ENVIRONMENTAL SCIENCE IN LOCAL GOVERNMENT: A FELLOWSHIP WITH THE CITY OF HAMILTON, OH

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ABSTRACT

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by Chad A Toussant

This report summarizes my experiences as an environmental scientist professional with the local government of Hamilton, OH. This report outlines my responsibilities over an 11-month fellowship, particularly in regards to use of Geographic Information Systems (GIS). It discusses specific projects such as an inflow and infiltration study with the municipality’s sanitary system as well as a GIS model constructed to reenact a historic flood event in 1913. This paper presents the steps that initiated the creation of the model and highlights the procedures needed to build an animated model within GIS. This paper discusses some of the challenges and problem-solving processes used in a professional setting.
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Introduction

As young environmental enthusiasts, we all have a vision of the job we will be working at when we embark into the professional world- macrobiologist with the EPA, sustainability coordinator at a local park, or wetland delineation specialist for a national consulting firm. We never really know what a job will be like until we work there. But for arguments sake, our vision may be spot on, maybe that ideal job is out there waiting for us to come fill its void, the question then becomes- how do you get there? Is it the first job you land out of the Institute for the Environment and Sustainability (IES) or is it many stepping stones away?

Upon completing the coursework for a Master of Environmental Science degree with a concentration in Water Resources, I accepted a Local Government Management Fellowship (LGMF) position with the City of Hamilton, OH. I was assigned to work in the Department of Underground Utilities. I spent 11 months working with the municipal government and in that time, contributed to other various departments as a City of Hamilton Fellow: Economic development, Public Works, Police, General Counsel, Information Technology, and Utilities.

The role of local government is difficult to define because it has many jobs. Even what we define as a local government has four different categorizations. Local governments can be municipal governments, county governments, township governments, or even special-purpose governments. As a fellow, I was involved in many facets of local governments, not all glamorous but in one way or another every assignment I received either directly or indirectly affected the citizens of Hamilton, Ohio.
History of Hamilton

Hamilton, Ohio, is located on the banks of the Great Miami River. It comprises approximately 62,477 people (US Census Bureau, 2010) on 22.08 mi$^2$. Hamilton is the county seat for Butler County, which is the 8$^{th}$ most populous county in Ohio (USAToday, 2010).

Originally founded as Fort Hamilton (namesake of Alexander Hamilton), it was established in 1791. Fort Hamilton was primarily used as a supply fort during the Northwest Indian War. Due to underutilization of the fort, combined with rich soils and the proximity to the Great Miami River, Hamilton became a trading and agriculture town. By 1803, the town was named, platted, and became a government seat. Hamilton eventually absorbed the town of Rossville in 1855 (Blount, 1989), which sits on the west bank of the Great Miami River. Though there are many bridges connecting the east bank and west bank of Hamilton, there is still a social divide between the two sides. There are even drafted documents that require certain buildings to stay under the City of Hamilton’s possession or the former Rossville has the authority to secede.

Since the late 1880s, the City of Hamilton has been the sole provider of utilities to its citizens. The City does not generate profits payable to stockholders because it is a municipal utility- all profits are re-invested into the improvement or expansion of existing utilities. It is the only community in Ohio to own and operate all four primary utility systems – electric, natural gas, water, and sanitary (Utilities, 2013).

Hamilton has a rich history in industry and in the mid-19$^{th}$ century, it had become a significant manufacturing city, building machines to harvest and process its heavy agriculture production. Manufacturing continued to expand in Hamilton, and by the 20$^{th}$ century it had become a world leader in vault and safe manufacturing as well as paper and paper-making machines (Blount, 1989), industries which were still around until the mid-2000s. With the downturn in the economy, Hamilton experienced the shifts in the manufacturing industries, the rise in unemployment, and migration of industries. Like most of the country in 2012-2013, Hamilton is trying to redefine itself by creating new
industries, moving focus to new energy or alternative energy, and emphasizing quality of life.

**Local Government Management Fellow**

The City Manager of Hamilton, Joshua Smith, has been a driving force in getting Hamilton to redefine itself. He has been a huge proponent of bringing in young professionals to work and participate in many divisions within the City. Hamilton is attracting young professionals is through a partnership with a nationwide fellowship program called the Local Government Management Fellowship (LGMF). The LGMF program was started in 2004 through a partnership with the International City/County Management Association (ICMA). The LGMF is a career-development opportunity for individuals to participate in full-time local government management-track positions. These positions include but are not limited to: city managers, assistant city managers, or heads of departments within the city manager’s office. It is highly competitive, allowing only master degree students to apply to these fellowship openings that are under direct leadership of senior government leaders.

The LGMF is meant to be a stepping stone into local government as well as an accelerant to job promotion and growth in local government management. The LGMF program has been very successful and growing. In the pilot year of 2004, there were six fellows. In 2012, there were 27 fellows from 18 different communities (cities/counties). The success of the LGMF has encouraged expansion of the program and Hamilton agreed to be part of the pilot for this expansion in 2011. Hamilton asked for and received a modification to the fellowship criteria, by proposing fellowship positions that were more technically specific. ICMA authorized the requests which led to the Hamilton sponsoring three fellowship positions- one in the Economic Development Department, one in the Electric Department, and one in the Underground Utilities Department. In this new fellowship format, fellows are designated to individual departments instead of the city manager’s office. Two of the three positions use the alternative fellowship format and the third position (in Economic Development) follows a more traditional route. The fellowship positions in Hamilton are usually filled in the spring and summer and last for 11 months.
In other fellowship locations the positions last at least a year and can be renewed for a second year depending on the position and the willingness for an employer to renew a fellow’s position. There are two stipulations that each host division must follow, including Hamilton.

1) There is a minimum compensation that is provided to the fellows.
2) The fellowship program obligates that the hiring body (city or county government) send each of the fellows to the annual ICMA conference. At the conference there are many opportunities to learn, explore, and network through keynote speeches, panel discussions, and social activities both sponsored and unsponsored by ICMA.

In October 2012, I attended the conference in Phoenix along with the fellows in the Electric and Economic Development departments. I spent time attending many of the panel discussions on renewable energy, waste management, and personal financing.

