closest to "pristine" condition, with minimum anthropogenic influence
3. Using datasets generated from sections 1 and 2 to find riverbank sections that are worthy of **restoration** and/or other improvements.

Access

Three grades of riverbank access were observed and recorded during the 2003 field season on the Ohio River; 1) Easy access, 2) Moderate access, and 3) Vertical, or no access. These three access grades were determined by the difficulty (or ease) of landing on the bank or berm using a 16 foot long outboard motor powered pleasure boat as a reference standard. Many riverbank and berm characteristics influence ease of landing from the water. The competence of the berm is a major factor in boat landing; people stepping into a soft mudbank will sink into the mud, but a sandier area will support people's weight better.

A steep bank or berm that is covered with boulder or cobble sized material also inhibits easy access. Boat landing is difficult, and one can sprain an ankle easily on the slippery stones. Boat size can factor into ease or difficulty of access; a canoe can approach banks bounded by shallow water more readily than powered watercraft of deeper draft.

An ideal area of riverbank access would have deep water for an easy approach by powerboat, a sandy berm with some pebble-sized material for added competence, a shallow berm slope, and a minimum amount of plant undergrowth. Other ideal access areas include man-made launching areas and other riverbank portions that have had access improved. The three grades of access have been plotted on a map of the Ohio River study area using GIS computer mapping methods (figure 35).

Floodplains

To assist in identifying a riverbank section's preservation and restoration rank, the lowest elevation floodplains were identified using GIS techniques on riverbank topographical base maps. To qualify as an inventoried floodplain, the following criteria must have been met:

- Floodplain must be under 10 high, above pool level
- Floodplain must measure 100 feet wide from the bank, inshore, at least at one point in the 1/10th mile section under observation
- Floodplain is affected by the 2-tear flooding events

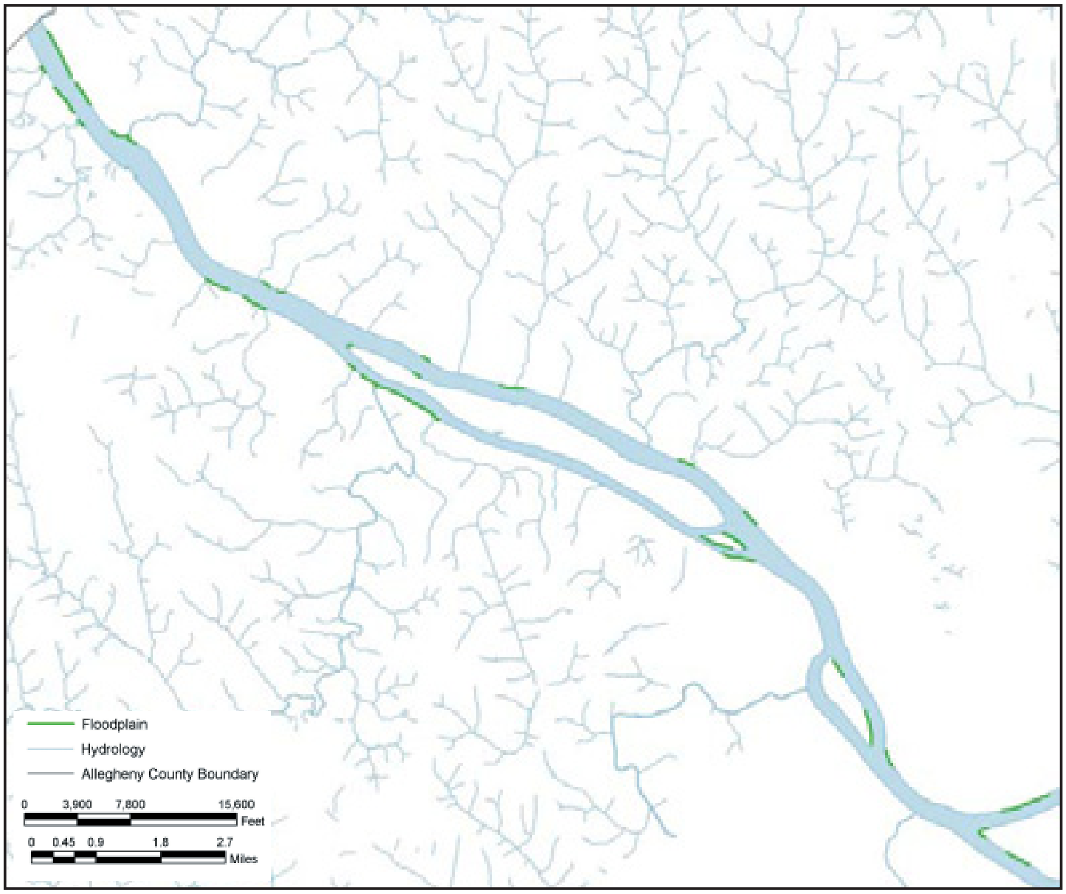


Figure 36.

