# The Impact of Environmental Disamenities on Property Values: Evaluating the Municipal Fringe

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# Abstract

This paper analyzes the municipal fringe of cities in Eastern North Carolina between 2006-2016, and how the values of individual properties on the outskirts can fluctuate after they are incorporated within a city. A large portion of the research process consisted of manually re-creating annexation ordinances from scanned photocopies on ArcGIS, creating the first geographic archive of annexations in North Carolina compatible with digital software. As environmental nuisances, such as landfills and hazardous waste sites, are often located on town borders, this study pays specific attention to how their presence affects the change in property values before and after annexation. Results show that incorporation brings with it higher property values, and that the impact of annexation is greater in the presence of nuisances that threaten water quality for private wells.



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# I. Introduction

Water access is a common feature of a home in the United States, yet the infrastructure and location of the property highly influence the water's cleanliness and reliability. Often, water quality depends on the incorporation status of a piece of land. Commonly known as a city or town, the U.S. Census Bureau (2007) defines an incorporated area as being an area with "legally defined municipal boundaries [with]…. appointed officials [and]…. provided services," such as water infrastructure and public schooling. Census differentiates an unincorporated community outside of a municipality's boundaries as having services "provided…by the county." While each type of governing area comes with its own costs and benefits, unincorporated county-led areas are by nature more independent with less provided infrastructure; therefore, access to water services can differ widely conditional on the incorporation status of an individual household.

The municipal fringe, discussed by Durst (2013) as being the area "within 400 meters of the nearest municipality," provides an opportune location to measure the value of incorporation by comparing properties that are similar in condition and location, yet serviced by different administrative systems. This is especially beneficial to explore near areas with environmental disamenities, which are often found in unincorporated regions, as Anderson (2008) outlines that they frequently have a high "concentration of undesirable land uses." Although house values are most typically thought of as varying directly with structural attributes, such as square footage, this does not represent the entire picture. The hedonic pricing model, given theoretical foundations by Rosen (1974), describes the value of a commodity as the bundled values of each of its characteristics. In the case of housing, prices also depend on neighborhood characteristics and environmental quality variables.

In this paper, I examine the differences in housing values arising from proximity to environmental nuisances, namely landfills and hazardous waste sites. Given that the majority of the disamenities in question are located on the outskirts of municipalities, I pay specific attention to the effect of annexation on properties on the municipal fringe. By utilizing ArcGIS coordinate-based modeling, I have merged property sales of homes near municipal annexations, including those that were and were not annexed, with the locations of two major environmental nuisance types in North Carolina. Using treatment and control groups for differing variables across time allows me to ascertain the property value impacts of noted environmental disamenities both before and after annexation. Past research described in the next paragraph led to this study operating under the assumption that properties relied on groundwater pre-annexation. By utilizing a triple-difference estimator across transactions from 2006-2016 in Eastern North Carolina to obtain hedonic estimates of household values, I have parsed out the effect of groundwater contamination risk on the property values.

According to the EPA (1990), “95% of rural Americans get their household water supplies from…groundwater.” This stems from past judgements made by municipalities across the nation as they slowly extended their reach and annexed surrounding areas. In one of their first Information Reports (1958), the American Society of Planning Officials noted that “cities…adopted a policy of prohibiting or limiting utilities or services to outside areas unless they agree to annex.” Citing examples in both Colorado Springs, Colorado and Santa Rosa, California, they explained that municipalities considered such a decision to be “in the public interest and welfare” of their incorporated citizens. In North Carolina specifically, The University of North Carolina Chapel Hill Center for Civil Rights (2013) announced in a recent study that “fifty-two percent of North Carolina’s population depends on groundwater.” Alongside this, the University’s Population Center (2016) relayed that the 2000 census “marked the first time in state history that the majority of the population (50.3%) was living in an incorporated municipality.” However, this means that approximately half of the state lives in an unincorporated area without the ability to rely on a large-scale water system for safe water. Furthermore, these figures illustrate a tendency to withhold piped water access to a home until it is annexed into a city.

The annexation procedures in North Carolina, alongside the opportunity to begin developing the first set of ArcGIS-based maps of historical annexations, make the region an exemplary area to research and I will use the data within the state as the basis for my work. The School of Government at The University of North Carolina Chapel Hill (2013) outlines the three processes through which annexation may occur: by act of the General Assembly (legislative), by initiation from the city (involuntary), or by petition from unincorporated property owners (voluntary). The latter two are the most significant in this analysis, as perspectives from both sides of the municipal boundary line can be taken into consideration. The School of Government outlines recent reform legislation in 2011 that brought greater power to the voluntary annexation scenario, requiring annexation if 75% of the owners in an unincorporated area can show that they reside in a “high poverty area as defined in the statute.” This ability, which is not found in many states, directly aligns with the purpose of my research in this paper and will point towards areas influenced by environmental disamenities that would benefit from incorporation.

This paper will continue in the following order. Section II provides an introduction to the relevant literature. Section III offers an in-depth outline of the data sources used in the research and Section IV describes the empirical specification employed in the methodology. Section V analyzes the results and Section VI offers an overall conclusion. An Appendix is attached to the end with additional information on the data, data cleaning specifications, and extended results.

## II. Literature Review

Although there is extremely limited economic research on the specific effects of annexation on property values or other related variables, there has been a recent interest in the study of communities on the municipal fringe, comparing those inside of city limits with those just outside. The University of North Carolina Chapel Hill Center for Civil Rights (2013) launched "The State of Exclusion," an empirical analysis of "unincorporated clusters near municipalities" across North Carolina. Though they note that "access to clean drinking water continues to be a crucial issue for [non-incorporated] communities in North Carolina," they explicitly state that their research into water access is "incomplete [and] outdated." My work will contribute to this ongoing conversation of households with higher risks of water contamination, specifically those just outside of municipalities. As background, this section will employ relevant literature surrounding the effects of contamination from a variety of environmental disamenities on housing values.

