Section 3
Watershed Management Input from Completed Investigations and Analyses

A series of successive tasks has been conducted to develop and implement the watershed planning process for Nine Mile Run (NMR). These tasks included field investigations, data collection activities, and analyses that provided the information needed to characterize existing watershed problems, develop watershed goals and objectives, and determine relevant watershed management approaches. This section will briefly summarize the input data that was provided by these previously completed and documented tasks and how the data was assimilated into the watershed planning process.

3.1 Watershed Management Input from Stakeholders, Historic Information, & Existing Background Data

Public Coordination: Public meetings were conducted with watershed residents and stakeholders to identify and prioritize problems and goals for the NMR watershed. Watershed management planning activities were coordinated with municipalities, agencies, and citizen groups that have active programs in the NMR watershed to integrate their efforts into the watershed planning process and verify that proposed management and restoration activities are consistent with their vision and goals for the watershed.

Historic Information: Pertinent historic and existing background information was obtained on the NMR watershed. Research papers were obtained from various academic authors who had written on the history of the watershed. Several aquatic habitat, riparian vegetation, and wildlife studies have been conducted within the NMR watershed over the past 53 years, and these were collected as well. These papers and studies provided a valuable historic backdrop for the watershed management planning process.

GIS Database Information: Geographic and soils information for the NMR watershed were obtained from a county-wide geographic information system (GIS) data base maintained by the Three Rivers Wet Weather Demonstration Program (3RWWDP). The GIS is based upon aerial photography flown in 1990, and the database layers include topography, building footprints, streets, land uses, surface streams, and tree cover. Population data were obtained from the 1990 census and added to the database. Existing digital data on municipal sewer systems and soils data from the County Conservation District were also incorporated. The GIS database information was used to generate watershed maps, delineate sub-sewershed areas, determine impervious cover and soil infiltration rates, calculate average surface slopes and runoff travel times, and estimate depression storage.

Precipitation Data: Rainfall is one of the driving forces in the hydrologic cycle and accurate precipitation data are needed for watershed planning and management. A long-term gauge located at the Pittsburgh International Airport provided the historic precipitation record for the NMR watershed. Long-term hourly precipitation was obtained for the period from 1902 through 1999. Corresponding daily maximum and minimum temperatures were also obtained in order to perform snowmelt analyses. This digital data and the results of previously completed statistical analyses were integrated into the hydrologic simulation models.

Water Quality Data: Water quality data that previously had been collected within the NMR watershed and stream channel condition information from previous field studies and reports were obtained and documented. The existing data was used to characterize existing conditions and problems within the watershed and to identify opportunities to mitigate these problems.

3.2 Watershed Management Input from the Hydrologic & Hydraulic Modeling Report

Nine Mile Run, and its principal tributary Fern Hollow Run, is the one of the largest streams within the City of Pittsburgh that still have reaches that are open and accessible. Many other streams throughout the City have been culverted. Restoration of the open reaches of NMR provides a unique opportunity to demonstrate stream and habitat restoration techniques, including integrated wet and dry weather flow management. To ensure the success of reconfigured stream channels and new wetland areas that are planned for the NMR watershed, an accurate and reliable understanding of surface hydrology and stream hydraulics was needed.

Hydrologic and hydraulic numerical simulation models were developed for the NMR watershed. The surface hydrology modeling results provided the needed watershed storm water runoff and stream flow data to support the environmental assessment, alternatives analysis, and design activities. The hydrologic models also quantified the storm water runoff impacts of the new multiple-phase Summerset development plan that has commenced in the slag disposal area. The stream hydraulic modeling results provided depths and velocities along stream channels and adjacent floodplain over-banks. The model results form the basis of fluvial morphological design for the planned reconfiguration of channel sizes and shapes, channel meandering configuration to restore sinusoidal geometry, rock and boulder sizes for planned step pools and riffles, and other channel stabilization and restoration measures. The models also provide flooding frequency-depth-duration data that form the basis of design for planned revisions to floodplain over-banks and new wetland areas. The results of the modeling analyses were documented in the following reports.

- Nine Mile Run Aquatic Ecosystem Restoration Project, Hydrologic and Hydraulic Modeling Report, March 2000

- Section 206 Ecosystem Restoration Report and Environmental Assessment, Nine Mile Run Watershed, Pittsburgh, PA, April 2000

- Revised Hydrologic and Hydraulic Analyses for the Nine Mile Run Watershed, A Long-Term Continuous Simulation Approach.