Floodplain

After selecting these floodplain areas, a map was generated showing these areas bounded by floodplains (figure 36).

Preservation

Three different grades of riverbank preservation were created with the idea of determining which sections are best preserved in their natural state. There are no high banks which are still in their natural condition, as perhaps would have been seen before European settlement in the Pittsburgh area. All the high banks have been extensively modified, especially by railroad building activity over the past 150 years. Much material was imported as fill to raise track beds above the floodplain level. The Ohio River has active railroads along both of its banks although to a slightly lesser extent than when Pittsburgh was an industrial center.

The riverbank areas that are in their natural state are those that have their materials reworked by flooding action. The low lying banks and berms are affected by periodic floods to a greater

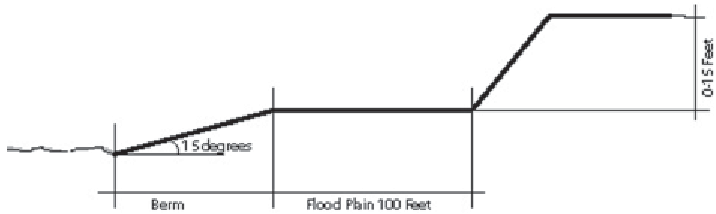


Figure 38.

P1 100% Natural Materials

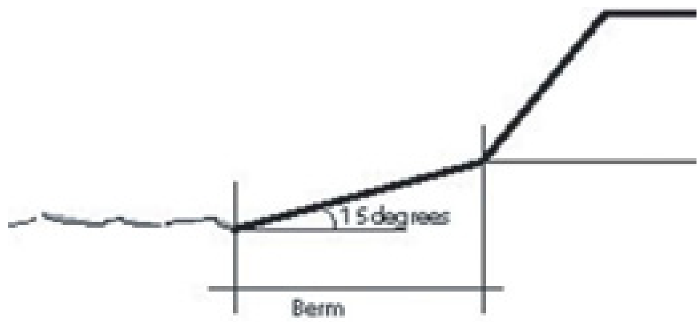


Figure 39.

P2 100% Natural Materials

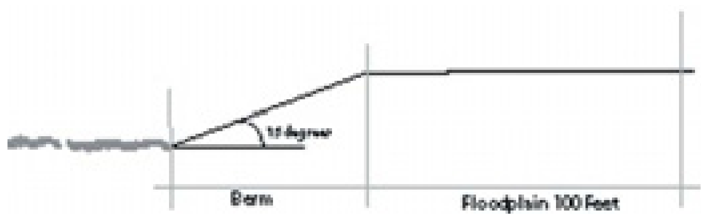


Figure 40.

P3 100% Natural Materials

extent than the higher ones; since there is constant dynamic change from erosion and deposition of material, these low sections represent the most "natural" portions of the riverbank.

To determine which areas qualify as best preserved, the height and frequency of flooding along the Ohio River has to be taken into account. The typical 5 year flooding event has a water level height of 15 feet. Any banks or berms below these elevations will have their materials and geometries reworked and changed due to the erosive and depositional action of the water. Hence, these low-lying portions of the banks can be interpreted as the closest to natural state.

Another criteria used to determine preservation is the amount of manmade material present. If there is a smaller manmade material percentage in the bank or berm makeup, this can be interpreted as existing closer to a natural state.

The three grades of riverbank/berm preservation and their criteria for selection are shown in figure 37, a matrix used as a geological analysis tool for preservation and restoration grading. Figures 38, 39, and 40 are schematic riverbank cross-sections that further illustrate the three grades of riverbank preservation. Preservation 1 (P1) must contain a floodplain AND 100% natural berm and bank materials, as well as a bank height of less than 15 feet. Preservation 2 (P2) must contain 100% natural berm and bank materials, and have a bank height of less than 15 feet. Preservation 3 (P3) must contain a floodplain and a 100% natural berm; no bank is needed for P3. The surface area of a P1 case is greater than that of P2 or P3. The sorting and grading of the

Geology Analysis Matrix							
Analysis	Floodplain	Operator	Berm Material		Bank Material		Bank Height
			Natural	Manmade	Natural	Manmade	
Preservation 1 (P1)	X	AND	100		100		< = 15
Preservation2 (P2)			100		100		< = 15
Preservation 3 (P3)	X	AND	100				
Preservation 4 (P4)	X						
Restoration 1 (R1)	X	AND				> = 50	
Restoration 2 (R2)						< = 50	> 6 and < = 15
Restoration 3 (R3)						< = 50	> 15 and < = 30
Note: Overlaps when they occur are valued from top down, removed from lower ranking and with a precedence on preservation vs restoration							

Figure 37.

areas of P1, P2, and P3 imply a descending surface area value for each case. P4 preservation grade is simply whether a floodplain is present (figure 36).