As previously stated, if a large, potentially polluting facility exists, it is primarily located on the outskirts of a town. Nelson, J. Genereux and M. Genereux (1992) were one of the first teams to attempt to determine whether landfills had a significant effect on nearby houses. They recognized upfront that "families tend to equate landfill proximity with diminished…quality of life," but that the lower costs of living might attract certain households. Estimating the effect of one Minnesota landfill on 708 nearby property values by employing the hedonic pricing model, they found that property values on the landfill border were reduced 12% from average, with values rising by approximately $5,000 for each additional mile out. The impact ceased to be significant 2.5 miles from the landfill. Nearly two decades later in South Africa, Preez and Lottering (2009) conducted a similar analysis of properties surrounding a landfill. The two economists found that distance from the landfill was highly statistically significant, with property values increasing 0.44% for every 100 meters from the landfill. These two papers established the idea of decreasing home values with respect to landfill proximity. I hypothesize that these effects will be lower for homes within a city's limits when compared to those in an unincorporated area because of their differing water sources.

Even without the presence of a large-scale facility, past literature indicates that the presence of groundwater contamination itself can directly decrease the value of a home. Guignet, Walsh, and Northcutt (2016) consider the impact of ground water contamination on property values, specifically those with private wells. Utilizing the hedonic pricing model, they find that a decrease in home value is significant after a contaminated well is found, but that the decreased property value begins to rebound after a few years, likely because of cleanup. I predict that this conclusion on water quality can be directly applied to the potential of water contamination from landfills and hazardous waste sites; although the presence may decrease the property value for an unincorporated property, this fall in value will likely be reduced after annexation. Muehlenbachs, Spiller, and Timmins (2015) extended the idea of analysis of water contamination on property values, but without direct water quality measurements. They employed a methodology that I use in my research, known as "difference in differences," to tease out the effects. Looking at a subset of properties near shale gas development in Pennsylvania, they analyze the overall effects of well development. Noting that the wells bring advantages such as royalties as well as disadvantages such as pollution risks, the paper asserts that contamination risks "negatively affected house values on groundwater" outside of city limits, but that values of properties with more reliable water sources "might [net] benefit" from the presence because of royalty payments.

This methodology essentially analyzes the differential effect of a treatment on a treatment group versus a control group. After identifying all shale gas wells within the area in question, Muehlenbachs et al. (2015) outlined a buffer zone of 2 km around the wells and split the locations into two categories: homes on groundwater (similar to those outside of city limits) and those on public water service areas (similar to those in city limits). The four identified impact categories of shale gas on housing values were adjacency effects, vicinity effects, groundwater contamination risk, and macroeconomic trends. To recover estimates of each of these impacts on the value of a property, the authors employed the method of triple-differencing, discussed in detail in Section IV. By effectively controlling for and cancelling out effects from the other impact categories' effects on property value, the authors were left with only the effect of groundwater contamination risk from a new well pad. The large negative impact on groundwater-related homes is a key reasoning behind my thesis work, as I believe that I will find similar diminished impacts from landfills and hazardous waste sites for homes within city limits on piped water than those outside on ground water.

## III. Data

The majority of my data calculations originated in ArcGIS, a geographic information system that works as an object-relational database for storing and using spatial data. As much of my work inherently looks at the proximity of various elements to each other, such as a house and a hazardous waste site, the program allowed me to locate their presence on a map. Afterwards, I was able to extract the data into spreadsheet format, creating the ability to statistically analyze spatial relationships. I will begin by discussing the data sources themselves and then delve into my findings regarding their attributes and relations.

The underlying foundation of my work is water access type across North Carolina. North Carolina OneMap, an organized effort of various governmental agencies and private partners providing geospatial information across the state, released an ArcGIS data set in 1997 that mapped water supply for households across North Carolina. This data illustrates water supply system areas in three categories. Type A systems are larger piped water systems that serve a substantial population. Type B systems, while still piped, are smaller water systems that cater towards a specific group of households. Type P are proposed water distribution systems. Given little information on the progress and future water system type of Type P systems, these were removed from consideration. Type A and Type B water supply system types can be considered synonymous with piped water access, and residents outside of these two systems rely on more personal groundwater systems for water.

Given that North Carolina OneMap's static water map dates before the time period of my research, I am unable to directly monitor how household water access changes with annexation, and therefore am unable to assign a specific water type for each individual household in my analysis. As specified in the introduction, I work under the assumption that households were on groundwater (i.e., not Type A or B) before annexation, essentially implying that incorporation brings with it access to a piped water distribution system. Although North Carolina OneMap's data may not be suitable for inclusion in the actual regression, its ArcGIS visualizations are still useful for explaining this assumption and any disparities that may stem from it. Figure 1 below depicts the city of Burgaw. The gray checkered area represents the 2017 city outskirts, including areas that were annexed between 2006-2016. The blue background represents households that are serviced by the city's Type A piped water supply system. Areas that overlap (i.e., are checkered and blue) show homes that are both within city limits and serviced by the city's piped water. Homes not covered by the blue background are on groundwater. The picture shows that the vast majority of the town's core is serviced by piped city water, but that areas on the periphery are much more likely to lie outside the city water system, relying instead on more personal water systems. This city follows the above logic that incorporation brings piped city water access, with properties on the outskirts likely extended services soon after they are incorporated into the city.