**Underground Utilities Fellow**

2012-2013 was the second year of Hamilton’s fellowship program. I was chosen from a pool of candidates to be placed in the Underground Utilities fellowship position. Every department has a director or an assistant director to whom each employee within that department directly reports. Jim Collins was the Director of Underground Utilities for my first eight months, and then Doug Childs filled in as acting director for the remaining three months of my fellowship. Working in the Underground Utilities Department allowed me to work with the utilities of gas, water, and wastewater, conduct some fieldwork, assist in administrative duties, and work extensively as a GIS analyst. As a free-lance worker within the department, I helped my superiors with research, data analysis, and problem solving. However, most of my time was devoted to working with Rose Haverkos, Senior Engineering Technician. Rose Haverkos’ duties were to maintain the utilities in GIS for gas, water, and wastewater. Rose is used interdepartmentally and is
asked to assist on other projects related to GIS work within the city, particularly Public Works and the City Manager’s Office.

Early in the fellowship position, in addition to working with GIS, I assisted Darla Bokeno, Administrative Assistant III, on several small projects. One of the projects involved researching and drafting new regulations for the city regarding the prevention of fats, oils, and grease (FOG) build-ups in sanitary laterals. The city has had a history of grease problems in the sanitary system where a “grease-ball” gets stuck within a pipe and causes sewage to backup in the system. I researched the surrounding municipalities to determine what regulations (preventative measures, penalties, reporting) existed for FOGs. Through researching many municipal regulations, the newly crafted regulations for Hamilton offered more protection to the City of Hamilton against problems associated with FOGs but at the same time were not as restrictive as other municipalities so not discourage businesses with too many or too restrictive regulations. The City of Hamilton also wanted to update its policies regarding service laterals (the entry point from private property to sanitary line connection) to mandate house owners to be completely responsible for fixing problems on the entire lateral. Most municipalities have regulations that mandate property owners to be responsible to the right-of-way and Hamilton wanted that same responsibility to go to the property owner, too. After a draft of regulations for both FOGs and service laterals was written, it was reviewed by our head plumbing inspector, Andy Flum, to determine what is acceptable and applicable with the City. The draft is going through its final revision and will be sent to the director of the department and then presented to the City for the final approval (Appendix A).

Another project Darla Bokeno asked me to take the lead on was an industrial survey that is required by the Environmental Protection Agency (EPA) to be distributed to all industrial wastewater customers. The survey’s intent is to identify individuals responsible where a wastewater account is located as well as any possible contamination issues present at the property in question. Respondents are asked to report all solvents, chemicals, acids, oils, and principal raw materials used at the site in question. They are also asked if the given property/facility they are reporting on has a Spill Prevention,
Containment and Control (SPCC) plan. Though already drafted, I was asked to clarify the wording for improved interpretation by those receiving the survey. For this project I collected, recorded, and filed all information reported by returned surveys.

Throughout my term of employment, I had various other projects and tasks to complete including creating maps for grants, proofreading work to be published, and serving as a consultant on a possible wetland development project in the City’s industrial park. I also served on a subcommittee of the Economic Development Department to help create ideas to be investigated and possibly implemented to supplement Hamilton’s economic growth. However, I had two projects that I really enjoyed and were a great benefit to the City and Underground Utilities Department. The first project I worked on had to do with mapping a section of the City’s sanitary layer for an Inflow and Infiltration study. The second project and the one I was the most passionate about at the City involved creating a video model of the historic 1913 flood.

Inflow and Infiltration

Hamilton has been operating a wastewater utility since 1893. Today, it serves about 23,000 customers within the City and surrounding area and it consists of sanitary sewer collectors and wastewater treatment facilities. The City’s wastewater system is issued a National Pollutant Discharge Elimination System (NPDES) permit from the state of Ohio, which is required by the Ohio and Federal Water Pollution Control Acts (Gruenemeyer, 2012). The NPDES Permit Program is authorized by the Clean Water Act of 1972 and “controls water pollution by regulating point sources that discharge pollutants into waters of the United States” (EPA, 2012). The program has been significant in improving our nation’s water quality. NPDES permits must be obtained by municipalities, wastewater industries, and other industries if their discharges go directly to surface waters. (EPA, 2012) A wastewater discharge operation must stay compliant with the guidelines of the NPDES permit by limiting effluents and by following monitoring requirements and operating parameters. (Gruenemeyer, 2012)
In older cities, a lot of the sanitary and stormwater systems are combined systems, meaning that the flow from sanitary use and flow from stormwater collection share the same system of pipe. Unique for an older city, Hamilton’s sanitary and storm sewer collection systems are separate, but even with sanitary and storm collections flowing through different pipes, the City still has overflow problems. If Hamilton’s system becomes too inundated, sanitary water will back up to and flow out of Sanitary Sewer Overflows (SSOs). SSOs are specific discharge areas spill into a body of water (usually a stream or river). Sanitary systems discharge at these designated points instead of backing up into residents homes. It is estimated that 40,000 instances of overflows in SSOs occur every year throughout the U.S., dumping untreated sewage into U.S. waterways (EPA, 2012). As part of the NPDES compliance requirements all discharges out of an SSO must be reported. At each SSO, the City has flow meters that can track and log when the system overflows. The overflows in the City of Hamilton’s system are caused by Inflow and Infiltration (I&I) - mostly during wet weather events. I&I problems result from leaks within the system. The main instigators for leakage include pipe joints, manhole lids, customer laterals and cleanouts, and improper connections (Gruenemeyer, 2012).

In 1991, the EPA and the City created a Consent Order – a final and binding judicial decree – that would settle a claim that the City was non-compliant with its NPDES Permit. In 2007, the Ohio EPA alleged that the City was violating the terms of the 1991 Consent Order. This resulted in a Modified Consent Order that required the City to address all non-compliance issues by October 1, 2014. To satisfy the 2007 Order, the City of Hamilton began investigating the NPDES non-compliance issues in 2012. It was assumed that the problems with overflows occurring in the sanitary system were a result of I&I and mostly the result of weather precipitation events. One of the earliest assignments I received was to investigate two of the City’s sewersheds where the surcharges in the overflows were occurring. Within the City’s sanitary system, there are 17 monitoring meters- 5 of those meters are located in the two sewersheds of interest (the sewersheds that have overflows) - to track flow and possible problem areas from month to month should a problem arise. For the two sewersheds of interest, I download the data from the meters at the two overflows and the rain data for gauges closest to the areas of
interest. Gathering the data and checking it for missing/inaccurate data as well as cleaning the data so it was in a usable format took several weeks. Once the data was clean, I used Microsoft Excel to download and standardize thousands of records from multiple data sources. Compiling the data and gathering results from the data took an additional week of time.