These data operators were entered into the ARCINFO computer mapping program and a map of the riverbank section's preservation potentials were plotted (figure 41). A fold out map of the total 3R2N study area (Allegheny, Monongahela, Ohio, and Youghiogheny Rivers) showing the grades preservation and restoration is pictured in figure 35.1.

Restoration

The restoration potential is contingent on bank height (and potential floodplain affect) as well as soil composition. As depicted in the geology matrix (figure 37), there are 3 grades of restoration; Restoration 1 (R1) requires the presence of a floodplain (as in two of the grades of preservation) and a bank made up of >50% manmade materials. Restoration 2 (R2) needs only a bank with <50% manmade materials and a height that is greater than 6 feet, but lower than 15 feet. Restoration 3 (R3) is the same as R2, but with a higher bank, ranging from 15 to 30 feet high.

As was the case with preservation grades, there is a change in surface area with the three restoration grades. R3 has the greatest area, and R1 has the smallest surface area. Figures 42, 43, and 44 are schematic riverbank cross-sections that illustrate R1, R2, and R3. Figure 45 is a GIS generated map of the study area, showing restoration grades and their placement.

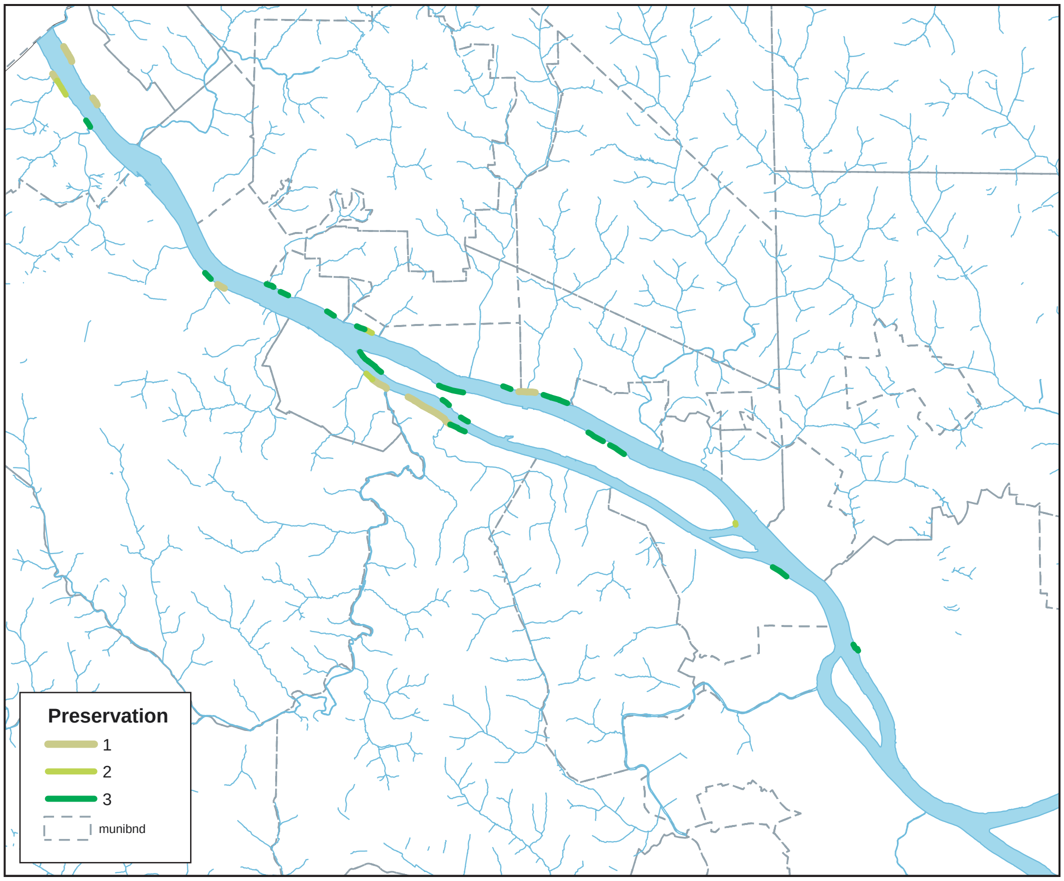


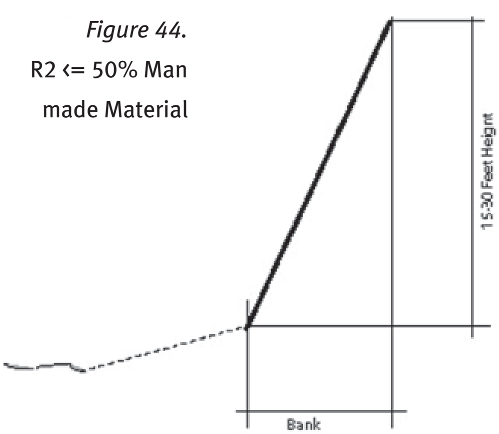
Figure 41.

