Data User’s Manual: Historical Urban Ecological Data Set

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BIBLIOGRAPHIC DESCRIPTION

Title: Historical Urban Ecological Data Set

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Grant Number: P01 AG010120


Summary of Study: This sample is comprised of 9,425 ecological variables and GIS maps of ward boundaries, street centerlines and sanitation infrastructure pertaining to the following seven urban centers: Baltimore, Boston, Brooklyn, Chicago, Cincinnati, Manhattan, and Philadelphia. This project will be of interest to those studying aging problems in the increasingly urbanized societies of both the developed and the developing world in the twenty-first century. The data is useful to researchers analyzing the impact of exposure to bad environments over various sequences of the life span, and the effect of public health reforms on age-specific morbidity and mortality rates by wards on cause-specific morbidity and mortality. This project is also a resource for those interested in the impact of particular public health reforms on the rate of aging over the life cycle and on the age-specific capacity to perform manual labor, by healthy and unhealthy wards, and the political economy of when, where, and how particular public health reforms were implemented in each of the 7 cities.

Project Period: 2007 - 2015

Institutions: Center for Population Economics (now defunct), University of Chicago Booth School of Business, and The National Bureau of Economic Research
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I. INTRODUCTION

The Historical Urban Ecological (HUE) data set falls under the Impact of Urban Disparities on Aging and Mortality project and enables researchers to explore and analyze the urban health environments of seven major US cities—Baltimore, Boston, Brooklyn, Chicago, Cincinnati, Manhattan, and Philadelphia—from 1830 through 1930. The HUE data set includes ward boundary changes, street networks, and ward-level data on disease, mortality, crime, and other variables reported by municipal departments for each study city. These materials constitute a framework on which users can build additional spatial data and conduct a wide range of historical inquiries.

The HUE data set was produced for the Early Indicators of Later Work Levels, Disease and Death project, funded by the National Institute of Aging under Program Project Grant P01 AG10120. Researchers selected the HUE study cities and variables in order to best analyze the effects of intra-urban health disparities and public health interventions on individual mortality and longevity as observed through the Union Army and US Colored Troops cohorts. See UAdata.org for information regarding the Early Indicators project UA and USCT samples. The general utility and diversity of the HUE resources, however, enable applications well beyond the Early Indicators project.

The HUE data set is provided to the public and interested researchers for download at hue.UAdata.org.

This document is organized as follows:

- **Section II** – “Historical Health Conditions in Major U.S. Cities: the HUE Data Set” published in Historical Methods outlines the HUE sample design and methodology.
- **Section III** – Descriptions of available HUE GIS downloads, their sources, and their availability for each HUE city.
- **Section IV** – Source and collection information for the HUE tabular ward-level ecological variables. Sections IV.B instructs how to use the HUE Variable Data Dictionary to locate variables in the Excel spreadsheets and Section IV.C links to the Missing HUE Variable Dictionary.
- **Section V** – Instructions for users on how to import the HUE tabular ward-level variables into a GIS environment.
- **Section VI** – Guide for geocoding veterans of the Early Indicators project.
- **Section VII** – Important information regarding the citation and use of the HUE data set.
II. **HISTORICAL HEALTH CONDITIONS IN MAJOR U.S. CITIES**¹

*Historical Health Conditions in Major U.S. Cities*

The HUE Data Set

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**Abstract.** The Historical Urban Ecological data set is a new resource detailing health and environmental conditions within seven major U.S. cities during the study period from 1830 to 1930. Researchers collected and digitized ward-level data from annual reports of municipal departments that detail the epidemiological, economic, and demographic conditions within each city. They then drafted new geographic information system data to link the tabular records to ward geographies. These data provide a new foundation to revisit questions surrounding the urban mortality transition and the growth of U.S. cities.

**Keywords:** cities, GIS data, historical GIS, neighborhood health, urban health, urban history

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"In all the problems we may devise for the sanitary or the social welfare of this great metropolis, we must accept and duly estimate the fact that its vast population is already more densely crowded in its domiciles than that of almost any other city; and that the evils attendant upon overcrowding and the aggregation of vast numbers will be continually augmented as the population increases, unless the resources of Sanitary Science and the beneficent operations of wisely-administered sanitary regulations are interposed." —1865 Report of the Council of Hygiene and Public Health of the Citizens Association of New York upon the Sanitary Condition of the City, p. xxxix

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The crude mortality rate in the seven largest U.S. cities dropped from 22.31 deaths per 1,000 persons in 1890 to 12.44 in 1930. Early studies on the urban mortality transition focused on reductions in city-level mortality (Condran and Crimmins-Gardner 1978; Meeker 1974), water filtration and chlorination (Cutler and Miller 2004; Troesken 2004), the construction of sewer systems (Costa and Kain 2003), sanitation capital (Cain and Rotella 2001), and gross population (Cain and Hong 2009). Mortality rates, however, varied more within cities than between them, and little is known about health patterns within cities. Existing intra-city studies are limited either to a specific city (Condran and Cheevey 1982), year (Higgs and Booth 1979), or disease (Cradock 2000; Hinman 2002; Hinman, Blackburn, and Curtis 2006), and several fundamental questions have not been adequately addressed: What was the structure of neighborhood-level health changes during the urban mortality transition? What role did the healthiest and unhealthiest neighborhoods play in driving this phenomenon? Were intra-city transition patterns comparable between cities? Improvements in the urban health environment developed unevenly within cities, and until now researchers have lacked the neighborhood-level data and analytical framework to investigate intra-urban variation in health environment.

We built the Historical Urban Ecological (HUE) data set to investigate the changing health and environmental conditions.

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within seven of the largest U.S. cities during the study period from 1830 to 1930 at the ward level. The HUE data set focuses on seven northern cities: Baltimore, Boston, Brooklyn, Chicago, Cincinnati, New York, and Philadelphia. It includes crime, disease, vital and demographic statistics, property and land values, and tax information recorded at the ward level as found in surviving municipal reports.

Up until this point, federal censuses have been the primary records of intra-city data at the ward level. The HUE data set is the first to digitize the large amount of data collected by municipalities, providing inter-censal statistics and greatly expanding the scope of feasible inquiries. These ward-level data would be of limited use without information on the spatial extent of the wards. Urban redevelopment programs in the mid- and late twentieth century razed many historically prominent neighborhoods, making contemporary maps inadequate for the reconstruction of the historical urban environment. Identifying the historical ward boundaries thus required the comprehensive reconstruction of historical cities in a geographic information system (GIS).

We used GIS tools to draft a new set of historical street centerlines in the seven study cities and from those data reconstructed ward boundary histories from 1830 through 1930. These GIS data provide the critical information to link and compare tabular ward-level data spatially and longitudinally. This project contributes to a growing body of historical GIS (HGIS) work. The National Historical GIS Project6 (Fitch and Ruggles 2003), the Atlas of Historical County Boundaries,4 and a number of international GIS’s (De Moor and Wiedemann 2001; Gregory and Healey 2002) have created historical census, parish, and other aggregated data. Extant work at the urban and intra-city level has heretofore been limited to either a specific year (Logan et al. 2011) or city (De Bats and Lethbridge 2005; Gilliland and Olson 2003; Gilliland, Olson, and Gauvreau 2011; Lutz et al. 2013). Historical changes to administrative boundaries have long impeded intercensal and intracensal quantitative spatial analysis. The NHGIS created tract-level boundaries from 1910 onward, but earlier intra-city census geographies have not been consistently available. Wards were well-defined political and administrative areas within cities that in addition to being census aggregation areas from 1790 through 1940, were the primary scale at which municipal departments reported aggregate statistics. The HUE GIS captures all the ward boundary changes, expansions, and subdivisions for the seven study cities, extending the usability of intra-city census data back to 1830.

The cities selected for inclusion in the HUE data set were identified primarily for their size and their relevance to the Early Indicators project. Other selection factors included data availability and our ability to find and geocode companies of urban Union Army veterans in those cities. The Early Indicators of Later Work Levels, Disease and Death5 project is a linked collection of the medical, pension, military, and census records of 39,000 Union Army veterans and was shown to be largely representative of northern, white males of that cohort (Fogel and Costa 1997). We expanded the Early Indicators project by adding nearly 14,000 veterans who enlisted in and around the target cities. Researchers used address information in these data to spatially geocode each veteran at the address-level within the cities. Having their location through time, we can then link complete, individual medical histories to ward-level data collected for the HUE data set, allowing the examination of the effects of environmental exposures on later health and socioeconomic outcomes.

The initially selected cities were the eight largest in the United States in 1860 excluding New Orleans, which lacked Union Army veterans. Pittsburgh and St. Louis were originally slated for inclusion in the HUE data set but were later removed based primarily on our inability to find and geocode veteran residences. Historical street centerlines (see below) were constructed with heavy reliance on landmarks visible in modern street maps and orthophotography. Historical Pittsburgh streets could not be satisfactorily identified using these methods. St. Louis, while geographically less opaque, frequently changed street names over this period, and we could not accurately determine address locations.

The HUE GIS’s historical street centerlines create a framework for the development and integration of increasingly detailed historical data: sewer or school districts, transit and water systems, and address-level points of interest or disease cases are a few possibilities. Statistics can be calculated at several levels of spatial granularity for the multilevel analysis of area effects. The core HUE GIS and collected tabular data are available for download at the Early Indicators project website (hue.uadata.org).

The HUE data are of interest not only to researchers interested in the health environment within cities, but also to economists, historians, geographers, and demographers interested in cities more broadly. Allison Shertzer (2012) used a preliminary version of HUE to examine the political integration of new immigrants within cities. Carlos Villarreal (2013) used the HUE maps to examine the persistence of initial settlement patterns on Manhattan Island from 1830 to the present as measured by the spatial distribution of the rental price of housing and income. He found that areas with poor natural drainage, a disamenity before the installation of sewer pipes, remains undesirable despite the later introduction of water and sewer pipes which should have eliminated the initial environmental disadvantage. Using the HUE data, he was able to investigate several explanations for the persistence of this initial disadvantage, including the durability of housing, the location of polluting manufacturers, immigrant enclaves, and preferences for high income neighbors.

The remainder of this article provides an in-depth description of HGIS methodology and collected tabular data. We conclude with early applications and research extensions.
Reconstructing Historical Cities Using GIS

A GIS of historical street centerlines forms the core of the HUE data set. We developed networks of street centerlines for each of the sample cities as they were in 1930 and subsequently added administrative boundaries, sewer and water pipelines, and point-level address data. Each supplementary data set is spatially and topologically coherent and allows for spatial linking of disparate historical data sets. Wards were the most common geographies municipal departments used for statistical aggregation, and the HUE GIS data provide ward boundary histories for each sample city that span the century of vigorous urban development from 1830 to 1930. Street centerlines, wards histories with collected ward-level tabular data, and additional smaller scaled spatial data, organized under the HUE data framework, will allow researchers to perform analysis over longer intervals than previously available at an intra-urban scale. The following sections document the creation of these core HUE GIS components and present potential applications.

Constructing Historical Street Networks

Each HUE GIS street centerline network is based on a single street map produced in or around 1930. The networks include all named streets and alleys as they were observed at each map's date of publication. By 1930, Manhattan, Brooklyn, Boston, Chicago, Cincinnati, Philadelphia, and Baltimore had, for the most part, reached their modern spatial extents. Between 1830 and 1930, the street network managed by each city grew through the annexation of neighboring areas and through the development of new infill and sparsely populated areas. Street removal would have been difficult and unnecessary, resulting in changes that were largely additive. As a result, the HUE street centerline networks constitute nearly all named streets that existed throughout the study period and provide a starting point for the creation of street networks particular to earlier decades.

When compared to the 1880 Urban Transition HGIS street centerlines and early maps, the HUE networks were observed to include nearly all named street segments extant in 1880. During this comparison, we noted several minor differences between conditions in 1880 and 1930. As industrial areas became more established and cities reshaped interior waterways and shorelines, excess roads disappeared in zones of transition. Between 1880 and 1930, Chicago built three locomotive switching yards in areas where streets once ran. One such area was along the eastern shore of the South Branch of the Chicago River, already a shipping hub in 1880. We found that a number of alleys and other minor streets in Boston, Baltimore, and Cincinnati were also no longer in existence by 1930. The street removals that did occur were largely in industrial areas, and our work in geocoding residences, identifying ward boundaries, and mapping the construction of sewer and water pipelines were largely unhindered by those changes. With only minor differences, the HUE street centerline networks prove a solid baseline for mapping earlier conditions and for executing nearly all longitudinal projects between 1830 and 1930, such as those seen later in this article.

While the 1930 HUE street networks serve as consistent references for earlier periods, they diverge significantly from those of the present day. In the mid- to late-twentieth century, American city street networks experienced significant programs of demolition, redirection, and expansion resulting from urban renewal programs, redevelopment, and the construction of interstate highways and cross-urban expressways. For this reason, our survey of publicly available modern GIS data revealed that official census geographies and street centerlines available from the United States Census Bureau (TIGER/Line shapefiles) and private and municipal GIS resources would not be suitable for an HGIS reconstruction. The sections of street networks that have remained unchanged since 1930, however, provide the starting point for our historical reconstruction.

Those modern street centerlines that had not changed since 1930 were identified by comparing the 1930 street maps with modern satellite imagery. Once identified, unmodified centerlines were drawn referencing modern orthoimagery downloaded from the National Map, a contemporary spatial database provided by the U.S. Geological Survey. Unmodified streets in the historical core of each sample city were reproduced in this way, as was the entirety of Chicago and Manhattan Island. Where cities annexed substantial districts outside the historic urban core, modern TIGER centerlines provided unmodified streets geographies. This method provides a level of spatial accuracy that would be difficult to achieve with georeferenced historical maps alone.

We then used these networks of unmodified streets to interpolate those streets and blocks that had been significantly modified or disappeared altogether during the intensive urban reconfiguration since 1930. Figure 1 shows a sizeable area west of downtown Chicago that was razed to accommodate a highway interchange in the late 1950s. Our interpolation of 1930 street centerlines is shown both in the left panel, which shows the modern orthoimagery that we used to create the centerlines, and in the right panel, showing the demolished neighborhood and the streets in the aerial photograph circa 1930. Despite significant alterations, many of the streets that surrounded the razed district persist through to the present day and allow us to reconstruct the missing streets by extending the extant centerlines through demolished areas in a manner consistent with the intersections and termini marked on the historical street maps.

Some street centerlines, however, could not be satisfactorily extended through demolished areas, and their realignment required additional effort. Streets that curved within razed districts proved to be especially complicated. For example, in Boston's West End, the construction of a complex of high-rise apartment towers and the Massachusetts General
Hospital altered the street network to the extent that our standard interpolation approach was inadequate. In these cases, centerlines were drafted over georeferenced Sanborn Fire Insurance Map plates and USGS topological surveys dating to the period around 1930. Figure 2 shows the HUE 1930 centerlines, modern orthoimagery, and the Sanborn map used in our reconstruction.

The accuracy of the HUE street centerlines maps has two main caveats. Historical aerial surveys of Chicago and New York, such as that presented in Figure 1, confirmed that our reconstruction techniques provided a high degree of spatial accuracy. They are not, however, official surveys and cannot substitute for GIS data produced using modern remote sensing methods. Secondly, for data integrity purposes, HUE GIS centerlines reflect a single source street map. These source maps often reflected future plans that may or may not have been implemented. They do not provide perfect snapshots of the cities’ contemporary street networks. Beyond confirming the spatial accuracy of HUE centerlines, the early aerial surveys also showed streets in southeast Brooklyn that had not yet been completed by the 1930s. We have no solid evidence that HUE street centerlines in southwest Philadelphia were ever more than contemplated. These suspicions seem confirmed by later work geocoding VA veterans, and these areas lacked any residents in our sample. Despite these limitations, the HUE street centerline networks function best as historically appropriate and spatially accurate reference layers on which further data can be constructed.

**Constructing Ward Boundary Histories**

The HUE data set provides a full set of the historical ward systems used in each sample city from 1830 to 1930. Descriptions of ward boundaries and the dates each system was adopted and discarded were determined from a survey of archival and reference documents, municipal reports and ordinances, collected ward maps, and contemporary studies.

Ward boundaries were delimited by street centerlines, surveyed city limits, and other geographic features such as shorelines, waterways, and railroads. HUE ward boundary polygons were drawn along the 1930 street centerline networks, and additional bounding features, such as shorelines or abstract boundary lines, were derived from georeferenced maps and HGIS resources.
The cities' ward boundary histories are highly idiosyncratic. In Manhattan, ward boundaries were not modified after 1854, while Philadelphia changed its ward boundaries 20 times between 1830 and 1930. The quality of changes to ward systems also varied between cities. Figure 3 compares Philadelphia and Boston ward boundary changes between early and later points in the study period. Philadelphia wards in the central business district remained stable and comparable as peripheral wards divided through the study period. Boston ward boundaries, on the other hand, often changed quite significantly and were further altered by extensive landfill. The HUE ward histories provide scholars the opportunity to observe changing ward boundaries throughout the study period and to accurately link tabular ward-level data on population and public health compiled for the HUE data set to period-specific geographies.

We created individual shapefiles for each ward boundaries alteration. Chicago, for instance, reconfigured its ward boundaries 18 separate times between its incorporation in 1837 and 1930. During this period, it redistricted eight times and annexed new land 15 times. The last redistricting in the HUE data set was in 1923 and resulted in 50 wards.

Each of these changes to the extent and boundaries used by the city is provided as a separate ward system shapefile. Table 1 summarizes the ward changes of each city over the study period.

The source documents used to create ward boundary histories also differed between cities. The ward histories of Baltimore and Philadelphia were taken from the secondary compilations of other researchers. We derived Manhattan's ward history from archival research aids provided by the New York City Hall Library. Without the benefit of single sources that covered the extent of the study period, researchers compiled the remaining ward histories from maps, city directories, city council records, and newspaper articles. The Boston ward history was compiled from 21 primary documents. Complete documentation on the sources for each city's ward history is available for download on the HUE website.

**Building Tabular Ward-Level Data**

During the study period, municipalities primarily reported intra-city statistics at the ward-level. State and federal censuses often reported ward-level statistics as well. The sheer
quantity of data available makes analyzing cities at the ward level an attractive option for intra-city analysis. Since collection and publication of the municipal ward-level data was at the discretion of the cities themselves, statistics collected varied across time and between cities. The statistics published by each city generally expanded over the study period. Early reports tend to be terse, reporting only key vital statistics or statistics idiosyncratic to the city. The scope of published statistics expanded during the latter half of the nineteenth century, responding in part to the cities’ desire to track and prevent disease outbreaks. As medical diagnosis methods improved, cities published more data on cause-specific case and mortality rates. City health departments were in close contact with each other, which resulted in the rapid dissemination of advances in medicine and the equally rapid introduction of new statistics into annual health reports.14

In our collection efforts, we attempted an exhaustive search of municipal reports’ recordings of ward-level statistics during the study period. We collected 3,365 tables of ward-level statistics from 312 unique sources. We digitized each table by hand, attached source and metadata, and compiled the data into a relational database. The database’s size created several problems of taxonomy. Variable categorization was not merely required post facto for extraction purposes, but to aid inputers in the assignment and aggregation of variables as they were found across time and source material. Strict rules were maintained in variable naming conventions and categorization. Nonetheless, as the number of variables being input increased, their categorization must adapt and expand to contain them. In the end, the tabular data are divided into five broad categories: crime, disease, municipal, property, and vital statistics, and 19 subcategories. Table 2 gives an overview of each main category and presents the earliest year each type of data is available.

Crime refers to statistics related to criminality, including homicides and crime reports. Disease refers to specific disease recording and contains the cases, deaths, and vaccination subcategories. Municipal refers to data on tax receipts, sewer and water outlays, schools, animal populations, and elections statistics. Property refers to data on value and amount of personal property, chiefly real estate stock. Finally, vital statistics refers to data on births, deaths, and population. We see from the table that there is a great deal of variation for when

FIGURE 3. Reconstruction of the historical Philadelphia and Boston ward boundary systems. Left panel: Philadelphia wards 1855 and 1914. Right panel: Boston wards 1830 and 1913. Note: These maps show early and late ward boundary systems. While peripheral wards in Philadelphia simply split over time, with central wards remaining static, Boston wards underwent drastic changes in both street boundaries and coastlines that were altered by landfill.
TABLE 1. Number of Wards and Ward Changes Per Decade

<table>
<thead>
<tr>
<th>Decade</th>
<th>Baltimore</th>
<th>Boston</th>
<th>Brooklyn</th>
<th>Chicago</th>
<th>Cincinnati</th>
<th>Manhattan</th>
<th>Philadelphia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1830–9</td>
<td>12 (1)</td>
<td>12 (2)</td>
<td>9 (0)</td>
<td>6 (0)</td>
<td>*</td>
<td>14–17 (3)</td>
<td>15 (0)</td>
</tr>
<tr>
<td>1840–9</td>
<td>12–20 (2)</td>
<td>12 (0)</td>
<td>9 (0)</td>
<td>6–9 (1)</td>
<td>*</td>
<td>17–18 (1)</td>
<td>15–17 (1)</td>
</tr>
<tr>
<td>1850–9</td>
<td>20 (0)</td>
<td>12 (2)</td>
<td>11–19 (2)</td>
<td>9–10 (1)</td>
<td>16 (0)</td>
<td>19–22 (3)</td>
<td>17–24 (1)</td>
</tr>
<tr>
<td>1860–9</td>
<td>20 (1)</td>
<td>12–15 (2)</td>
<td>19–22 (2)</td>
<td>10–20 (2)</td>
<td>16–20 (3)</td>
<td>22 (1)</td>
<td>24–28 (5)</td>
</tr>
<tr>
<td>1870–9</td>
<td>20 (0)</td>
<td>16–25 (2)</td>
<td>22–25 (2)</td>
<td>20 (0)</td>
<td>24–25 (1)†</td>
<td>22 (0)</td>
<td>28–31 (2)</td>
</tr>
<tr>
<td>1880–9</td>
<td>20–22 (2)</td>
<td>25 (0)</td>
<td>25–26 (1)</td>
<td>20–34 (1)</td>
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<td>1890–9</td>
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<td>26–32 (3)</td>
<td>34–35 (4)</td>
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<td>22 (0)</td>
<td>35–41 (4)</td>
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<tr>
<td>1900–9</td>
<td>24 (1)</td>
<td>25 (0)</td>
<td>32 (0)</td>
<td>25 (1)</td>
<td>*</td>
<td>22 (0)</td>
<td>41–47 (4)</td>
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<td>1910–9</td>
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<td>25–26 (2)</td>
<td>32 (0)</td>
<td>35 (3)</td>
<td>*</td>
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<td>1920–30</td>
<td>28 (0)</td>
<td>25–22 (1)</td>
<td>32 (1)</td>
<td>35–50 (2)</td>
<td>*</td>
<td>22 (0)</td>
<td>48 (0)</td>
</tr>
</tbody>
</table>

*We were unable to find sufficient data for these years.
†CPE shapefiles only contain interior 20 wards for 1870–2.

Each city began reporting different statistics. Boston began reporting vital statistics in 1849, followed by Philadelphia in 1860, New York City (only encompassing Manhattan Island at this time) in 1865, and Chicago later still beginning in 1866. Disease reporting expanded in the 1870s.

Table 3 highlights a sample of more specific variables available by time period. The nine statistics presented illuminate the disparities between each city’s reporting and collection efforts. Vital statistics are the most consistently reported across cities. Population and deaths are present by ward for the majority of the sample period, and births are somewhat less represented. In the disease variables, we have shown two sample statistics: cases and deaths from smallpox. Early reporting on these diseases was sporadic and generally linked to disease outbreaks in the cities. As time went on, reporting became more regular and consistent. Smallpox data appear to have been collected frequently in early years but not collected with the same frequency in the decades of 1900s and 1910s, with the exception of Philadelphia and New York. As a sample of other municipal records available, four statistics are presented: tax receipts, number of registered voters, acres of land, and value of real estate. Here we see the divergence of statistical reporting diligence: Boston published these statistics most consistently, showing relatively few gaps in the post-Civil War period. New York published acres of land and value of real estate consistently after the Civil War, while Chicago and Philadelphia only published these statistics intermittently.

A key challenge to the use of historical ward-level data is the determination of ward-level population baselines. U.S. Census figures provide the best-studied population counts, but between each decennial census the population of a ward changed through natural fertility and mortality processes, immigration and emigration, the incorporation of new

TABLE 2. Earliest Available Ward-Level Data From Municipal Sources by Broad Category

<table>
<thead>
<tr>
<th>City</th>
<th>Crime</th>
<th>Disease</th>
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<td>Baltimore</td>
<td>1863</td>
<td>1881</td>
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Note: Crime refers to statistics related to criminality (e.g., homicides); diseases include cases of and deaths from specific diseases; municipal records include results from municipal elections and tax statistics; property refers to values and amount of personal property; vital statistics are primarily births and deaths.
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*New York includes Brooklyn and Manhattan. An “x” indicates at least one record exists of the variable in that decade. For reasons of brevity, Cincinnati and Baltimore have been excluded.