![Graph of rainfall and flow](image)

Figure 1 Rainfall (tenths of inches) and flow at overflow 027 at Schwartzwald Park in Hamilton, OH. The graph also displays the occurrences when another meter was detecting an overflow at this specific location are shown.

The results we found were not as conclusive as we hoped from initial investigation. In some instances there seemed to be a direct correlation between a rain event and an increase in flow- sometimes leading to an overflow occurrence (Figure 1). Several times in Figure 1, there is not a definitive dependence, but upon deeper investigation, it was determined that most of these disparities could be attributed to a malfunctioning machine. We also determined that the area we were investigating was too large with too many pipes to review from just a quick compilation of flow and precipitation. The sewersheds in the City relating to the overflow locations have 92+ miles of pipe that flow into them, and specifying a smaller location became important to finding a solution to the overflow problem(s). Once smaller areas could be established, more monitoring meters would be placed in the system to provide more data.
To begin the monitoring process, Stantec (a nationwide consulting firm the City of Hamilton uses to help maintain its sanitary system) came to the office to discuss terms of the project. The City of Hamilton does not own flow meters. The meters in Hamilton’s system are leased by Stantec. Using Stantec representatives as advisors on this project, it was decided that the monitoring duration should be at least three months long and that the spring season would provide the most precipitation events so that the hypothesized correlation could be confirmed. The City of Hamilton determined that the data would be collected monthly from the flow meters. In hopes that the study would lead to the discovery of areas of high I&I, the City would take the next initiative to locate specific pipes. However, before any of the monitoring could begin, a map had to be created signifying the number and locations of the new monitoring meters that would need to be placed in the two sewersheds. I was tasked with researching and designing a layout of how the sanitary system would be monitored in the two overflow sewersheds in the NW corner of the City.

To design the project, I used Geographic Information System (GIS), a computer system that integrates hardware, software, and data to manage, capture, analyze, and display all forms of geographically referenced information (ESRI, 2012). The program integrates maps and visual representations of physical attributes to allow for processing, assessing, and modeling. When operations in GIS are used to emulate geographic processes in the world, variable to time, this is known as modeling in GIS (Maguire et al., 2005). There are several programs within the GIS software that may be used to create a model. ArcMap is the mostly widely used interface. It is visualized in a 2-D aerial perspective. An extension of this interface is ArcScene which is an application that displays information in three dimensions. For more information see Appendix B.

Within GIS, one can build a geometric network which is created from a set of points and lines (or edges and junctions) that have connectivity rules. This network is used to create/represent a common network infrastructure. The geometric network is specifically designed to simulate utility infrastructure such as electric network, sanitary and water
systems, and telephone services. To make changes or use the geometric network for extracting information one uses the infrastructure toolbar.

The infrastructure toolbar has several tools that allows for a series of different modeling activities. One of those modeling features is the trace tool. This tool simulates path of travel, meaning that a point (in a sanitary system- a spot on the pipe or manhole) can be picked and one can see all the possible places the flow in that line came from at that specific point (Figure 2) - in other words, where did flow drain from to end up at the specific location in question. The trace tool also can display all the places the flow in the pipe at that point can go downstream.

When it was decided that GIS could perform this kind of analysis, researching criteria needed for investigative modeling became top priority, so that the most accurate data could be collected. After consulting with Stantec, it was determined that no meter should monitor more than 20,000 feet of pipe. It was also recommended that isolating pipe would help secure better data and narrow the areas for further investigation. Creating isolation for monitored pipe is difficult because the system intertwines so much (Figure 3). To improvise, some monitors were collecting data for more than 20,000 ft, but some of that pipe system was being monitored by another meter, so that any one meter would
not be monitoring any more than 20,000 absolute feet. If the study would have been set to total pipe isolation, some meters would have been monitoring more than the 20,000 foot limit.

As specific locations were being determined for placing the flow meter, we encountered two other obstacles. First, flow meters are located in manholes and they can only accurately monitor water coming into the manhole and only one meter per manhole is allowed. Second, manholes that had recorded a surcharge could not be used. A surcharge is when a manhole becomes filled (also called a backup) with sewage from blockage within the pipe. It can also be caused by too much water trying to enter a pipe that is too small. After some of the manholes had been chosen and the placement of meters had begun, it was discovered that some of the manholes had recently surcharged. Some of these surcharges were occurring in manholes that should not have been showing back-ups, so crews were sent to the manhole and the pipes downstream of the manhole to clean out the pipe and stop the blockage in the pipe.
Figure 3 NE section of study area for Inflow and Infiltration.
The result from isolating and measuring the proposed sanitary line for each monitoring meter determined that an additional 25 flow meters should be added to the system for this study. The meter to pipe length (ft.) ratio was ~1:18,000. Along with the map (Figure 4), a document of manholes, inflow direction, pipe diameter, and river crossings (a river crosses over a pipe being monitored) was supplied to Stantec for reference. The final map displays the flow meter locations as well as the lines that were monitored. Monitoring began in the middle of April 2012. Our first couple months of results helped support our hypothesis about the relationship between precipitation events and increased flow within the sanitary system. Namely, more rain appears to cause the system to fill beyond capacity and pour out of the overflows.
Proposed Flow Meter Locations

Figure 4 Map of proposed meter locations for the I&I study in the City of Hamilton, OH.
Modeling the 1913 Flood

History of the Flood

In 1913, the City of Hamilton was part of a series of natural disaster events that occurred across the whole eastern half of the United States. Coined as a ‘National Calamity’ by historian Trudy E. Bell, the flooding events that occurred the third week of March 1913 had an unprecedented effect on Hamilton. The two counties north of Cincinnati, OH, Butler and Montgomery, suffered the greatest flooding in the country (Horton, 1913). Many cities saw historic flood levels and many experienced great losses and suffering. The cities of Dayton and Hamilton faced more devastation than most and maybe all others. Dayton suffered the most in property damages claimed by the United States Geological Survey (USGS), but “in proportion to its size (damage in dollars per capita), the city of Hamilton probably suffered more seriously than any other” (MCD, Vol1). In 1913, flooding in Hamilton took place over the course of 3 days, killed hundreds of people, destroyed thousands of homes, and cost millions in damages (Horton, 1913).