Riverbank Grain Size and Material Type Trends

Grain size attributes are important descriptive properties of riverbanks. Riverbank morphology can be predicted based on grain size measurements and material makeup. Grain size can also predict river hydrological dynamics; erosional cutbanks versus depositional sand bar banks. This prediction holds true for natural or man-made materials. Grain size distribution trends in a riverbank also reflect watershed drainage, which depends on land use, geology, and climatic factors.

Figure 44.

R2 <= 50% Man made Material



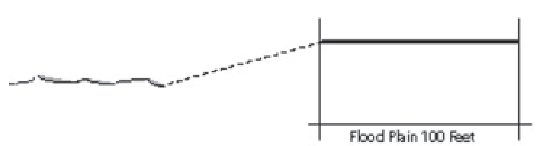


Figure 42.

R1 >= 50% Man made Material

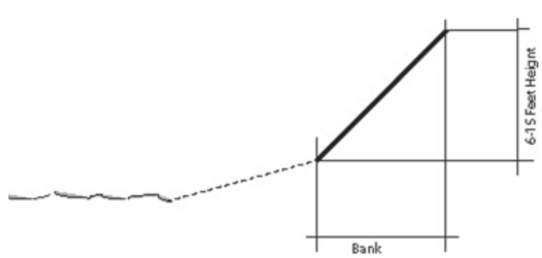


Figure 43.

R2 <= 50% Man made Material

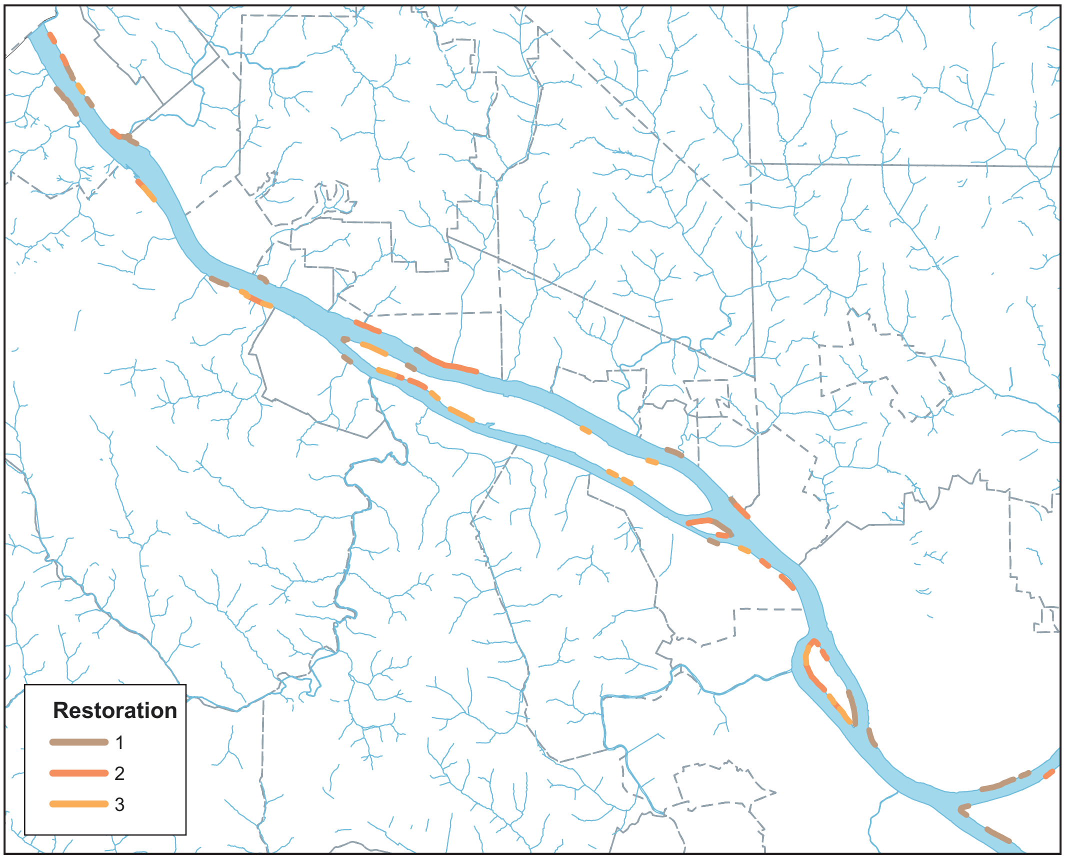


Figure 45.