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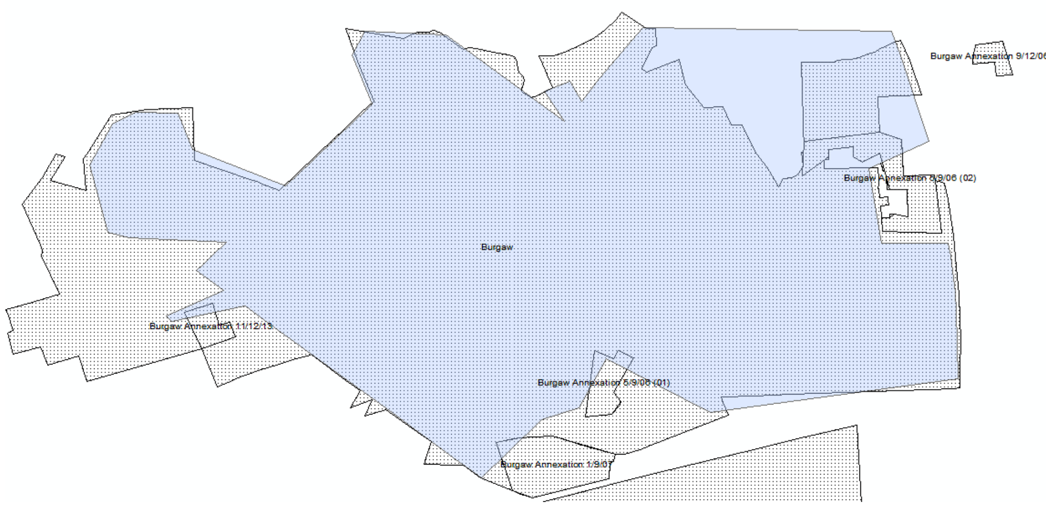
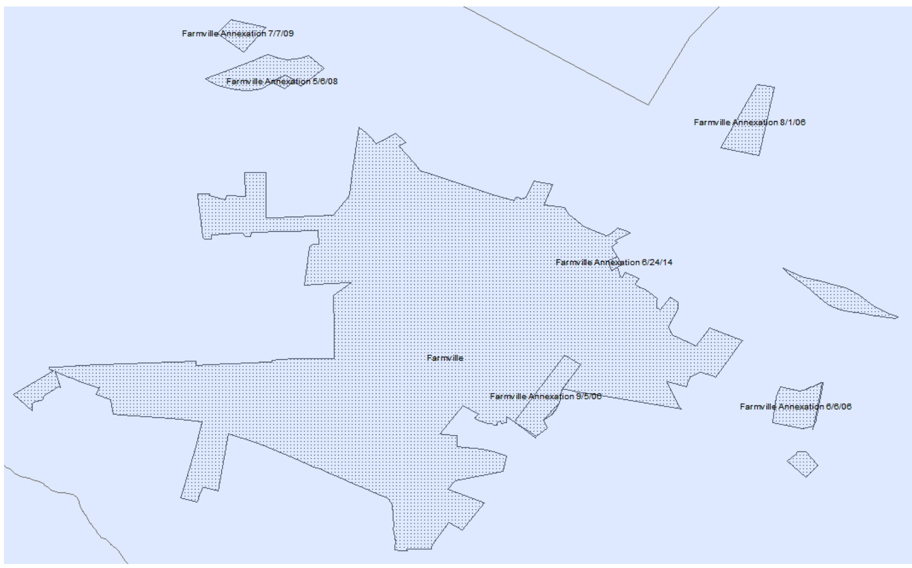
Figure 1: Burgaw 2017 City Limits (Gray Checkered) and 1997 Type A Water Supply System Area (Blue)




A few cities, however, seem to differ from the given rationale, instead including all areas on the periphery within a piped water supply system. As an example pictured below in Figure 2, the city of Farmville, as well as all of the properties on its periphery, appears to be completely contained within a Type A water system. Similar to Figure 1, the gray checkered outline represents the 2017 city limits, and the blue background represents areas serviced by the city's Type A piped water system. While it does seem out of the ordinary, this does imply that every household within the scope of this picture is covered by Farmville's city piped water. In this case, it appears that households on the periphery already have access to city water before they are annexed into the city. This scenario is important to consider, as it may potentially skew my results through a dampened effect of annexation with regards to piped water access. These will be discussed in further detail in the results section of this paper, but they are critical to mention beforehand in order to gain a complete picture of the underlying formation of Eastern North Carolina cities and their water supply system areas.

Figure 2: Farmville 2017 City Limits (Gray Checkered) and 1997 Type A Water Supply System Area (Blue)




The first major data set that I employ includes the location of landfills and hazardous waste sites across North Carolina, which are publicly available on the North Carolina Department of Environmental Quality website in ArcGIS format. There are three separate sets of data. The one landfill type is pre-regulatory landfill sites, which are sites that ceased accepting waste by 1983 when new permit regulations were established. Active landfills were also initially included in this research, but these were removed from consideration after finding that none of the properties in question were nearby this type of nuisance. The two hazardous waste types include active hazardous waste sites, which are regulated and designated under the Resource Conservation and Recovery Act (RCRA), and inactive hazardous sites, which are closed remediation sites that have land use restrictions recorded as part of the clean-up remedy. Although the pre-regulatory and inactive sites are no longer in use, their past purpose could have led to contamination that still exists today and it is important to include their presence in my research. In North Carolina, there are 657 pre-regulatory landfills, 2,577 hazardous waste sites, and 1,894 inactive hazardous waste sites. Only those near areas included within the scope of my work are analyzed, and I will break that information down in detail later in this section.