Rain began falling on the Miami Valley on Easter Sunday, March 23, 1913. A substantial area of Ohio faced excessive precipitation which was the main cause for the extreme flooding in the area. Estimates conclude that about 8-10” inches of precipitation fell over a 4 day period. This coupled with the already saturated ground from a January that produced the fifth wettest month on record from 1885-1920, led to a 90% runoff (amount of precipitation that is not absorbed into the ground) rate at the head of the Miami River. Heavy rains in January had caused the ground to reach saturation, and a cold and cloudy February kept the ground saturated. For the year of 1913, the total runoff was 23.09”.

What made 1913 precipitation events unique were the maximum values of rainfall and runoff during the storage period (January to April) in early 1913. Because January 1913 was the fifth wettest month in that 25 year period and March was the wettest (Woodward, 1920), the water had nowhere to go but into the rivers of the Miami Valley.

Dayton, OH is located at a convergence of three rivers: the Mad, Great Miami, and Stillwater. The Mad and Stillwater are tributaries to the Great Miami. Because Dayton
was at this convergence it had levees built around it, and Dayton had even strengthened its levees from a flood in 1897, when the water had backed up and flooded a section of town (Sullivan, 1940). Unlike Dayton, Hamilton had very gently sloping banks and no flooding prevention structures. It is widely accepted that Hamilton had flooding issues prior to the 1913 flood. Historical accounts coupled with geologic samples and geomorphology studies suggest that flooding events had actually reached downtown streets in previous years (Horton, 1913). However, no flood was ever so threatening that it warranted a plan and development for protection. This has led to the belief that “a large share of blame for the resulting damage must be laid to man, not only for the positive harm done by the works for municipal and rural improvements but also because of the entire absence of an comprehensive engineering works built for the prevention of such flood damages” (Horton, 1913). The flood led the City of Hamilton to the realization that it was completely vulnerable to excessive flooding, which brought about a conscious effort that would see outstanding planning and engineering in the next several years after the flood.

The follow excerpt from “The Floods of 1913” presents a timeline and describes the rising water and the post destruction:

    The official river gage at Hamilton showed 4.8 feet of water in the river on the morning of the 24th. By noon it had risen 4 feet and at 5 p.m. the reading was 12 feet. At 6 a.m. March 25, the reading was 18.8 feet, at 5 p.m. it was 25 feet, and at 3 a.m. of the 26th it had reached its highest point of 34.6 feet. The observer, Mr. Earl W. Scott, reports that by noon on the 25th the water was 2 ½ feet over the main street bridge and that the bridge was destroyed at 12:25 p.m. Later in the day the railroad bridges went out, thus leaving no connection with the two sections of the city. By night of the 25th, the water covered all streets on the east side of the river and four streets running north and south on the west side. The water was not high enough in most of the business section to damage goods on the first floor, but in some of the of the residence districts it was from 10 to 18 feet in depth. Forty-six percent of the city was flooded, 335 houses were destroyed, and over 200 lives were lost. (Henry, 1913)

The damage caused by the flood in Dayton and Hamilton was incredible. The city of Hamilton claimed $15,000,000 in damages, which equates to about $343 million in 2012 dollars. Dayton had damages that were estimated at over 6 times that valuation. The damage was catastrophic, but a citizen’s rally around the idea, proposed to bring in the best engineers for consultation, led to a citizen’s group of 23,000, headed by local
businessmen John Patterson and Edward Deeds to raise over 2 million dollars. On average, each individual in attendance of the rally donated $87 dollars (Horton, 1913). In today’s money that would mean 23,000 people would average a donation of $2,000 dollars each- quite a feat for a pair of cities that had just been destroyed by a natural disaster.

In February 1914, the proper legislation was written and approved for the formation of Conservancy Districts throughout the state of Ohio and the Miami Conservancy District (MCD) was formed in 1915 (MCD, 2009). With the guidance from engineer Arthur Morgan, a Tennessean, the plan MCD formulated to protect against flood waters was extensive and thorough. It was obvious that the current river channel could not support the volume of water flowing in 1913 with previously built levees all along the Great Miami River. Investigations and limiting factors were explored at all the municipalities along the Great Miami River channel. The Conservancy District could not simply or exclusively widen the channel or make it deeper. In many spots, there were encroachments of both building and streets which restricted widening the channel. The Great Miami River had an average slope of 0.066% which is fairly steep and creates high velocities at high water, so deepening the channel would increase the slope and consequently increase the river velocity unless significant work was done further downstream and out of the scope of the project (Engineering News-Record, 1920). Eventually it was agreed upon to widen the channel and construct levees in Hamilton.

The channel was up to 150 feet narrower in Hamilton than in Dayton, but the river channel was deeper which generally allowed it to hold all the water coming from Dayton. The extra depth of the river was not enough to contain the volume of water in the channel in 1913, so this mandated a physical change to the channel. The plans advised widening the channel from 390 feet to 520 feet. Widening the channel forced many of the buildings close to the channel to relocate, which was somewhat controversial considering the importance and size of some of the structures. Widening the channel and increasing the levee height created a free-board (at least 3 feet remain on the levee above a 100 yr flood projected volume within the levee banks) of 3 feet to 10 feet from the south to the north ends of town, respectively. The channel plan was designed to protect against a flood
discharge near 40% greater than the discharge crest during the flood or 1913 (Woodward, 1920). The Miami Conservancy District was ambitious and began construction on all 5 proposed dams from its flood prevention plan for the Great Miami River in 1918, while also building the levees and widening the river in Hamilton. The work was completed in an astounding 5 years, which included the five earthen dams. It employed over 2,000 workers and cost more than $30 million. At the time it was completed, it was the most comprehensive flood protection system in the nation. Since the original completion year (1922), the dams have stored flood waters over 1,700 times.

Today, MCD’s system protects over 48,000 properties in five counties, more than $5.1 billion worth of buildings and land, and tens of thousands of people in 40 municipalities. MCD currently maintains 5.1 miles of levee and 3.8 miles of “improved” channel in Hamilton (Figure 5), which is the most downstream local protection feature (MCD, 2009).