Figures 46, 47, and 48 are "pie" charts that show natural materials and grain sizes for pools 1, 2, and 3 of the Ohio River. Grain size trends for man-made materials are not relevant, as they were not deposited through long-term natural geological processes. In general, there is a trend of finer grains along the upstream direction. This is an opposite trend for most rivers and streams even though material was added to the system from the Allegheny River, resulting from glacial outwash deposit erosion and transportation. Pool 1 has 92% mud, pool 2, 80%, and pool 3, 73%. The amount of sand decreases upstream, and the cobble/gravel values decrease upstream, also.

Figures 49, 50, and 51 are "pie" charts showing percentages of man-made riverbank material in pools 1, 2, and 3 of the Ohio River. In general, there is an increase of historical heavy industry (particularly steelmaking) along a downstream stream direction. The largest steelmaking site on the Ohio River was in pool 3, at the old American Bridge Division of United States Steel Company in Ambridge, PA.

Most other heavy industrial activity along the Ohio River was steel fabricating, (such as Pittsburgh Demoines Steel Co.) which generates little or no slag. These riverbank industries can be correlated to the amount of slag found as bank material; pool 1 has only 12% slag, where pools 2 and 3 have 41% and 21% respectively.

The amount of rubble and fill decreases fairly consistently downstream over the study area; at pool 1, (65% rubble/fill) there was a greater amount of fill dumped over time to increase land area in and near the City of Pittsburgh. Pools 2 and 3 have a lesser amount of rubble and fill, due to railroad construction along both riverbanks (66% and 31%, respectively). The amount of concrete (used for retaining walls and freight docks) is about the same for pools 1, 2, and 3.

A general decrease of man-made bank materials can be traced along the downstream direction (figures 52, 53, and 54). Even though there is no increase of industrial activity in the upstream portions of the study area, the impact of the City of Pittsburgh and other historical building