Areas into the cities, and the shifting of ward boundaries. The annual reports used in the creation of the Hue data set often included estimated ward-level mortality and other rates calculated using the population from the previous census year, which reduced the reliability of their estimates as time elapsed from the previous census. Some cities only provided raw counts by ward. To address these problems with the quality and availability of historical population statistics, we used our historical ward GIS in conjunction with census data to generate annual ward-level estimates of the population from 1850 through 1930.

The estimates we provide were derived using the simplest forms of areal and temporal interpolation, leaving further refinement to future research. We began by calculating the geometric union of each set of ward boundaries between two observed censuses using GIS software. This process subdivides the wards as observed at two bounding censuses (e.g., 1870 and 1880), based on the geographical boundary changes that were enacted during the intervening years. We redistributed raw ward-level populations from the U.S. Census statistics reported for each bound among these smaller areas, weighted by the percent of the original ward area. Using the populations observed at both census years as bounds, we then interpolated the intercensal years linearly for each section. We then created annual ward-level estimates by recombining these small areas into the wards from which they originated.
This methodology makes a number of assumptions, most notably that population is uniformly distributed within each ward. Improved estimates will be possible once the full set of nineteenth-century census enumeration district shapefiles and population counts become available.

The availability of variables broken down by race and ethnicity ranges widely for each HUE city but can be supplemented by ward-level Census data from IPUMS and other suitable sources. Vital and disease records found in Baltimore between 1882 and 1913 are frequently divided into observations for whites and blacks. Observations by race, however, are more sporadic for the other study cities. Twentieth-century reports from Boston and Philadelphia detail black births and provide some information on black deaths and population, but they do not categorize disease incidences by race. Racial specification is sparse for Brooklyn, Chicago, Cincinnati, and Manhattan. This disparity in reporting is perhaps due to the relative prevalence of black residents in the HUE cities during the study period. In 1890, blacks accounted for nearly 16% of Baltimore’s total population, as compared to fewer than 2% of Manhattan’s. Ethnicity variables appear in the vital statistics from Boston and sporadically for the study cities but are not strongly or consistently represented across the data set. To bolster these variables, researchers can now aggregate microdata available from IPUMS to the ward-level by adding the “WARD” household geographic variable to their extract (not available for 1850 and 1880 samples). This aggregated microdata can then be joined to the HUE ward boundary shapefiles. All manner of additional censal characteristics including race, ethnicity, income, employment, and housing (among many others) can then be utilized alongside a wide variety of GIS and ecological data. A complete list of HUE variables is available on the HUE website.

Four Sample Use Cases

This section shows four use cases for the HUE GIS. The first is a straightforward creation of choropleth maps using the tabular ward-level data with the HUE ward boundary files. The next two show how the HUE GIS data, used as geospatial references, give a framework for creating new historical data. The fourth describes how HUE GIS data can revitalize existing data sets and provide new dimensions for linking and analyzing disparate data sets.

Choropleth Maps

The website provides tabular data extracts, GIS data, and pertinent source and metadata information for analysis and visualization. These files can be used with any standard desktop GIS software to create choropleth maps to the user’s specification. Figure 4 is a simple example of such a map.

We selected Baltimore infant mortality in 1906 using the extraction system found at the HUE data portal.16 The city and year of the statistic indicate that the relevant ward boundary map is Baltimore 1902–18. Combining the ward boundary map and the tabular statistics, we can reveal patterns in the spatial distribution of infant mortality in that period. With relative ease, the HUE data set can display data with new temporal and spatial granularity.

Geocoding

The HUE HGIS street centerline networks also provide a base reference for the creation of new spatial data. Address- or block-level data can be accurately placed and novel relations between data sets can be discovered by aggregating to uniform areal units or by multi-scale methodologies. New spatial data sets may be address-level disease cases or census information, street level information on sewer and water systems, or other aggregation geographies such as school and sanitary districts. By using the HUE GIS street centerline networks to place these data, they can be used independently or spatially linked to HUE ward-level tabular data.

Project staff created the HUE data set in an effort to analyze the effects of exposure to bad urban health environments over various sequences of the lifespan on individual longevity and disability. The veterans from the Union Army, U.S. Colored Troops, Andersonville, Oldest Old, and Urban samples15 who lived in the HUE cities provide a population through which these interactions between health and environment can be explored.18 In order to match veterans to the ward-level ecological data, the residences reported in their linked Census, Pension, and Surgeon’s Certificates records were mapped to their geographic locations, a process also known as geocoding. Figure 5 shows geocoded living in Chicago, located at the block level and placed within municipal ward boundaries.

We observed veterans of the Union Army and U.S. Colored Troops samples living in the study cities from 1816 through 1949. Over this period, the physical locations of addresses were very unstable. As they developed, the cities adopted new address numbering systems to accommodate annexations and new construction. Renumbering schemes seen during the study period range in scope from complete reworkings in Baltimore and Chicago to annual incremental shifts in Manhattan. Cities also experienced minor ad hoc modifications on top of these systematic changes. Streets were frequently renamed in this period, sometimes two or more times, most prevalently in Philadelphia. Each of the study cities adopted further changes to their address numbering and street names between 1930 and the present day.

Automated geocoding procedures reference address data embedded in each street segment detailing the range of addresses on each side of the street. These ranges are typically seen in the LFROM/LTO, RFROM/RTO format. The HUE
II. Historical Health Conditions in Major U.S. Cities

street centerlines do not contain this embedded information as our geocoding objectives spanned more than a century of address instability. Researchers can code the address range(s) particular to their area and period of study if desired. The HUE street centerlines are provided in a format that supports such endeavors. Address ranges can be imported from modern GIS data and carefully back-cast where necessary based on information from street directories and historical maps. This is not recommended for periods before 1900 in most cities.

We have devised a procedure for manually geocoding addresses spanning the HUE study period. Staff first collected historical resources reporting addresses such as maps, fire insurance atlases, street directories, and address change documents. These items were accessed through private providers such as Ancestry.com and Proquest as well as public and non-profit entities such as the City of Philadelphia and the Chicago History Museum. Working record-by-record, a team of trained GIS-inputters then used these collected materials and the HUE street centerlines to determine the address's correct spatial location based on the year in which the veteran was living at each residence. We located each address to the correct block and side of the street, but identifying the exact building was unnecessary. This allowed inputters to compare addresses against block-by-block address ranges described in street directories and to approximate the location of an address on an ungeo-referenced map. Due to incomplete records and the sporadic

availability of historical materials, not all addresses could be geocoded or placed with certainty, and these addresses were dropped from the sample. A full list of sources and a more detailed walkthrough of our geocoding procedure can be found in the documentation section at hue.uadata.org.

Sanitation Systems

In the next use case, we show the collection of block-level sewer pipes for the City of Chicago from 1857 to 1910. In this period, Chicago’s Board of Sewerage Commissioners and subsequently the Department of Public Works recorded the construction of sewers on a block-by-block basis. Figure 6 shows the digitized map of these reports. The data are accurate to the year and presented in three periods. At the block-level, these data can be aggregated to ward geographies to interact directly with HUE tabular data, or they can be displayed over tabular data of dysentery cases and rates. They can also be linked to address-level data such as the geocoded veterans described above to show in what year an individual would have first had access to the public sewer system. By establishing the availability of sanitation systems, we can better measure and study the effect of public health reforms on cause-specific morbidity and mortality as observed through the Union Army cohort.

We have digitized sewer and water system construction data for each of the target cities, though there is variance in data availability. In-street sanitation data such as year of initial water and sewer pipe installation collected from maps and historical reports were entered by hand into fields added to the street centerlines. Data from modern GIS files can be linked to the HUE street centerlines by using spatial joins and proximity analysis tools. The sanitation documentation located at hue.uadata.org discusses the manual inputting procedure created for the project as well as sanitation data sources and coverage in more detail.

Transportation Systems

The nineteenth century also saw the expansion of public transportation networks that significantly reduced travel times within cities, affecting the accessibility of new
neighborhoods and creating new paths for infectious disease transmission. Figure 7 shows the New York City passenger transportation system in 1878. The lack of descriptions of their construction, however, precluded the block-by-block collection method used for city water and sewer. Being of general interest, many maps were discovered which contain information on the location of these historical transit routes. From these maps and collected local transportation histories, we were able to digitize the urban transportation networks block-by-block and derive approximate dates of opening and abandonment of each individual line. The data were created using HUE street centerlines and so can be used in combination with other data to derive distances to transit, travel times, and, in concert with ward-level data, to examine the effects of transit on the development and makeup of the city.

Conclusion

The HUE data set provides new tools for the analysis of neighborhood differentials in socioeconomic, demographic, and health characteristics within cities from the mid-nineteenth century to the 1930s, a time of rapid economic and demographic change. Preliminary research using this data set has concentrated on economic divergences within cities (Shertzer 2012; Villareal 2013), but the data provide many opportunities for epidemiological, historical, and demographic research.

The GIS framework permits researchers to spatialize newly created or pre-existing data, thus enhancing our ability
to analyze long-run changes in the growth of cities. The HUE centerlines for Philadelphia, for example, could be used to reopen Theodore Hershberg’s Philadelphia Social History Project (PISHIP) to a new generation of investigation. This early machine-readable spatial data set, which advanced the study of industrialization, social stratification, individual mobility, and the uses of urban space in nineteenth-century Philadelphia (see Hershberg 1981), has not yet been systematically incorporated into a GIS framework due to the lack of appropriate historical geographies, though the data have seen limited use in several recent case studies (Condran 2008; Hargis and Horan 2004). With minimal effort, the Philadelphia street centerlines could provide the necessary spatial reference to rebuild the grid unit system used by the PSHIP in a modern GIS. Our digitization of Homer Hoyt’s (1933) land value maps of Chicago also demonstrates the suitability of the HUE data set for such endeavors. Using the Chicago street centerlines as a guide (just as Hoyt used Chicago’s mile streets to demarcate his study areas), we digitized the grid system he used in his analysis. This allows us to combine both HUE ward-level data and Hoyt’s land values in a seamless model. The socioeconomic, demographic, and epidemiological data included in the HUE data set can enrich these formative studies and create a common basis on which to extend them through to present-day conditions.

The HUE data set contributes to a growing body of HGIS research that emphasizes spatiotemporal interoperability of data sets across platforms and disciplines. By placing historical data in a public, modern GIS framework, the HUE data set opens the historical situation of American cities to modern empirical methodologies from a variety of disciplines, its extensibility allows for the integration of newly created or revitalized data, and opens new avenues into the discussion of urban form and development.

Acknowledgements

We thank Lou Cain, Nathaniel Grotte, Noelle Yetter, Hoyt Bleakley, and Dora Costa for their extensive comments. Andrea Zemp, Alexander Onsini, Tom Blaser, Heather DeSomer, Lewis Meineke, and Anna Wielgosz provided outstanding research assistance.

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NOTES

1. For more up-to-date correspondence info, see http://www.undata.org/contact_us/


3. For example, in 1890, mean infant mortality (IMR) in the city of Chicago was 212.2 deaths per 1,000, but it varied between individual wards from 95 to 415 deaths per 1,000.


6. The Early Indicators (EI) project was carried out at the Center for Population Economics (CPE) at the University of Chicago under the direction of Robert W. Fogel. The CPE will close effective February 2014. EI and HUE data will continue to be available at undata.org, hosted by the National Bureau of Economic Research.

7. Due to the sporadic availability of appropriate historical maps, we were unable to find comprehensive, detailed examples for every city at the appropriate extent and scale in 1930. The date of publication of maps used ranged from 1922 to 1932. Private and municipal cartographers created these maps for use as road maps, street directories, and for administrative and planning purposes.

8. Many streets were renamed throughout the study period, largely as a result of name redundancy after annexation of neighboring areas. By employing periodic-specific maps as reference, historical addresses at ward boundaries can still be located. Several cities, such as Philadelphia, also maintain queryable street name change databases (http://www.phillyhistory.org/historicstreets/). Alternate or duplicate street names are not included in HUE GIS data.

9. The U.S. Census Bureau’s TIGER/Line geographies were used extensively only as the MAPI/TIGER Accuracy Improvement Project (MATIP) approached completion. Highly accurate street networks are crucial, as errors in the initial street reference maps propagate into subsequent layers of spatial data.

10. These areas include suburban Philadelphia and Cincinnati, in addition to areas annexed by Baltimore in 1919, the neighborhood adjacent to Boston proper, and southern Brooklyn.

11. Sanborn Fire Insurance Maps were produced irregularly in atlases. Consequently, the publication dates of maps used differ and are frequently from years before or after 1930. Sanborn maps are among the most detailed sources of urban spatial data available before the second half of the twentieth century. They provide an immense amount of information on the built environment at fine spatial resolution (1:600 scale or 50 feet to the inch).

12. There were no cases in which earlier ward lines ran along streets that had been demolished by 1930. Street widening or straightening, however, was not taken into account in the construction of historical ward boundaries.

13. In cases where historical city limits were analogous to historical county limits, as in the case of Philadelphia after 1854, the 1930 county boundary was drawn from the Minnesota Population Center’s National Historical GIS. Where historical city limits remained constant to the modern day, contemporary city boundaries were used as a guide.


15. For example, the 1874 New York Report of the Board of Health includes a discussion (26–7) on whether a recent cholera infection in New Orleans was Asiatic cholera or its more benign cousin, cholera morbus. A doctor was dispatched to determine the nature of this strain, and in his subsequent report he described conferencing with physicians in Cincinnati, Nashville, and Murfreesboro, TN on its pathology and how it should be appropriately classified (415–8).

16. For reasons of brevity, Cincinnati and Baltimore have been excluded in the table. Brooklyn and Manhattan have been aggregated into New York.

17. Being between quinquennial census years, these data are not available from any federal census extract. They were collected and reported by the city in tables 3 and 5 of the Annual Report of the Board of Health to the Mayor and City Council of Baltimore for the year 1906, and digitized as part of our tabular ward-level data collection efforts.

18. More information on samples created for the Early Indicators project and the sources from which they are derived can be found at UADaTa.org.

19. No addresses in Cincinnati were geocoded as we were unable to identify any Union Army companies with high percentages of Cincinnati residents, yielding a sample with insufficient numbers for analysis.

20. Ward-level water and sewer data were rarely reported in annual municipal reports; it was more common for municipal departments overseeing infrastructure installation to report specific locations and cost of new pipe segments.
III. GIS Downloads

Historical GIS files including ward boundaries, street centerlines, and urban sanitation systems are available for download at hue.UAdata.org/gis/.

1. HUE Ward Boundaries
   Ward boundary changes 1830-1930 in shapefile format
   • See Section III.A for more information

2. HUE Street Centerlines
   Historically accurate street centerlines c. 1930 in shapefile format
   • See Section III.B for more information

3. HUE Complete Geodatabases
   Street centerlines and ward boundary changes in Geodatabase format
   • See Section III.A and Section III.B for more information

4. Sanitation Infrastructure
   In-street sewer and water sanitation systems (partial – complete) in shapefile format
   • See Section III.C for more information
   • For Cincinnati - sanitation infrastructure is not available
   • For Baltimore - only water infrastructure is available

All HUE GIS files include historically accurate shorelines. Historical shoreline documentation is available in Section III.D.
A. HUE Ward Boundaries Data Sources

Ward boundaries for the period 1830 – 1930 are available for all seven of the HUE cities in shapefile format. Ward boundary changes are also available with street centerlines in geodatabase format. The following Ward Histories contain information on the sources and decisions made in the construction of the ward GIS files for each city.

Baltimore Ward History

Introduction

This resource documents the creation of the Historical Urban Ecological (HUE) data set Baltimore ward boundary shapefiles and feature classes. All sources pertaining to the delineation and numbering of each ward system (the unique configuration of ward boundaries over a defined period), encompassing cartographic materials, city ordinances, newspaper reports, and ward boundaries described in the historical literature, have been included. Exclusions are noted where applicable. This document also describes ambiguities found between sources and a discussion of how these ambiguities were resolved in our published data. Table 1 provides a general ward history, 1818-1930.

Table 1: General Ward History of Baltimore, 1818-1930

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Number of Wards</th>
<th>Type of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1818 – 1831</td>
<td>12</td>
<td>Redivision</td>
</tr>
<tr>
<td>1832 – 1840</td>
<td>12</td>
<td>Redivision</td>
</tr>
<tr>
<td>1841 – 1845</td>
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<td>1846 – 1860</td>
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<td>1861 – 1882</td>
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<td>1888 – 1889</td>
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<td>1890 – 1898</td>
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<td>Redivision</td>
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<tr>
<td>1899 – 1901</td>
<td>24</td>
<td>Redivision</td>
</tr>
<tr>
<td>1902 – 1918</td>
<td>24</td>
<td>Redivision</td>
</tr>
<tr>
<td>1919 – 1930</td>
<td>28</td>
<td>Annexation</td>
</tr>
</tbody>
</table>

Sources

The main source used in the creation of the Baltimore Wards is the Guide to Research in Baltimore City and County. This book was compiled in 1993 by Robert William Barnes. It contains written descriptions of each ward and ward maps originating from official city documents describing the 10 main redivisions that occurred between 1818 and 1930.

This primary history has been checked against ward maps that were periodically released during this time period. These include maps located at the University of Chicago Map Collection and the Library of Congress as well as maps available online through the JHU Library, the Maryland State
Throughout this period Baltimore expanded very rapidly by the incorporation of nearby areas and through landfill. Annexations added large areas of land and substantial numbers of new residents to the growing city at clearly specified dates; as such they initiate a new system in our ward history even if redivisions were not explicitly issued. Throughout the study period Baltimore expanded slightly through landfill. Landfill occurred gradually, taking decades to complete. As a result landfill does not trigger a new ward system. The shoreline most generally applicable to the period, taken at one point during the system's use, is reflected in the shapefile/feature class. Maps collected from the archives listed above were used to determine the extent and timing of landfill during the study period.

Street centerlines delimited many ward boundaries. We have checked the HUE ward boundaries for topological consistency against the CPE’s HUE Street Centerlines for Baltimore. These streets were created from georeferenced historical maps, modern orthographic imagery, and Census TIGER Line files from 2007. Ambiguities between street names and instances where boundaries ran on streets that were no longer extant by 1930 are noted below. An Index of Streets and Alleys found in Records, Plats, Atlases and Miscellaneous Drawings at the Baltimore city Archives, compiled in 1993 by Rebecca Gunby and found through the Maryland State Archives, was referenced extensively. Georeferenced historical maps, contemporary orthoimagery, and GIS data were used in cases where abstract lines and natural features constituted ward boundaries.

The monthly and annual tabular data reported by various municipal departments that accompany and implement the HUE GIS resources reveal the effective (rather than legislated) timing of changes to ward and city boundaries. These reports are often quite clear, with references to "old" and "new" wards, or the expansion of tables to include new ward numbers. The HUE ward system dates pertain to the official implementation of the wards as reporting units, making many of them unsuitable for use in determining the passage of the ordinances and acts from which they were created due to administrative lags.

**Ward Systems**

**1818-1831**
Change: Redivision  
Number of Wards: 12  

**1832-1840**
Change: Redivision  
Number of Wards: 12  
1841-1845
Change: Redivision
Number of Wards: 14

1846-1860
Change: Redivision
Number of Wards: 20

1861-1882
Change: Redivision
Number of Wards: 20

1883-1887
Change: Redivision
Number of Wards: 20

Notes:
• *Guide to Research in Baltimore City and County* offers inconsistent descriptions of the border between Wards 13 and 14; the Ward 14 border description is used.

1888-1889
Change: Annexation
Number of Wards: 22

1890-1898
Change: Redivision
Number of Wards: 22

1899-1901
Change: Redivision
Number of Wards: 24

1902-1918
Change: Redivision
Number of Wards: 24
1919-1930
Change: Redivision
Number of Wards: 28

Citations
**Boston Ward History**

**Introduction**

This resource documents the creation of the Historical Urban Ecological (HUE) data set Boston ward boundary shapefiles and feature classes. All sources pertaining to the delineation and numbering of each ward system (the unique configuration of ward boundaries over a defined period), encompassing cartographic materials, city ordinances, newspaper reports, and ward boundaries described in the historical literature, have been included. Exclusions are noted where applicable. This document also describes ambiguities found between sources and a discussion of how these ambiguities were resolved in our published data. Table 2 provides a general ward history, 1830-1930.

**Table 2: General Ward History of the City of Boston, 1830 - 1930**

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Number of Wards</th>
<th>Type of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1830 – 1835</td>
<td>12</td>
<td>--</td>
</tr>
<tr>
<td>1836 – 1837</td>
<td>13</td>
<td>Annexation</td>
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<tr>
<td>1838 – 1850</td>
<td>12</td>
<td>Redivision</td>
</tr>
<tr>
<td>1851 – 1855</td>
<td>12</td>
<td>Redivision</td>
</tr>
<tr>
<td>1856 – 1865</td>
<td>12</td>
<td>Annexation</td>
</tr>
<tr>
<td>1866 – 1867</td>
<td>12</td>
<td>Redivision</td>
</tr>
<tr>
<td>1868 – 1869</td>
<td>15</td>
<td>Annexation</td>
</tr>
<tr>
<td>1870 – 1873</td>
<td>16</td>
<td>Annexation</td>
</tr>
<tr>
<td>1874 – 1875</td>
<td>21</td>
<td>Annexation</td>
</tr>
<tr>
<td>1876 – 1894</td>
<td>25</td>
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<tr>
<td>1895 – 1912</td>
<td>25</td>
<td>Redivision</td>
</tr>
<tr>
<td>1913 – 1914</td>
<td>26</td>
<td>Annexation</td>
</tr>
<tr>
<td>1915 – 1925</td>
<td>26</td>
<td>Redivision</td>
</tr>
<tr>
<td>1926 – 1930</td>
<td>22</td>
<td>Redivision</td>
</tr>
</tbody>
</table>

**Sources**

The main source used in the creation of the Boston Wards is A Catalogue of the City Councils of Boston 1822-1908 Roxbury 1846-1867 Charlestown 1847-1873 and of the Selectmen of Boston, 1634-1822 also of Various Other Town and Municipal Officers. This document was compiled and printed in 1909 by the City of Boston. It contains written descriptions of each ward for the six main redivisions between 1822 and 1895.

This primary history has been supplemented by annexations that occur between redivisions and checked against ward maps that were periodically released during this time period. These include maps located at the University of Chicago Map Collection and the Library of Congress as well as maps available online through the Boston Public Library, the David Rumsey Map Collection, and ProQuest Sanborn Maps Geo Edition.

Throughout this period Boston expanded very rapidly by the incorporation of nearby areas and through landfill. Annexations added large areas of land and substantial numbers of new residents to the growing city at clearly specified dates; as such they initiate a new system in our ward history.
even if redivisions were not explicitly issued. Land fill occurred much more gradually, taking decades to complete. As a result land fill does not trigger a new ward system. Changes to the shoreline, however, are reflected generally. The shoreline most generally applicable to the period, taken at one point during the system’s use is reflected in the shapefile. The document “HUE Shoreline Sources,” available from the CPE, notes all sources used in the creation of shorelines. For more specific information please contact the CPE. Nancy Seasholes’ authoritative volume Gaining Ground A History of Landmaking in Boston was critical in determining the extent and timing of landfill during the study period.

Street centerlines delimited many ward boundaries. We have checked the HUE ward boundaries for topological consistency against the CPE’s HUE Street Centerlines for Boston. These streets were created from georeferenced historical maps, modern orthographic imagery, and Census TIGER Line files from 2007, that were edited to reflect the streets as they existed in 1922 according to Sampson & Murdock’s street map. Many ward lines were set against these streets. Ambiguities between street names and instances where boundaries ran on streets that were no longer extant by 1922 are noted below. Georeferenced historical maps, contemporary orthoimagery, and GIS data were used in cases where abstract lines and natural features constituted ward boundaries.

The monthly and annual tabular data reported by various municipal departments that accompany and complement the HUE GIS resources reveal the effective (rather than legislated) timing of changes to ward and city boundaries. These reports are often quite clear, with references to "old" and "new" wards, or the expansion of tables to include new ward numbers. The HUE ward system dates pertain to the official implementation of the wards as reporting units, making many of them unsuitable for use in determining the passage of the ordinances and acts from which they were created due to administrative lags.