In commemoration of the 1913 Flood, the Michael J Colligan History Project, a joint program between the Hamilton Community Foundation and the Hamilton Campus of Miami University, put together a 2-month program that included speeches, public presentations, walking tours of important events relating to the flood, and dedications of commemorative sculptures. Most of these events were arranged and attended by senior members of the community. These members either had a direct connection to the flood—parents or grandparents who actually lived through the event or were historical enthusiasts. One of these members was named Curt Ellison. He is a professor at Miami University Hamilton and is the head of the Michael J Colligan History Project. At a
meeting in early February 2013, he inquired if there was a model somewhere of the flood that could be shown to the public. Alison Haskins, a City of Hamilton employee and amateur historian notified Ellison that a model did not exist, but told him it could be done by a couple individuals at the City. Through Haskins, Rose Haverkos approached me about this project to gauge my interest and if she thought it was feasible. At first, I was very intimidated and apprehensive, but with reassurance from Haverkos that we would work together, I accepted the project.

**Constructing a Model**

A model is “a representation that simplifies a system by focusing on key features to explain and predict scientific phenomena” (Schwarz et al, 2009). Models are often used for two different representations: a target system or a theory. A target system models data or phenomenon. Most phenomenon models are scientifically based. They use physical features that have known limits and measured responses to assumed accurate predictability (Frigg, 2012). Modeling the flood of 1913 is an example of phenomenon modeling because it takes known observable quantities with physical attributes and ties them together. When beginning to construct a model, it is important to understand who will benefit from it; it is important to “engage learners in scientific practices”- social interactions, tools, and language that represent the scientific knowledge the modeler gathered, constructed, and evaluated before being communicated to the targeted viewer (Schwarz et al., 2009). Once the goal the modeler has for the audience is defined, the efforts of the modeler can be focused on that end goal/product.

**Purpose of the Model**

From the inception of the idea to model the 1913 flood, we agreed that the audience for this model would be the general public. It would serve as an educational piece to interested citizens who had a curiosity about the flood and who wanted a more holistic perception of the flood than could be obtained through audio recordings and black-and-
white photos. We decided through the creation of this model, we could tell a story of those who lived through the flood and relate to current citizens of Hamilton. We decided that the model would focus on topography and stream gauge measurements of 1913, but the details (specifically the High/Main St Bridge and the buildings) within the model would be accurate for today. In other words, what if there had not been the movement by the citizens of Hamilton and Dayton to invest large amounts of money to seek out Arthur Morgan or prodded the governor to create the conservancy districts? What if MCD had never been created and the work to expand the channel and raise the levees had never been initiated and today Hamilton faced a flood as furious as the one in 1913? What would the city look like under those conditions?

**Contour input data**

To recreate the 1913 flood in GIS, the data requirements included elevation data, stream gauge heights, and elapsed time. Finding a suitable dataset to extract the data from was the first step. Originally, elevation data was going to be pulled from the 1915 USGS topographical map. Though it was two years after the flood, it was agreed that the landscape had not changed much from the flood. A U.S. Geological Survey (USGS) quadrangle, topographical map provides contour lines in 20 foot intervals, which was too broad to get the desired accuracy, so another map was chosen to be the baseline for the model. A topographical map that the Miami Conservancy District had created in 1915 provided much more detailed contours often displaying the contours in 1-ft increments (Figure 6). This map also had high water marks at various locations as well as a visual gradient of the depths of water at the peak of the flood. Entering elevation data is a time-consuming process, as all numerical inputs and designs must be manually put into the system. For this project, that meant importing the map into GIS and tracing all contour lines within the GIS software.
Figure 6 1915 Topographical map created by MCD displaying data on both land contours and high water marks from the 1913 flood in Hamilton, OH (Miami Conservancy District, 1918).


**TIN and DEM creation**

Once the contour lines were put into the GIS software, there were several processes that had to be completed to get a surface representative of the area that was being modeled. The first process involved converting the line data into a Triangulated Irregular Network (TIN). TINs are used mostly for small areas that need high precision. They are constructed by triangulating an irregular spaced set of nodes (Figure 7). TINs use the Delaunay triangle criterion, which means that the shortest distance between nodes is used to connect all the vertices within the study area. This guarantees that no vertex lies within the interior of any of the circumcircles of the triangles in the network. TINs are important for creating surface interpolation because the edges form non-overlapping, contiguous triangular features that capture linear features like ridgelines and stream courses really well (ESRI, 2008). The actual construction of the TIN is done internally and only needs contours as input data. In Figure 7, the lighter color represents the lowest elevation in the image. The grey color in the bottom right corner represents the highest elevation.

If the elevation nodes had been collected in a regular, gridded format, then the process of creating the TIN could have been skipped and the Digital Elevation Model (DEM) could have been created a step sooner. Because the elevation nodes had been collected at high-water marks, the TIN had to be constructed before the actual surface could be built. The DEM is a representation of a continuous surface using digital data on a cell-based system (Figure 8). The specificity of a DEM is determined by the resolution, which is the length of the cell-size (ESRI, 2012). When choosing cell-size interpolation there is a tradeoff:
specificity vs. time and data storage space. For this particular project, a resolution of 2.5 ft. was chosen. This provided good interpolation of the changes in topography with the given study area, but it was not so detailed that the processing required a huge amount of time and data storage space. The DEM more clearly displays the gradual changes in elevation. The deeper purple colors signify areas of low elevation and the darker green colors represent higher elevation areas.

**Integrating with ArcScene**

ArcScene is an application within ESRI’s GIS software. It allows for the 3D visualization of data. It takes the creator or viewer from a strict bird’s eye view and allows for a full 360-degree rotation in both the x and y directions. With the ability to change the visual perspective, ArcScene also allows for a process called draping to occur. Draping is another aesthetically pleasing attribute in ArcScene where a modeler can take pictures and overlay them on a 3-D object to give the 3-D object (e.g., a building) an authentic look (ArcGIS, 2012). Besides the visual enhancements that can be found in ArcScene, the extension also has other practical use, such as allowing a modeler to gather heights within datasets to be interpolated.

Because this model was going to be used for general public education, Rose Haverkos and I wanted to use ArcScene for the visual authenticity that the extension provides, but we also wanted our model to be accurate and show the height of the water on buildings at a proper level. ArcScene has the ability to display a feature’s vertical component. The data imported from the original ArcMap file has to have the following two components of the display designated properly: the stretch of the raster and the vertical exaggeration of the model. Raster data (ex. DEM) represents continuous data; you can apply a stretch (dependent on the input data) that allows for better color representation. Datasets that cover large areas or a small range usually need some kind of stretch so that the change within the data can be better displayed—creates more contrast. The study area for the 1913 flood was not very big, and with over a hundred feet of elevation change throughout the study area, changing the stretches had only small effects on the representation of the data.
The best stretch for the data was the Minimum-Maximum stretch. A Minimum-Maximum stretch helps spread out tightly-grouped numbers. Applying the Minimum-Maximum stretch provided the best display of color, which showed the changes in elevation the most prominently.