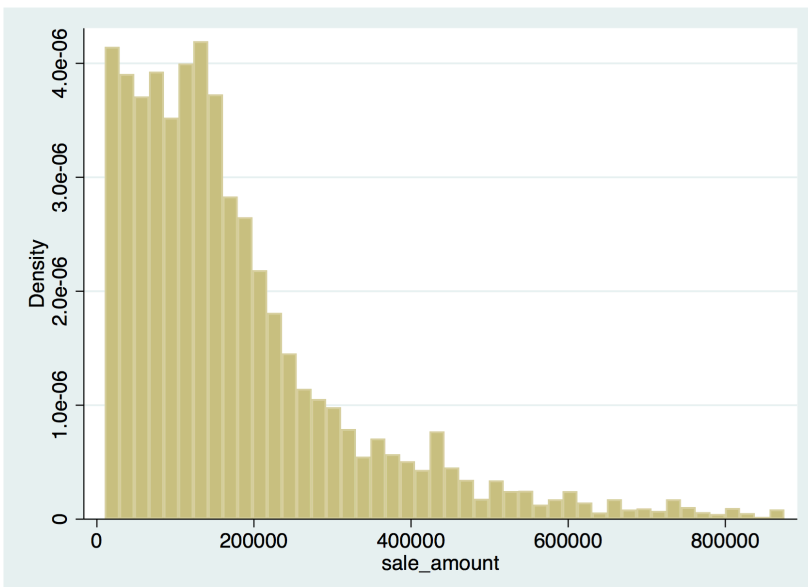
My second significant data source is CoreLogic Real Estate transaction data available in ArcGIS format. These data encompass public housing sales made across the United States between 1920-2016, although I will only employ the data from 2006-2016 in the Eastern North Carolina region. Specific variables of interest within the data set are sales date and amount and housing characteristics (e.g., size of house, size of plot, number of rooms). Property value is the dependent variable in my regression. I define the value of a home as its sale amount, for which I have exact dates and numbers adjusted for inflation.

The distribution of the CoreLogic data set, broken down to include only house transactions from the years 2006-2016 that are in areas included in my scope of research, as defined later in this section, can be seen in Table 1 below. There have been 44,522 transactions with a mean sale amount of $178,121 and median sale amount of $138,500. The minimum sale amount is $10,000 and the maximum is $875,000. Figure 3 below is a histogram further illustrating the distribution of property sale amounts. The CoreLogic data has been cleaned in order to secure an accurate data set representative of properties in Eastern North Carolina. Certain outliers have been removed, such as "non-arm's length" transactions in which a property is registered as sold to a relative or friend for much less than market value to get around tax brackets and other barriers. Similarly, observations with missing data have been removed from consideration. See Appendix A for a complete outline of the steps taken to filter the data.

Table 1: CoreLogic Summary Statistics of Property Sale Amounts in Eastern NC, 2006-2016

| Variable | Mean | Min | Max | Standard Deviation |
|---|---|---|---|---|
| Sale Amount ($) | 178,121.4 | 10,000 | 875,000 | 150,571.1 |
| Total Square Feet | 1643.4 | 120 | 8,000 | 739.4 |
| Total Acres | 0.429 | 0 | 10 | 0.729 |
| Total Rooms | 1.3 | 0 | 10 | 2.5 |
| Total Bathrooms | 1.6 | 0 | 6 | 1.2 |
| Garage Square Feet | 47 | 0 | 996 | 146.9 |

Figure 3: CoreLogic Histogram of Property Sale Amounts in Eastern NC, 2006-2016




My final source of data is a subset of recent property-specific annexations in North Carolina over the last 10 years. The North Carolina Department of the Secretary of State requires all municipalities to submit ordinances to their office for approval and maintains an electronic database of all previous annexations throughout the state, containing both written information and a map. There is no location-based format of the annexation; the submitted maps are simply scanned photocopies that cannot be uploaded into ArcGIS or any other system (see Figure 4 below for an example). Given this limitation, it was not feasible to have an entire record of all annexations across North Carolina over the past ten years. For this reason, I limited my scope of study to the Eastern North Carolina Region (see Figure 6 below).

The largest portion of time spent during the development of this thesis was manually converting each annexation photocopy in Eastern North Carolina from 2006-2016 to ArcGIS format. The final product led to the first recorded geo-enabled archive of annexations in the entire state. This advance will allow for much easier analysis on a plethora of potential future projects and opens up the ability to view all of the annexations at once on a single map. Now that they are in ArcGIS format, the annexations can also be simultaneously viewed alongside other online downloadable features, such as transportation maps and census tracts. After speaking with employees at North Carolina's Department of the Secretary of State and Department of Environmental Quality, this is a highly sought after component in the direction that many states are moving towards in the era of online, real-time analysis.

Each annexation was created on ArcGIS by manually editing the 2017 North Carolina municipal boundaries file from Census Tiger, a subsidiary of the U.S. Census Bureau. Using an overlaid satellite map, I was able to locate each annexation area under consideration through the use of roads, physical landmarks, and latitude / longitude coordinates (see Figure 5 below for an example). Once pinpointed, I created a separate polygon for each annexation area by cutting it off from its existing city polygon. A polygon is simply a defined area that contains information about features in that area; by creating different polygons for each annexation, it makes it possible to analyze those specific areas separately from the entire city. In the case of my research, this made it possible to directly compare the attributes of properties in the annexation areas on the periphery of the cities with those inside city limits.