**Ward Systems**

**1830-1835**
Change: Redivision
Number of Wards: 12

Notes:
- Descriptions of Ward 1, 2 and 3 describe the ward line running down 'North' and 'Middle' streets. Although these street names were not found on the most contemporary (Fuller) map, they are present on the Norman 1806 map as describing the Hanover St north of Mill Creek.
- Description of Wards 4 and 7 describe the ward line running through 'Bowdoin Square', which is an area along between Court and Cambridge Streets that doesn’t show up in our GIS. This line has been imputed.
- Descriptions of Wards 4 and 5 include ‘Leverett Place’. Our GIS uses its later name of ‘Lyman St’. The placement of the older name is confirmed by the Fuller 1826 map.
• Descriptions of Wards 4 and 5 describe the boundary lines as running directly from Prospect Street to Causeway street. These do not line up perfectly in our GIS, so we show them running for a short section along Merrimac Street in between the two.

• Descriptions of Wards 6 and 7 include ‘Belknap Street’. Our GIS uses its later name of ‘Joy St’. The placement of the older name is confirmed by the Fuller 1826 map.

• Descriptions of Wards 7 and 8 include ‘Cornhill’, ‘Marlboro’, and ‘Newbury’ streets. Our GIS uses their later names of ‘Washington St’. The placement of the older names is confirmed by the Norman 1806 map.

• Descriptions of Wards 7 and 10 include ‘Common Street’. Our GIS uses its later name of ‘Tremont St’. The placement of the older name is confirmed by the Fuller 1826 map.

• Descriptions of Wards 8 and 9 include ‘Atkinson Street’. Our GIS uses its later name of ‘Congress St’. The placement of the older name is confirmed by the Fuller 1826 Map.

• Descriptions of Wards 8 and 9 include ‘Adams Street’. Our GIS uses its later name of ‘Kilby St’. The placement of the older name is confirmed by the Norman 1806 map.

• We have included the entirety of Long Wharf in Ward 4. There is some ambiguity in the Ward 9 description, the Ward 4 description seems to only cover the northern half of the wharf. The Eddy 1835 map depicts Long Wharf belonging to Ward 4 in its entirety.

• Descriptions of Wards 10 and 11 describe the ward lines as running directly from Boylston to Essex Streets. These do not line up perfectly in our GIS, so we show them running for a short section along Washington Street between the two.

• Descriptions of Wards 10 and 11 include ‘Rainsford Lane’. The Norman 1806 map includes Rainsford Lane and it appears to have been connected to Harrison Street when land extension made this possible. We have thus used Harrison Street.

• Descriptions of Wards 11 and 12 describe ‘Pleasant Street’. This street in the Fuller 1826 and Norman 1806 maps appears to cross Park Square and turn into Washington Street (c. 1922). This is reflected in the shapefile.

• Descriptions of Wards 11 and 12 describe ‘Warren Street’. Our GIS uses its later name of ‘Warrenton St’. The placement of the older name is confirmed by the Fuller 1826 map.

• Descriptions of Wards 11 and 12 describe ‘Orange Street’. Our GIS uses its later name of ‘Washington St’. The placement of the older name is confirmed by the Norman 1806 map.

1836-1837
Change: Annexation of East Boston
Number of Wards: 12 + East Boston
Primary Source: “Boston in 1880: Showing Areas and Dates of Annexations of Territory.” [map].
George E. Waring, Jr., 1880. UT Library Historical Maps Collection.
Notes:
• We were unable to find a source identifying a ward number for the newly annexed area. Tables from the period use “East Boston.” No ward number has been assigned but a new Field called “Ward Name” has been created to reflect these conditions.
• Ward 11 incorporates all made land south of Beach Street in S. Cove west of South St. and made land north of Worcester Railroad tracks as depicted in the Eddy 1835 map and Boynton 1838 map.
1838-1850
Change: Redivision
Number of Wards: 12 (East Boston incorporated into Ward 4)


Notes:
- Descriptions of Wards 1 and 3 describe ‘Richmond St’. Our GIS uses its later name of ‘Parmenter St’ between Hanover and Salem Streets. The placement of the older name is confirmed by the Fuller 1826 map.
- Descriptions of Wards 2 and 4 include ‘Dock Square’, which appears from the Norman 1806 map to be a continuation of Union St.
- Descriptions of Wards 3 and 5 include ‘Lyman Place’. Our GIS uses its later names of ‘Stanford’ and ‘Lyman’ Streets. The placement of the older name is confirmed by the Boynton 1839 map.
- Descriptions of Wards 3 and 5 describe the ward lines as running directly from Prospect St to Causeway St. These do not line up perfectly in our GIS, so we show them running for a short section along Merrimac St in between the two.
- Descriptions of Wards 3 and 4 describe the ward lines running along ‘Bowdoin Square’. This square is at the intersections of Green, Court and Cambridge Streets and is not included in our GIS. (The square itself is placed in Ward 4).
- Descriptions of Wards 4 and 6 include ‘Belknap Street’. Our GIS uses its later name of ‘Joy St’. The placement of the older name is confirmed by the Fuller 1826 map.
- Descriptions of Wards 7 and 9 include ‘Franklin Place’. Our GIS uses its later name of ‘Franklin St’.
- Descriptions of Wards 7 and 9 include ‘Chauncy Place’. We were unable to locate this on a historical map, but from the description ‘Chauncy Place’ is assumed to refer to ‘Chauncy Street’ between Bedford Street and Essex Street.
- Descriptions of Wards 7 and 9 describe ‘Rowe Street’. Our GIS uses its later name of ‘Chauncy St’. The placement of the older name is confirmed by the Boynton 1839 map.
- Descriptions of Wards 8 and 9 describe ‘Berry Street’. Our GIS uses its later name of ‘Channing St’. The placement of the older name is confirmed by the Boynton 1839 and Fuller 1826 maps.
- Descriptions of Wards 8 and 9 describe ‘Atkinson Street’. Our GIS uses its later name of ‘Congress St’. The placement of the older name is confirmed by the Boynton 1839 and Fuller 1826 maps.
- Descriptions of Wards 10 and 11 include ‘Pleasant Street’. Our GIS uses its later name of ‘Broadway’ as well as ‘Park Sq’.
- The Boynton Map shows the ward line between Wards 10 and 11 going from Boylston directly down Carver to Pleasant. The Catalogue description moves this by extending Ward 10 to include the block bordered by Pleasant, Elliot, Carver and Boylston. We have used the Catalogue’s description.
- Descriptions of Wards 10 and 11 include ‘a new street crossing the South Cove’. The Boynton map shows the map going down ‘Orange Road’. Being the first road to the south of the Worcester Railroad at this location this street corresponds to ‘Way St’ in our GIS.
1851-1855:
Change: Redivision
Number of Wards: 12
Notes:
- Descriptions of Wards 1 and 4 describe ‘Richmond St’. Our GIS uses its later name of ‘Parmenter St’ between Hanover and Salem Streets. The placement of the older name is confirmed by the Fuller 1826 map.
- Descriptions of Wards 4 and 6 describe Temple Street. Our GIS doesn’t include Temple Street running from Derne Street to Mount Vernon Street. The location is imputed.
- Descriptions of Wards 6 and 9 describe ‘Western Ave’. Our GIS uses its later name of ‘Beacon St’. The placement is confirmed by the Boynton 1853 map.
- Descriptions of Wards 9 and 10 describe ‘Warren Street’. Our GIS uses its later name of ‘Warrenton St’. The placement is confirmed by Boynton 1853 map.
- Descriptions of Wards 9 and 11 refer to the “Centre of the Boston and Worcester Railroad.” This line is imputed.

1856-1865
Change: Annexation of Dorchester Neck
Number of Wards: 12

1866-1867
Change: Redivision
Number of Wards: 12
Notes:
- Descriptions of Wards 2 and 4 describe ‘Haymarket Square’. Our GIS displays the ward boundary running down N Charleston St between Haverhill St and Blackstone St. The placement is confirmed by the 1863 plan of Boston.
- Descriptions of Wards 5 and 7 describe ‘Federal St’ to ‘Mt. Washington Ave’. Our GIS uses Atlantic Ave to Kneeland St and a direct line to the water where the Mt. Washington Ave would be. The placement is confirmed by the 1863 plan of Boston.
- Descriptions of Ward 9 describe ‘Pleasant St’ between Carver St and Washington St. Our GIS uses the name ‘Broadway St’ as the ward boundary between Carver St and Washington St. This placement is confirmed by the 1867 plan of Boston.
- Descriptions of Wards 9 and 10 describe the ward boundary from Harrison Ave to Florence St crossing Washington St to ‘Chapman St’. Our GIS uses ‘Compton St’ instead.
1868-1869
Change: Annexation of Roxbury
Number of Wards: 15
Notes:
- The Catalogue does not include descriptions of the newly created ward boundaries. They have been derived from the Johnson 1870 map.

1870-1873
Change: Annexation of Dorchester
Number of Wards: 16

1874-1875
Change: Annexation of Brighton, Charlestown, and West Roxbury
Number of Wards: 21
Notes:
- The Catalogue does not include descriptions of the newly created ward boundaries. They have been derived from the Hopkins 1874 map.
- The northwestern boundary between Wards 20 and 22 is appears as Williams Street to the water on the Hopkins 1874 map, our GIS lacks this street, its location has been imputed.

1876-1894
Change: Redivision
Number of Wards: 25
Notes:
- Descriptions of Ward 1 and 2 describe the ward boundary following Port St through Central Sq, Border St then to the water. Our GIS shows the ward boundary following Porter St to Meridian St to Central Sq to Border St to the water.
• Descriptions of Wards 3 and 5 describe the boundary following 'Chestnut Street.' Our GIS uses the name 'Lexington St'. This placement is confirmed by the A. Williams 1876 map.

• Descriptions of Wards 4 and 5 describe the boundary following 'Lincoln Street.' This street does not exist in our GIS, the location has been imputed.

• Descriptions of Ward 6 describe the boundary crossing 'Dock Square' from North St. to Devonshire St. Our GIS uses 'Union St'. This placement is confirmed by the A. Williams 1876 map.

• Descriptions of Wards 9 and 11 describe the boundary following 'Otter Street'. Our GIS uses part of Embankment Rd with a direct line to the water.

• Descriptions of Wards 10 and 12 describe the boundary from Devonshire St to Lincoln St. Our GIS map however does not have a direct intersection between Devonshire St and Lincoln St. Our GIS therefore displays the ward boundary extending from the intersection of Devonshire St and Summer St to the intersection of Lincoln St and Bedford St. This placement is confirmed by the A. Williams 1876 map.

• Descriptions of Wards 10, 11 and 12 describe the ward boundary running from Tremont St to Boylston St. to Arlington St. back to Beacon St. The additional portions of Ward 10 are the public gardens. This placement is confirmed by the A. Williams 1876 map.

• Descriptions of Wards 11 and 12 describe the ward boundary following Tremont St to Chandler St. Our GIS however does not show an intersection between Tremont St and Chandler St. so our GIS shows the ward boundary extending from Tremont St to the intersection of Chandler St and Arlington St in a direct line following Chandler St.

• Descriptions of Wards 12 and 16 describe the boundary following Tremont St. to 'Pleasant Street' Our GIS uses the name 'Broadway St'.

• Descriptions of Ward 15 describe the ward boundary following 'Dorchester Street.' Our GIS uses the name 'Boston St' which is the same as Dorchester St. but south of Southampton St.

• Descriptions of Wards 16 and 17 describe the boundary following Tremont St to Milford St. across Shawmut St. to Bradford St. to Medford Ct. to Washington St. to Ashland place to Harrison Ave. to Bristol St. to the water. Our GIS replaces Ashland place with Laconia St. This placement is confirmed by the A. Williams 1876 map.

• Descriptions of Wards 20 and 21 describe the boundary following ‘Grenville St.’ Our GIS uses the name 'Greenville St'. This change is confirmed by the Sampson 1878 map.

• Descriptions of Wards 21, 22 and 23 describe the boundary following the Boston and Providence Railroad to the junction of Centre St. and Amory St. Our GIS shows the boundary following Columbus Ave.

• Descriptions of Wards 21 and 23 use the name 'Codman St.' Our GIS uses the name ‘Dimock St.’ This is confirmed by the Sampson 1878 map.

• Descriptions of Wards 21 and 23 describe the boundary following Egleston square from Washington St to Seaver St. Our GIS uses the name 'Columbus Ave' instead.

• Descriptions of Wards 21 and 23 describe the boundary following Pynchon St between Roxbury St and Tremont St. Our GIS shows the boundary running along Gardner St from Roxbury to Tremont St.

• Descriptions of Wards 23 and 24 describe the boundary following Back St from Blue Hill Ave. Our GIS used the name 'Harvard St.' This change is confirmed by the Sampson 1878 map.
1895-1912
Changes: Redivision
Number of Wards: 25
Notes:
- Descriptions of Wards 1 and 2 describe the ward boundary following Front St to Marion St to Bennington St to Central Sq to Border St. Our GIS does not contain a Front St. Our placement is confirmed by the Sampson 1896 map.
- Descriptions of Wards 3 and 5 describe the boundary following ’Chestnut St’. Our GIS uses the name ’Lexington St’.
- Descriptions of Wards 4 and 5 describe the boundary following High St to Walker St to Main St to Lincoln St. Our GIS follows this description except Lincoln St does not exist on our GIS. Our placement of the ward boundary and between Frothingham St and S Eden St is confirmed by the Sampson 1896 map.
- Descriptions of Wards 7 and 10 describe the boundary following ’Pleasant St’. Our GIS uses the name ’Broadway St’. This name change is confirmed by the Sampson 1896 map.
- Descriptions of Wards 10 and 19 describe the boundary following ’Rogers St’. Our GIS uses the street name ’Ruggles St’. This name change is confirmed by the Sampson 1896 map.

1913-1914
Changes: Annexation of Hyde Park
Number of Wards: 26
Primary Source: Bromley, George W. and Walter S. Bromley. “Atlas of the City of Boston.”

1915-1925
Changes: Redivision
Number of Wards: 26

1926-1930
Changes: Redivision
Number of Wards: 22
Citations


"Map of the City of Boston." [map]. Sampson, Daveport & Co, 1922.


**Brooklyn Ward History**

**Introduction**

This resource documents the creation of the Historical Urban Ecological (HUE) data set Brooklyn ward boundary shapefiles and feature classes. All sources pertaining to the delineation and numbering of each ward system (the unique configuration of ward boundaries over a defined period), encompassing cartographic materials, city ordinances, newspaper reports, and ward boundaries described in the historical literature, have been included. Exclusions are noted where applicable. This document also describes ambiguities found between sources and a discussion of how these ambiguities were resolved in our published data. Table 3 provides a general ward history, 1834-1930.

**Table 3: General ward history of Brooklyn 1834-1930**

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Number of Wards</th>
<th>Type of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1834 – 1839</td>
<td>9</td>
<td>Incorporation</td>
</tr>
<tr>
<td>1840 – 1849</td>
<td>9</td>
<td>Redivision</td>
</tr>
<tr>
<td>1850 – 1854</td>
<td>11</td>
<td>Redivision</td>
</tr>
<tr>
<td>1855 – 1856</td>
<td>18</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1857 – 1863</td>
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<tr>
<td>1864 – 1867</td>
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<td>1868 – 1872</td>
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<td>1873</td>
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<td>1874 – 1886</td>
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<td>1887 – 1891</td>
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<td>1892 – 1893</td>
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<tr>
<td>1894 – 1895</td>
<td>31</td>
<td>Annexation</td>
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<tr>
<td>1896 – 1924</td>
<td>32</td>
<td>Annexation</td>
</tr>
<tr>
<td>1925 – 1930</td>
<td>32</td>
<td>City boundary change</td>
</tr>
</tbody>
</table>

**Sources**

No single source provides a satisfactory overview of Brooklyn's ward boundary changes. A broad collection of historical maps, city ordinances, and laws recorded by the State of New York were employed in the creation of the Brooklyn Wards GIS data.

This ward boundary history combines Brooklyn's ward redivisions with all of its annexations from incorporation in 1834 up to 1930. Annexations for any one year include the addition of one or many towns in Kings County. The inauguration of a new ward system in the HUE Brooklyn ward boundary data accounts for either a change in internal ward boundaries, significant annexations, or historically significant changes to the city boundary. Changes to the Brooklyn City Charter discovered in archival city-issued documents and proceedings detailed in the Laws of the State of New York form the core of this composite ward history. The Laws of the State of New York describe all acts taken up and passed by the state legislature and encapsulate nearly every change to Brooklyn's city charter, including all minor amendments.
This composite history has been supplemented by and checked against ward maps that were periodically released during this time period. These include maps located at the University of Chicago Map Collection as well as maps available online through the New York Public Library, the David Rumsey Map Collection, and ProQuest Sanborn Maps Geo Edition.

Changes to the shoreline, are reflected generally in this data set. The shoreline most generally applicable to the period, taken at one point during the system's use is reflected in the shapefile. The document “HUE Shoreline Sources,” available from the CPE, notes all sources used in the creation of shorelines. For more specific information please contact the CPE.

Street centerlines delimited many ward boundaries. We have checked the HUE ward boundaries for topological consistency against the CPE’s HUE Street Centerlines for Brooklyn. These streets were created from georeferenced historical maps, modern orthographic imagery, and Census TIGER Line files from 2007, that were edited to reflect the streets as they existed in 1916 according to Ullitz’s map, *Atlas of the Borough of Brooklyn: City of New York*, and Tuttle’s *Sectional Aerial Maps of the City of New York* in 1924 Many ward lines were set against these streets. Ambiguities between street names and instances where boundaries ran on streets that were no longer extant are noted below. Georeferenced historical maps, contemporary orthoimagery, and GIS data were used in cases where abstract lines and natural features constituted ward boundaries.

The monthly and annual tabular data reported by various municipal departments that accompany and complement the HUE GIS resources reveal the effective (rather than legislated) timing of changes to ward and city boundaries. These reports are often quite clear, with references to "old" and "new" wards, or the expansion of tables to include new ward numbers. The HUE ward system dates pertain to the official implementation of the wards as reporting units, making many of them unsuitable for use in determining the passage of the ordinances and acts from which they were created due to administrative lags.

**Ward Systems**

**1834-1839**  
Change: City Incorporated  
Number of Wards: 9  
Note:  
- Wards formed on incorporation based on the wards of the village of Brooklyn.

**1840-1849**  
Change: Redivision  
Number of Wards: 9  
**1850-1854**
Change: Redivision
Number of Wards: 11
Note:
- Despite divisions presented and accepted to convention in 1847, Act adopting new ward boundaries not passed until April 4, 1850

**1855-1856**
Change: Redivision/Annexation
Number of Wards: 18
Notes:
- Williamsburgh and Bushwick annexed.
- The eastern boundary of the 18th ward is described as running southeast along Newton creek to “the intersection of the Williamsburgh and Jamaica turnpike, thence in a southeasterly direction to a certain rock called ‘Arbitration rock;’ thence south twenty seven degrees east one hundred and fifty five chains to a heap of stones; thence in a direct line until it is intersected by the western boundary of New Lots.” This boundary was recreated from georeferenced historical maps as the historical location of Arbitration Rock is disputed and the heap of stones unknown.

**1857-1863**
Change: Redivision
Number of Wards: 19

**1864-1867**
Change: Redivision
Number of Wards: 20
Note:
- Ward boundary change not found in index of the Laws of the State of New York, but municipal reports issued 1864 through 1867 specify 20 wards

**1868-1872**
Change: Redivision
Number of Wards: 22
1873
Change: Redivision
Number of Wards: 25
Note:
- Enacted 6/28/1873

1874-1886
Change: Redivision
Number of Wards: 25
Notes:
- Only change to a small part of boundary of ward 7, passed 6/1/1874
- Only 25 wards in all digitized and collected Brooklyn HUE data for 1886 despite annexation timing of New Lots (see 1887-1891 ward history).

1887-1891
Change: Annexation
Number of Wards: 26
Note:
- New Lots annexed 8/1/1886. All HUE tabular data excludes ward 26 (New Lots), reporting only the original 25. First instances of 26 wards appear in 1887 data, although some tables continue to report 25. All reports include all 26 wards by 1888.

1892-1893
Change: Redivision
Number of Wards: 28

1894-1895
Change: Annexation
Number of Wards: 31
Note:
- Flatbush annexed 4/25/1894; Gravesend annexed 5/8/1894; New Utrecht annexed 7/1/1894; though changes to city charter discuss annexation of Flat Lands, town is not officially added to the City of Brooklyn until 1896
1896-1924
Change: Annexation
Number of Wards: 32
Notes:
- Flatlands annexed 1/1/1896
- Greater New York City Charter enacted in 1897 (taking effect in 1898), does not interfere with ward numbering scheme nor boundaries (all Boroughs maintain their own ward systems).

1925-1930
Change: City Boundary Change
Number of Wards: 32
Primary Source: (none)
Notes:
- Brooklyn-Queens boundary redrawn in 1925, interior ward boundaries remain unchanged
- Shoreline drawn to contemporary infill in Jamaica Bay
- The redrawn boundary is based on the “Administrative and Political Districts” shapefile, edition 13b, released May, 2013 by the New York City Department of Planning

Citations

City of Brooklyn. “Charter of the City of Brooklyn,” in *Brooklyn City Charter and Ordinances*. Brooklyn: Brooklyn City Clerk, 1855 & 1888.


“Map of the Town of Brooklyn in the County of Kings” [map]. Jeremiah Johnson, 1834.

**Chicago Ward History**

**Introduction**

This resource documents the creation of the Historical Urban Ecological (HUE) data set Chicago ward boundary shapefiles and feature classes. All sources pertaining to the delineation and numbering of each ward system (the unique configuration of ward boundaries over a defined period), encompassing cartographic materials, city ordinances, newspaper reports, and ward boundaries described in the historical literature, have been included. Exclusions are noted where applicable. This document also describes ambiguities found between sources and a discussion of how these ambiguities were resolved in our published data. Table 4 provides a general ward history, 1837-1930.

**Table 4: General ward history of Chicago, 1837-1930**

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Number of Wards</th>
<th>Type of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1837 – 1846</td>
<td>6</td>
<td>City Incorporated</td>
</tr>
<tr>
<td>1847 – 1852</td>
<td>9</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1853 – 1862</td>
<td>10</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1863 – 1868</td>
<td>16</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1869 – 1888</td>
<td>20</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1889</td>
<td>34</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1890</td>
<td>34</td>
<td>Annexation</td>
</tr>
<tr>
<td>1891 – 1892</td>
<td>34</td>
<td>Annexation</td>
</tr>
<tr>
<td>1893 – 1894</td>
<td>34</td>
<td>Annexation</td>
</tr>
<tr>
<td>1895 – 1898</td>
<td>34</td>
<td>Annexation</td>
</tr>
<tr>
<td>1899 – 1900</td>
<td>35</td>
<td>Annexation</td>
</tr>
<tr>
<td>1901 – 1909</td>
<td>35</td>
<td>Redivision</td>
</tr>
<tr>
<td>1910 – 1911</td>
<td>35</td>
<td>Annexation</td>
</tr>
<tr>
<td>1912 – 1913</td>
<td>35</td>
<td>Redivision</td>
</tr>
<tr>
<td>1914</td>
<td>35</td>
<td>Annexation</td>
</tr>
<tr>
<td>1915 – 1922</td>
<td>35</td>
<td>Annexation</td>
</tr>
<tr>
<td>1923 – 1926</td>
<td>50</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1927 – 1930</td>
<td>50</td>
<td>Annexation</td>
</tr>
</tbody>
</table>

**Sources**

No single source provides a satisfactory overview of Chicago’s ward boundary changes. A broad collection of historical maps and city ordinances were employed in the creation of the Chicago Wards GIS data.

This ward boundary history combines Chicago’s ward redivisions with all of its annexations from incorporation in 1837 up to 1930. Annexations for any one year ranged from multiple towns to a single small neighborhood. The inauguration of a new ward system in the HUE Chicago ward boundary data accounts for either a change in the ward boundary system, a large city expansion, or the incorporation of a small annex into the city. Three resources were of particular importance to this endeavor: the Chicago Bureau of Maps and Plats’ *Map of Chicago Showing Growth of the City by Annexations*, 1911 and 1930, and Ann Durkin Keating’s map from the Encyclopedia of Chicago,
Annexations and Additions to the City of Chicago. Additional information regarding annexations and their timing was found in Goodspeed and Healy's History of Cook County, written in 1909. History of Cook County contains more detailed information for respective annex-ward connections, in particular from 1890 through 1893.

This composite history has been supplemented by and checked against ward maps that were periodically released during the study period. These include maps located at the University of Chicago Map Collection and the Library of Congress as well as maps available online through the David Rumsey Map Collection and the Encyclopedia of Chicago.

Street centerlines delimited many ward boundaries. We have checked the HUE ward boundaries for topological consistency against the CPE's HUE Street Centerlines for Chicago. These streets were created from georeferenced historical maps, historical aerial surveys, and modern orthographic imagery that were edited to reflect the streets as they existed in 1929 according to Rand McNally & Company's New Street Number Guide Map of Chicago. Many ward lines were set against these streets. Georeferenced historical maps, contemporary orthoimagery, and GIS data were used in cases where abstract lines and natural features constituted ward boundaries.