The second component to be considered when displaying data in ArcScene is the vertical exaggeration. Vertical exaggeration is a process that stretches features vertically based on their elevations. Vertical exaggeration can/should be used in two instances: 1) If the elevation component or z-value is not in the same coordinates system as units in other datasets within the map (e.g. contours in meters and buildings in feet), then a conversion through a vertical exaggeration should be applied to align the units of the different coordinates systems. 2) If the topography of the feature(s) being highlighted needs to be emphasized to demonstrate a point, then a z-factor should be applied to make the point more prevalent (ArcGIS, 2013). In this project, vertical exaggeration was analyzed to determine if it should be used to accent subtle changes in the surface. When contemplating the use of vertical exaggeration, one should consider that all layers will have the vertical exaggeration applied to them. Specifically using this project as an example, buildings were added to the surface of the project at a later point and providing a vertical exaggeration made the buildings become unrealistically tall. For the 1913 flood model, a vertical exaggeration was not necessary to add. The model focused on everything east of the Great Miami River, which is very flat (and why it flooded so badly). If a vertical exaggeration had been added to the project, the notion that the slightest change in flood stage affected vast areas of land and buildings because of the flat geography on the east side of Hamilton would not have translated visually.

**Adding stream gauge data**

ArcScene is a 3D visualization application. It allows any GIS display to be moved in the horizontal and vertical directions. For this model, a layer simulating the river was created to recreate the 1913 flood. The river polygon in this model was originally constructed as a flat surface and as a slicing layer, where it dissected the surface layer already imported.
into ArcScene. For this model, the river polygon’s position in space and its thickness were changed to give a better representation of the actual river rising. In the 1913 model, the orientation in space was a height above sea level and the thickness was the measured depth of the river at different time intervals throughout the flooding timeline.

Within the properties of each layer in the ArcScene application, there are two functions that are necessary for modeling water in particular: base-heights and extrusion. The base-height tab allows one to place the layer in the z-direction (the height above sea level). From data collected, it was determined that the bed of the river in 1913 was at 569 ft above mean sea level. Using the base-height’s tab, the river polygon was set to 569 ft. The next step was to adjust the depth of the river polygon to match the measured data from 1913. To set the depth of the river for different points throughout the four days that the model would emulate, the extrusion tab was used (see Figure 9). Using the extrusion application provides the viewer more information than simply changing the base height but it also provides a more realistic view of the dynamics of the river.

![Image](Figure 9 The river polygon demonstrating the effects of extrusion. The river on the left has a depth of 5 ft and the one on the right has a depth of 12 ft.)

**Data Verification**

A program called Sketchup, a 3-D modeling program for architecture and building design, was used to create and incorporate the current buildings in Hamilton into the
model of the 1913 flood. This proved to be a great asset because it allowed for the audience/viewers to identify the expanse of the flood and the heights it reached within the city in 1913 on buildings they were familiar with today. It also helped serve as a data verification interface. Once the buildings were added to the model, verification of the data could begin. Using the measure tool, water heights on buildings were tested against historical markers on buildings that existed in 1913 and had been previously surveyed. It was determined that the model was very accurate, displaying flood levels within a 1ft. Because GIS is not an architectural program and does not have the accuracy specificity of other programs such as AutoCAD, the outcomes from this model were very acceptable, especially given the audience. This model was not intended to find anything new relative to the flood, but it was instead intended to be used as a visual informational piece for citizen education and enjoyment.

One of the more satisfying accuracies in this model is shown in Figure 10. This image shows water on the east side of town coming down 9th street. This is often unknown to many citizens yet crucial to the understanding of why citizens ended up stranded in their homes. The north reservoir broke and water rushed down 9th Street to effectively create an island on the morning of March 25. This island effect drove many citizens to the second story of their homes since they no longer had the option to flee further east away from the river. By many accounts, people in 1913 were stranded several days in the upstairs of their homes.
Creating the animation

The last step for this model was producing it as an animation. ArcScene has an animation feature that allows for two different types of animation—group layer animation and fly-over animation. Fly-over animation does not allow for a time component, but does allow the viewer to travel continuously all over the map. The group layer animation works better for a stationary setting (though one may choose to move within the map, it will not be continuous) and time lapse. Because the time component is crucial to understanding the flood and how people died and were trapped in their homes, we opted to use the group animation feature for our model. The group layer animation takes snapshots and strings them together like a flipbook. It also interpolates what happens between those snapshots when a time component is used. Within the animation one can change the background effects as well as the altitude and azimuth of the sun, so one may display
daylight and shadows accurately. This gives a more realistic perception within the animation. For more information on group layering and animation, refer to Appendix C.

**Enhanced Video Production**

Once the modeling within the ArcScene program was complete, the animation was converted to a video. The exported animation from ArcScene could not stand alone; there was no context without a verbal introduction. If one were to view the animation without an introduction or an explanation of what they were about to see, they would not understand what was being shown. The whole goal of this project as stated previously was to provide a visual and educational piece to help people understand and relate to the flood. To enhance the experience, it was decided that additional visuals and audio should be added to the video. Collecting a sound bite from a 1980 interview from a woman who had lived through the flood was the first piece. It took several hours of editing and cutting to create succinct dialogue between the interviewer and interviewee that fit with the model. To supplement the original video, several images were also added to mesh with the some of the events that the woman discusses in the sound bite. Finally, to help give more substance to the video, several slides of text were added to help people understand what the model was showing them as well as explaining why Hamilton has not had a flooding problem in recent history. I have added screen shots (Figure 11) of the flood from the model.
Figure 11 Timeline of the flooding stages from the morning of March 24 (a), evening of March 24 (b), noon March 25 (c), evening March 25 (d), peak 3 am March 26 (e), and flood retreat noon March 27 (f).

Results

The final product was a two minute, 54 second video that has received over 2300 views on YouTube: http://www.youtube.com/watch?v=0Z4R-IsSATA as of May 1, 2013. The
model took over 100 hours to develop, calibrate, and edit. The learning curve with GIS and its extensions is incredible. If I were to repeat the process, I could now build it start to finish in eight hours. The reception has been great and the positive reviews have been really appreciated. The video has been presented at several banquets and was also a featured article in the Hamilton-Journal News. Rose Haverkos is hoping to present the model at the national ESRI conference in the fall of 2013. This would be a great recognition for Rose Haverkos and me as the modelers and for the City of Hamilton and the great GIS system they have to offer.