Figure 4: Photocopy of 2012 Ahoskie Annexation of Multiple Properties

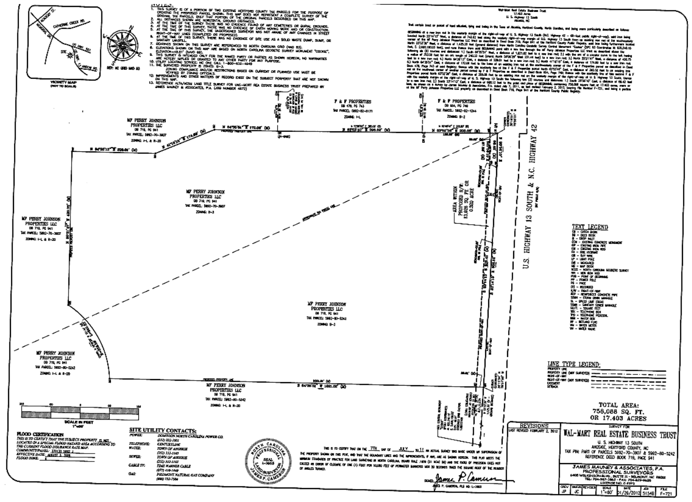
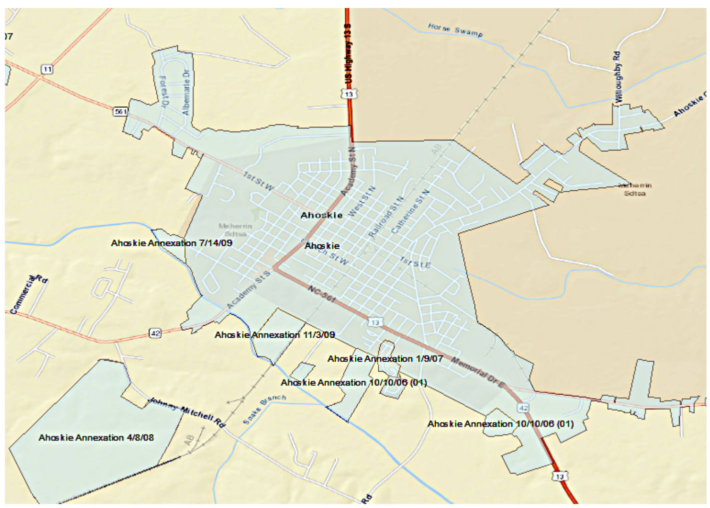



Figure 5: 2017 Ahoskie Municipality ArcGIS Polygon Overlaid with Satellite Features




The Eastern North Carolina Region was chosen due to the number of smaller, comparable cities alongside a high transaction frequency in the CoreLogic housing data. Within this region, there are 4 cities with a population over 50,000 and 54 cities with a population under 50,000. In order to create a more consistent, similar subset, I excluded the four largest cities: Greenville, Jacksonville, Rocky Mount, and Wilmington. I also excluded the city of Wilson because of its unusually high number of annexations; the time required to add them all was not feasible given the time constraints of this paper. Using the Census Bureau's 2015 American Community Survey (ACS), I recorded notable demographic and income data for each of these cities to ensure their similarities. Table 2 below shows the average summary statistics across the 54 cities included in this research. See Appendix B for a detailed breakdown by each city, both for the 53 cities used in this study and the 5 cities omitted. These initial analyses yielded proficiently similar demographic and income outcomes for each city. Between them all, there are 373 total annexations, with 27 of the 53 including any annexations. This result of approximately half with annexations and half without perfectly aligns such that the cities are split between a control and test group when testing the impact of annexation on property values.

Figure 6: Eastern North Carolina Region

Table 2: Summary Statistics of Eastern North Carolina Municipalities Within Scope of Study

| Population | % White | % Black | % Hispanic or Latino | Median Household $ |
|---|---|---|---|---|
| 4,407 | 65% | 29% | 7% | $39,756 |

Source: American Community Survey Data Profiles (2015)

At this point, I overlaid my edited ArcGIS map of city limits and annexation areas with the CoreLogic household location points, such that it was possible to tell which properties were in each area. This allowed me to narrow down to only properties within the cities and annexation areas included in this research. Simultaneously, I overlaid this new data set with the location points of both active and inactive hazardous waste sites, as well as pre-regulatory landfills, across Eastern North Carolina. Based off of past research noted in the Literature Review, I also created a 2km buffer around each environmental nuisance in ArcGIS to isolate homes experiencing an impact from the disamenities. Table 3 below demonstrates a breakdown of both the total number of properties included in my research (noted as “All Properties”) and those on the city limits periphery that were annexed at one point in time over the period from 2006-2016, alongside their respective percentages of households that are within a 2km buffer of an identified nuisance. Given that the properties on the city limits periphery are the main focus area of this research, it is important to include a representation that indicates a sufficient population group.

The higher percentage of properties on the city limits periphery that are within a 2km radius of an active hazardous waste site, compared to pre-regulatory landfills and inactive hazardous waste sites, is likely due to the higher frequency of active hazardous waste sites in North Carolina. As mentioned earlier, there are nearly twice as many active hazardous waste sites than inactive, and four times as many active hazardous waste sites than pre-regulatory landfills.

Table 3: Percentage of Properties Within 2km Nuisance Buffer in Eastern NC

| | **All Properties** | **Properties on the City Limit Periphery that were Annexed in the Period 2006-2016** |
|---|---|---|
| Observations | 44,522 | 3,110 |
| Pre-Regulatory Landfill | 14.28% | 2.93% |
| Active Hazardous Waste Site | 29.91% | 45.43% |
| Inactive Hazardous Waste Site | 23.68% | 2.73% |