Two different hydrologic analysis approaches were used for the flow studies conducted within the NMR watershed: a single-event design storm approach, and a long-term continuous simulation approach. In the single-event design storm approach, a calibrated model was applied to individual synthetic design storms to determine design flows through stream channels. The individual design storms applied statistically derived rainfall depths to a regionally derived theoretical rainfall distribution. In the continuous simulation approach, the calibrated model is applied to the measured long-term precipitation record instead of synthetic design storms. The actual storms and rainfall patterns that occurred over a 20-year period were input to the model to simulate the flow along the stream channel on a continuous basis. Frequency-duration statistics were calculated from the continuous simulation runs and the statistical results became the basis for determining design flows through the stream channel.

The continuous simulation approach provided a more realistic basis for design for the proposed stream restoration and wetland enhancement work within the NMR watershed. The traditional single-event analysis methods tend to yield design flows that are conservatively high. These highly conservative design flows provide useful and appropriate margins of safety when applied to most traditional hydraulic structural design situations, such as highway culverts and municipal storm drain systems. However, the traditional design methods significantly overestimate stream-flows for natural channel designs, especially for predictions of the bank-full-flow conditions important in considerations of natural stream restoration, channel sizing and stabilization, and wetland creation.

The use of the continuous simulation approach for the determination of design flow values was critically important to the NMR watershed project. Fluvial geomorphologists use extremely large events such as the 25-year design storm when designing stream stabilization / erosion protection measures such as vortex weirs, rock weirs, root wad placement, and boulder step pools. If a single-event design storm approach were to be used, the gross overestimate of design flow would lead to over-predicting design velocities, resulting in wasted money on much larger rocks and boulders and much more restrictive requirements for embedding rock weirs and tying them back to the banks. Fluvial geomorphologists use bank-full flow conditions, typically a 12-month to 18-month return period for undeveloped watersheds, to size and proportion stream channels and to configure meanders. The overly conservative design flows derived from a single-event design storm approach would result in an oversized stream channel. The use of a long-term continuous simulation approach

resulted in optimal stream channel and wetland area designs for the NMR watershed, combining realistic design flows with fluvial geomorphologic principles.

Finally, fluvial geomorphologists use frequency / return interval-duration statistics to determine the frequency and duration that storm flows are expected to exceed the capacity of the stream channel and flood adjacent over-bank and wetland areas. This determination was critical to assuring that proposed new wetland areas received sufficient water to sustain wetland vegetation and habitat quality. The use of a single-event design storm approach would have resulted in the over-prediction of flooding frequency and the possible failure of the wetland due to lack of water.

3.3 Watershed Management Input from New Field Studies, Data Collection, and Analyses

Field Survey Data: A field survey crew collected cross-section geometry data and channel invert data. The locations of significant sewer structures, such as access manholes, diversion structures, and CSO outfalls were surveyed with a global positioning system (GPS). This new data was used to supplement and refine existing GIS mapping and database information and was used as input to the hydraulic simulation models.

Precipitation and Flow Monitoring: To supplement the long-term precipitation record, two new precipitation gauges were installed and maintained within the NMR watershed. Both gauges were used to measure the precipitation associated with monitored changes in stream and wastewater flow. Carnegie Mellon University (CMU) and the Army Corps of Engineers (ACOE) established a network of stream depth gauges. Rating curves were calculated and applied to the monitored depths to estimate stream flow during dry and wet weather conditions. The Pittsburgh Water and Sewer Authority (PWSA) established a network of flow monitors throughout the NMR watershed. Wastewater flows were continuously monitored during both dry and wet weather conditions. This monitoring data was analyzed and used to characterize hydrologic / hydraulic relationships within the watershed and provided input data to the simulation models.

Fluvial Geomorphology Assessment: An environmental consulting firm conducted a fluvial geomorphology study and assessment of the NMR watershed. Stable channel morphology is defined as the ability of the stream to maintain over time its dimension, pattern and profile in such a manner as it is neither aggrading or degrading and is able to transport without adverse consequences. The scope of work included field investigations and measurements, analyses, simulation modeling and the preparation of a report. The study concluded that the NMR stream channel is not stable and that the natural recovery process would not correct the current condition. The stream is actively adjusting as evidenced by accelerated bank erosion, channel

incision, and lateral scouring including meander migration. Stream restoration was recommended to stabilize the channel, provide adequate sinuosity, reconnect the channel to the floodplain, and improve both aquatic and terrestrial habitat. The findings, conclusions and recommendations from the fluvial geomorphology assessment were used in the watershed management analyses to identify watershed problems, formulate watershed goals, and identify potential watershed management and rehabilitation measures.