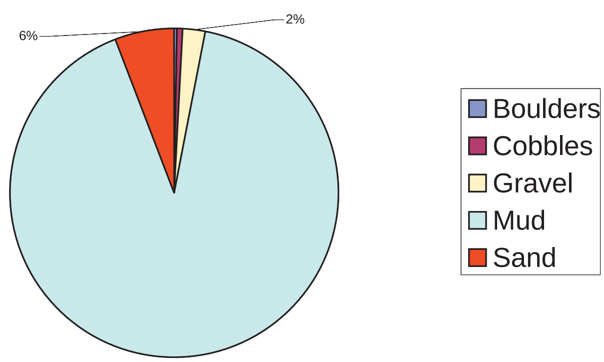


Figure 46. Pool 1 Ohio River: Natural Materials

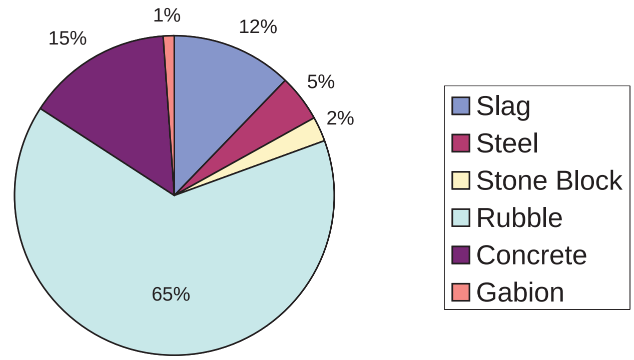


Figure 49. Pool 1 Ohio River: Man-Made Materials

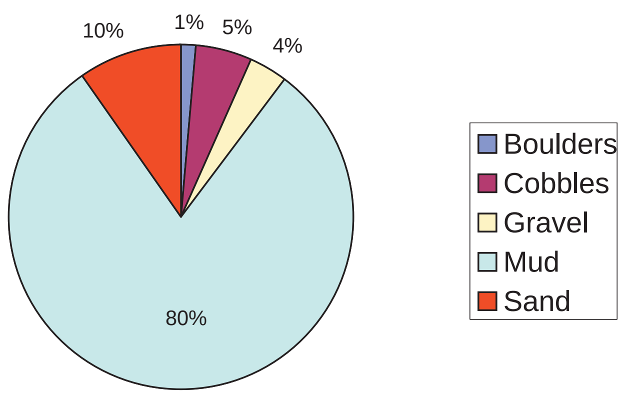


Figure 47. Pool 2 Ohio River: Natural Materials

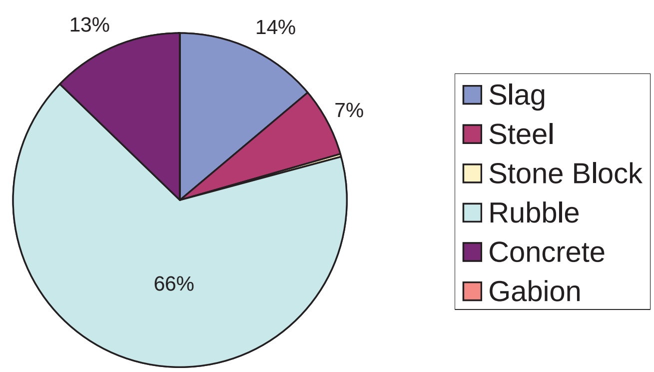


Figure 50. Pool 2 Ohio River: Man-Made Materials

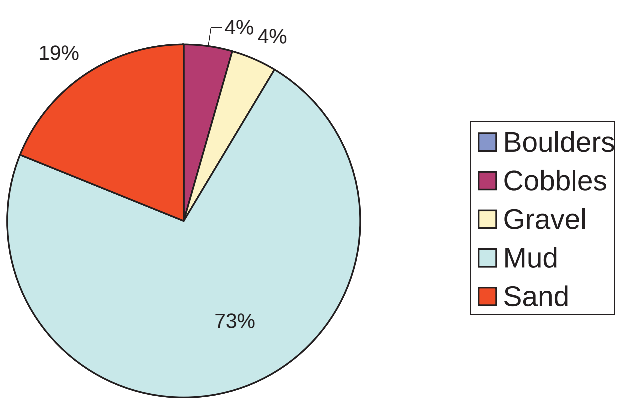


Figure 48. Pool 3 Ohio River: Natural Materials

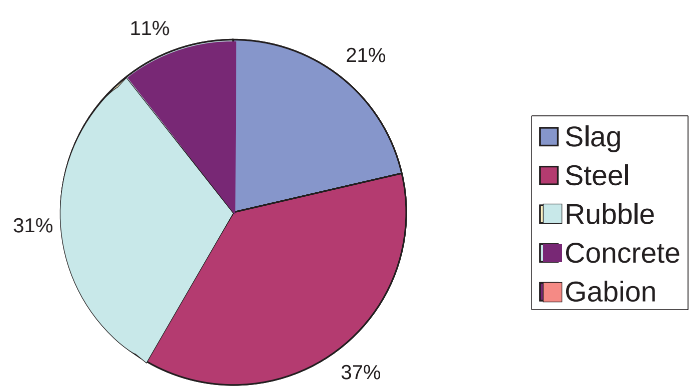


Figure 51. Pool 3 Ohio River: Man-Made Materials

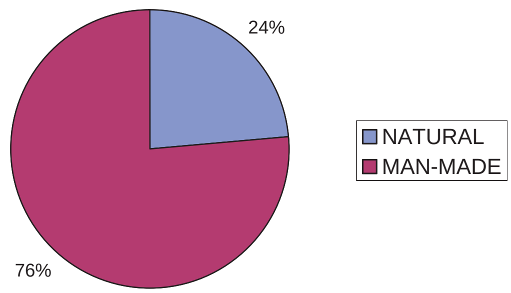


Figure 52. Pool 1 Ohio River: Man-Made to Natural Materials

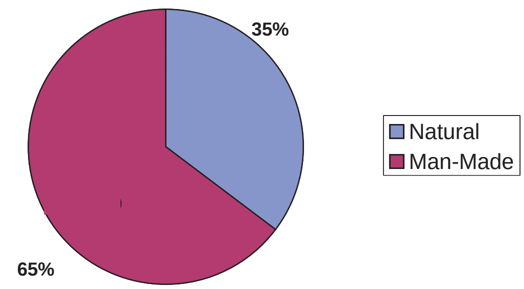


Figure 54. Pool 3 Ohio River: Man-Made to Natural Materials

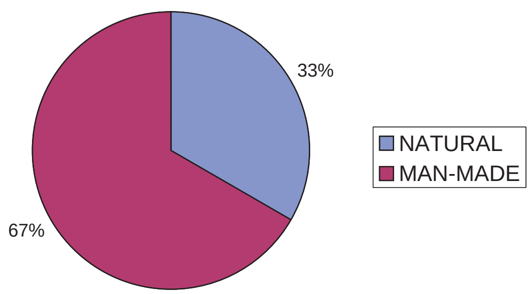


Figure 53. Pool 2 Ohio River: Man-Made to Natural Materials

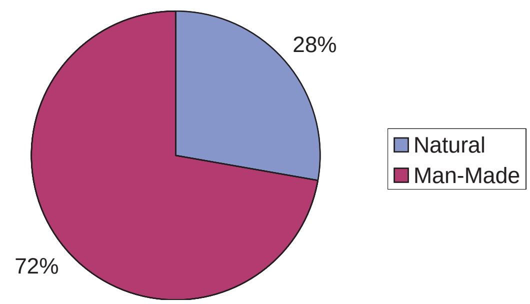


Figure 55. Ohio River: Man-Made to Natural Materials

activities result in the trends seen in the chart figures. Figure 55 is a chart with the total average amount of natural vs. man-made material percentages for the whole Ohio River study area, with 28% natural bank materials and 72% man-made material.