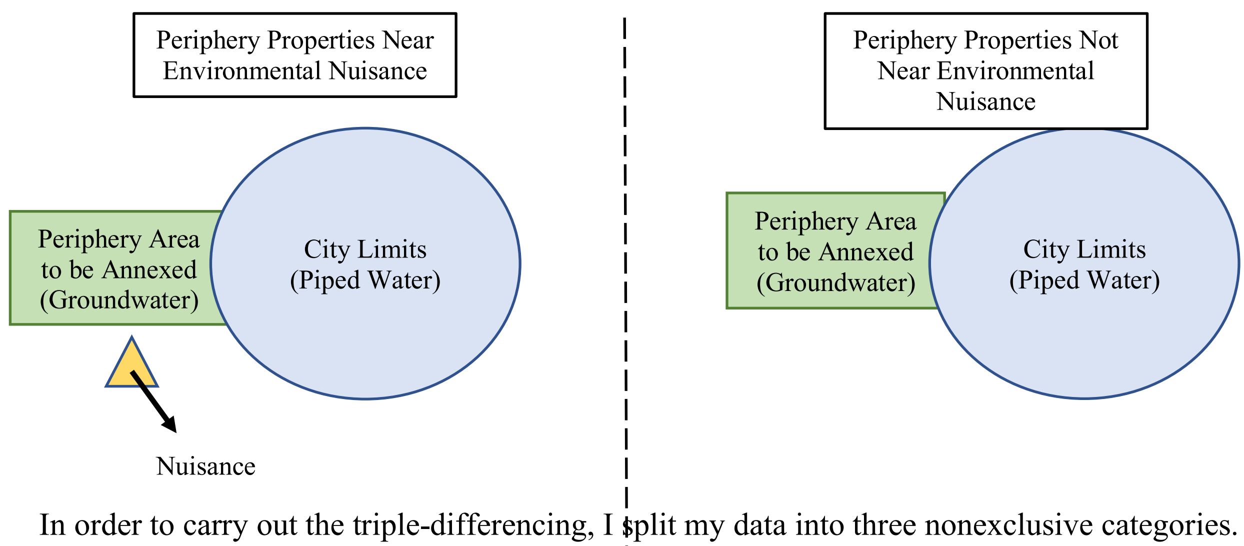
Similarly, I analyzed the connections between sale amount of households in my research area of eastern North Carolina that are within a 2km buffer of the three types of environmental disamenities that I observe. Households within a 2km buffer of both pre-regulatory landfills and inactive hazardous waste sites indicate a higher mean sale amount inside city limits as compared to households on the periphery of the city. This finding is consistent with expected results. On the other hand, average sale amount for homes within a 2km radius of active hazardous waste sites within city limits, as compared to those on the periphery, are slightly lower. While this outcome was not anticipated, it is possible that this simply stems from the population of properties used in this study. A full breakdown of these findings can be found in Appendix C.

# IV. Empirical Specification

## a. Qualitative Discussion

As previously briefly discussed in the paper by Muehlenbachs et al. (2015), the differences in differences, or more specifically triple-differencing, will be the methodology that I employ to empirically estimate my model. This will allow me to take the change in variables over time, represented in control and test groups, and pull out the measured effect of nuisances on households serviced by groundwater. I have previously explained my core assumption that annexation leads to piped water access; therefore, this value of groundwater contamination risk, which assumedly only effects homes outside of a municipality, is important in that it represents the value of being on piped water when near an environmental disamenity. Figure 7 below is an illustration of the mechanics behind this research. I will use it to explain my empirical work.

Figure 7: Visualization of Triple Difference Process




In order to carry out the triple-differencing, I split my data into three nonexclusive categories. The first category is location: either always within city limits or on the periphery of city limits (i.e., an area that is annexed into a city at some point in time between the years 2006-2016). Through Figure 7, one can see that those within city limits have access to piped water, while those on the periphery are on groundwater pre-annexation. The second category is the time period: whether or not the time of sale was before or after annexation occurred, determined on a house-by-house basis (homes not on a city limit periphery are categorized as always being sold after their annexation). Once annexation occurs, those on the periphery are thereby included within the new city limits (such that the green periphery rectangle in Figure 7 would be absorbed by the blue city limits circle). After this happens, it is assumed that periphery homes gain access to all of the same public resources as those located within city limits. The final category is proximity to an environmental nuisance. Those within a 2km radius of a nuisance site are represented as "near" an environmental nuisance. One of the main effects from each nuisance is perceived groundwater contamination risk, which is noted in this study as the additional cost to households found within the defined 2km buffer area due to potential contamination.

The first difference in this methodology is simply whether or not an area will be incorporated (i.e., is it on the periphery). The second difference compares homes before and after annexation, both between homes that are annexed and those that are not. At this point we have separated out which houses will be annexed and have differenced across the time of annexation. In order to ascertain the potential groundwater contamination risk associated with being near a nuisance, we must employ a third difference between those that are near and far from a nuisance. This differences across each existing double-difference to cancel out and act as a control for all other effects.

While there are not tangible dollar amounts connected directly to groundwater contamination risk, the ability to compare similar properties under different conditions (i.e., near vs far from a landfill, in vs. out of city limits) can be used to calculate the portion of a property's value that is attributable to the existence of groundwater contamination risk. Through the three differences described above, outside influences such as incorporation status and macroeconomic trends are "differenced away" in the end to leave only the presence (or not) of groundwater contamination risk as the uniquely distinctive factor when comparing property values. In the second half of this section, I will illustrate the principal methodology and accompanying regression that I run and explain the connections between the process and this background discussion.