The monthly and annual tabular data reported by various municipal departments that accompany and complement the HUE GIS resources reveal the effective (rather than legislated) timing of changes to ward and city boundaries. These reports are often quite clear, with references to "old" and "new" wards, or the expansion of tables to include new ward numbers. The HUE ward system dates pertain to the official implementation of the wards as reporting units, making many of them unsuitable for use in determining the passage of the ordinances and acts from which they were created due to administrative lags.

Ward Systems
1837-1849
Change: City Incorporated
Number of Wards: 6
http://www.encyclopedia.chicagohistory.org/pages/11480 (Accessed Feb 21, 2013);

1847-1852
Change: Annexation and Redivision
Number of Wards: 9
http://www.encyclopedia.chicagohistory.org/pages/10343.html (Accessed Feb 18, 2013);
III. GIS Downloads


1853-1862
Change: Annexation and Redivision
Number of Wards: 10

1863-1868
Change: Annexation and Redivision
Number of Wards: 16

1869-1888
Change: Annexation and Redivision
Number of Wards: 20

1889
Change: Annexation and Redivision
Number of Wards: 34

Notes:
- Lake Township annexed, area spans multiple wards
- Southeastern boundary of Ward 28 confirmed via maps available through “A Look at Cook” – Genealogy in Cook County Illinois, http://www.alookatcook.com/

1890
Change: Annexation
Number of Wards: 34

Notes:
- Areas annexed: West Roseland (joins Ward 34, see History of Cook County), Gano (34, see History of Cook County), South Englewood (no ward specified in source; entire area added to Ward 31 due to adjacency, majority of new area abuts and continues Ward 31, addition of part or all to Ward 34 is a less likely alternative)

1891-1892
Change: Annexation
Number of Wards: 34

Notes:
- Areas annexed: Washington Heights (joins Ward 31, see History of Cook County), Fernwood (31, see History of Cook County)

1893-1894
Change: Annexation
Number of Wards: 34
III. GIS Downloads


Notes:
- Areas annexed: Norwood Park (joins Ward 27, see History of Cook County), West Ridge (26, see History of Cook County), Rogers Park (25, see History of Cook County)

1895-1898
Change: Annexation
Number of Wards: 34
Notes:
- Area annexed: A portion of Calumet (joins Ward 34, see History of Cook County)

1899-1900
Change: Annexation
Number of Wards: 35
Notes:
- Area Annexed: Austin (incorporated as its own discrete ward, Ward 28)

1901-1909
Change: Redivision
Number of Wards: 35

1910-1911
Change: Annexation
Number of Wards: 35
Notes:
- Area annexed: Edison Park (no source; area added to ward 27 due to unambiguous adjacency, i.e. boundary completely abuts a single ward edge, not split across multiple wards)
1912-1913
Change: Redivision
Number of Wards: 35
Primary Source: “School Map of Chicago” [map]. Board of Education of the City of Chicago, 1914
University of Chicago Map Collection.
http://www.lib.uchicago.edu/e/collections/maps/chi1900/G4104-C6E68-1914-C7.html

1914
Change: Annexation
Number of Wards: 35
Primary Sources: “Map of Chicago Showing Growth of the City by Annexations” [map]. Chicago
http://www.lib.uchicago.edu/e/collections/maps/chigov/G4104-C6S1-1930-C7.html
(Accessed Feb 18, 2013); “School Map of Chicago” [map]. Board of Education of the City of
Chicago, 1914 University of Chicago Map Collection.
http://www.lib.uchicago.edu/e/collections/maps/chi1900/G4104-C6E68-1914-C7.html
Notes:
- Area annexed: Morgan Park (no source; entire area added to Ward 32 due to adjacency,
majority of new area abuts and continues Ward 32, addition of part or all to Ward 9 is a less
likely alternative)

1915-1922
Change: Annexation
Number of Wards: 35
Primary Source: Keating, Ann Durkin. “Annexations and Additions to the City of Chicago” in
Notes:
- Area annexed: Clearing (no source; entire area added to Ward 29 due to adjacency, majority
of new area abuts and continues Ward 29, Ward 5 is a less likely alternative)

1923-1926
Change: Annexation and Redivision
Number of Wards: 50
Primary Sources: “Ward Map of Chicago, 50 Ward Plan” [map]. Chicago: Chicago City Council, 1921;
Keating, Ann Durkin. “Annexations and Additions to the City of Chicago” in Encyclopedia of
http://www.lib.uchicago.edu/e/collections/maps/chigov/G4104-C6S1-1930-C7.html
Notes:
- Area annexed: Part of Town of Maine (no source; area added to Ward 41 due to unambiguous adjacency)

1927-1930
Change: Annexation
Number of Wards: 50
http://www.encyclopedia.chicagohistory.org/pages/3716.html (Accessed Feb 18, 2013);
Notes:
- Area annexed: Mount Greenwood (no source; area added to Ward 19 due to unambiguous adjacency)

Citations


**CINCINNATI WARD HISTORY**

**Introduction**

This resource documents the creation of the Historical Urban Ecological (HUE) data set Cincinnati ward boundary shapefiles and feature classes. All sources pertaining to the delineation and numbering of each ward system (the unique configuration of ward boundaries over a defined period), encompassing cartographic materials, city ordinances, newspaper reports, and ward boundaries described in the historical literature, have been included. Exclusions are noted where applicable. This document also describes ambiguities found between sources and a discussion of how these ambiguities were resolved in our published data. Table 5 provides a general ward history, 1851-1903.

Table 5: General ward history of Cincinnati, 1851-1903

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Number of Wards</th>
<th>Type of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1851 – 1860</td>
<td>16</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1861 – 1864</td>
<td>17</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1865 – 1867</td>
<td>18</td>
<td>Redivision</td>
</tr>
<tr>
<td>1868 – 1869</td>
<td>20</td>
<td>Redivision</td>
</tr>
<tr>
<td>1870 – 1872</td>
<td>24</td>
<td>Redivision</td>
</tr>
<tr>
<td>1873 – 1887</td>
<td>25</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1888 – 1889</td>
<td>30</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1890 – 1895</td>
<td>30</td>
<td>Annexation</td>
</tr>
<tr>
<td>1896 – 1901</td>
<td>31</td>
<td>Annexation</td>
</tr>
<tr>
<td>1902 - 1903</td>
<td>31</td>
<td>Redivision</td>
</tr>
</tbody>
</table>

**Sources**

No single source provides a satisfactory overview of Cincinnati’s ward boundary changes. A broad collection of historical maps and city directories were employed in the creation of the Cincinnati Wards GIS data.

This ward boundary history combines Cincinnati’s ward redivisions with all of its annexations from 1851 up to 1903. Ward boundary data was unreliable or non-existent from the incorporation of the city in 1831 through 1850. The same was true for years following 1903. The inauguration of a new ward system in the HUE Cincinnati ward boundary data accounts for either a change in the ward boundary system, a large city expansion, or the incorporation of a small annex into the city. Among the numerous resources used while constructing the data set, A.W. Gilbert’s *Map of Hamilton County, Ohio*, Stedman, Brown & Lyon’s *City of Cincinnati Map*, and a complete collection of the *Williams’ Cincinnati Directory* were all of particular importance in constructing an accurate ward history.

For much of this time period, map resources were unavailable or unreliable for determining ward history. Instead, numerous editions of the *Williams Cincinnati Directory* were used throughout the project, and these were treated as the final primary source when addressing discrepancies between...
data sources. As an overall data source, these written descriptions provided accurate descriptions on the evolution of Cincinnati’s Ward history.

Beginning in 1873, the city expanded dramatically outward. These areas contained minimal infrastructure and development. The *Williams Cincinnati Directory* often used domestic property lines to delineate the new ward boundaries in these areas, which presented a new challenge in accurately mapping the boundaries. A.W. Gilbert’s *Map of Hamilton County, Ohio* proved invaluable in accurately identifying these property lines.

This composite history has been supplemented by and checked against ward maps that were periodically released during the study period. These include maps located at the University of Chicago Map Collection, University of Cincinnati Library, and the Library of Congress as well as maps available online through the David Rumsey Map Collection.

Street centerlines delimited many ward boundaries. We have checked the HUE ward boundaries for topological consistency against the CPE’s HUE Street Centerlines for Cincinnati. The Cincinnati Streets shapefile is an amalgamation of many historical and modern maps. The central area was digitized from the City of Cincinnati Topographical Survey of 1912, which had in turn been georeferenced onto modern orthographical images. The periphery was created using 2007 Tiger Census line files and edited to resemble Mendenhall’s New Standard of Map Cincinnati, published by C.S. Mendenhall in 1920 and available at the University of Chicago Map Collection. Spatial attributes were further checked against orthoimagery downloaded September 26th and November 17th 2008 from seamless.usgs.gov

There were certain instances where discretion was necessary to move forward with the project. These cases are listed below for the particular years in which they occurred. In general these cases were limited to the far outer boundaries of the city where data were vague or limited.

The monthly and annual tabular data reported by various municipal departments that accompany and complement the HUE GIS resources reveal the effective (rather than legislated) timing of changes to ward and city boundaries. These reports are often quite clear, with references to "old" and "new" wards, or the expansion of tables to include new ward numbers. The HUE ward system dates pertain to the official implementation of the wards as reporting units, making many of them unsuitable for use in determining the passage of the ordinances and acts from which they were created due to administrative lags.

**Ward Systems**

**1851-1860**
Change: Annexation and Redivision
Number of Wards: 16
1861-1864
Change: Annexation and Redivision
Number of Wards: 17

1865-1867
Change: Redivision
Number of Wards: 18

1868-1869
Change: Redivision
Number of Wards: 20

Notes:
- Ward 17 outer boundaries are approximated based on later delineations of Fulton Township

1870-1872
Change: Redivision
Number of Wards: 24
http://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~23314~810003:City-of-Cincinnati,-Ohio--1872---Pu?sort=Pub_Date%2CPub_List_No%2CSeries_No&qvq=w4s:/where/Ohio/Cincinnati%20%28Ohio%29;q:Cincinnati;sort:Pub_Date%2CPub_List_No%2CSeries_No;lc:RUMSEY~8~1&mi=33&trs=48 (Accessed May 28, 2013).
Notes:
- Actual number of wards for this period was 24 (based on Williams’ City Directories). Full, readily mappable descriptions of the extent of peripheral annexation and interior divisions were not included for wards 21-24. They are excluded from the shapefile.
- Stedman Brown and Lyon provided accurate data of only inner 20 wards.
- Due to lack of information on outer boundaries, they were omitted.

1873-1887
Change: Annexation and Redivision
Number of Wards: 25

Notes:
- Northern Boundaries were mapped from Williams City Directory in conjunction with boundary lines presented in Map of Hamilton County, Ohio.

1888-1889
Change: Annexation and Redivision
Number of Wards: 30

Notes:
- Northern Boundaries were mapped from Williams City Directory in conjunction with boundary lines presented in Map of Hamilton County, Ohio.
- Ward 24 eastern boundary is based on the location of the canal and the western boundary of Ward 12.

1890-1895
Change: Annexation
Number of Wards: 30

Notes:
- Only significant change is to Ward 28
- Northern Boundaries were mapped from Williams City Directory in conjunction with boundary lines presented in Map of Hamilton County, Ohio.

1896-1901
Change: Annexation
Number of Wards: 31

Notes:
- Northern Boundaries were mapped from Williams City Directory in conjunction with boundary lines presented in Map of Hamilton County, Ohio.
- North boundary line of Ward 12 was moved from N Corporation line of city to Howell Ave. per Williams City Directory and changing street systems.
- Ward 31 based upon best estimates of Avondale and Clifton Township boundaries.

1902-1903
Change: Redivision
Number of Wards: 31

Notes:
- Northern Boundaries were mapped from Williams City Directory in conjunction with boundary lines presented in Map of Hamilton County, Ohio.

Citations

“Plan of Cincinnati and Vicinity” [map]. S. Augustus Mitchell, 1860. *David Rumsey Map Collection*  


“City of Cincinnati” [map]. Stedman, Brown & Lyon, 1872. *David Rumsey Map Collection*  
http://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~23314~810003:City-of-Cincinnati,-Ohio--1872---Pu?sort=Pub_Date%2CPub_List_No%2CSeries_No&qvq=w4s:/where/Ohio/Cincinnati%20%28Ohio%29;q:Cincinnati;sort:Pub_Date%2CPub_List_No%2CSeries_No;lc:RUMSEY~8~1&mi=33&trs=48 (Accessed May 28, 2013).


“Plan of Cincinnati and Vicinity” [map]. Wm. M. Bradley & Bro, 1887. *David Rumsey Map Collection*  


**Manhattan Ward History**

**Introduction**

This resource documents the creation of the Historical Urban Ecological (HUE) data set Manhattan ward boundary shapefiles and feature classes. All sources pertaining to the delineation and numbering of each ward system (the unique configuration of ward boundaries over a defined period), encompassing cartographic materials, city ordinances, newspaper reports, and ward boundaries described in the historical literature, have been included. Exclusions are noted where applicable. This document also describes ambiguities found between sources and a discussion of how these ambiguities were resolved in our published data. Table 6 provides a general ward history, 1827-1930.

**Table 6: General ward history of Manhattan Island, 1830-1930**

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Number of Wards</th>
<th>Type of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1827 – 1831</td>
<td>14</td>
<td>Redivision</td>
</tr>
<tr>
<td>1832 – 1835</td>
<td>15</td>
<td>Redivision</td>
</tr>
<tr>
<td>1836</td>
<td>16</td>
<td>Redivision</td>
</tr>
<tr>
<td>1837 – 1845</td>
<td>17</td>
<td>Redivision</td>
</tr>
<tr>
<td>1846 – 1849</td>
<td>18</td>
<td>Redivision</td>
</tr>
<tr>
<td>1850</td>
<td>19</td>
<td>Redivision</td>
</tr>
<tr>
<td>1851 – 1852</td>
<td>20</td>
<td>Redivision</td>
</tr>
<tr>
<td>1853 – 1856</td>
<td>22</td>
<td>Redivision</td>
</tr>
<tr>
<td>1857 – 1862</td>
<td>22</td>
<td>Creation of Central Park</td>
</tr>
<tr>
<td>1863 – 1873</td>
<td>22</td>
<td>Expansion of Central Park</td>
</tr>
<tr>
<td>1874 – 1897</td>
<td>24</td>
<td>Annexation of the Bronx</td>
</tr>
<tr>
<td>1898 - 1930</td>
<td>22</td>
<td>The Bronx changes from Wards 23 &amp; 24 to a separate borough</td>
</tr>
</tbody>
</table>

**Sources**

The main source used in the creation of the Manhattan Wards History is a collection of ward cards available at the New York City Municipal Archives showing New York City's wards from 1817 to 1913. The cards were compiled by the staff of the City Register, a unit of the Department of Finance. They do not have a call number. Drawings of each ward and years for which certain boundaries were in use are included on each card. The cards show 8 redivisions between 1827 and 1853. The creation of Central Park is also included as it dramatically impacts later ward size. While New York City grew beyond Manhattan Island during the study period we have not included the outlying islands, Marble Hill, or the neighboring boroughs save the Bronx and Brooklyn, which inhabits its own section of the HUE data set.

The primary source has been checked against ward maps that were periodically released during this time period. These include maps located at the New York City Department of Records, New York Public Library, the Brooklyn Historical Society, the University of Chicago Map Collection, and the Library of Congress as well as maps available online the David Rumsey Map Collection and ProQuest Sanborn Maps Geo Edition.
Throughout the study period Manhattan Island expanded slightly through landfill. Landfill occurred gradually, taking decades to complete. As a result landfill does not trigger a new ward system. The shoreline most generally applicable to the period, taken at one point during the system's use, is reflected in the shapefile/feature class. Maps collected from the archives listed above were used to determine the extent and timing of landfill during the study period.

Street centerlines delimited many ward boundaries. We have checked the HUE ward boundaries for topological consistency against the CPE’s HUE Street Centerlines for Manhattan. These streets were created from georeferenced historical maps, historical aerial imagery, modern orthographic imagery, and Census TIGER Line files from 2007. Many ward lines were set against these streets. Georeferenced historical maps, contemporary orthoimagery, and GIS data were used in cases where abstract lines and natural features constituted ward boundaries.

The monthly and annual tabular data reported by various municipal departments that accompany and complement the HUE GIS resources reveal the effective (rather than legislated) timing of changes to ward and city boundaries. These reports are often quite clear, with references to "old" and "new" wards, or the expansion of tables to include new ward numbers. The HUE ward system dates pertain to the official implementation of the wards as reporting units, making many of them unsuitable for use in determining the passage of the ordinances and acts from which they were created due to administrative lags.

**Ward Systems**

**1827-1831**
Change: Redivision  
Number of Wards: 14  
Primary Source: Municipal Archives Ward Cards

**1832-1835**
Change: Redivision  
Number of Wards: 15  
Primary Source: Municipal Archives Ward Cards

**1836**
Change: Redivision  
Number of Wards: 16  
Primary Source: Municipal Archives Ward Cards

**1837-1845**
Change: Redivision  
Number of Wards: 17  
Primary Source: Municipal Archives Ward Cards
1846-1849
Change: Redivision
Number of Wards: 18
Primary Source: Municipal Archives Ward Cards

1850
Change: Redivision
Number of Wards: 19
Primary Source: Municipal Archives Ward Cards

1851-1852
Change: Redivision
Number of Wards: 20
Primary Source: Municipal Archives Ward Cards

1853-1856
Change: Redivision
Number of Wards: 22
Primary Source: Municipal Archives Ward Cards

1857-1862
Change: Redivision
Number of Wards: 22

1863-1873
Change: Redivision
Number of Wards: 22

1874-1897
Change: Annexation
Number of Wards: 24
Note: Wards 23 and 24 comprised the Bronx

1898-1930
Change: Redivision
Number of Wards: 22

**Additional Information**

**Wards 23 and 24**

New York City annexed Wards 23 and 24 on January 1, 1874, changing the number of wards to 24. Wards 23 and 24 comprised the Bronx. In 1898, the Bronx became a borough of New York City and on January 1, 1914, Bronx county separated from New York county along borough boundaries. As a result, data for Wards 23 and 24 may be found on Manhattan related tables dated 1874-1914.

**Note on Borough Data**

Occasionally, data for boroughs other than Manhattan is found on tables related to the borough of Manhattan.

**Citations**


**Philadelphia Ward History**

**Introduction**

This resource documents the creation of the Historical Urban Ecological (HUE) data set Philadelphia ward boundary shapefiles and feature classes. All sources pertaining to the delineation and numbering of each ward system (the unique configuration of ward boundaries over a defined period), encompassing cartographic materials, city ordinances, newspaper reports, and ward boundaries described in the historical literature, have been included. Exclusions are noted where applicable. This document also describes ambiguities found between sources and a discussion of how these ambiguities were resolved in our published data. Table 7 provides a general ward history, 1825-1931.

<table>
<thead>
<tr>
<th>Date Range</th>
<th>Number of Wards</th>
<th>Type of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1825 – 1846</td>
<td>15</td>
<td>Redivision</td>
</tr>
<tr>
<td>1847 – 1854</td>
<td>17</td>
<td>Redivision</td>
</tr>
<tr>
<td>1855 – 1860</td>
<td>24</td>
<td>Redivision/Annexation</td>
</tr>
<tr>
<td>1861 – 1863</td>
<td>25</td>
<td>Redivision</td>
</tr>
<tr>
<td>1864</td>
<td>26</td>
<td>Redivision</td>
</tr>
<tr>
<td>1865</td>
<td>26</td>
<td>Redivision</td>
</tr>
<tr>
<td>1866</td>
<td>27</td>
<td>Redivision</td>
</tr>
<tr>
<td>1867 – 1870</td>
<td>28</td>
<td>Redivision</td>
</tr>
<tr>
<td>1871 – 1874</td>
<td>29</td>
<td>Redivision</td>
</tr>
<tr>
<td>1875 – 1887</td>
<td>31</td>
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</tr>
<tr>
<td>1888</td>
<td>33</td>
<td>Redivision</td>
</tr>
<tr>
<td>1889</td>
<td>34</td>
<td>Redivision</td>
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<tr>
<td>1890 – 1891</td>
<td>35</td>
<td>Redivision</td>
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<tr>
<td>1892 – 1895</td>
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<td>Redivision</td>
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<td>1896 – 1897</td>
<td>38</td>
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</tr>
<tr>
<td>1898</td>
<td>40</td>
<td>Redivision/Annexation</td>
</tr>
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<td>1899 – 1900</td>
<td>41</td>
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<td>1901 – 1904</td>
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<td>1905</td>
<td>43</td>
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<tr>
<td>1906</td>
<td>45</td>
<td>Redivision</td>
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<tr>
<td>1907 – 1913</td>
<td>47</td>
<td>Redivision</td>
</tr>
<tr>
<td>1914 – 1931</td>
<td>48</td>
<td>Redivision</td>
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**Sources**

The main source used in the creation of the Boston Wards is John Edward Daly's and Allen Weinberg's 1966 book, *Genealogy of Philadelphia County Subdivisions*. It contains maps depicting each of the 22 ward redivisions between 1825 and 1931.

This primary history has been checked against ward maps that were periodically released during this time period. These include maps located at the University of Chicago Map Collection and the Library of Congress as well as maps available online through the David Rumsey Map Collection and ProQuest Sanborn Maps Geo Edition.
Philadelphia expanded significantly in 1854 when the surrounding townships in Philadelphia County were annexed to the city. These areas are included in the ward history at this time. Throughout the study period Philadelphia expanded slightly through landfill. Landfill occurred gradually, taking decades to complete. As a result landfill does not trigger a new ward system. The shoreline most generally applicable to the period, taken at one point during the system’s use, is reflected in the shapefile/feature class. Maps collected from the archives listed above were used to determine the extent and timing of landfill during the study period.

Street centerlines delimited many ward boundaries. We have checked the HUE ward boundaries for topological consistency against the CPE’s HUE Street Centerlines for Philadelphia. These streets were created from georeferenced historical maps, modern orthographic imagery, and Census TIGER Line files from 2007. Many ward lines were set against these streets. Street names have changed many times throughout Philadelphia’s history. We made great use of the Philadelphia Historic Streets Index, created by the City of Philadelphia Department of Records (http://www.phillyhistory.org/historicstreets/), to resolve ambiguities between historical and modern names. Georeferenced historical maps, contemporary orthoimagery, and GIS data were used in cases where abstract lines and natural features constituted ward boundaries.

The monthly and annual tabular data reported by various municipal departments that accompany and complement the HUE GIS resources reveal the effective (rather than legislated) timing of changes to ward and city boundaries. These reports are often quite clear, with references to "old" and "new" wards, or the expansion of tables to include new ward numbers. The HUE ward system dates pertain to the official implementation of the wards as reporting units, making many of them unsuitable for use in determining the passage of the ordinances and acts from which they were created due to administrative lags.

**Ward Systems**

**1825-1846**
Change: Redivision
Number of Wards: 15

**1847-1854**
Change: Redivision
Number of Wards: 17
1855-1860  
Change: Redivision/Annexation  
Number of Wards: 24  

1861-1863  
Change: Redivision  
Number of Wards: 25  

1864  
Change: Redivision  
Number of Wards: 26  

1865  
Change: Redivision  
Number of Wards: 26  

1866  
Change: Redivision  
Number of Wards: 27  

1867-1870  
Change: Redivision  
Number of Wards: 28  
1871-1874
Change: Redivision
Number of Wards: 29

1875-1887
Change: Redivision
Number of Wards: 31

1888
Change: Redivision
Number of Wards: 33

1889
Change: Redivision
Number of Wards: 34

1890-1891
Change: Redivision
Number of Wards: 35

1892-1895
Change: Redivision
Number of Wards: 37
### 1896-1897
Change: Redivision
Number of Wards: 38

### 1898
Change: Redivision/Annexation
Number of Wards: 40
Note:
- League Island, the site of the Philadelphia Navy Yard at the far southern tip of Philadelphia appears to be excluded from the ward system until 1898 based on the Daly/Weinberg Genealogy. No other sources could be found that explicitly describe the status of this island in the administrative or cartographic record.

### 1899-1900
Change: Redivision
Number of Wards: 41

### 1901-1904
Change: Redivision
Number of Wards: 42

### 1905
Change: Redivision
Number of Wards: 43

### 1906
Change: Redivision
Number of Wards: 45

1907-1913
Change: Redivision
Number of Wards: 47

1914-1931
Change: Redivision
Number of Wards: 48

Citations
B. STREET CENTERLINE DATA SOURCES

Historically accurate street centerlines are available for all of the HUE cities in shapefile format. Street centerlines are also available with ward boundary changes in geodatabase format. The street centerline networks were created based on a single source street map of each city produced in or around 1930 for use with the Historical Urban Ecological (HUE) data set. The 1930 network captures streets added through annexation and infill. This network also precedes significant changes brought about by later urban development and the construction of intra-urban expressways. Earlier street networks are, by and large, a subset of these 1930 networks, although cities changed many street names between 1830 and 1930. Centerlines remained remarkably stable, making the provided centerlines an accurate spatial reference throughout the period. While the street centerline network depicts the streets seen in the primary reference source, additional supporting sources were consulted to determine the most spatially accurate paths possible.

