Analyzing utility systems at Brookhaven National Laboratory to maintain infrastructure more efficiently

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ABSTRACT

Data for the utility systems found on the property of Brookhaven National Laboratory (BNL) are currently stored and viewed within a program called AutoCAD®. While this software is effective at showing locations and differentiating between the types of utilities that exist at BNL, it does not include options for further analysis or data storage. When handling large amounts of data, such as that which makes up these systems, it is important to store it in one place and have the ability to make necessary evaluations. Using ArcGIS, a platform designed for managing spatial data, this can be accomplished. The utility data has been exported from AutoCAD to ArcGIS in the past, however, there are many inconsistencies. Correcting these deviations and fully recreating the utility maps within ArcGIS Pro was the first required step. Once successfully developed, these systems were exported into their own networks where they could be evaluated further using the ArcGIS Network Analyst extension. Storing utility data in this format enables knowledge of the utilities to be accessible and understandable. Furthermore, this is beneficial to employees at BNL, because it allows them to generate solutions more efficiently when issues arise such as a break in a potable water main.

INTRODUCTION

Potable Water System:

- This expansive utility system contains 682 valves and 38.4 miles of pipes, while providing clean water to the buildings at BNL.
- Maintaining this system is important because the health and safety of employees depends on it functioning properly.
- Data for this system are currently stored within AutoCAD, which cannot perform any analyses.
- When emergencies occur such as the main break shown in Figure 1, workers will need to use their knowledge of the system to determine what action to take.
- Moving these systems into ArcGIS will allow situations like this to be evaluated in depth so issues can be responded to in the quickest and most effective manner.

Sanitary System:

- The sanitary system also exists beneath a considerable section of the BNL property and it operates using the force of gravity.
- The waste coming from each of the buildings connected to this system will flow into the sewage treatment facility.
- This system is less complex since it is gravity-driven, however, its aging infrastructure has led to it being comprised of various materials and pipe sizes, attributes which can more effectively be stored in ArcGIS.

Underground Injection Controls (UICs):

- A UIC is a structure that is used to bring liquids beneath the surface and recharge the surrounding groundwater.
- Examples of UICs are dry wells, which reduce runoff by reintroducing storm water into the ground below, and cesspools, which bring our waste underground, letting liquids seep into the soil.
- These are an important component of the infrastructure at BNL, but their data is scattered throughout paperwork, AutoCAD maps, and other databases, with some that are even lost in documentation.
- The lack of a comprehensive data source makes it difficult and time consuming to get anything done that involves these UICs, and ideally, all this data should be compiled in a single location.

Figure 1. A main break at BNL in the summer of 2019. These happen frequently onsite which is why it's important to know how to properly handle them.

MATERIALS AND METHODS

Potable and Sanitary Systems:

- In the past, spatial data for the features of the potable and sanitary systems were exported from AutoCAD to ArcGIS.
- Initially, these files were completely unusable within ArcGIS, since there were hundreds of unconnected pipeline segments, causing many dangles to occur, as shown in Figure 2.
- These dangles can be targeted and repaired within ArcGIS by entering certain criteria into the topology tool and running it.
- After the system was fully reconstructed, it could be successfully exported as a network dataset.
- In the case of the potable system, this allowed for the ArcGIS Network Analyst extension to be utilized, in which this system can be evaluated using various analytical tools.
- When it came to the sanitary system, this dataset was exported into a utility network within ArcGIS, but more information was necessary before analysis could be run.

Underground Injection Controls:

- In order to find the inconsistencies that exist throughout the UIC data for BNL, it required comparing the current AutoCAD map, ArcGIS map, the most recent UIC inventory sheet (from 2011), and a map created by P.W. Grosser after the lab was surveyed in 1999.
- Data from these sources were compiled within an Excel spreadsheet, and this was used to identify any UICs that did not match with other records.
- Any deviations were noted, and these locations will be checked manually in the future.

Figure 3. A demonstration of what can be performed by using Network Analyst and the potable water system. Shown above is the result of placing an "incident," or main break, on the line. After this is run, the program will highlight the valves that need to be closed to isolate the break as well as the surrounding buildings that should have their water tested afterward.

Figure 4. A list of the data attributed to one of the UICs at BNL. This is a great example of the data storage that is capable within ArcGIS, and how it allows for quicker and simpler access.