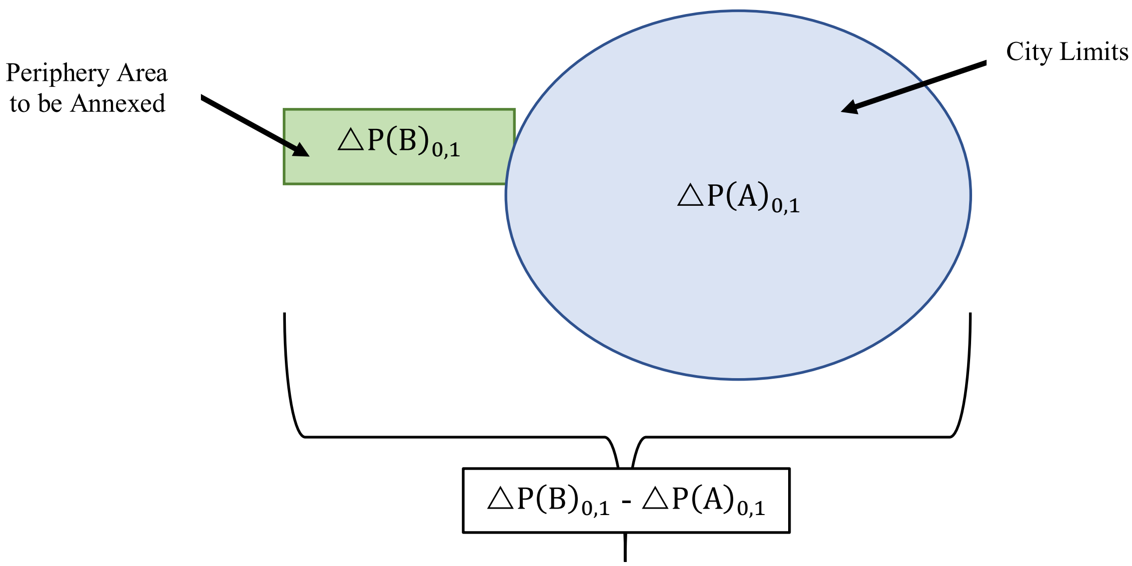
## b. Changes in the Averages

In order to ascertain the effect of cancer health risk on housing values, Davis (2004) employed a non-regression approach that analyzed how average property values changed across two time periods within various control and test clusters. The first portion of my work utilizes a similar methodology as a way to measure the effect of groundwater contamination risk on housing values, the triple difference outlined above. For each of the 77 individual annexations included in this study, I complete a process illustrated in Figure 8 below. The area in green is the area annexed at some point over the period of 2006-2016, and the area in blue is the city limits of the town that is incorporating the annexed area. Because of limited property sale data for some annexation areas, only 23 annexation areas were able to be analyzed under this process; of those 23, 11 included households within proximity of a nuisance and 12 did not. Within the 23 annexation areas, there were 2,117 housing transactions analyzed. Similarly, there were 22,757 housing transactions analyzed from the accompanying cities of the annexation areas. See Appendix E for further details.

I split property sales for each annexation area into two periods, 0 and 1, that reflect the incorporation status of the annexation area (such that the area is unincorporated in period 0 and incorporated in period 1). The average log of property values are taken before and after the annexation occurs, separately calculated for both the annexation area and city area. The change in the log of average property value from before and after annexation occurred was then determined through $\triangle \mathrm{P(B)}_1 - \triangle \mathrm{P(B)}_0$ for the annexed area, and identically for the city area. This gives us both $\triangle \mathrm{P(A)}_{0,1}$ and $\triangle \mathrm{P(B)}_{0,1}$ , as identified in Figure 8 below. At this point, I subtracted the two values from each other through $\triangle \mathrm{P(B)}_{0,1}$ - $\triangle \mathrm{P(A)}_{0,1}$. This value represents a "double difference," or the difference between how the log of average property value in the annexed area changed before and after incorporation compared to how the log of average property value within the city changed before and after incorporation. A positive value from this difference reflects a larger increase in property value over time in the annexed area (compared to within the city), and a negative value reflects a larger increase in property value over time within city limits (compared to the annexed area). It is expected that the value will be positive, as households being annexed theoretically gain more than those that are already within the city over this time period because of the various benefits associated with incorporation.

To analyze the role of potential groundwater contamination risk, I then took the difference in the average change across boundaries [$\triangle \mathrm{P(B)}_{0,1}$ - $\triangle \mathrm{P(A)}_{0,1}$] for all annexation areas near a nuisance, as well as the difference in the average change across boundaries for all annexation areas not near a nuisance. This value is the final "triple difference" of the methodology. As specified earlier in the paper, properties within a 2km radius of a nuisance are deemed to be near it. Essentially, this shows the average increase or decrease in annexation area property values, as explained in the paragraph above, split in to two categories based upon nuisance proximity. While it is expected that both of these values will be positive, I anticipate the average value of those near a nuisance to be higher than those not near a nuisance. This would reflect the fact that while all annexation areas gain value on average from incorporation, those near an environmental disamenity gain more than those which are not.

Figure 8: Visualization of the Changes in the Averages Process




## c. Regression Methodology

Alongside the changes in the averages approach, I also developed a more traditional regression that measures the double and triple differences through interaction terms, while additionally controlling for house attributes and other factors that influence property value. This gives a secondary analysis to confirm the results and test the robustness of the original methodology. While this methodology requires more of the limited variation in the data in order to include covariates, it is able to control for changes in the mix of houses being brought to market. The interaction terms are broken down into further detail below. Although each step described in the Qualitative Discussion is not directly calculated in the final regression, the regression will output results similar to those defined in Part A. The regression is formulated as follows:

$$\log(price)_{it} = B0 + B1\,(Periphery)_{it} + B2\,(Nuisance)_{it} + B3\,(Periphery * CityLimits)_{it} + B4\,(Periphery * Nuisance)_{it} + B5\,(Periphery * CityLimits * Nuisance)_{it} + \sum Bn\,(Attributes)_{it} + i.City + i.YearSold + i.YearBuilt + \varepsilon_{it}$$

The variables attached to coefficients B1 through B5 are dummy variables, such that they equal one if the property in question exhibits those qualities. Periphery refers to if a house is in on the outskirts of a city's limits, in a zone that is annexed at some point between the time 2006-2016. In actuality, not all properties on every periphery are annexed into a city; however, given that this research study is comparing homes on the periphery before and after annexation, all properties on the periphery in this case are annexed at some point between 2006-2016. CityLimits refers to whether or not a specific household was within a city's limits when it was sold. If a household on the periphery of a city (in an annexation area) is sold before the area was annexed, CityLimits is 0; if a household on the periphery of a city was sold after the annexation occurred, the household had been incorporated into the city and CityLimits is 1. If a household was always within city limits (i.e., not on the periphery), CityLimits is always 1. Nuisance refers to if a house is within a proximity of 2km of one of the three previously noted environmental nuisances. These directly align with the three "differences." The sum of Attributes for each house controls for characteristics such as square footage and number of rooms. The variable $i$.City represents fixed effects to control for individual city characteristics. Similarly, $i$.YearSold and $i$.YearBuilt represent fixed effects to control for trends regarding when each house was sold and built, respectively. The error term is depicted by $\boldsymbol{\varepsilon}_{it}$.