**BALTIMORE**


*Supporting Sources:* Orthoimagery made available through the USGS’s National Map (http://nationalmap.gov/);

**BOSTON**


*Supporting Sources:* Orthoimagery made available through the USGS’s National Map (http://nationalmap.gov/);

**BROOKLYN**

Supporting Sources: Orthoimagery made available through the USGS's National Map (http://nationalmap.gov/);


CHICAGO


Supporting Sources: Orthoimagery made available through the USGS's National Map (http://nationalmap.gov/);


CINCINNATI


Supporting Sources: Orthoimagery made available through USGS National Map (http://nationalmap.gov/);


MANHATTAN

Supporting Sources: Orthoimagery made available through the USGS’s National Map
(http://nationalmap.gov/);

Sanborn Fire Insurance Company. “Insurance Maps of the City of New York (Borough of
(http://www.nypl.org/locations/schwarzman/map-division/fire-insurance-topographic-
zoning-property-maps-nyc);

Tuttle, Arthur S. “Sectional Aerial Maps of the City of New York” [aerial imagery]. Scale not
given. New York: City of New York Board of Estimate and Apportionment, 1924.
(http://gis.nyc.gov/doitt/nycitymap/).

Philadelphia

Primary Source: Hagstrom Company. “Hagstrom’s Street and House Number Map of
Philadelphia” [map]. Scale not given. New York: Hagstrom Co., ca. 1930.; U.S. Census Bureau
TIGER/Line Shapefiles, 2007

Supporting Sources: Orthoimagery made available through the USGS’s National Map
(http://nationalmap.gov/);

C. Sanitation Infrastructure

Sources Overview

In-street Water and Sewer infrastructure data come from annual reports that include tables and/or written descriptions detailing the construction of sewer and/or water distribution pipes and mains that ran under, in, or just alongside city streets. These reports were created and published by city councils as well as various city departments, commissions, and boards. Sanitation Infrastructure coverage metadata documents issued alongside the Sanitation shapefiles detail the year for which partial or full construction data was found and which sources were consulted.

These annual reports were collected from city, county, and state archives, university libraries, historical societies, and from online repositories such as GoogleBooks, Archive.org, and HathiTrust. CPE staff and researchers looked for records covering the period of inauguration of public sanitation systems, which were typically up and running by the mid-1800s, up through 1930. Due to fires, loss, decay, and lack of access, it was not possible to collect complete data for every year for every city, resulting in incomplete coverage.

The majority of the reports used in the creation of these data contain distribution tables that list each main street along which the sewer or water pipe was laid, the two cross streets where the pipe installation started and stopped, and other pipe information (see Table 8 for example). For the few years for which only textual descriptions are available, the infrastructure information in the shapefile tends to be more limited. This is because fewer installations were reported in the absence of distribution tables (because fewer pipes were installed, only certain projects were emphasized, or because the report was incomplete) and any installations that were described too vaguely were not codeable.

Table 8: Example of Distribution Pipe Table
Table quality, where reports are available, is generally good across cities for this time period. Most reports include construction tables with information on the location of new pipes between two geographic features such as intersections. This style of reporting is the norm for all cities for which the CPE provides in-street sanitation data. Some reports contain more information than others on contracts, pipe materials, and costs. The variables input by the CPE are described in more detail in the following section.

Unfortunately, some reports do not contain complete or even partial annual construction tables, further reducing overall coverage. For Chicago Sewers detail dropped off after 1915 when distribution tables were no longer included in the documents and inputters relied on textual descriptions where available. For Chicago Water after 1922, a section of each table titled "Installed by Special Assessment" did not include pipe diameters. Boston Water data are limited or nonexistent for the period 1908–14 as distribution tables are absent in the available materials. For the most part, the Boston Water textual descriptions of pipe additions were descriptive enough to code some new construction though many fewer installations were documented for these years than for years with distribution tables. Annual reports of the Philadelphia Bureau of Water do not include construction tables after 1899. Some reports contain tables that recapitulate several years of construction. These intricacies and omissions are found in reports across all cities and noted where appropriate in the accompanying metadata.

During the infrastructure coding process, additional materials were sometimes used to cross check or confirm street names and locations given in the distribution tables. Table 9 lists major resources used for each city:

### Table 9: Resources by City

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<thead>
<tr>
<th>City</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boston</td>
<td>A Record of the Streets, Alleys, Places, Etc. in the City of Boston (Google Books)</td>
</tr>
<tr>
<td></td>
<td><a href="http://dca.lib.tufts.edu/features/bostonstreets/cowpaths/">http://dca.lib.tufts.edu/features/bostonstreets/cowpaths/</a></td>
</tr>
<tr>
<td>Chicago</td>
<td><a href="http://www.chsmedia.org/househistory/nameChanges/start.pdf">http://www.chsmedia.org/househistory/nameChanges/start.pdf</a></td>
</tr>
<tr>
<td>Baltimore</td>
<td><a href="http://mdhistory.net/msaref07/html/">http://mdhistory.net/msaref07/html/</a></td>
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<td>Manhattan</td>
<td><a href="http://www.nypl.org/node/196237">http://www.nypl.org/node/196237</a></td>
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<td>Brooklyn</td>
<td><a href="http://www.nypl.org/node/196237">http://www.nypl.org/node/196237</a></td>
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### Baltimore

**Coverage**

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</tbody>
</table>

**Key:**

- a,b,c,d: Complete construction data found and input for year; letter denotes source
- –: No useable data found for year
- DNE: No public infrastructure as-yet in existence
Sources


Variable Descriptions

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<th>FID</th>
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Codes:

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<td>Original segment created by the CPE using orthoimagery and georeferenced historical maps, see CPE_Baltimore_Streets_HUE_v1 metadata for full biblio.</td>
<td>8,949</td>
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<td>TIGER2007</td>
<td>TIGER/Line files downloaded from US Census Bureau in 2007</td>
<td>11,510</td>
</tr>
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</table>

**Shape_Leng**  
Length of street segment (ft)

Variable Type: Double

Description: Length of street segment in feet as observed in CPE_Baltimore_Streets_HUE_v1 feature class

**WaterDate**  
Year of earliest observed water pipe installation

Variable Type: Short

Description: Year of earliest known water pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Baltimore_Sanitation_Infrastructure_Coverage” document

Codes:

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>12,874</td>
</tr>
</tbody>
</table>

Statistics:

- Count: 7,585 (of 20,459 total)
- Min: 1855
- Max: 1930
- Mean: 1888.3

Records missing values excluded

Distribution: (see next page)
W_Pipe_In  Diameter of water pipe in inches

Variable Type:  Short

Description:  Diameter of water pipe laid in street segment during year "WaterDate," in inches

Codes:

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>12,874</td>
</tr>
<tr>
<td>8888</td>
<td>Information on pipe length not included in collected data</td>
<td>71</td>
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</tbody>
</table>

Statistics:  

Count:  7,514 (of 20,459 total)  
Min:  1.3333  
Max:  56  
Mean:  7.9  

Records missing values excluded

Distribution:  

(see next page)
**W_Pipeleng**  
**Length of installed water pipe described in orig.source (feet)**

**Variable Type:** Long  
**Description:** Length of all continuous water pipe in feet laid in street between well-described end points during year "WaterDate" recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment.

**Codes:**

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<tr>
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<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>12,874</td>
</tr>
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<td>Information on pipe length not included in collected data</td>
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**Statistics:**

- **Count:** 5,236 (of 20,459 total)  
- **Min:** 100  
- **Max:** 17,544  
- **Mean:** 1223.9  

Records missing values excluded.

**Distribution:** (see next page)
**OBJECTID**

**Variable Type:** Long

**Description:** Database ID particular to CPE_Baltimore_Streets_HUE_v1 feature class

**Notes:** This field can be used to join data from the Sanitation Infrastructure feature class to CPE_Baltimore_Streets_HUE_v1
## BOSTON

### Coverage

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<td>e</td>
</tr>
<tr>
<td>Sewer</td>
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<td>–</td>
<td>–</td>
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<table>
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<td>–</td>
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<td>f</td>
<td>f</td>
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<td>f</td>
</tr>
<tr>
<td>Sewer</td>
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<td>–</td>
<td>–</td>
<td>–</td>
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<table>
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<td>f</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

### Key:

- **a,b,c,d,e,f**: Complete construction data found and input for year; letter denotes source
- **–**: No useable data found for year
- **DNE**: No public infrastructure as-yet in existence

* Data found and input for year determined to be partial


**Sources**


**Variable Descriptions**

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<tr>
<th>FID</th>
<th>Feature ID</th>
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<tbody>
<tr>
<td>Variable Type:</td>
<td>Object ID</td>
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<tr>
<td>Description:</td>
<td>Database ID of street segment particular to this shapefile</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Shape</th>
<th>Shape of street segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Type:</td>
<td>Geometry</td>
</tr>
<tr>
<td>Description:</td>
<td>Geometry of street segment particular to this shapefile</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Full_Name</th>
<th>Full street name of segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Type:</td>
<td>String</td>
</tr>
</tbody>
</table>
Description: Street name of segment as observed in CPE_Boston_Streets_HUE_v1 feature class

**Source**

**Original source of street segment**

| Variable Type: | String |
| Source | Source of street segment as observed in CPE_Boston_Streets_HUE_v1 feature class |

**Codes:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPE Overlay</td>
<td>Original segment created by the CPE using orthoimagery and georeferenced historical maps, see CPE_Boston_Streets_HUE_v1 metadata for full biblio.</td>
<td>9,498</td>
</tr>
<tr>
<td>TIGER2007</td>
<td>TIGER/Line files downloaded from US Census Bureau in 2007</td>
<td>4,019</td>
</tr>
</tbody>
</table>

**Shape_Leng**

Length of street segment (ft)

| Variable Type: | Double |
| Description: | Length of street segment in feet as observed in CPE_Boston_Streets_HUE_v1 feature class |

**SewerDate**

Year of earliest observed sewer pipe installation

| Variable Type: | Short |
| Description: | Year of earliest known sewer pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Boston_Sanitation_Infrastructure_Coverage” document |

**Codes:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>12,475</td>
</tr>
</tbody>
</table>

**Statistics:**

| Count: | 1042 (of 13,517 total) |
| Min: | 1887 |
| Max: | 1926 |
| Mean: | 1910.2 |
Records missing values excluded

Distribution:

S_Pipe_ft

<table>
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<tr>
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<th>Meaning</th>
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</thead>
<tbody>
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<td>0</td>
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</tr>
<tr>
<td>5555</td>
<td>Pipe shape is not circular</td>
<td>108</td>
</tr>
<tr>
<td>8888</td>
<td>Information on pipe width not included in collected data</td>
<td>103</td>
</tr>
</tbody>
</table>

Variable Type: String

Description: Diameter of sewer pipe laid in street segment during year “SewerDate,” in feet

Codes:

Statistics: Count: 829 (of 13,517 total)
Min: 0.5
Max: 12
Mean: 1.12
**S_PipeLeng**  
**Length of sewer pipe described in orig. source (feet)**  

**Variable Type:** Short  

**Description:** Length of all continuous sewer pipe in feet laid in street between well-described end points during year "SewerDate" recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment.

**Codes:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>12,475</td>
</tr>
<tr>
<td>8888</td>
<td>Information on pipe length not included in collected data</td>
<td>90</td>
</tr>
</tbody>
</table>

**Statistics:**

- Count: 952 (of 13,517 total)
- Min: 100
- Max: 3,166
- Mean: 652.2

Records missing values excluded
III. GIS Downloads

Distribution:

![Histogram showing frequency of sewer pipe lengths (feet)]

**WaterDate**

*Year of earliest observed water pipe installation*

**Variable Type:** Short

**Description:** Year of earliest known water pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Boston_Sanitation_Infrastructure_Coverage” document

**Codes:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
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</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>4,019</td>
</tr>
</tbody>
</table>

**Statistics:**

Count: 9,498 (of 13,517 total)
Min: 1851
Max: 1930
Mean: 1887.3

Records missing values excluded
**W_Pipe_In**  
**Diameter of water pipe in inches**

**Variable Type:** Short

**Description:** Diameter of water pipe laid in street segment during year "WaterDate," in inches

**Codes:**

<table>
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<tr>
<th>Code</th>
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<tr>
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<td>Information on pipe length not included in collected data</td>
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</table>

**Statistics:**

- Count: 9,465 (of 13,517 total)
- Min: 1
- Max: 48
- Mean: 9.6

Records missing values excluded
Distribution:

![Histogram of Water Pipe Diameter](image)

**W_PipeLeng**  
Length of installed water pipe described in orig.source (feet)

**Variable Type:** Long

**Description:** Length of all continuous sewer pipe in feet laid in street between well-described end points during year “SewerDate” recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment

**Codes:**

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<tr>
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**Statistics:**

- **Count:** 9,420 (of 13,517 total)
- **Min:** 100
- **Max:** 8,589
- **Mean:** 1043.1

Records missing values excluded
**OBJECTID** | **Object ID of street segment**
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Variable Type: | Long
Description: | Database ID particular to CPE_Boston_Streets_HUE_v1 feature class
Notes: | This field can be used to join data from the Sanitation Infrastructure feature class to CPE_Boston_Streets_HUE_v1
### BROOKLYN Coverage

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<td>b</td>
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<tr>
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</table>

**Key:**

- **a,b,c,d,e,f,g**: Complete construction data found and input for year; letter denotes source
- **-**: No useable data found for year
- **DNE**: No public infrastructure as-yet in existence
Sources


Variable Descriptions

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<th>Description</th>
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<tr>
<td>Shape</td>
<td>Geometry of street segment particular to this shapefile</td>
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<td>Full_Name</td>
<td>Full street name of segment</td>
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### Description
Street name of segment as observed in CPE_Brooklyn_Streets_HUE_v1 feature class

### Source
**Original source of street segment**

| Variable Type: | String |
| Description: | Source of street segment as observed in CPE_Brooklyn_Streets_HUE_v1 feature class |

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<td>Original segment created by the CPE using orthoimagery and georeferenced historical maps, see CPE_Brooklyn_Streets_HUE_v1 metadata for full biblio.</td>
<td>8,324</td>
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<td>TIGER2007</td>
<td>TIGER/Line files downloaded from US Census Bureau in 2007</td>
<td>11,116</td>
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### Shape_Leng
**Length of street segment (ft)**

| Variable Type: | Double |
| Description: | Length of street segment in feet as observed in CPE_Brooklyn_Streets_HUE_v1 feature class |

### SewerDate
**Year of earliest observed sewer pipe installation**

| Variable Type: | Short |
| Description: | Year of earliest known sewer pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Brooklyn_Sanitation_Infrastructure_Coverage” document |

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| Statistics: | Count: | 2,880 (of 19,440 total) |
Min: 1863
Max: 1911
Mean: 1878.9

Records missing values excluded

Distribution:

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<th>Diameter of sewer pipe in feet</th>
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<td>Description:</td>
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III. GIS Downloads

Distribution:

![Histogram](image)

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<td>Length of all continuous sewer pipe in feet laid in street between well-described end points during year “SewerDate” recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment</td>
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<td>Codes:</td>
<td></td>
</tr>
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<td>Meaning</td>
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Records missing values excluded
**WaterDate**  
*Year of earliest observed water pipe installation*

**Variable Type:** Short

**Description:** Year of earliest known water pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Brooklyn_Sanitation_Infrastructure_Coverage” document

**Codes:**

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**Statistics:**

- Count: 4,634 (of 19,440 total)
- Min: 1860
- Max: 1994
- Mean: 1870.04

Records missing values excluded

**Distribution:**

![Frequency Distribution Chart]
III. GIS Downloads

### W_Pipe_In

**Diameter of water pipe in inches**

**Variable Type:** Short

**Description:** Diameter of water pipe laid in street segment during year “WaterDate,” in inches

**Codes:**

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**Statistics:**

- **Count:** 4,582 (of 19,440 total)
- **Min:** 1
- **Max:** 48
- **Mean:** 9.12

Records missing values excluded
**W_PipeLeng**  
**Length of installed water pipe described in orig.source (feet)**

**Variable Type:** Long

**Description:** Length of all continuous sewer pipe in feet laid in street between well-described end points during year “SewerDate” recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment.

**Codes:**

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**Statistics:**

- Count: 4,567 (of 19,440 total)
- Min: 118
- Max: 26,396
- Mean: 2,940.5

Records missing values excluded.
III. GIS Downloads

Distribution:

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### CHICAGO Coverage

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</table>

Key:

- a,b,c,d Complete construction data found and input for year; letter denotes source
- † No useable data found for year
- DNE No public infrastructure as-yet in existence
III. GIS Downloads

* Data found and input for year determined to be partial

† All water construction from system inauguration (1852) up through 1854 reported in a single, undifferentiated table in the “Seventh Semi-Annual Report of the Board of Water Commissioners” (1855). As dates could not be clearly separated, CPE data records this construction at the only known date: 1854.

‡ All sewer construction from system inauguration (first pipes laid in 1856) up through the dissolution of the Board of Sewerage Commissioners (1860) reported in a single, undifferentiated table in the “Fifteenth Annual Report of the Board of Public Works” (1875). As dates could not be clearly separated, CPE data records this construction at the only known date: 1860. Maps in two reports from the Board of Sewerage Commissioners cover construction completed in 1856 and 1857.

Sources


Variable Descriptions

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<table>
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<td>Geometry</td>
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<tr>
<td>Description:</td>
<td>Geometry of street segment particular to this shapefile</td>
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</table>
### Full_Name

**Full street name of segment**

**Variable Type:** String  
**Description:** Street name of segment as observed in CPE_Chicago_Streets_HUE_v1 feature class

### Source

**Original source of street segment**

**Variable Type:** String  
**Description:** Source of street segment as observed in CPE_Chicago_Streets_HUE_v1 feature class

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<td>Original segment created by the CPE using orthoimagery and georeferenced historical maps, see CPE_Chicago_Streets_HUE_v1 metadata for full biblio.</td>
<td>42,476</td>
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</table>

### Shape_Leng

**Length of street segment (ft)**

**Variable Type:** Double  
**Description:** Length of street segment in feet as observed in CPE_Chicago_Streets_HUE_v1 feature class

### SewerDate

**Year of earliest observed sewer pipe installation**

**Variable Type:** Short  
**Description:** Year of earliest known sewer pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Chicago_Sanitation_Infrastructure_Coverage” document

<table>
<thead>
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<th>Meaning</th>
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<tbody>
<tr>
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<td>No construction indicated in collected data</td>
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</table>
III. GIS Downloads

Statistics:

- Count: 23,480 (of 42,476 total)
- Min: 1856
- Max: 1930
- Mean: 897.6

Records missing values excluded

Distribution:

```
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<tbody>
<tr>
<td>0</td>
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<td>18,996</td>
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<tr>
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<td>Information on pipe length not included in collected data</td>
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<tr>
<td>9999</td>
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<td>15,018</td>
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Variable Type: Double

Description: Diameter of sewer pipe laid in street segment during year “SewerDate,” in feet
Statistics:

- Count: 5,115 (of 42,476 total)
- Min: 0.25
- Max: 11.5
- Mean: 1.9

Records missing values excluded

Distribution:

<table>
<thead>
<tr>
<th>Sewer pipe diameter (feet)</th>
<th>Frequency, n=5,115</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2,000</td>
</tr>
<tr>
<td>2</td>
<td>1,500</td>
</tr>
<tr>
<td>3</td>
<td>500</td>
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<tr>
<td>4</td>
<td>300</td>
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<tr>
<td>5</td>
<td>200</td>
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<tr>
<td>6</td>
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<td>7</td>
<td>50</td>
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<td>8</td>
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<td>5</td>
</tr>
<tr>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
</tr>
</tbody>
</table>

S_PipeLeng

- **Variable Type:** Short
- **Description:** Length of all continuous sewer pipe in feet laid in street between well-described end points during year "SewerDate" recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment
III. GIS Downloads

Codes:

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>18,996</td>
</tr>
<tr>
<td>8888</td>
<td>Information on pipe length not included in collected data</td>
<td>3,339</td>
</tr>
<tr>
<td>9999</td>
<td>Variable not recorded during inputting</td>
<td>15,411</td>
</tr>
</tbody>
</table>

Statistics:

- Count: 4,730 (of 42,476 total)
- Min: 102
- Max: 6,619
- Mean: 1,047.1

Records missing values excluded

Distribution:

WaterDate: Year of earliest observed water pipe installation

Variable Type: Short

Description: Year of earliest known water pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Chicago_Sanitation_Infrastructure_Coverage” document.
Codes:

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>13,803</td>
</tr>
</tbody>
</table>

Statistics:

- Count: 28,673 (of 42,476 total)
- Min: 1854
- Max: 1930
- Mean: 1901.2

Records missing values excluded

Distribution:

Variable Type: Short

Description: Diameter of water pipe laid in street segment during year “WaterDate,” in inches
III. GIS Downloads

Codes:

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>13,803</td>
</tr>
<tr>
<td>5555</td>
<td>Pipe shape is not circular</td>
<td>188</td>
</tr>
<tr>
<td>8888</td>
<td>Information on pipe length not included in collected data</td>
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<tr>
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<td>Variable not recorded during inputting</td>
<td>14,037</td>
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</table>

Statistics:

- Count: 12,869 (of 42,476 total)
- Min: 2
- Max: 80
- Mean: 9.5

Records missing values excluded

Distribution:

<table>
<thead>
<tr>
<th>Water pipe diameter (inches)</th>
<th>Frequency, n= 12,869</th>
</tr>
</thead>
</table>

W_Pipeleng

Length of installed water pipe described in orig.source (feet)

Variable Type: Long

Description: Length of all continuous water pipe in feet laid in street between well-described end points during year “WaterDate” recorded in
construction records found by the CPE; not necessarily covering or limited to one single street segment

### Codes:

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>13,803</td>
</tr>
<tr>
<td>8888</td>
<td>Information on pipe length not included in collected data</td>
<td>12</td>
</tr>
<tr>
<td>9999</td>
<td>Variable not recorded during inputting</td>
<td>14,381</td>
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### Statistics:

- **Count**: 14,280 (of 42,476 total)
- **Min**: 12
- **Max**: 56,388
- **Mean**: 2,963.6

Records missing values excluded

### Distribution:

![Histogram showing frequency distribution of water pipe length (feet)]

### OBJECTID

**Object ID of street segment**

**Variable Type:** Long

**Description:** Database ID particular to CPE_Chicago_Streets_HUE_v1 feature class
Notes: This field can be used to join data from the Sanitation Infrastructure feature class to CPE_Chicago_Streets_HUE_v1
**MANHATTAN**  
**Coverage**

<table>
<thead>
<tr>
<th>Year</th>
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<th>1828</th>
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<th>1830</th>
<th>1831</th>
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<th>1834</th>
<th>1835</th>
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<tr>
<td>Water</td>
<td>DNE</td>
<td>DNE</td>
<td>DNE</td>
<td>DNE</td>
<td>DNE</td>
<td>DNE</td>
<td>DNE</td>
<td>DNE</td>
<td>DNE</td>
<td>DNE</td>
</tr>
<tr>
<td>Sewer</td>
<td>-†</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>b</td>
<td>b</td>
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<table>
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<td>DNE</td>
<td>DNE</td>
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<tr>
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<td>-</td>
<td>a</td>
<td>b</td>
<td>b</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
<td>c</td>
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<tr>
<td>Sewer</td>
<td>ab</td>
<td>a*b</td>
<td>b</td>
<td>ab</td>
<td>b†</td>
<td>b</td>
<td>bc</td>
<td>bc</td>
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<tr>
<td>Water</td>
<td>b</td>
<td>b</td>
<td>b</td>
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<td>-</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
</tr>
<tr>
<td>Sewer</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>-</td>
<td>b</td>
<td>b</td>
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<table>
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<th>1870</th>
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<td>b</td>
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<th>1884</th>
<th>1885</th>
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</thead>
<tbody>
<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<table>
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<tr>
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<td>-</td>
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<td>-</td>
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<td>-</td>
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<table>
<thead>
<tr>
<th>Year</th>
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<th>1897</th>
<th>1898</th>
<th>1899</th>
<th>1900</th>
<th>1901</th>
<th>1902</th>
<th>1903</th>
<th>1904</th>
<th>1905</th>
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</thead>
<tbody>
<tr>
<td>Water</td>
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<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Key:**

- **a**, **b**, **c**, **d**  Complete construction data found and input for year; letter denotes source
- **-**  No useable data found for year
- **DNE**  No public infrastructure as-yet in existence
* Data found and input for year determined to be partial

† “Map of the Croton Water Pipes with Stop Cocks”, illustrating all pipes laid up to Dec 31, 1850 was included in the 1850 Annual Report of the Croton Aqueduct Department. Pipes with WaterYear 1850 are therefore all pipes laid from the inauguration of the Croton Aqueduct (water began flowing to the city in June of 1842) through 1850.

‡ Earliest recorded sewers installed in 1797, reflected in Sanitation Infrastructure file and codebook

**Sources**


**Variable Descriptions**

<table>
<thead>
<tr>
<th>FID</th>
<th>Feature ID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Object ID</td>
</tr>
</tbody>
</table>

Description: Database ID of street segment particular to this shapefile

<table>
<thead>
<tr>
<th>Shape</th>
<th>Shape of street segment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Geometry</td>
</tr>
</tbody>
</table>

Description: Geometry of street segment particular to this shapefile
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full_Name</strong></td>
<td>Street name of segment as observed in CPE_Manhattan_Streets_HUE_v1 feature class</td>
</tr>
<tr>
<td><strong>Source</strong></td>
<td>Source of street segment as observed in CPE_Manhattan_Streets_HUE_v1 feature class</td>
</tr>
<tr>
<td><strong>Shape_Leng</strong></td>
<td>Length of street segment in feet as observed in CPE_Manhattan_Streets_HUE_v1 feature class</td>
</tr>
<tr>
<td><strong>SewerDate</strong></td>
<td>Year of earliest known sewer pipe installation based on construction records found by the CPE. For a full list of construction record sources and year covered see the &quot;CPE_Manhattan_Sanitation_Infrastructure_Coverage&quot; document</td>
</tr>
</tbody>
</table>

### Source Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPE Overlay</td>
<td>Original segment created by the CPE using orthoimagery and georeferenced historical maps, see CPE_Manhattan_Streets_HUE_v1 metadata for full biblio.</td>
</tr>
</tbody>
</table>

### Shape_Leng Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>4,395</td>
</tr>
</tbody>
</table>

### Statistics

- Count: 2,873 (of 7,268 total)
Min: 1797  
Max: 1896  
Mean: 1858.5  

Records missing values excluded

Distribution:

```
<table>
<thead>
<tr>
<th>Year of sewer installation</th>
<th>Frequency, n= 2,873</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1838</td>
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<td>1839</td>
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<td>1893</td>
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</tr>
<tr>
<td>1895</td>
<td>640</td>
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</tbody>
</table>
```

**S_Pipe_ft**  
Diameter of sewer pipe in feet

**Variable Type:** Double  
**Description:** Diameter of sewer pipe laid in street segment during year "SewerDate," in feet

**Codes:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>4,395</td>
</tr>
<tr>
<td>5555</td>
<td>Pipe shape is not circular</td>
<td>1,404</td>
</tr>
<tr>
<td>9999</td>
<td>Variable not recorded during inputting</td>
<td>851</td>
</tr>
</tbody>
</table>

**Statistics:**  
Count: 618 (of 7,268 total)
Min: 1
Max: 8.5
Mean: 1.9

Records missing values excluded

Distribution:

**S_PipeLeng**  
**Length of sewer pipe described in orig. source (feet)**

**Variable Type:** Short

**Description:** Length of all continuous sewer pipe in feet laid in street between well-described end points during year “SewerDate” recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment

**Codes:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>4,395</td>
</tr>
<tr>
<td>9999</td>
<td>Variable not recorded during inputting</td>
<td>2,873</td>
</tr>
</tbody>
</table>
Statistics:  
Count: 0 (of 7,268 total)  
Min: 0  
Max: 0  
Mean: 0  
Records missing values excluded

**WaterDate**  
**Year of earliest observed water pipe installation**

Variable Type: Short  

Description: Year of earliest known water pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Manhattan_Sanitation_Infrastructure_Coverage” document

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
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</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
<td>3,018</td>
</tr>
</tbody>
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Statistics:  
Count: 4,250 (of 7,268 total)  
Min: 1849  
Max: 1872  
Mean: 1853.3  
Records missing values excluded

Distribution:

![Frequency distribution of WaterDate](chart.png)
<table>
<thead>
<tr>
<th>W_Pipe_In</th>
<th>Diameter of water pipe in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable Type:</td>
<td>Short</td>
</tr>
<tr>
<td>Description:</td>
<td>Diameter of water pipe laid in street segment during year “WaterDate,” in inches</td>
</tr>
<tr>
<td>Codes:</td>
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</tr>
<tr>
<td>Code</td>
<td>Meaning</td>
</tr>
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<td>---------</td>
</tr>
<tr>
<td>0</td>
<td>No construction indicated in collected data</td>
</tr>
<tr>
<td>8888</td>
<td>Information on pipe length not included in collected data</td>
</tr>
<tr>
<td>9999</td>
<td>Variable not recorded during inputting</td>
</tr>
<tr>
<td>Statistics:</td>
<td>Count: 1,438 (of 7,268 total)</td>
</tr>
<tr>
<td></td>
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<td>Mean: 8.48</td>
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<tr>
<td>Water pipe diameter (inches)</td>
<td>Frequency, n=1,438</td>
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</tbody>
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### W_Pipeleng

**Length of installed water pipe described in orig.source (feet)**

| Variable Type: | Long |
| Description: | Length of all continuous water pipe in feet laid in street between well-described end points during year “WaterDate” recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment |

<table>
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**Statistics:**

- Count: 0 (of 7,268 total)
- Min: 0
- Max: 0
- Mean: 0

Records missing values excluded

### OBJECTID

**Object ID of street segment**

| Variable Type: | Long |
| Description: | Database ID particular to CPE_Manhattan_Streets_HUE_v1 feature class |

Notes: This field can be used to join data from the Sanitation Infrastructure feature class to CPE_Manhattan_Streets_HUE_v1
## Philadelphia Coverage

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### Yearly Data

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</tr>
<tr>
<td>Sewer</td>
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<td>–</td>
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</tbody>
</table>

**Key:**

- a, b, c, d, e, f, g, h: Complete construction data found and input for year; letter denotes source
- –: No usable data found for year
- DNE: No public infrastructure as-yet in existence

**Sources**


**Variable Descriptions**

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<td>Object ID</td>
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<tr>
<td>Description:</td>
<td>Database ID of street segment particular to this shapefile</td>
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<table>
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<th><strong>Shape</strong></th>
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<table>
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<table>
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<th><strong>Source</strong></th>
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<td>10,581</td>
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<td>TIGER2007</td>
<td>TIGER/Line files downloaded from US Census Bureau in 2007</td>
<td>29,037</td>
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### Shape_Leng

**Length of street segment (ft)**

**Variable Type:** Double

**Description:** Length of street segment in feet as observed in CPE_Philadelphia_Streets_HUE_v1 feature class

### SewerDate

**Year of earliest observed sewer pipe installation**

**Variable Type:** Short

**Description:** Year of earliest known sewer pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Philadelphia_Sanitation_Infrastructure_Coverage” document

**Codes:**

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<th>Meaning</th>
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</thead>
<tbody>
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**Statistics:**

- **Count:** 5,675 (of 39,618 total)
- **Min:** 1860
- **Max:** 1912
- **Mean:** 1897.2

Records missing values excluded

**Distribution:**

[Graph showing frequency distribution of SewerDate]
**S_Pipe_ft**  
*Diameter of sewer pipe in feet*

**Variable Type:** Double

**Description:** Diameter of sewer pipe laid in street segment during year “SewerDate,” in feet

**Codes:**

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<tr>
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<td>Pipe shape is not circular</td>
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<td>Information on pipe length not included in collected data</td>
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</table>

**Statistics:**

- **Count:** 719 (of 39,618 total)
- **Min:** 0.5
- **Max:** 20
- **Mean:** 4.25

Records missing values excluded

**Distribution:**

![Histogram of Sewer Pipe Diameter](image)

*Frequency, n=719 vs. Sewer pipe diameter (feet)*
**S_PipeLeng**  
Length of sewer pipe described in orig. source (feet)

**Variable Type:** Short

**Description:** Length of all continuous sewer pipe in feet laid in street between well-described end points during year “SewerDate” recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment

**Codes:**

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**Statistics:**  
Count: 4,956 (of 39,618 total)  
Min: 100  
Max: 8,517  
Mean: 1,201.4  
Records missing values excluded

**Distribution:**

![Sewer pipe length distribution chart](chart.png)
### WaterDate: Year of earliest observed water pipe installation

**Variable Type:** Short

**Description:** Year of earliest known water pipe installation in street segment based on construction records found by the CPE. For a full list of construction record sources and year covered see the “CPE_Philadelphia_Sanitation_Infrastructure_Coverage” document.

**Codes:**

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**Statistics:**

- **Count:** 15,980 (of 39,618 total)
- **Min:** 1810
- **Max:** 1899
- **Mean:** 1870.1

Records missing values excluded

**Distribution:**

![Frequency distribution graph showing the number of records per year for the year of sewer installation.](attachment:image.png)
### W_Pipe_In

**Diameter of water pipe in inches**

**Variable Type:** Short

**Description:** Diameter of water pipe laid in street segment during year “WaterDate,” in inches

**Codes:**

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<tr>
<th>Code</th>
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<td>No construction indicated in collected data</td>
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<tr>
<td>8888</td>
<td>Information on pipe length not included in collected data</td>
<td>567</td>
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**Statistics:**

- **Count:** 15,413 (of 39,618 total)
- **Min:** 1
- **Max:** 60
- **Mean:** 6.3

Records missing values excluded

**Distribution:**

![Frequency Distribution Chart]

- Frequency, n= 15,413
  - Water pipe diameter (in)
  - 0 - 6
  - 6 - 12
  - 12 - 18
  - 18 - 24
  - 24 - 30
  - 30 - 36
  - 36 - 42
  - 42 - 48
  - 48 - 54
  - 54 - 60

- Counts:
  - 14,400
  - 1,200
  - 200
  - 100
  - 50
  - 10
  - 0
  - 0
  - 0
  - 0
**W_Pipeleng**  
*Length of installed water pipe described in orig.source (feet)*

**Variable Type:** Long

**Description:** Length of all continuous water pipe in feet laid in street between well-described end points during year “WaterDate” recorded in construction records found by the CPE; not necessarily covering or limited to one single street segment

**Codes:**

<table>
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**Statistics:**

- Count: 2,443 (of 39,618 total)
- Min: 100
- Max: 12,151
- Mean: 882.5

Records missing values excluded

**Distribution:**

[Histogram showing frequency distribution of water pipe lengths]
### OBJECTID

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**Infrastructure Inputting Methodology**

In-street sanitation infrastructure data described in collected reports were added to historically accurate street centerline shapefiles created as part of the Historical Urban Ecological (HUE) Data Set. These street centerlines reflect streets in place c.1930, and exhibit the street names used at the time. These streets were planarized and thus form a new segment at each intersection. Data was input segment by segment by a team of trained research assistants. Additional variables and explanatory information were entered mid-way through the project. The most complete and constant variables are those specifying the earliest known/recorded construction of Sewer or Water pipes in a particular street segment. Information on missing variable codes, descriptive statistics, and frequency distributions can be found in the Sanitation Infrastructure Codebook specific to each city.

1. Data input:

   - Sewer and Water infrastructure data were coded on separate street centerline shapefiles to eliminate errors resulting from entry into the wrong set of fields (sewer vs water), then later combined into the final HUE Streets product. SewerDate (the date each street segment in the shapefile first received sewer service) and WaterDate were collected for all construction table entries that could be located in or along a street segment or segments and were specified at over 100 feet in length (where noted in the construction tables).

   - Additional fields preserved from the Sewer records are as follows: S_PipeLeng (the length of the sewer pipe installed, in feet), S_Pipe_Width (the diameter of the pipe, in feet), S_Inputter (the initials of the person who coded that segment, internal data only), and S_Comments (any additional information about the pipe or information about replacement pipes in subsequent years, internal data only). The fields preserved for Water records are similar: W_PipeLeng, W_Pipe_in (the pipe diameter in inches), W_Inputter, and W_Comments.

   - Note: PipeLeng values do not necessarily correspond to the geometric length of a given street segment since a pipe installation often covers more than one segment, or may not cover a full segment from cross street to cross street. These values were recorded to enable the joining of separate segments that were part of a single installation as specified in the construction table.

2. Procedure:

   - First, an intersection shapefile was created from the c.1930 street centerline file to expedite the coding process and allow the correct street segments to be located easily.

   - The "Find" tool in ArcMap was then used to find the location of the desired segment. When the main street for a particular record was searched, the resulting list included all streets intersecting that main street.

   - The two cross streets for the record were located in the list and the segment(s) of main street between them were centered in the map viewer.
• All segments of the main street between those cross streets were selected.

• The fields described above were populated using the data in the infrastructure report (not all fields were populated during all stages of data inputting)

Exceptions that came up during infrastructure coding were handled as follows:

• **Main or cross street name did not match any streets in the shapefile:** Using the district/neighborhood listed on the table to narrow the options, the street was located on a historic map and/or the street name was searched in a street name change table. Maps were also used to resolve issues when two streets did not intersect as expected. In areas where significant change had occurred in the streets, historic maps from a year close to the report document's publish date could be used to clarify intersections that varied in the shapefile.

• **A street located on a map was completely missing from the shapefile:** The street lines were drawn based on maps contemporary to 1930. Due to the quality of available historic maps as well as the scope of the project, some small streets and all alleyways were not drawn in the shapefile. Furthermore, streets that appeared for only a brief time in history or were built over prior to 1930 may not appear. Any records in the distribution table that referenced a completely missing street were not coded. Records where one part of the street was missing from the shapefile are denoted with "YYYY/BB" in the comments field. See below for complete descriptions of the quality codes.

• **The pipe length (as specified in the construction table) was less than 100 feet:** The segment was not coded. Most street segments in the shapefile are significantly longer than 100 feet; therefore these small records (which are frequently pipes laid between alleys or small repair segments) were judged to be less significant to the project as a whole and were not searched out.

• **A segment was already coded for a previous year:** In most cases, the segment’s comments field was edited to reflect the data for all subsequent installations using the "YYYY/AA" quality code. However, the date of initial pipe installation for any particular street segment was not changed.

• **Instead of two cross streets, the second column of the distribution table lists "From XXX street" or "At XXX street":** If the main street (first column) began/ended at the listed cross street, the segment was coded. If the main street continued on either side of the cross street, not enough information was available to code the pipe. The "At XXX street" records tended to have lengths shorter than 100 feet (in which case they would not be coded) or occasionally, existed between two sides of a divided boulevard and would be coded. (For similar records "East/West/North/South from XXX street", the coding was possible except in cases where the main street did not run in the direction specified.)

• **Instead of a cross street, a neighborhood line ("Newton Line", "Dedham Line", etc) was specified:** If the line could be located on a chronologically close historic map or the line segment in the shapefile near the edge of the city ended approximately where the neighborhood border should be, the installation was coded.
• **Instead of a cross street, a building or landmark ("Asylum", "Mr. XXX's House", "Theatre") was specified:** In the case of some landmarks or buildings, the geographic coordinates of the site could be determined from other online records. Otherwise, the record was not coded.

• **Pipe ends at railroad/water/alley that does not exist in the shapefile/"XX feet from cross street":** The full segment was coded (no segments were split or merged during the infrastructure coding process) and the appropriate quality code was placed in the comments field. If a railroad/railroad bridge was specified but the other cross street was missing or not locatable in the shapefile, the installation could not be coded.

• **One important piece of information (length, width) was missing from the distribution table:** See quality code "8888".

• **Multiple lengths were listed in the distribution table/report for a single pipe:** If the multiple lengths both corresponded to a single pipe diameter, they were added together and coded as a normal width/length pair. If the multiple lengths corresponded to different pipe widths, they were entered in the comments field in a "repeat covering of street segment during the same year" quality code ("YYYY/MM/width1/length1/width2/length2") and the pipe information fields, if not already coded, were populated with either one of the width/length sets if not already coded (otherwise, a "YYYY/AA" quality code was used in addition to the "YYYY/MM" code). Exception- if one of the lengths was less than 100 feet, it was largely disregarded.

3. Quality of infrastructure coding:

• **Missing pipe construction** was judged to be preferable to incorrect pipe coding in cases where the descriptions were vague and incomplete.

• **Coverage.** Lower coverage in certain areas of a city may be due to the city's infrastructure timeline- the areas where infrastructure construction began are likely to have the best overall coverage by the end of the time period-but may also be a result of major differences between the shapefile streets and the streets of various historical maps, especially if a lot of change and expansion occurred during the time period. The Hyde Park area of Boston, for example, underwent significant development and, furthermore, no detailed historical atlases existed for that neighborhood. As a result, when street names in the records did not match street names in the shapefile, most could not be coded.

• **Partial coverage of street segments.** The data do not always cover the entirety of every coded street segment. The lengths specified in the construction tables might only cover just over 100 feet of a particular segment, or might stop 10 feet short of the terminal intersection. As such the data are not appropriate for determining flow dynamics or overall network connectivity. Where the data explicitly indicated that that construction fell short of completing a specific block in question that segment was coded using the "NN" comment code (described in more detail later). Not all segments coded for every city received this code, however. Where early termination was not explicitly stated it was assumed that the pipe in question ran the complete length of the segment.
• **House connections.** Comprehensive information on individual house connections were not available for all cities for which sanitation infrastructure was input, nor were records found adequate to describe the timing of all house connections across the city. The installation of pipes denotes *the earliest possible availability* of access to the public sanitation system, but not the exact date of entry into that system.

• **Pipes not located in or adjacent to street segments.** If a sewer or water pipe was not laid in relation to a street and thus its construction could not be attributed to a particular street segment, it was not included in the sanitation infrastructure data.

4. Infrastructure Comment Codes:
- Codes are listed in the table spanning the next several pages.
- Because these codes were developed partway through the infrastructure coding process, not all comments will exactly follow these guidelines.
- Multiple comments are separated by the ";" delimiter.
- Note: the comments are not provided parsed, they are provided as a single text string.

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
<th>Example</th>
<th>Entry for Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>Additional pipe along segment</td>
<td>In the year 1865, a pipe 6 inches in diameter and 600 feet in length was installed along the selected street segment. But the shape-file tells that this pipework is alongside existing pipework on the selected street segment.</td>
<td>1865/AA; 1865/6/600</td>
</tr>
<tr>
<td>BB</td>
<td>Pipe continues on segment that does not exist in the shape-file</td>
<td>In the year 1865, a pipe 6 inches in diameter and 600 feet in length was installed along a street segment between intersections “Alpha” and “Beta.” However, the pipe clearly extends beyond the intersection “Beta,” a jutting segment that is not available on the shape-file.</td>
<td>1865/BB</td>
</tr>
<tr>
<td>CC</td>
<td>New pipe completes coverage of segment</td>
<td>In the year 1865, a pipe 6 inches in diameter and 200 feet in length was installed along a street segment between “400 feet from Beta towards Alpha” and “Beta.” The geocoder notes that the preceding entry in the ledger was about a pipe installed from “Alpha” to “400 feet from Beta towards Alpha.”</td>
<td>1865/CC; 1865/6/200</td>
</tr>
<tr>
<td>Code</td>
<td>Meaning</td>
<td>Example</td>
<td>Entry for Example</td>
</tr>
<tr>
<td>------</td>
<td>---------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>EE</td>
<td>Pipe layout is along street segment that in shape-file could be one of many parallel street segments</td>
<td>In the year 1865, a pipe of 6 inches in diameter and 600 feet in length was installed along a street segment between intersections “A” and “B.” However, in the shape-file instead of “A,” there are split intersections “A1,” “A2,” A3” and “A4.” Moreover, instead of corresponding terminus “B,” the shape-file has the split termini “B1,” “B2,” “B3,” and “B4.” Note: the counts are north to south; or east to west.</td>
<td>1865/EE</td>
</tr>
<tr>
<td>LL</td>
<td>Pipe layout involves alley</td>
<td>In the year 1865, a pipe 6 inches in diameter and 600 feet in length was installed along a street segment between intersections “Alpha” and “Beta,” the latter of which is specifically mentioned as an alley.</td>
<td>1865/LL</td>
</tr>
<tr>
<td>MM</td>
<td>Pipe layout involves repeat covering of street segment during same year</td>
<td>In the year 1865, a pipe 5 inches in diameter and 630 feet in length was installed along a street segment. However, later in the ledger it is indicated that another pipe 3 inches in diameter and 380 feet in length was also installed along the same street segment.</td>
<td>1865/MM/5/630/3/380</td>
</tr>
<tr>
<td>NN</td>
<td>Segment not fully covered by pipe</td>
<td>In the year 1865, a pipe 6 inches in diameter and 600 feet in length was installed along a street segment between intersections “Alpha” and “Beta,” but specifically mentioned to be 101 feet short of the intersection “Beta.”</td>
<td>1865/NN</td>
</tr>
<tr>
<td>QQ</td>
<td>Pipe noted in ledger’s write-up but not in ledger’s main list of pipework</td>
<td>While reading through the written report in a ledger about infrastructure activity in 1865, a geocoder notes mention of a pipe missing from the accompanying list of pipework contracts.</td>
<td>1865/QQ</td>
</tr>
<tr>
<td>RR</td>
<td>Pipe layout involves railroad</td>
<td>In the year 1865, a pipe 6 inches in diameter and 630 feet in length was installed along a street segment is specifically mentioned to terminate at a railroad line</td>
<td>1865/RR</td>
</tr>
<tr>
<td>Code</td>
<td>Meaning</td>
<td>Example</td>
<td>Entry for Example</td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>S_</td>
<td>Pipe layout involves information on side of street utilized for construction (N,S,E,W)</td>
<td>In the year 1865, a pipe 5 inches in diameter and 580 feet in length was installed along the north side of a street segment.</td>
<td>1865/SN</td>
</tr>
<tr>
<td>SY</td>
<td>Pipe is part of system that covers an area, individual blocks of which are not specifically described</td>
<td>In the year 1865 a sewer system of mains and laterals on 1000 acres approximately bounded by 1st St, 6th St, Avenue A and Avenue H. (all streets within area get SY code)</td>
<td>1865/SY</td>
</tr>
<tr>
<td>TB</td>
<td>Construction technology is specifically called out to be brick-based</td>
<td>In the year 1865, a sewer 8 feet in diameter and 600 feet in length was installed along the selected street segment. The sewer is specifically mentioned to be made up of bricks.</td>
<td>1865/TB</td>
</tr>
<tr>
<td>TC</td>
<td>Construction is specifically called out to be concrete-based</td>
<td>In the year 1865, a sewer 8 feet in diameter and 600 feet in length was installed along the selected street segment. The sewer is specifically mentioned to be made up of concrete.</td>
<td>1865/TC</td>
</tr>
<tr>
<td>TG</td>
<td>Construction is specifically called out as egg-shaped</td>
<td>In the year 1865, a sewer 600 feet in length was installed along the selected street segment. The sewer is specifically mentioned to be egg-shaped, unknown height and 11 feet in width</td>
<td>1865/TG/8888/11</td>
</tr>
<tr>
<td>TO</td>
<td>Construction is specifically called out as oval in shape</td>
<td>In the year 1865, a sewer 600 feet in length was installed along the selected street segment. The sewer is specifically mentioned to be oval in shape, unknown height and 6 feet in width.</td>
<td>1865/TO/8888/6</td>
</tr>
<tr>
<td>WW</td>
<td>Drainage from the pipe is specifically mentioned to be water-body based</td>
<td>In the year 1865, a pipe 6 inches in diameter and 600 feet in length was installed along the selected street segment. The pipe is specifically mentioned to be draining into a body of water.</td>
<td>1865/RR</td>
</tr>
<tr>
<td>ZZ</td>
<td>Geocoder’s observation not encompassed by other comment-code categories</td>
<td>In the year 1865, a sewer 8 feet in diameter and 600 feet in length was installed along the selected street segment. The sewer worked its way through a public park.</td>
<td>1865/ZZ/Pipe flows through public park</td>
</tr>
<tr>
<td>8888</td>
<td>Information on diameter or length for pipe is not available</td>
<td>In the year 1865, a pipe of unknown diameter and 600 feet in length was installed along the selected street segment.</td>
<td>1865/8888/600</td>
</tr>
</tbody>
</table>
D. HUE HISTORICAL SHORELINES SOURCES

The HUE historical shorelines are incorporated in all HUE GIS files. The following cartographic bibliographies note the maps consulted in the recreation of these shorelines. Digital images of each map were georeferenced using the HUE historical street centerlines. Shorelines were redrawn with the ultimate purpose of providing approximate land area for historical wards bordering on water features. No further uses are claimed or intended. The accuracy of original sources cannot be assured.

**Baltimore**


**Boston**


http://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~22763~770057:Map-of-Boston--for-1888--Published--?sort=Date%2CPub_Date%2CPub_List_No%2CSeries_No (Accessed Jan 24, 2013).

http://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~29217~1130276:Outline-and-index-map-of-Boston-pro?sort=Date%2CPub_Date%2CPub_List_No%2CSeries_No&qvq=w4s:/where/Boston%20%28Mass.%29;q:boston;sort:Date%2CPub_Date%2CPub_List_No%2CSeries_No;lc:RUMSEY~8~1&mi=93&trs=190 (Accessed Jan 21, 2013).


**CHICAGO**


http://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~34337~1171252:Blan
chard-s-guide-map-of-Chicago--A?sort=Date%2CPub_Date%2CPub_List_No%2CSeries_No


https://data.cityofchicago.org/Facilities-Geographic-Boundaries/Boundaries-City/q38j-zgre


http://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~1570~190004:Map-Of-Chicago--Rufus-Blanchard,-
52?sort=Pub_List_No_InitialSort%2CPub_Date%2CPub_List_No%2CSeries_No (Accessed Jan 24, 2013).


http://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~214633~5501753:Ran


**CINCINNATI**


**MANHATTAN**


III. GIS Downloads


**PHILADELPHIA**


IV. Tabular Ward-Level Data

The HUE data set includes tabular ward-level data for all seven HUE cities for the years 1830-1930, when available. Ward-level ecological variables fall into several categories of information: socioeconomic (wealth, taxes, and education); health (vital statistics and disease prevalence rates, both case and fatality rates); public health improvements (water filtration or chlorination, milk pasteurization, and vaccinations); and municipal government.

The HUE ward-level data is available in Excel format on the GIS Files HUE Bulk Downloads page at http://hue.uadata.org/gis/ (see Figure 1). Download links are organized by city, and thereunder by year. Spreadsheets containing data for multiple years are located under the earliest data year. Tables with data for both Brooklyn and New York City are filed under New York City.

A. Data Sources

The strength of the ecological variables data set stems from the discovery and collection of detailed information reported annually by city institutions. Ward-level data was transcribed from the annual health department reports, 1830-1930 when available. Due to fires, loss, decay, and lack of access, it was not possible to collect complete data for every year for every city, resulting in incomplete coverage.

HUE project staff located the annual health reports from city, county, and state archives, university libraries, and from online repositories such as GoogleBooks and HathiTrust. Each available volume was reviewed for ward-level data. These data were transcribed verbatim into Excel spreadsheets.
Each spreadsheet includes Source Identification (SID) and Table Identification (TID) numbers generated by the project to link the chart back to its source document. Complete bibliography information is available upon request. Contact HUE project staff at http://uadata.org/contact_us/ with the appropriate SID and TID numbers.

Reporting of ward-level data was inconsistent across cities and decades. Inconsistencies are related to the:

- First year for which data is available
- Aggregation level of the data
- Availability of a variable
- Time period reported (day, week, year)
- Beginning and ending dates for a year period

Most departments were established earlier than the first year for which ward-level data is available. Prior to the availability of ward-level data, the cities often reported data at the city-level. In addition, cities occasionally reported data at the assembly district, sanitary district, or district-level. Project staff collected all data reported at the ward, assembly, district, or sanitary district-levels.

The availability of specific variables differs between cities and within a single city, between years. These differences were due to changing administrations, modernization of the health profession, and changing public policy concerns.

Depending on the city and the year, the time period for which the data was reported may not correspond to a calendar year. Some annual reports provide data for a year defined as June to May, January to December, or an alternative time period. Careful attention should be paid to the variable labels and Excel spreadsheets for time period explanations. See the startdate and enddate fields in the HUE Variable Dictionary to clarify the time period to which a variable relates (see Section IV.B for more information).

The following table is representative of birth data found in the annual reports. This particular table is sourced from the *Health Officer’s Annual Report of Births, Marriages, and Deaths, for the City of Philadelphia, 1882.*
Figure 2: Philadelphia, Births by Ward 1882

The following table presents the births in each Ward during the year 1882:

<table>
<thead>
<tr>
<th>WARD</th>
<th>Births</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>1,154</td>
</tr>
<tr>
<td>Second</td>
<td>592</td>
</tr>
<tr>
<td>Third</td>
<td>383</td>
</tr>
<tr>
<td>Fourth</td>
<td>506</td>
</tr>
<tr>
<td>Fifth</td>
<td>345</td>
</tr>
<tr>
<td>Sixth</td>
<td>216</td>
</tr>
<tr>
<td>Seventh</td>
<td>525</td>
</tr>
<tr>
<td>Eighth</td>
<td>287</td>
</tr>
<tr>
<td>Ninth</td>
<td>195</td>
</tr>
<tr>
<td>Tenth</td>
<td>384</td>
</tr>
<tr>
<td>Eleventh</td>
<td>372</td>
</tr>
<tr>
<td>Twelfth</td>
<td>392</td>
</tr>
<tr>
<td>Thirteenth</td>
<td>371</td>
</tr>
<tr>
<td>Fourteenth</td>
<td>529</td>
</tr>
<tr>
<td>Fifteenth</td>
<td>1,009</td>
</tr>
<tr>
<td>Sixteenth</td>
<td>465</td>
</tr>
<tr>
<td>Seventeenth</td>
<td>549</td>
</tr>
<tr>
<td>Eighteenth</td>
<td>646</td>
</tr>
<tr>
<td>Nineteenth</td>
<td>1,376</td>
</tr>
<tr>
<td>Thirtieth</td>
<td>673</td>
</tr>
<tr>
<td>Twentieth</td>
<td>1,016</td>
</tr>
<tr>
<td>Twenty-first</td>
<td>698</td>
</tr>
<tr>
<td>Unknown</td>
<td>139</td>
</tr>
<tr>
<td>Twenty-second</td>
<td>764</td>
</tr>
</tbody>
</table>

The largest number of births occurred in the Nineteenth Ward, one thousand three hundred and seventy-six (1,376), and the lowest number in the Ninth Ward, one hundred and ninety-five (195).

The above Philadelphia annual report table was transcribed for the HUE project as TID 5792 from source SID 437. These identification numbers are used by the project to uniquely identify each Excel spreadsheet and to locate bibliographical information in the project’s Source Database.
IV. Tabular Ward-Level Data

Figure 3: Transcribed Table

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PHILADELPHIA</td>
<td>1882</td>
<td>437</td>
<td>TABLE II - BIRTHS IN EACH WARD, 1882.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>HEALTH OFFICE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>TABLE II - BIRTHS IN EACH WARD, 1882.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>WARD</td>
<td>BIRTHS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>1154</td>
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<tr>
<td>7</td>
<td>2</td>
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</tr>
<tr>
<td>8</td>
<td>3</td>
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<tr>
<td>9</td>
<td>4</td>
<td>503</td>
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<td></td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>345</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>11</td>
<td>6</td>
<td>216</td>
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<tr>
<td>12</td>
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<tr>
<td>13</td>
<td>8</td>
<td>287</td>
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<td></td>
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<tr>
<td>14</td>
<td>9</td>
<td>195</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>384</td>
<td></td>
<td></td>
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<tr>
<td>16</td>
<td>11</td>
<td>372</td>
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</tr>
<tr>
<td>17</td>
<td>12</td>
<td>372</td>
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<td></td>
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</tr>
<tr>
<td>18</td>
<td>13</td>
<td>371</td>
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</tr>
<tr>
<td>19</td>
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<td>620</td>
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</tr>
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<td></td>
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<tr>
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</tr>
<tr>
<td>22</td>
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<td></td>
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</tr>
<tr>
<td>23</td>
<td>18</td>
<td>646</td>
<td></td>
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<tr>
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<td>19</td>
<td>1375</td>
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<td></td>
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<tr>
<td>25</td>
<td>20</td>
<td>1031</td>
<td></td>
<td></td>
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<tr>
<td>26</td>
<td>21</td>
<td>698</td>
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<td></td>
</tr>
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<td>28</td>
<td>23</td>
<td>526</td>
<td></td>
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<td>29</td>
<td>24</td>
<td>1016</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>25</td>
<td>790</td>
<td></td>
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</tr>
<tr>
<td>31</td>
<td>26</td>
<td>982</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>27</td>
<td>600</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>33</td>
<td>28</td>
<td>1053</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>29</td>
<td>329</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>30</td>
<td>673</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>31</td>
<td>774</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>UNKNOWN</td>
<td>139</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>20396</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The first four rows of each Excel spreadsheet contain header information for the transcribed table. Headings are formatted as follows:

<table>
<thead>
<tr>
<th>Excel Spreadsheet Cell</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>City name</td>
</tr>
<tr>
<td>B1</td>
<td>Book identification year</td>
</tr>
<tr>
<td>C1</td>
<td>SID</td>
</tr>
<tr>
<td>D1</td>
<td>TID</td>
</tr>
<tr>
<td>E1</td>
<td>Table title, Data year</td>
</tr>
<tr>
<td>A2</td>
<td>City department</td>
</tr>
<tr>
<td>A3</td>
<td>Additional city department information</td>
</tr>
<tr>
<td>A4</td>
<td>Table title, Data year</td>
</tr>
</tbody>
</table>
C. HUE VARIABLE DICTIONARY

The HUE Variable Dictionary is available in Excel format. The dictionary indicates the spreadsheet in which each variable is located. However, the Variable Dictionary is not an exhaustive list of available spreadsheets. Spreadsheets containing duplicate variables are not listed, but are available for download on the HUE site. Furthermore, the dictionary does not list those spreadsheets containing city-level data. The HUE Variable Dictionary can be downloaded at hue.uadata.org/documentation.

The Variable Dictionary provides details for each HUE variable transcribed by the project team. For each variable the source information (SID, TID) and the file name of the corresponding Excel Spreadsheet is listed, as well as the variable's name, label, category, dates, and enumeration level. For example, the birth variable in Figure 3 for 1882 Philadelphia corresponds to variable v_b listed in the last row of the HUE Dictionary image in Figure 4.

Figure 4: HUE Dictionary

| A | city | City which the variable relates |
| B | category | Variable category |
| C | variable | Variable name |
| D | description | Variable label |
| E | startdate | Beginning date of the data in YYYY-MM-DD format |
| F | enddate | End date of the data in YYYY-MM-DD format |
| G | enumtype | Enumeration level |
| H | datetype | Time period designation |
| I | title | Table title, Data year |
| J | sid | Source identification number (SID) |
| K | tid | Table identification number (TID) |
| L | filename | Excel spreadsheet filename |

The enumeration type field (enumtype) describes the level of the data. The HUE project team transcribed data at the ward, assembly district, district, enumeration district and sanitary district levels. Note that although some spreadsheets may contain city-level data, those spreadsheets and variables are not listed in the Variable Dictionary.
### Table 12: Enumeration Type (*enumtype*) Codes

<table>
<thead>
<tr>
<th>CODE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>Assembly District</td>
</tr>
<tr>
<td>D</td>
<td>District</td>
</tr>
<tr>
<td>ED</td>
<td>Enumeration District</td>
</tr>
<tr>
<td>SD</td>
<td>Sanitary District</td>
</tr>
<tr>
<td>W</td>
<td>Ward</td>
</tr>
</tbody>
</table>

The data type field (*datatype*) describes the time period to which the data relates. It contains the following codes:

### Table 13: Data Type (*datatype*) Codes

<table>
<thead>
<tr>
<th>CODE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>Decade</td>
</tr>
<tr>
<td>Y</td>
<td>Year (Jan – Dec)</td>
</tr>
<tr>
<td>OY</td>
<td>Year defined other than Jan-Dec</td>
</tr>
<tr>
<td>Q</td>
<td>Quarter</td>
</tr>
<tr>
<td>M</td>
<td>Month</td>
</tr>
<tr>
<td>W</td>
<td>Week</td>
</tr>
<tr>
<td>D</td>
<td>Day</td>
</tr>
</tbody>
</table>

DataType codes may be preceded by a number to indicate the number of years, months, days, etc. to which the data relates. For example 6M indicates six months and 13W indicates thirteen weeks.

Variables can be filtered into categories using the *category* field. HUE variables are organized into the following categories:

- Crime
- Disease (cases)
- Disease (death)
- Disease (vaccination)
- Employment
- Government
- Municipal (animal)
- Municipal (other)
- Municipal (political)
- Municipal (school)
- Municipal (sewers, etc.)
- Municipal (water)
- Property (buildings)
- Property (financial)
- Property (land)
- Property (other)
- Vital (birth)
- Vital (death)
- Vital (other)
- Vital (population)

HUE variables were named according to a prefix naming convention. Each *variable* name has a category prefix as follows:
### Table 14: Variable Prefixes (variable)

<table>
<thead>
<tr>
<th>CODE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>c_*</td>
<td>Crime</td>
</tr>
<tr>
<td>d_*</td>
<td>Disease</td>
</tr>
<tr>
<td>e_*</td>
<td>Employment</td>
</tr>
<tr>
<td>g_*</td>
<td>Government</td>
</tr>
<tr>
<td>m_*</td>
<td>Municipal</td>
</tr>
<tr>
<td>p_*</td>
<td>Property</td>
</tr>
<tr>
<td>v_*</td>
<td>Vital</td>
</tr>
</tbody>
</table>

#### D. Missing HUE Variable Dictionary

During the course of the HUE project 128 Excel spreadsheets out of the 5,686 transcribed were lost. The missing 128 tables contained 2,439 variables. Some missing variables may be duplicated in the spreadsheets that are available for download. For those that are not duplicated, copies of the original sources are available. For access to the original source image contact HUE project staff at [http://uadata.org/contact_us/](http://uadata.org/contact_us/) with the appropriate Source Identification (SID) and Table Identification (TID) numbers.

The Missing HUE Variable Dictionary is available in Excel format and can be downloaded at [hue.uadata.org/documentation](http://hue.uadata.org/documentation). This Dictionary lists descriptions of the 2,461 missing variables and indicates the SID and TID for the source in which the original tables can be located. See Section IV.B for an explanation of the spreadsheet fields.
V. User Instructions for Importing HUE Tabular Data into a GIS Environment

This tutorial serves to instruct those new to the use of GIS tools on the formatting requirements necessary to import the tabular data into ESRI ArcGIS 9.3 and the steps needed to join properly formatted tabular data to the provided HUE shapefiles. The user should then be able to freely manipulate the information in a GIS environment.

A. SOFTWARE REQUIREMENTS

The user must have access to the following software packages in order to complete this tutorial:

- Extraction software capable of decompressing .zip files (open-source packages such as 7zip are available for those that do not have extraction software pre-installed on their machines).
- Microsoft Excel or similar spreadsheet software capable of saving files to .csv format.
- GIS software such as ESRI ArcGIS suite (Basic through Advanced, must include ArcMap). Several packages are available, both proprietary and open source, and will allow the user to manipulate the HUE spatial data. This tutorial, however, will cover ArcGIS 9.3 and later, as this package is available in many academic settings.

Note that once properly prepared, the tabular and spatial data may be added to a custom database capable of storing both types of data, such as PostgreSQL. Instructions for formatting and importing data into such formats are not provided in this tutorial.
B. Downloading Data from the HUE Website

The full HUE data set is available at hue.uadata.org. The “Overview” page describes the data set and the “Documentation” data set provides information on the sources used to build the GIS portions of the data set for user reference. All of the data is available for direct download on the “GIS Files” page (Figure 1).

Figure 1: HUE “GIS Files” page

The user may download tabular data by city and year in Excel format as well as GIS files in shapefile and geodatabase format on the “GIS Files” page. The linked bulked downloads contain all HUE ward-level data in Excel format organized by city, then by year. All data digitized by the Early Indicators project for that year are included in the downloadable .zip file available at each link.

Following formatting, the tabular data may be joined to the ward boundaries in place during that year (e.g. tabular data for Boston in 1882 would be merged with the ward boundary shapefile for Boston 1876-94). Note that data not in ward format cannot be joined the ward boundary shapefiles, some bulk downloads may include data that corresponds to other geographical units.

New users are advised to download the ward-level HUE Ward Boundaries in shapefile format. For the purposes of this tutorial, the user is directed to download the tabular data for Philadelphia in 1890 as well as the ward boundary shapefiles for Philadelphia 1830-1930.
C. **CLEANING DATA FOR IMPORT INTO ESRI ArcGIS (9.3 AND LATER)**

In order to bring format the downloaded data for proper import into ArcGIS, the user must follow the steps outlined below. All tabular data available from hue.uadata.org must be reformatted for use in a GIS environment. HUE data from 1891 specific to the city of Philadelphia are used to illustrate the necessary steps.

1. Navigate to the folder containing the .zip file including all data for the desired city and year.
2. Extract the files using the decompression software of your choice.
3. Open the first file in the folder “1891_WL-SID536_TID6908_1891-Philadelphia_Bureau_Health_Deaths_by_Ward_1891.pg_54” in Excel or .xls-compatible spreadsheet program. Figure 2 shows part of the open file prior to reformatting.

**Figure 2: HUE Data, Philadelphia 1891 example, no formatting**