The techniques used for grain size and material data analysis can be applied down to the 1/10th mile bank section scale, if more detail is needed.

Comparison: Allegheny, Monongahela, and Ohio Rivers

A discussion that compares the characteristics of the three major rivers in Allegheny County should describe each river in terms of the bank and bottom material type, the bank and bottom material grain sizes, and the slope (or gradient) of each river. Also, the industrial impacts to each river can be compared.

Using the material and grain size charts from the previous two year's studies, differences between the Allegheny, Monongahela, and Ohio Rivers can be illustrated. All of the charts that contain material and grain size information from the Phase III and Phase II riverbank studies can be found in the Phase III and II reports (Prellwitz and Kyshakevych, 2002), and (Prellwitz and Kyshakevych, 2001).

The amount of industrial impact on the Ohio River versus the Monongahela and Allegheny Rivers can be seen by comparing the amount of man-made and natural bank material percentages. The

Monongahela River (pools 1, 2, and 3) averages 73% manmade materials; the Allegheny River, 55%, and the Ohio River, 72%. The reasons for the low industrialization along the Allegheny River have been discussed in the Phase III report; the Pittsburgh Coal seam outcrops along the Monongahela River (and not the Allegheny) thus encouraging more industry due to a more readily available supply of fuel. The similar percentages of manmade material abundances between the Ohio and Monongahela Rivers infers a similar amount of past industrial activity along both rivers, even though the character of the industries was different. The main industry along the Ohio River was ship building and steel fabricating, contrasting with the blast furnace and open hearth activity along the Monongahela River. Close access to coal resources played a major part in this industrial "sorting." The iron was smelted, and the steel manufactured in the Monongahela valley (and the smelting and steelmaking processes are fuel intensive) and then shipped to the Ohio valley (with some exceptions) to be formed into a finished product (fabrication). American Bridge, Dravo, and Pittsburgh Demoins Steel are all steel fabricating concerns that were based along the Ohio River.

The average grain size of natural materials in the Monongahela and Ohio Rivers decreases upstream, in contrast with the Allegheny River, where the grain sizes of natural material increases upstream. The reason for these differences have been explained (Phase III Report) by the extra glacial outwash material introduced in to the Allegheny River watershed at the end of the Ice Age.

The bedrock in which the Monongahela and Allegheny Rivers flow consists mainly of shale layers, with sandstone and minor limestone. Since shale is made up of 60% to 70% clay, the grain size of the resulting sediment (from the weathering and breakdown of the parent bedrock) has a large percentage of fine material, in the clay and silt sizes. The clay in the parent shales is not resistant to weathering, and clay is liberated into the drainage quickly.

The Allegheny River has had a large influx of exotic material, due to the last two glacial ice advances during the Pleistocene epoch. This material (due to sorting and erosion during the Ice Ages) has had most of the fine sized material removed. The leftover sediment that has outwashed into the Allegheny River is coarser than the sediment in the Monongahela, and consists mainly of quartz. Quartz is very resistant to weathering and solution in water, while clay is very soluble, indicating that the material added to the Allegheny River has had its clay fraction winnowed out before entering the river's valley.

The greater amount of clay in the Monongahela River gives the water a muddy color, while the water in the Allegheny River (at normal water level) is clearer, due to the lesser amount of clay available to suspend itself in the stream.

The Ohio River contains a mixture of natural materials from both the Allegheny and Monongahela Rivers, and shares morphological and material characteristics of both.

The lithology of natural riverbank material in the Ohio River can be seen as a mixture of sediment from both tributaries; glacially derived gravel (from the Allegheny) and a large amount of mud (from the Monongahela) coexist in the Ohio. One sees less glacial material in the Ohio than in the Allegheny and less mud than the Monongahela. Glacial material in the Ohio River can be seen downstream as far as Louisville, Kentucky. All of this glacial sediment has been transported from northwestern Pennsylvania, and northern Ohio.

Another major difference in natural materials between the Ohio, Allegheny and Monongahela Rivers, apart from lithology, is the amount of material in each river valley, usually referred to as the sediment load. There is a limit to how much sediment a river can carry. When that limit is reached, the morphology of the river changes greatly. A river that has a small sediment load has one channel in its valley; as the sediment load is increased, islands start to form, dividing the channel somewhat. If there is even more sediment load, the river changes its shape to a braided stream, with amastomizing channels separated by many small islands. Many river deltas have this shape. Generally, for a given amount of sedimentary load, rivers with smaller gradients will tend to have a braided shape due to the sediment load dropping out of the water from lower water velocity.