Aquatic Habitat Assessment: Detailed electro-fishing evaluations and rapid biological assessments were conducted within the NMR watershed by the ACOE as part of the *Section 206 Environmental Restoration Report*. The aquatic habitat report was completed in April 2000. The report identified three significant deterrents to aquatic habitat quality, 1) existing sewer line crossings through the stream channel that create a barrier to fish migration, 2) highly alkaline leachate discharges from the slag disposal site, and 3) dry and wet weather wastewater discharges from the highly urbanized watershed. During higher Monongahela River stages, a wide variety of fish species were found to enter the embayment area at the bottom of the NMR watershed. However, during lower stages, no fish were observed. This condition was attributed to the high pH slag leachate discharges that deterred fish from entering the embayment. Along the flowing portion of NMR upstream of the embayment, a depressed species diversity was observed. Entire expected taxonometric categories were missing, and the few species that were present were all tolerant of pollutants and other environmental stresses. The report was highly optimistic of the potential aquatic habitat quality that could be achieved if stream restoration measures were implemented. The observations and recommendations from the aquatic habitat assessment were significant inputs into the watershed planning process to help identify watershed problems, formulate watershed goals, and identify potential watershed management and rehabilitation measures.

Riparian Vegetation and Wildlife Assessment: A detailed riparian vegetation and wildlife study was conducted by the ACOE as part of an Environmental Restoration Report that was completed in April 2000. Riparian areas within the NMR watershed include wetlands, mowed or cleared areas, mid-successional woodlands, and both immature and mature forests. Aggressive and invasive exotic species from the urbanized watershed were observed to colonize disturbed areas, out competing native species while offering lower habitat value. The study concluded that vegetation in the NMR riparian zone and wetlands is significantly degraded due to the impacts of urbanization in the watershed. The study recommended that wetland creation and enhancement should be a key component of a NMR aquatic ecosystem restoration project. The new wetland areas would purify water, mitigate storm flows, provide low flow augmentation, improve habitat quantity and quality, and enhance species diversity.

The report indicated that the Nine Mile Run - Fern Hollow valley that includes Frick Park and Homewood Cemetery is a large oasis of green space within an urban environment that is particularly unique and valuable. The size of this green space increases its value to wildlife as well as the potential for ecosystem restoration. There are resident populations of whitetail deer and turkey. A wide variety of amphibian and reptile species were observed along the riparian valley. Frick Park is a prized destination for bird watchers and a popular site for outings sponsored by the Audubon Society of Pennsylvania. The reported findings and recommendations from the riparian vegetation and wildlife assessment were used in the watershed planning analyses to identify watershed problems, formulate watershed goals, and identify potential management and rehabilitation measures for the NMR watershed.

3.4 Watershed Management Input from the Water Quality Analyses

A water quality study and assessment was conducted to establish a baseline characterization of the degraded ecosystem in the NMR watershed, which was used to develop a feasibility level watershed restoration plan. The quality of waters within the NMR watershed is influenced by several factors. In dry weather, illicit wastewater discharges are responsible for a significant amount of sewage entering the NMR stream. During wet weather, sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs) discharge a mixture of wastewater and sewage. In the urbanized portions of the watershed, heavy metals, deicing salts, and other pollutants are washed into the stream from highways and nutrient pollutants are washed from lawns. The watershed is also negatively impacted from approximately 17 million cubic yards of steel mill slag that has been piled over an area of over 238 acres near the bottom of the watershed. Leachate from the slag has a very high pH value and discharges into the stream.

3.4.1 Watershed Water Body Conditions During Dry Weather

To collect sufficient data for the water quality analyses, 5 dry weather sampling surveys were conducted by the ACOE at monthly intervals from July through November. In addition, a sixth wintertime low flow survey was conducted in January to quantify the effects of deicing salts. During each survey, samples were collected at eight selected locations along the Nine Mile Run and Fern Hollow stream channels. A list of 50 water quality parameters was selected for the ACOE water quality study for the NMR watershed. Digital data from the laboratory results were input into a statistical analysis that was conducted to compare parameter values from dry weather stream samples to Pennsylvania water quality standards applicable to the NMR watershed.

The following dry weather water quality results were reported. These results were a valuable input into the watershed planning process to help identify watershed

problems, formulate watershed goals, and identify potential watershed management and rehabilitation measures.

- Water quality in the NMR watershed is strongly influenced by dry weather discharges of sanitary sewage and wet weather CSO and SSO discharges. Animal wastes from unleashed dog running also contribute to high bacteria concentrations. The highest concentrations of Coliform bacteria were observed at the outfall of the Braddock Avenue culvert, and concentrations tended to decline sharply as the waters flowed downstream.