```
<p>| | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>G</td>
<td>H</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>1</td>
<td>PHILADELPHIA</td>
<td>1891</td>
<td>536</td>
<td>0908</td>
<td>DEATHS BY WARD DURING THE YEAR 1891</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>BUREAU OF HEALTH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>DEATHS BY WARD DURING THE YEAR 1891</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>WARDS</td>
<td>DEATHS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>1233</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>809</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>3</td>
<td>509</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>721</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>475</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>228</td>
<td></td>
<td></td>
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<tr>
<td>11</td>
<td>7</td>
<td>797</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>8</td>
<td>440</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<tr>
<td>14</td>
<td>10</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>11</td>
<td>273</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>12</td>
<td>316</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>13</td>
<td>307</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>14</td>
<td>438</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
4. Clean the data to a machine readable format. To successfully import the data into a GIS environment, the following steps must be taken (Figure 3 demonstrates properly formatted data):

a) Rows must be ordered by ward number, with one column (or field) for ward number and one or more columns containing data points for the desired variable (such as deaths or cases of scarlet fever) by ward. If the columns are ordered by ward number instead of variable, the data must be transposed.

b) The ward column must be formatted as an integer number (e.g. TWENTY-TWO must be edited to 22, etc.)

c) All data not at the ward level (e.g. OTHER, INSTITUTIONS, TOTAL etc. must be discarded)

d) Extraneous, non-machine readable data such as source headers, notes, extraneous variables and fields, and sub-headers must be deleted.

e) Field names must not contain non-alphanumeric characters or spaces and must be under ten characters in length.

f) Numeric fields such as deaths per ward must only contain numeric and null data, string characters must be expunged

g) The spreadsheet must not contain any merged cells.

Figure 3: Properly formatted HUE Data, Philadelphia 1891 example
5. Save reformatted data as a csv (comma delimited) file. Earlier versions of ArcGIS cannot read in .xlsx format files and .cls files can prove to be tricky for new users. The file is now ready to be imported into GIS.

**D. JOINING CLEANED SPREADSHEETS TO SHAPEFILES IN ESRI ArcGIS (9.3 AND LATER)**

Once the tabular data has been reformatted it can be imported into ArcGIS. The following steps use the cleaned ward-level mortality data from Philadelphia as shown earlier in this tutorial to illustrate the process.

1. Unzip HUE_Philadelphia_Wards.zip as downloaded from hue.uadata.org
2. Start ArcMap from the start menu or a desktop shortcut.
3. In ArcMap, navigate to the top ribbon and click the “Add Data” icon (the orange-yellow diamond with an overlaid plus sign) as seen in Figure 4

*Figure 4: Adding Data in ArcMap*
4. Browse to the unzipped HUE_Philadelphia_Wards folder and select the ward boundaries shapefile that corresponds to the year of the variable of interest ("philadelphia_wards_1890_1891.shp") as shown in Figure 5. The shapefile will appear on the screen as a layer, and will also appear in the Table of Contents.

**Figure 5: Adding shapefiles in ArcMap**

5. Click the “Add Data” button again and browse to your cleaned spreadsheet. Double click on the .csv file to add it to the ArcMap session See Figure 6.
V. User Instructions for Importing HUE Tabular Data into a GIS Environment

Figure 6: Adding .csv files in ArcMap

6. In the table of contents (located as a default on the left sidebar), right click the imported spreadsheet and click open to review the imported data as in Figure 7. Check that the data matches the formatted data. If it does not, review the original data for non-numeric characters.

Figure 7: Opening the Tabular Data in ArcMap
7. Once the tabular data has been added and verified, right click the “philadelphia_wards_1890_1891” shapefile in the table of contents and select Joins and Relates > Join as shown in Figure 8

Figure 8: Joining the Tabular Data to the Ward Shapefile

8. In the Join Menu select “Join attributes from a table” from the dropdown menu at the top of the dialog box, “Ward_Num” as the join field for the layer, the cleaned .csv file as the table to join to the layer, and “WARDS” as the join field for the table. Select “Keep All Records” and click “Okay,” as shown in Figure 9. The join will be completed instantly. Note that ArcMap is simply creating a relationship between the layer and the table, no data has been saved and no file has been altered.
9. Right click the “philadelphia_wards_1890_1891” layer and select “Open Attribute Table,” verify that the ward numbers from the shapefile match the ward numbers from the table. If they do and all fields and cells are properly read in, as in Figure 10 (do not mistakenly appear as <null>, for instance).

**Figure 10: Properly Joined Data**
10. The layer to which the tabular data has been joined must be exported and saved as a new shapefile. To execute an export, right click on the “philadelphia_wards_1890_1891” layer and select Data > Export Data, as in Figure 11. In the export dialog box, select a folder in which to save the completed file.

**Figure 11: Exporting Joined Data from ArcMap**
11. The join has been saved and the shapefile with the appended tabular data of interest is now available for mapping and analysis in ArcMap, as demonstrated in Figure 12

**Figure 12: Completed Join Showing Deaths by Ward, 1891**
VI. HISTORICAL GEOCODING GUIDE

A. INTRODUCTION

This essay documents the geocoding applications of the street centerline files included in the Historical Urban Ecological (HUE) data set. These streets centerlines and other historical GIS data can be found at the HUE data portal, hue.uadata.org.

In this document a discussion of the limitations of the street centerlines for automated geocoding is followed by an in-depth description of the procedure by which several thousand urban Union Army (UA) and US Colored Troops (USCT) veterans living in Baltimore, Boston, Brooklyn, Chicago, Manhattan, and Philadelphia were manually geocoded. Tables listing the sources used in this procedure can be found at the end of this document.

B. GEOCODING APPLICATIONS AND LIMITATIONS

The street centerline GIS files packaged in the Historical Urban Ecological (HUE) data set provide opportunities for creating spatial data pertaining to the major US cities of the nineteenth and early twentieth centuries, principally Baltimore, Boston, Chicago, Cincinnati, New York, and Philadelphia. They serve as a framework for georeferencing historical maps as well as digitizing census geographies and physical infrastructure. The street centerlines also allow historical addresses, and the individuals who lived at them, to be accurately located in space through a procedure called geocoding.

Geocoding refers to process by which a table of addresses, and the information linked to those addresses, are placed in space in a GIS and given x and y coordinates. While geocoding can be done at many scales, it typically refers to the address-level. In this case the address is placed at its approximate physical location rather than to the correct city, county, or state. Contemporary address-level geocoding operations are nearly completely automated. They reference the user-provided tabular address data against an address locator created using a street centerline file. The individual street segments, or blocks, within this street centerline file typically include information on the street name and range of house numbers located on each side of the street segment. Addresses from the table are located according to how well they match a unique street segment. Municipal GIS departments and private data providers maintain street networks appropriate for such tasks. Address ranges are conventionally stored in L/R TO/FROMADD fields. The HUE data set
does not include such information and is thus unsuitable for building an address locator and performing automated geocoding in the historical period.\(^2\)

The HUE data set spans a century of rapid urban growth from 1830–1930. Over this period addresses were very unstable. The developing cities adopted new numbering systems to accommodate annexations and new construction. Renumbering schemes seen during this time range in scope from complete reworkings in Baltimore and Chicago to annual incremental shifts in Manhattan. Each city experienced a multitude of minor ad hoc modifications on top of these systematic changes. Streets were also frequently renamed in this period, sometimes several times. Multiple renamings are most prevalent in Philadelphia. Taken in total, this instability would have necessitated the creation of multiple street centerline files for each city, each with extensive edits to automate geocoding. Researchers can add address range(s) particular to their area and period of study if desired. The HUE street centerlines are provided in a format that supports such endeavors.

Performing automated geocoding on historical addresses is a difficult task even with a complete address locator. The CPE’s data sets provide an example. The Union Army and USCT samples are created from hand-written Military Service Records, Pension documents, Surgeons Certificates, and Census ledgers. Many variables, including addresses, are misspelled or smudged. Residential data are further influenced by a doctor or enumerator’s personal relationship to a veteran or their familiarity with a particular place—resulting in incomplete or vernacular addresses. As a result, many of the addresses collected from the UA and USCT veterans’ records—and addresses found in many other historical sources—would not pass an automated geocoder.