The Ohio River in the Phase IV study area flows generally in a straight line, in a northwest direction; there are few sharp bends to allow deposition on point bars and erosion by cutbanks. This morphology contrasts with the Monongahela and Allegheny Rivers, which both have a more sinuous course, generating larger floodplain areas. Due to the influx of additional glacial sediment from the Allegheny River, the Ohio has three islands in the Phase IV study area. These islands represent a sediment load that is too great for the river to remove and transport downstream. The number of islands in the Ohio River is less than that of the Allegheny because of the addition of Monongahela River flow, with less sediment load, at the point in Pittsburgh. The Ohio River has a less steep gradient than the Allegheny, which also favors deposition and the formation of islands.

The Ohio River in the 3R2N study area is a fair average of the characteristics derived from the Monongahela and Allegheny Rivers.

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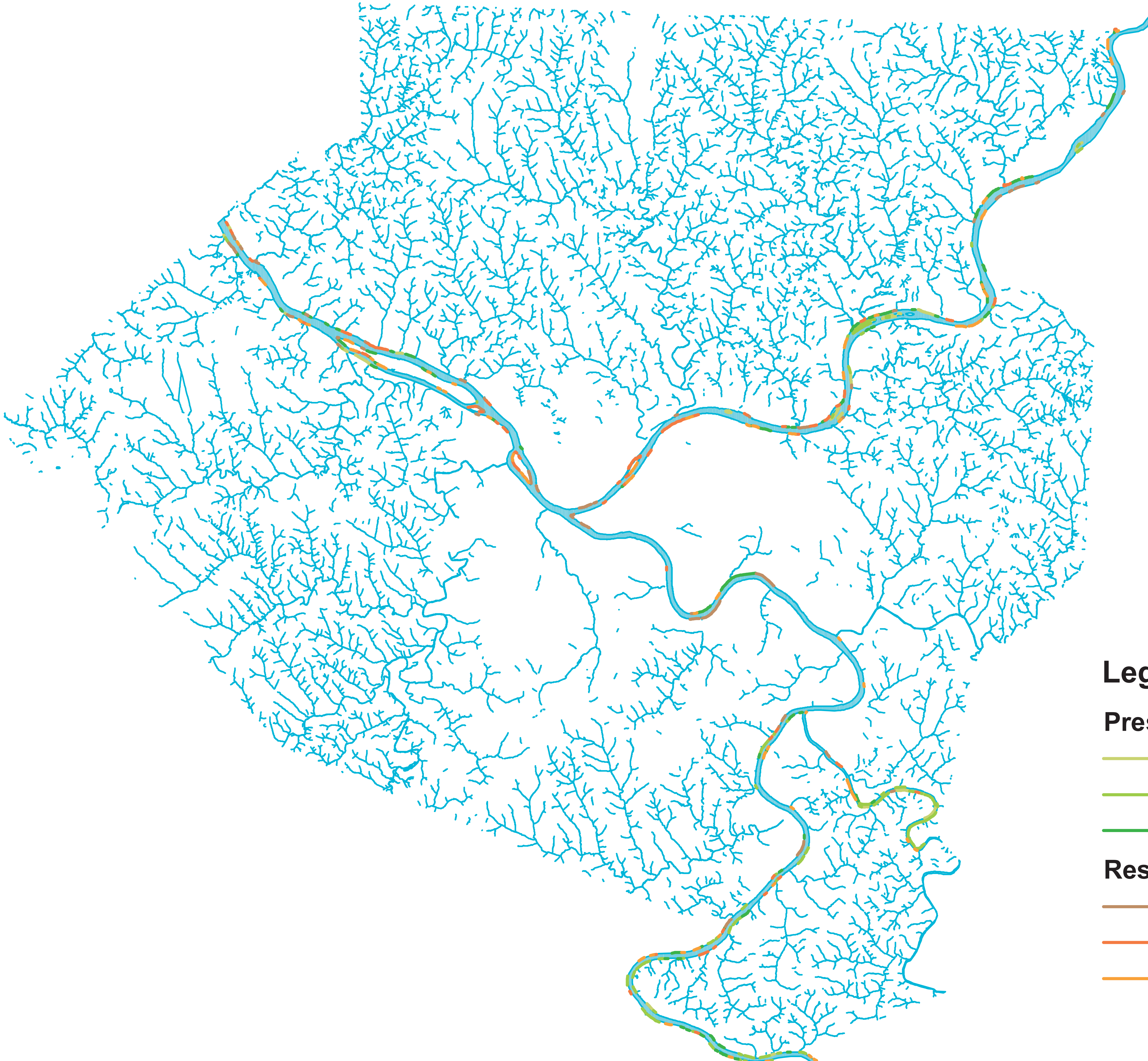
Figure 35.1

Geology

Restoration and Preservation



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Art Ecology Community

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Legend

Preservation

1

2

3

Restoration

1

2

3