**Conclusion**

Local governments serve the best interest of the people that reside in their jurisdiction. Through education, law crafting, and local mandates, local governments like Hamilton keep themselves, their citizens, and the environment progressing. Not all laws and mandates are received particularly well; for instance, the costs to prevent fats and greases from entering the sanitary pipes that individuals will incur from the newly drafted regulations will most likely receive opposition. However, the population as a whole will benefit from wastewater not backing up in the system. What is important is that a local government serves its people with the best interest of the population it serves and in the most efficient way. The one thing which the LGMF tries to do is provide you with a holistic view of the movements of a local government-through the encouragement of meeting attendance and a working/social relationship between departments. I think the program coupled with management of Hamilton successfully demonstrated to me the general processes needed to thrive in a local government.

The City of Hamilton is making strides to redefine itself through renewable energy and rejuvenation of the downtown area. Over the last 3-4 years, Hamilton has been working to move in a positive direction by infusing young, motivated talent. By integrating new professionals with established employees, the City hopes to create a movement that keeps operations that have worked well in the past running efficiently while incorporating new
ideas and directions which will help Hamilton rebound from the financial constraints that have plagued post-industrial cities.

Working for the City of Hamilton put some of the core principles of IES into perspective. As an IES student, we are taught to problem solve. For me, I experienced little snippets of problem solving in most projects I worked with, but constructing the 1913 Flood model really used those skills developed in IES. For instance, when Rose Haverkos and I had planned the steps to create the model, we had every intention of using the USGS 1915 topographical map, but when the contours turned out to be too general, we had to proceed to our backup plan within the first two days of working on the model.

Another staple of the IES program is learning to work in teams on a project. Every project I worked on this year required some kind of team work. With some of the database entry tasks, it was just a matter of discussing formatting of the data. But larger projects and especially the model, it took a real collective effort to overcome some of the obstacles to complete the model. There were times in those 11 months when I would work on a section of a project and hand off a task to another individual and then receive another task back or asked to alter my work 6-8 weeks after I had done the initial task. This was always challenging because trying to remember how or why you did something months ago can be difficult, but a key part of working with a group is that everyone works at different paces and has their own list of priorities in their work. Everyone has a set of prioritized tasks and synchronizing the efforts on a project is very difficult. As I move forward professionally, I will try to incorporate the lessons I have learned in the IES program and from my 11-month internship with the City of Hamilton to develop a better set of skills to coordinate in group projects and grow the skills of problem solving.
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Appendix A

City of Hamilton
Proposed Fats, oil, and grease (FOG) Regulations and Lateral Regulations
August 13, 2012

931.03- USE OF PUBLIC SEWERS, letter (q) No person shall discharge, cause to be discharged or permit to be discharged, into any City-owned sanitary sewer any of the following described substances Section 2- Any water or waste which may contain more than 100 parts per million, by weight, of fat, oil or grease, or which may cause pass through or cause interference as defined by this chapter.

For Food Establishments:
(s) Grease, oil and sand interceptors shall be provided for outlets connected with the City sewers when the content of fats, oils, and greases surpass the noted part per million by weight in the aforementioned paragraph. If excessive amounts of grease are expected or measured, a grease inceptor shall be installed and maintained by the owner, at his expense, in continuously efficient operation at all times.

(t) Grease interceptor sizing shall conform to the specifications of the current edition of the Ohio Plumbing Code, as enforced by the City of Hamilton Health Department. Minimum outside grease interceptor size shall be 1000 gallons. The inceptor shall also have the capacity as defined from table XXXXX.X.X.X.

(u) Properties with a grease inceptor shall submit appropriate documentation of all grease interceptor cleaning, pumping and/or maintenance activities to the City of Hamilton within five (5) business days of any such activity. Documentation may be faxed, mailed, emailed or hand delivered to ____________________.

Oil separators required.
(v) At repair garages, car-washing facilities, at factories where oily and flammable liquid wastes are produced and in hydraulic elevator pits, separators shall be installed into which all oil-bearing, grease-bearing or flammable wastes shall be discharged before emptying into the building drainage system or other point of disposal.

Garages and service stations.
(w) Where automobiles are serviced, greased, repaired or washed or where gasoline is dispensed, oil separators shall have a minimum capacity of 6 cubic feet (0.168 m³) for the first 100 square feet (9.3 '²) of area to be drained, plus 1 cubic foot (0.28 m³) for each additional 100 square feet (9.3 m²) of area to be drained into the separator. Areas’ of commercial garages utilized
only for storage of automobiles are not required to be drained through a separator.

Table XXXXXX.X.X.X

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<tr>
<th>Total Flow-through Rating (gpm)</th>
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(x) Properties with an oil separator shall submit appropriate documentation of all oil separator cleaning, pumping and/or maintenance activities to the City of Hamilton within five (5) business days of any such activity. Documentation may be faxed, mailed, emailed or hand delivered to ____________________.

CONNECTIONS TO PUBLIC SEWERS

All connection shall be gastight, watertight and subject to inspection by the Director of the Underground Utilities or designee; the property owner or his agent shall notify the Director or designee when the building sewer is ready for connection to the City's sewer line and the actual connection shall be made under the supervision of the Director unless indicated otherwise.

Size of Pipe
1) Within the public right-of-way or easement: 6-inch minimum from the public sanitary sewer main to the right-of-way or easement line
2) Outside of the public right-of-way or easement:
a. 4-inch (4”) diameter minimum - single family dwelling
b. 6-inch (6”) diameter minimum – commercial, industrial and multi-family

Approved Pipe Material
1) Plastic:
a. 4-inch (4”) Schedule 40 with Solvent Weld
b. 6-inch (6”) SDR 35 with Solvent Weld or Gasketco

Connections should only be made with Y connectors. No Tees.

Sewer laterals should be separated from water lines at least 10 feet (10’) horizontally unless there is a separation of one foot vertically, when crossing (measured from the outside of the pipe).
A sewer purveyor shall declare that a backwater valve be installed for only plumbing fixtures where the flood level runs of the lowest plumbing fixtures are below the elevation of the manhole cover of the next upstream manhole in the public sewer.