The 1930 street centerlines address several problems of modern street centerline files. These problems are principally the disappearance of historic areas that were razed to accommodate highway interchanges and large-scale redevelopments in the later twentieth century and the lack of period-specific street names. The researcher is supplied with spatially accurate street centerlines broadly appropriate to the period 1860–1930 with which to undertake manual geocoding for the longitudinal study of individual and neighborhood characteristics.

C. Geocoding the Union Army and US Colored Troops

**Overview**

The following sections describe the process by which CPE staff manually geocoded the addresses of all UA and USCT veterans found living in the HUE study cities of Baltimore, Boston, Brooklyn, Chicago, Manhattan, and Philadelphia. Cincinnati, while part of the HUE data set, was not included due to the difficulty of finding large numbers of urban Ohioans. These addresses span the major sources that constitute the individual histories of the men belonging to the UA, USCT, Andersonville,

\(^2\) As the HUE street centerlines are highly accurate, modern addresses derived from contemporary street centerline files can be overlaid and integrated into historical investigations.
Oldest Old, and Urban samples created for the Early Indicators of Later Work Levels, Disease and Death project\(^3\). The major sources include the Census, Pension, and Surgeons Certificates.

All told, our staff assessed 28,538 address records of 7,302 veterans observed in the study cities between 1816 and 1949.\(^4\) A more detailed breakdown of the number of addresses assessed by city and sample (the total potentially geocodable addresses) can be found in Table 1. The temporal distribution of these observations across all samples can be seen in Figure 1. These records were not necessarily unique as address data were extracted from multiple sources and men could be observed living in the same residence multiple times in a single year. Veterans were also observed living in the same building as other veterans. As such, “address” will not be used to reference a unique address such as 100 S. State St, Chicago, IL. It will be used instead to refer to an address at which a veteran is observed in the source material, e.g. 100 S State St, Chicago, IL, 1880 Census.

\(^3\) More information on Early Indicators Samples is available at http://www.UAData.org
\(^4\) Numbers based on collection work completed by CPE as of 6/24/2013 and subject to change.
Table 1: Addresses of Union Army and US Colored Troops Veterans Observed for HUE Study

<table>
<thead>
<tr>
<th>City</th>
<th>Number of addresses</th>
<th>Percent total (by city)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltimore</td>
<td>7,421</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>UA</td>
<td>4,971</td>
</tr>
<tr>
<td></td>
<td>USCT</td>
<td>2,450</td>
</tr>
<tr>
<td>Boston</td>
<td>2,236</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>UA</td>
<td>2,160</td>
</tr>
<tr>
<td></td>
<td>USCT</td>
<td>76</td>
</tr>
<tr>
<td>Chicago</td>
<td>3,803</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>UA</td>
<td>3,490</td>
</tr>
<tr>
<td></td>
<td>USCT</td>
<td>313</td>
</tr>
<tr>
<td>New York*</td>
<td>8,389</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>UA</td>
<td>7,862</td>
</tr>
<tr>
<td></td>
<td>USCT</td>
<td>527</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>6,689</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>UA</td>
<td>5,539</td>
</tr>
<tr>
<td></td>
<td>USCT</td>
<td>1,150</td>
</tr>
<tr>
<td>TOTAL</td>
<td>28,538</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>UA</td>
<td>24,022</td>
</tr>
<tr>
<td></td>
<td>USCT</td>
<td>4,516</td>
</tr>
</tbody>
</table>

*New York includes Manhattan and Brooklyn, with a small number of addresses from the other boroughs
Note: UA and USCT here encompass all samples, including Urban, Andersonville, and Oldest Old.

Figure 1: Distribution of Observed Urban Addresses of All Samples across Time

*Frequency greater than total observed addresses, some observations span multiple years

Note: 10 observations contain null or erroneous years, these records have been removed.

ADDRESS DATA
As noted above the veterans geocoded to the HUE street centerlines were drawn from the UA, USCT, Oldest Old, Andersonville, and Urban samples. The original UA and USCT samples are based on complete companies of mostly rural men. To increase the power of the UA for urban analysis, CPE staff oversampled companies that mustered in the HUE study cities. These companies constitute the Urban sample.

Research into the composition of the companies that mustered in Cincinnati revealed that the enlisted men came from rural areas outside the city and did not resettle in the city following the war in numbers great enough to construct a robust samples. As such, addresses in Cincinnati were not geocoded, though a partial ward history, ward-level data, and street centerlines are available through the HUE portal.
The complete records for each veteran contain thousands of variables detailing military service, individual health, socioeconomic status, and myriad other data points across the life cycle. Many of these data points have associated location information. Some, however, only specify the city, county, or state. Address-level place of residence information appears in the Census, Pension, and Surgeons Certificates sources.

The potentially geocodable addresses for the HUE cities seen in Table 1 were derived from a table of location data that spanned all samples. A cleaning program, executed in STATA, captured all records that could possibly be geocoded to the address level in these cities. Rural addresses, incomplete addresses, and urban addresses in non-HUE cities were omitted. To be eligible for geocoding an address needed to be in a HUE study city with street and house number information, and dates at which the veteran lived at that address. Table 2 illustrates a set of potentially geocodable addresses for the city of Chicago distilled from the residential information described above. The address information is found in the “oaddress,” “oinfo,” “oward,” and “ocity” fields.

Table 2 illustrates the difficulty of running an automated geocoder and the need to operationalize the manual geocoding process. The following sections explain how the various misspellings and incomplete or unorthodox records were assessed.

**Accuracy of Geocoding Procedure**

The manual geocoding procedure developed by the CPE was guided by the applications of the HUE data set as laid out in the aims of the *Early Indicators of Later Work Levels, Disease and Death* project (NIH P01 AG10120). These include:

1. Locating the veteran to the appropriate ward in order to link him to applicable ward-level ecological data
2. Locating the veteran to the appropriate block to link him to data detailing the year of installation of in-street sewer and water infrastructure

These applications in turn demanded the following requirements in terms of spatial accuracy:

1. Veteran must be located on the correct street, block, and side of street (N/S/E/W) as streets formed nearly all ward boundaries in the study period
2. Veterans must be located on the correct street and block as in-street sanitation infrastructure was coded to the block level

These requirements do not necessitate locating a veteran’s address to the exact building, though inputters were encouraged to do so where it was possible and expeditious. Depending on the address numbering scheme of a particular municipality, such fine spatial accuracy is not always
possible with a modern automated geocoder. Inputters were instructed to roughly estimate the addresses’ location on the block.

The addresses manually geocoded by CPE inputters differed significantly from those of the present day. In order to accurately place these points in space, inputters had to cross reference historical maps showing addresses, street directories issued by private companies, municipal ordinances, and a variety of other sources listed in more detail in the Resources section at the end of this walkthrough. These materials were not available for the full study period for every city. Some were available once every several years, some once a decade. Many addresses had to be inferred using several sources. As seen in Table 2, many addresses were partial or CPE inputters coded each hit with a confidence code based on their qualitative assessment of the available information. These codes are discussed in greater detail in the following section.

Table 2: Sample Address Information for Geocoded Veterans in Chicago

<table>
<thead>
<tr>
<th>recidnum</th>
<th>source</th>
<th>oaddress</th>
<th>oinfo</th>
<th>oward</th>
<th>ocity</th>
<th>ocounty</th>
<th>state</th>
<th>fyear</th>
<th>tyear</th>
</tr>
</thead>
<tbody>
<tr>
<td>100501052</td>
<td>r5</td>
<td>516 N WELLS ST</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1891</td>
<td>1891</td>
</tr>
<tr>
<td>100501052</td>
<td>sc6</td>
<td>516 N WELLS ST</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>-</td>
<td>IL</td>
<td>1892</td>
<td>1892</td>
</tr>
<tr>
<td>100501052</td>
<td>r6</td>
<td>770 W VAN BUREN ST</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1894</td>
<td>1894</td>
</tr>
<tr>
<td>100501052</td>
<td>c1900</td>
<td>1299 W MADISON ST</td>
<td>CHICAGO</td>
<td>12</td>
<td>WEST</td>
<td>COOK</td>
<td>IL</td>
<td>1900</td>
<td>1900</td>
</tr>
<tr>
<td>100501052</td>
<td>r2</td>
<td>40 E RANDOLPH ST</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1904</td>
<td>1908</td>
</tr>
<tr>
<td>100501052</td>
<td>c1910</td>
<td>2852 MADISON</td>
<td>TRACT 06</td>
<td>13</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1910</td>
<td>1910</td>
</tr>
<tr>
<td>100501052</td>
<td>r1</td>
<td>2852 W MADISON ST</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1912</td>
<td>1914</td>
</tr>
<tr>
<td>100501070</td>
<td>c1900</td>
<td>799 CONGRESS ST</td>
<td>CHICAGO</td>
<td>12</td>
<td>WEST</td>
<td>COOK</td>
<td>IL</td>
<td>1900</td>
<td>1900</td>
</tr>
<tr>
<td>1100108019</td>
<td>r5</td>
<td>NE CORNER 44 AND KINZIE ST</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1874</td>
<td>1874</td>
</tr>
<tr>
<td>1100108019</td>
<td>r3</td>
<td>4041 CARROLL AVE</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1891</td>
<td>1891</td>
</tr>
<tr>
<td>1100108019</td>
<td>r1</td>
<td>1951 CARROLL ST 28TH</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1891</td>
<td>1892</td>
</tr>
<tr>
<td>1100108071</td>
<td>r2</td>
<td>3207 CANAL ST</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>-</td>
<td>IL</td>
<td>1912</td>
<td>1923</td>
</tr>
<tr>
<td>1100108100</td>
<td>w1</td>
<td>HOME VAUGHAN</td>
<td>HOME</td>
<td>-</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1867</td>
<td>1867</td>
</tr>
<tr>
<td>1100108100</td>
<td>r1</td>
<td>S LYNN</td>
<td>-</td>
<td>-</td>
<td>CHICAGO</td>
<td>COOK</td>
<td>IL</td>
<td>1890</td>
<td>1890</td>
</tr>
</tbody>
</table>
PROCEDURE

All geocoding was performed using ArcGIS software versions 9.3 – 10.2. Inputters were trained in the basics of GIS or hired because of pre-existing GIS experience. Knowledge of the Early Indicators project and the accuracy demands and research goals of the geocoding process were required as well as: cartographic projection, data management in ArcCatalog, symbolization and feature/attribute table editing in ArcMap, snapping, archival research (especially with maps), and georeferencing.

Inputters were assigned groups of addresses to assess one city at a time. Assignments were generated by STATA as a tab-delimited text file in the format seen in Table 2. Columns for latitude and longitude coordinates, a “geocoded” quality code field, an assignment field, and a freeform text field for recording pertinent notes were also added. Addresses that had not yet been assessed were given dummy lat/long values corresponding to a landmark in the city in question. All addresses from the file were then added to the map as points using the “Add XY Data” tool. Later period geocoding included points that were mapped using an automated geocoder created using street centerlines created by the Census Bureau in 2010. These points were not taken to be correct, as good first approximations. They frequently ended up in the correct neighborhood, expediting the geocoding process.

Inputters were instructed to first sort the attribute table by “recidnum”—the veteran’s unique identification number—and then “fyear,” allowing them to gain additional information for each address based on a veteran’s previous location. Veteran 100501052 seen in Table 2 provides an example—the inputter is able to determine that the veteran is most likely living at 2852 W Madison St in 1910 as well as in 1912.

Each address was first reviewed for completeness and clarity. Inputters then attempted to locate full, unambiguous addresses. Using their knowledge of a particular city, inputters sought out the correct historical location of the address, which was verified using a combination of historical sources. This process is discussed in further detail below.

Once found, the inputter then dragged the address from the central landmark, or bucket, (or the location to which it was geocoded using the automated geocoder) to its intended location—the correct side of street, correct block, approximate position on that block—as it related to the HUE street centerlines. The point was snapped to the edge of a buffer created from the street centerlines. This buffer served to ensure that each address was clearly associated with the correct street segment for later proximity analysis. It also provided a 10.1 foot tolerance on each side of the street to provide flexibility for integrating the geocoded points with modern GIS resources. Figure 2 shows a section of Manhattan with all geocoded points in that area.

The steps below summarize the process the inputter might have taken to locate the historically correct physical location of the veteran living at 2852 W Madison St in Chicago as seen in Table 2.
Figure 2: Manhattan Geocoding Results
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Table 3: “Geocoded” Quality Code Definitions

<table>
<thead>
<tr>
<th>Code</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>(blank)</td>
<td>Not assessed</td>
</tr>
<tr>
<td>0</td>
<td>Un-geocodable, not enough information provided</td>
</tr>
<tr>
<td>1</td>
<td>Geocoded with certainty</td>
</tr>
<tr>
<td>5</td>
<td>Geocoded with certainty, but street no longer exists in 1930 streets shapefile</td>
</tr>
<tr>
<td>6</td>
<td>Specific to NYC. Address in boroughs other than Manhattan or Brooklyn, not geocoded</td>
</tr>
<tr>
<td>7</td>
<td>Specific to NYC. Address as entered could exist in more than one borough, not geocoded</td>
</tr>
<tr>
<td>8</td>
<td>Geocoded with 90% certainty</td>
</tr>
<tr>
<td>9</td>
<td>Not geocoded for now, more information required</td>
</tr>
</tbody>
</table>

1. Assess the “o*” fields, do they, taken together, provide a full address, i.e. a house number, a cardinal prefix (where applicable), and a street name? Sometimes information is shifted into the “oinfo” or “oward” column. Does the information disambiguate the address fully? If so, proceed to step two. If not, enter appropriate quality code in geocoded field as defined in Table 3. An address missing a N/S/E/W prefix would be coded a ’9’ while an address such as ‘HOME VAUGHN’ or ‘S LYNN’ would be coded as a ’0’. 2852 W Madison St judged to be complete.

2. Ascertain “tyear” – this was the year the veteran was found living at this address by a census enumerator or reported living at an address to a pension administrator. “fyear” the year the veteran can first remember living at his present residence. “fyear” is frequently the same as “tyear” and in any case would most likely be the very same address, though it may have changed over long spans. “tyear” = 1914.

3. Find source(s) with address information (see Resources section for list of sources by city) published for that “tyear” or those before and after the “tyear”, refer to list of major renumbering dates for the appropriate city. Proquest Sanborns exist for period.
4. Use available sources to locate the address to the correct block of the HUE street centerline. This could mean selecting the appropriate map plate(s) from a Sanborn Atlas or identifying the appropriate bounding intersections from a street directory. If a major address change occurs between the observed year and the “tyear” apply the appropriate transformation if it is listed. Sanborn map atlases for 2852 W Madison St neighborhood found in 1896 and 1922 using Proquest browse feature. Address change document for 1909 identified, 1299 → 1852.

5. If the particular address cannot be found on a chronologically appropriate map or the house number does not fit within range specified in a city directory, mark as ‘9’.

6. For NYC only: if address is not in Manhattan or Brooklyn, code ‘6’.

7. If the correct street segment does not exist in 1930, move point to approximate location in space, optionally using a modern basemap to detect possible location of former street (e.g. alleys and breaks in old buildings), code ‘5’.

8. If address can be found, mark as ‘1’ or ‘8’ depending on the chronological proximity of the available resources:
   a. For addresses located using sources published in that year, code ‘1’.
   b. If address is located on the exact same block in sources found before and after “tyear” after address range changes are applied where necessary, code ‘1’. Using these resources to locate 2852 W Madison Avenue in 1912 is illustrated in Figure 3. 2852 W Madison Avenue moved from un-assessed bucket, snapped to buffer, and geocoded ‘1’.
   c. If no earlier or later sources can be found but address isn’t excessively earlier or later than source and no address numbering changes have taken effect, mark as ‘8’.
   d. If physical location is different in earlier and later sources and no address numbering changes have taken effect code ‘8’ if address is chronologically close to either end code as ‘9’ if otherwise.

9. Snap to previously located point located at that exact location (check addresses and address change documents) where applicable. 1912 observation snapped to 1910 point.

10. Add notes regarding sources used, assumptions made, information missing, address range changes applied, and any other information pertinent to judge the quality of a geocoded address or additional information that would aid in locating an un-geocodable address.

When the inputter completed each assignment, they would recheck any notes they had left for themselves and attempt to locate any addresses they skipped or those with partial or ambiguous addresses that could be resolved to complete addresses at which the veteran was observed. All 0s, 6s, 7s, and 9s were dumped back in the starting bucket. The project coordinator then reprojected the shapefile to NAD 1983 where necessary and ran the “Add XY Coordinates” geoprocessing tool, creating latitude and longitude fields. The entire table was exported to a .csv and remerged into STATA.
Figure 3: Using historical atlases and address change documents to confirm the location of 2852 W Madison Street in 1912
**Geocoding Sources**

The following tables list the sources used by CPE inputters to determine the location of historical urban addresses. Block-level address information is most readily available in street listings included in many city directories, as well as in fire insurance atlases. In order to most efficiently assess the large number of addresses culled from across the Early Indicators samples, we focused on the most easy-to-use sources, those which could either be queried or easily browsed. Many such collections require paid subscriptions. As such the tables are neither comprehensive nor suitable for every project. Major numbering regime changes and available supplementary documentation for each city are noted below but are not necessarily complete. The tables not sources published between approximately 1860 through 1930.

Many suitable maps and directories can be collected from historical archives and library collections. The Library of Congress possesses a peerless collection of Sanborn Fire Insurance Atlases, for example. The overview below provides a general outline of where such materials have already been digitized and made available on the Internet.

**Overview**

- **Ancestry.com** – a very complete collection of city directories (subscription)
- **Proquest Sanborn Maps Geo Edition** – a comprehensive collection of black and white Sanborn Fire Insurance map plates queryable by address or browsable using a GoogleMaps interface (subscription)
- **David Rumsey Map Collection** – this large repository includes a number of fire insurance atlases (Perris, Sanborn, Bromley)
- **HistoricMapWorks.com** – a great source for historical maps, queryable by address, not available to users with a domain name ending in .edu
- **Library of Congress Online Map Collection** – online catalog, some Sanborn atlases are available for online viewing
- **Archive.org** – some city directories
- **Hathitrust.org** – some city directories
- **University libraries** – notable online collections include Harvard and the University of Chicago
- **Public libraries** – notable online collections include the Philadelphia Free Library, New York Public Library, and Boston Public Library
- **State and city archives** – notable online collections include the Maryland State Archive and Phillyhistory.org
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**Baltimore**

Street Name Change Source(s):


Major Changes:

- 1886 – Major address range change to 100-to-a-block grid numbering system
- 1888 – City limits expand for first time since 1816
- 1904 – Great Baltimore Fire
- 1919 – City limits expand roughly to present-day boundary

<table>
<thead>
<tr>
<th>Year</th>
<th>Source</th>
<th>Repository</th>
<th>Link</th>
<th>Collection</th>
<th>Pages/Vol</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td><em>Nothing found for year</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1862</td>
<td></td>
<td></td>
<td><em>Nothing found for year</em></td>
<td></td>
<td></td>
</tr>
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<td>Login required</td>
<td>City Directories Database</td>
<td>466-477</td>
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<tr>
<td>Year</td>
<td>Source</td>
<td>Repository</td>
<td>Link</td>
<td>Collection</td>
<td>Pages/Vol</td>
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<td>Login required</td>
<td>City Directories Database</td>
<td>400-412</td>
</tr>
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<td>Wood’s City Directory</td>
<td>Ancestry.com</td>
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<td>City Directories Database</td>
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</tr>
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<td>Ancestry.com</td>
<td>Login required</td>
<td>City Directories Database</td>
<td>445-457</td>
</tr>
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<td>Wood’s City Directory</td>
<td>Ancestry.com</td>
<td>Login required</td>
<td>City Directories Database</td>
<td>459-471</td>
</tr>
<tr>
<td>1873</td>
<td>Wood’s City Directory</td>
<td>Ancestry.com</td>
<td>Login required</td>
<td>City Directories Database</td>
<td>447-459</td>
</tr>
<tr>
<td>1874</td>
<td>Wood’s City Directory</td>
<td>Ancestry.com</td>
<td>Login required</td>
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<td>448-460</td>
</tr>
<tr>
<td>1875</td>
<td>Wood’s City Directory</td>
<td>Ancestry.com</td>
<td>Login required</td>
<td>City Directories Database</td>
<td>438-451</td>
</tr>
<tr>
<td>1877</td>
<td>Wood’s City Directory</td>
<td>Ancestry.com</td>
<td>Login required</td>
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<td>013-028</td>
</tr>
<tr>
<td>1878</td>
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<td>Login required</td>
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<tr>
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<td>Papenfuse Sanborns</td>
<td>Papenfuse Map Collection</td>
<td><a href="http://mdhistory.net/msaref07/html/">http://mdhistory.net/msaref07/html/</a></td>
<td>Baltimore City &amp; County Atlases</td>
<td>566-594; 626-688</td>
</tr>
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<td>Papenfuse Sanborns</td>
<td>Papenfuse Map Collection</td>
<td><a href="http://mdhistory.net/msaref07/html/">http://mdhistory.net/msaref07/html/</a></td>
<td>Baltimore City &amp; County Atlases</td>
<td>597-625; 626-688</td>
</tr>
<tr>
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<td>Wood’s City Directory</td>
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<td>010-025</td>
</tr>
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### VI. Historical Geocoding Guide

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Street Name Change Source(s):


Major Changes:

- No major renumberings in period

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Brooklyn
Street Name Change Source(s):

- Reynolds, H (c1900) *Henry A. Reynolds Brooklyn and Manhattan Street Name Records*. Archival material, Brooklyn Historical Society.

Major Changes:

- 1898 – Annexed to New York City

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**Chicago**

Street Name Change Source(s):

  <http://www.chsmedia.org/househistory/namechanges/start.pdf>

Major Changes:

- 1871 – Great Chicago Fire
- 1889 – annexation of Hyde Park and Lakeview Townships necessitates street name changes in new districts

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*Manhattan*

Street Name Change Source(s):


Major Changes:

- 1842 – Fifth Avenue designated as the division for crosstown streets running east and west
- 1852 – 100-to-a-block grid numbering system for crosstown streets adopted, 0 point at Fifth Avenue
- 1886 – House numbers on streets west of Central Park renumbered to commence at 1 at Central Park West

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## VI. Historical Geocoding Guide

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Philadelphia
Street Name Change Source(s):


Major Changes:

- 1857 – 100-to-a-block grid numbering system adopted
- 1858 – Significant changes to street names to remedy duplicated names
- Early 1880s – 100-to-a-block grid numbering system adopted in Kensington
- Mid-1890s – 100-to-a-block grid numbering system adopted in Germantown, Mount Airy, and Chestnut Hill
- 1897 – Significant changes to street names to remedy duplicated names

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## VI. Historical Geocoding Guide

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VII. Citation and Use

A. Citing HUE Data

Works using or referring to the HUE data set should contain the appropriate citation.

HUE Bibliographic Citation:


B. Acknowledging Federal Grant Support

The Early Indicators project collects and analyzes data on Union Army recruits and makes the material available for public use under the auspices of a generous program project grant from the National Institute on Aging of the National Institutes of Health. Each publication or other document that cites results from NIH grant-supported research must include an acknowledgement of NIH support and disclaimer such as "the project described was supported by Award Number P01 AG10120 from the National Institute on Aging. The content is solely the responsibility of the author(s) and does not necessarily represent the official views of the National Institute on Aging or the National Institute of Health." This mandate applies to all publications using the data, including working papers and posters, whether or not the researcher also received salary, travel, or other support from the grant. The title of the program project grant is Early Indicators of Later Work Levels, Disease and Death, Dora L. Costa, principal investigator. The reference number, which must be used in all acknowledgements, is P01 AG10120.

Additional Sample Acknowledgements:

- "This work was [supported] [supported in part] by NIH/NIA grant number P01 AG10120."
- "The authors gratefully acknowledge the support of NIH/NIA grant number P01 AG10120."
- "This work was conducted under the auspices of NIH grant number P01 AG10120, Early Indicators of Later Work Levels, Disease and Death, Dora L. Costa, principal investigator."
- "The content is solely the responsibility of the author(s) and does not necessarily represent the official views of the National Institute on Aging or the National Institutes of Health."
C. MANDATORY PUBLIC ACCESS TO PUBLICATIONS RESULTING FROM NIH-FUNDED RESEARCH

All users of Early Indicators data are required to provide, in electronic format, a copy of the final pre-publication (preprint) manuscript of every peer-reviewed article at the time of acceptance for publication. The NIH Public Access Policy and instructions for accessing the National Institute of Health’s on-line repository, PubMed, can be found at publicaccess.nih.gov. Contact the Early Indicators project staff with any questions. Contact information can be found at UAdata.org/contact_us.