FID	25
UICNO	1007B-DW-1
WELL_92	1007B-DW-02
BLDG_NO	1007B
MAP_NO	44
STAT_1992	Active
TYP	1
EPA_CODE	5W20
DSCHG_HST	Stormwater
STAT_1999	Active
FUT_STAT	Permitted
STR_DIAM	8.00
STR_DPTH	6.25
SOURCE	A
TOP_DPTH	6.25
MANWAY	NA
RIM_ELEV	65.8
NO_INLT	1
INLET_NO	
PIPE_ORG	Tunnel Floor Drain
DIAM_FR	6"
MAT_FR	NA
NO_OUTL	NA
OUTL_NO	NA
DSCHG_TO	NA
DIAM_TO	NA
MAT_TO	D.I.
SP_ID	4967
SOURCETHM	uic_pts.shp
X_COORD	1293880.74002
Y_COORD	261952.3924
GRID_ID	44

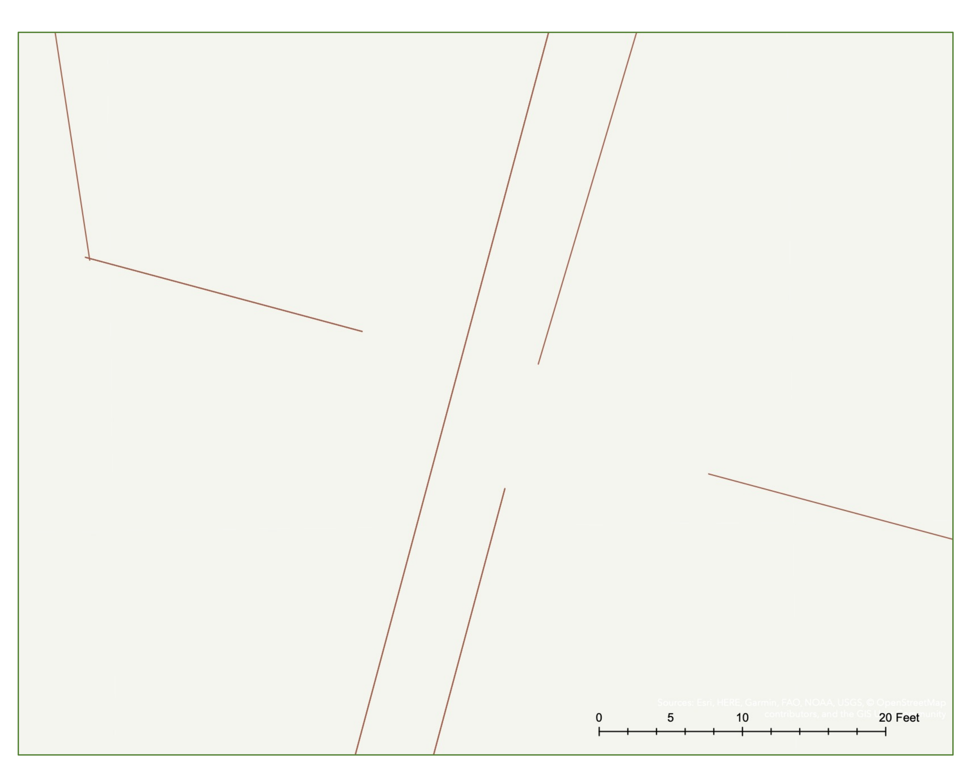

Figure 2. A cropped image of dangles that existed in the potable pipeline shapefile prior to its repair. Some dangles are up to fifteen feet away from the nearest line, while others are only a couple of inches. Regardless of the distance, these prevent the system from being contiguous, and need to be handled before a network dataset can be created.

RESULTS

Potable and Sanitary Systems:

- In the end, both systems were converted to network datasets within ArcGIS, which means they are no longer just a collection of lines and dots, but rather complete systems that can be analyzed and exploited in a variety of ways.
- If the potable main breaks, this location can be input on the network dataset, and when the Find Closest Facilities tool is run, it will highlight all the valves that need to be closed as well as the buildings that should have their water tested, as seen in Figure 3.

Underground Injection Controls:

- A total of 27 UICs were identified with conflicting data across multiple sources and therefore deemed inaccurate.
- These features are on a list and their position/current operating state will be verified manually against existing data sources.

DISCUSSION

The network dataset that was created in ArcGIS using the point and line shapefiles from the potable system will be valuable to anyone at BNL. When a break occurs in the potable water main, this can be used to quickly figure out what initiatives need to be taken to control the situation and then fix the pipeline. After this is resolved, the network can be analyzed further to select the buildings that should have their water tested to insure its cleanliness. Overall, this is going to improve the safety and health of those at BNL.

ArcGIS is also an appropriate platform to store the vast amounts of data related to any of the utility systems, like that shown in Figure 4. As seen with the UIC data, there is no comprehensive source where all necessary information can be found, and this will waste time and cause difficulties in the future. Efficiency will be greatly increased if all relevant data for each of the systems exists within the maps and attribute tables of ArcGIS. This will save time and prevent inaccuracies while also making it clear if data is missing from the current records.

What makes the steps of this project critical is that they can be executed using any of the utility systems that exist within AutoCAD. If this same procedure is followed, a new utility system will be created that can be analyzed and understood further in ArcGIS, while having all its data present. In an ideal future, all the utilities would be stored in ArcGIS, where they can be evaluated individually, or even as a group.

REFERENCES

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Autodesk 2020. *AutoCAD*. San Rafael, California: Autodesk

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