The lowest floor level served by a sewer lateral shall be at least three feet (36”) above the crown of the main line sewer at the point of connection to reduce the risk of backflow.

Cleanouts
Cleanouts shall be built at all changes of direction greater than 45° and at every 100 feet or fraction thereof along all straight lines.

Residential
The sanitary sewer lateral shall have a minimum grade of \( \frac{1}{4} \) inch per foot (2%) from the main to the right-of-way or easement. The sanitary sewer lateral should have a minimum grade of \( \frac{1}{4} \) inch per foot (2%). A 1/8 inch (1%) grade may be used in some cases and those cases must have the Director of Underground Utilities or designee’s approval. Laterals shall not be connected to the main at an angle greater than 45° from the horizontal.

Commercial and Industrial
Allowable grade and requirements will be determined on a case by case basis.
Appendix B

What is 3D Analyst?

The ArcGIS 3D Analyst extension provides tools for creating, visualizing, and analyzing GIS data in a three-dimensional (3D) context.

Capabilities with 3D Analyst

- View GIS data on a 3D globe using ArcGlobe.
- View GIS data within a 3D planimetric view using ArcScene.

- Build and maintain functional surfaces, such as a terrain dataset constructed from lidar.

- Query and analyze surfaces, such as slope and aspect.
- Import 3D data from multiple sources, such as multipatch buildings constructed in SketchUp.
- Edit and maintain 3D vector data, such as building interior transportation networks.
- Use interactive tools to make 3D queries, such as measuring heights inside 3D.

Environmentalists, forestry departments, and civil engineers can use 3D Analyst to understand and sculpt terrain to allow for events such as water runoff and flooding. Mining companies, geologists, and researchers can use 3D Analyst capabilities to

- Create contour lines in 2D (ArcMap).
learn more about subsurface geological bodies, such as the 3D intersections of deviated boreholes and subsurface strata. Local governments, city planners, and military organizations can leverage 3D Analyst to ask complex 3D questions about man-made structures, especially in regard to both current and proposed lines of sight within an urban area.

**Concepts unique to 3D**

When shifting to a 3D viewing environment, there are several new concepts to be aware of.

- There are [additional symbology options](#) available for vector features in 3D.
- Vector layers can be [displayed as rasters](#) for improved display performances.
- [ArcGlobe uses caches](#) to support fast display of large datasets.

**Concepts that are different in 3D from 2D**

There are also other well-accepted 2D concepts that no longer apply.

- Layers in a 3D view are not just for display—they can also be used to describe the surface. This means that [layers can have different roles](#) within the 3D view.
- A 3D view extent cannot be described as a simple rectangular shape (as is the case for 2D) because you can look at the data from an oblique angle. This means the [current extent of a 3D view](#) must be handled in a different manner from 2D.
- The [layer drawing priority](#) is no longer as simple as the order in the table of contents.

**Two 3D visualization applications**

Two 3D visualization applications, ArcGlobe and ArcScene, are also part of the 3D Analyst extension.

ArcGlobe gives you the power to tame voluminous data while fully employing all information the data can give you. ArcGlobe displays spatially referenced data on a 3D globe surface, displayed in its true geodetic location. You can manipulate the globe, then investigate and analyze its data while viewing the globe as a whole, or regions within it. You can view data covering a global extent then seamlessly zoom into highly detailed, localized data.

ArcScene manages your 3D GIS data, performs 3D analysis, and allows you to easily create 3D features, and display layers within a 3D planimetric view. You can create 3D features from existing two-dimensional (2D) GIS data, or you can digitize new 3D vector features and graphics in ArcMap using a surface to provide the z-values.

[Learn how to choose between ArcGlobe and ArcScene](#)
Using 3D Analyst in ArcCatalog and ArcMap

In ArcCatalog, the 3D Analyst extension allows you to manage 3D GIS data and create layers with 3D viewing properties. You can preview scenes and data in 3D in ArcCatalog using the same 3D navigation tools you use in ArcScene.

Learn more about 3D Analyst capabilities in ArcCatalog

In ArcMap, the 3D Analyst extension allows you to create new surfaces from your GIS data as well as analyze surfaces, query attribute values at a location on a surface, and analyze the visibility of parts of a surface from different locations. You can also determine the surface area and the volume above or below a surface and create profiles along a 3D line on a surface.

Learn more about 3D Analyst capabilities in ArcMap

Related Topics

3D Analyst and ArcGlobe
3D Analyst and ArcScene
3D Analyst and ArcMap
3D Analyst and ArcCatalog
What is a terrain dataset?
About enabling 3D Analyst
Appendix C

Making a group layer animation

Steps:

1. Click the **Add Data** button in *ArcMap*, *ArcScene*, or *ArcGlobe* to add the layers or group layer that you want to animate.
2. Click the **Animation** drop-down arrow and click **Create Group Animation**.
3. Optionally, choose a base name for tracks.
   
   You are provided with a default name for the tracks, but you can change it to something more meaningful.

4. Optionally, set the **Begin time** and **End time** parameters.
   
   Setting these times allows you to determine when the group animation will play relative to other tracks that may exist.

5. Choose a group layer.
   
   You can click a single group layer or click Top-level layers to select all the layers in the table of contents.

6. Optionally, set the transitions.
   
   These options help you determine how layers in an animation change from one to another. If you leave the **Blend layers when fading** option unchecked and just move the **Fading transition** slider, each layer will fade in and fade out separately. If you check **Blend layers when fading** and also move the slider, one layer will fade out, while the other layer fades in.

7. Optionally, uncheck **Overwrite existing tracks** with same name to add additional group animations.

8. Click **OK**.

**Tip:**

- On the **Time View** tab of the *Animation Manager*, group layer tracks are color coded to indicate their visibility. Green indicates that the layer is visible; red indicates that the layer is invisible; and pale yellow indicates that the layer is semitransparent, or in transitional visibility where the layer is either fading in or fading out.
• A group layer can be looped within the animation. Check **Create looped animation**, then set the **Begin time** value to 0.0 and the **End time** value to a number less than 1, such as 0.2. In this case, the group layer will animate five times within the animation time of 0 to 1.

• After playing an animation containing a group layer, if **Restore state after playing** is unchecked on the **Animation Controls** dialog box or **Restore state after preview** is unchecked on the **Time View** tab of the **Animation Manager**, the state of the layers at the end of the animation are retained (for example, the amount of transparency or their visibility). To return layers to their original state, play or preview the animation with the respective restore state option checked.