- The sewage discharges into NMR also contribute biochemical oxygen demand (BOD) to the stream. Oxygen consumption by a BOD load can suppress dissolved oxygen concentrations. However, the high gradient of the stream promotes efficient and turbulent gas exchange that tends to keep the stream well aerated.

- The sewage discharges into NMR contribute phosphorus, nitrogen, and other nutrients to the stream. Elevated ammonia, nitrate, and nitrite concentrations degrade aquatic habitat quality in the upper stream reaches below the Braddock culvert. The very alkaline slag leachate reacts synergistically with the ammonia contributed by the sewage and amplifies the toxicity of the ammonia load.

- The stream runs relatively clear at base flows. Average turbidity and suspended solids concentrations are usually low except along the Monongahela River embayment area where silt and phytoplankton elevate turbidity levels.

- Dry weather metals concentrations were low. Iron and manganese were the most abundant metals. Concentrations tended to decline as the water flowed downstream, except for the vicinity of the 238-acre steel mill slag pile where high pH leachate brought oxidized and insoluble metals back into solution.

- High pH leachate from the slag pile significantly increases the pH in the stream. The chemical equilibrium created by the slag leachate causes carbonate to form salts with calcium and magnesium that fall out of solution.

3.4.2 Watershed Water Body Conditions During Wet Weather

To collect sufficient data to analyze water quality during wet weather conditions, 5 wet weather sampling surveys were conducted by the ACOE during storms that occurred during the summer and autumn seasons. During each wet weather event, field parameters were measured and approximately 5 sets of samples were collected concurrently at 2 or 3 sampling sites along the NMR stream channel. Storm samples were not collected from Fern Hollow due to travel distances between sampling points and limitations in the number of field personnel. Continuously recording electronic water quality sensors were installed at four stations along the NMR stream channel. Three indicator parameters: water temperature, pH, and conductivity were selected

for remote water quality surveillance. Digital data from the electronic sensors and laboratory results were input into a statistical analysis that was conducted to compare parameter values from wet weather stream samples to Pennsylvania water quality standards applicable to the NMR watershed.

The following wet weather water quality results were reported. These results provided valuable input into the watershed planning process to help identify watershed problems, formulate watershed goals, and identify potential watershed management and rehabilitation measures.

- Storm-induced stream flow peaks along NMR are extremely flashy due to the urbanized nature of the watershed. For example, following a thunderstorm event on July 28, 1999, flow increased dramatically from 2.9 cubic feet per second (cfs) to 670 cfs in less than 30 minutes and receded back to base flow levels only eleven hours after the storm peak.

- Within hours, wet weather concentrations of Coliform bacteria along the stream can increase by several orders of magnitude. However, the Braddock culvert station is chronically degraded to such a degree that storm discharges at times provide some relative dilution to the sanitary sewage problems experienced along the culvert.

- Throughout most of the study period, a strong pattern was apparent from the continuous data during low flows where pH and conductivity were relatively elevated, but decreased sharply when flows increased.

- Continuous data showed the impacts of winter freeze/thaw cycles when deicing salts applied after snow and ice events were flushed into the stream by melting snow and rain. The observed sudden salinity peaks could cause osmoregulatory stress to susceptible fresh water aquatic organisms.

- From an aquatic habitat perspective, water temperature data collected from an in-stream water quality monitoring instrument showed that even during a severe draught year, NMR remains relatively cool during most of the summer. Observed cool temperatures are attributed to shading from steep slopes, a dense riparian tree canopy, and the extensive travel length through dark culverts. A stream this cool, if not degraded by pollutants, could support a prolonged spring season put-and-take trout fishery, with a strong possibility of maintaining summer hold-over trout.

- The continuous record data confirmed that turbulent aeration maintains a well-aerated condition despite the BOD associated with sanitary sewage discharges into the stream. However, moderate dissolved oxygen depressions were sometimes observed along the stream for short durations. These lower range concentrations occurred in the early morning hours during low flow periods and are attributed to

communities of algae that generate oxygen by photosynthesis by day and consume oxygen by respiration at night.

- It was apparent that when rain hit the hot urban streets in the watershed, the resulting storm water runoff could warm the stream by several degrees Celsius.

- Wet weather concentrations of numerous urban pollutant parameters can be highly elevated, but these high storm event concentrations occur at relatively low frequencies and because of the flashy nature of the watershed, for very short durations.