To further clarify, if a property is within an area that will be annexed, but is sold before the annexation occurs, Periphery is 1 while CityLimts is 0. If a property is within an annexation area and sells after the annexation occurs, then both Periphery and CityLimits are 1, as the house is now within the extended boundary of a city. Note that this research is not comparing sales from before and after a set date, but rather is measuring how property values in specific areas change relative to whether or not a household is unincorporated just outside of city limits or annexed and incorporated into a city and its encompassing infrastructure. This concept of the periphery, and how the value of similar properties can fluctuate depending on incorporation status, is the fundamental groundwork of this research.

The interaction between Periphery and CityLimits, $B3$, represents the "double difference," or the effect of a house being on the periphery after annexation takes place. In essence, the sale price of this annexed home can be compared to homes that were not annexed, but are similar in all other manners (time, attributes, demographics, etc.). The interaction between Periphery, CityLimits, and Nuisance, $B5$, represents the "triple difference" that is the basis of this paper. It shows the effect on the sale price of a home that is on the periphery, has been annexed into a city, and is near an environmental nuisance. It differs from the double difference in that it can be compared to the sale price of homes that were also on the periphery and annexed into a city, but were not near a nuisance. The only difference between these two property subsets is nuisance proximity, whose main effect on property value is groundwater contamination risk. By holding constant nearly every other characteristic that contributes to property value, the triple difference isolates the value of annexation in reducing groundwater contamination risk for those near disamenities. Through this way, even though there is no dollar amount given to support clean groundwater, the regression is able to pull apart the effect by comparing properties that are similar across attributes, but different along certain parts of the process, namely the final proximity to a disamenity that causes concern for groundwater contamination.

Overall, incorporation undoubtedly brings with it numerous benefits outside of piped water access, such as access to public schooling and similar public resources. Although this is an important consideration, the triple difference approach is able to isolate the effect of piped water on property values. These factors exist as a house is incorporated, but they will not contradict my findings under this methodology. Self-selection bias, on the other hand, is a potential risk of this study. It is possible that the population of households successfully annexed into a city are not representative of all properties on the periphery of all of the cities in question. Homes with certain demographic or income representations, or those with potentially favorable land, may be more appealing to cities, giving them a higher possibility of incorporation. Although the cities selected in this study represent comparable cities, this should nevertheless be considered when analyzing the results.

# V. Results

## a. Changes in the Averages

This section describes the results of the double and triple difference under the core methodology approach. As explained in the previous section, this process used the average of log property values in specific annexation areas and their accompanying cities and compared them across the time periods before and after annexation occurred. Summary results are below in Table 4 and complete data can be found in Table E1 in Appendix E. The right-hand column is represented by the average of the equation $\triangle \mathrm{P(B)}_{0,2}$ - $\triangle \mathrm{P(A)}_{0,2}$ across all annexation areas included in the noted designation.

Table 4: Change in Log Sale Amounts Between Annexation Areas and City Limits Covering the Time Periods Before and After Annexation

| **Annexation Areas (And Their Accompanying Cities) Included** | **Changes in the Average of Log Property Sale Amounts** |
|---|---|
| All | 0.0673 |
| All Not Within 2Km Proximity of a Nuisance | 0.0319 |
| All Within 2Km Proximity of a Nuisance | 0.1063 |

As expected, each of the three values are positive. The first row represents the "double difference." This can be understood to mean that, of the annexation areas included, properties within those areas increased an average of 6.7% more after they were annexed than similar properties that were always within city limits (i.e., never underwent annexation) over the same time period. This demonstrates that homes gain value from incorporation, likely from an increase in public resources available that outweighs the costs of increased tax burdens. Although this double difference does not necessarily point to questions of water quality, it is still a representation of the increased perceived value of a home on the periphery that is incorporated within a city, rather than unincorporated just outside the city limits. Outside the scope of environmental justice, this signals significant effects for property values due solely to their incorporation status, or lack thereof.

The second row, in the same manner, only includes annexation areas with properties that are not near an environmental nuisance. Properties under this designation rose an average of 3.2% more after they were annexed than their counterparts that were within city limits. The third row, on the other hand, includes only annexation areas with households within proximity of a nuisance. These rose on average 10.6% more after annexation than similar properties within city limits. While both of these represent positive changes, property values on the periphery near nuisances rose nearly 7% more on average after annexation than those on the periphery not near a nuisance. This value is the triple difference, an indicator that properties which are annexed into a city gain more on average if they are near an environmental disamenity than if they are not. While this does not definitively mean that perceived groundwater contamination risk from the effect of nuisances is the sole cause of this difference in average property value changes, it is a likely reason. As it can be assumed that all properties annexed into a city receive a similar bundle of public goods, this points to the fact that these goods (namely piped water access) were more valuable for homes near environmental nuisances.

### b. Standard Regression

This section analyzes the regression results, which act as a robustness check and allow for a better idea of the significance of the results found above. The regression measures the log of each property's sale amount regressed against whether or not each property is on the periphery, an interaction measuring the additional effect of a household on the periphery that has been incorporated into city limits post-annexation (the double difference), whether or not each property is near an identified environmental disamenity, as well as the previously-discussed household attributes and fixed effects. It also includes an interaction measuring the additional effect of a property on the periphery that is near a nuisance, compared to homes on the periphery not near a nuisance. Finally, it includes an interaction between homes that were on the periphery, annexed into city limits, and near a nuisance, as compared to those on the periphery and annexed, but not near a nuisance (the triple difference). The presence of an environmental nuisance is not separated between the three types. The variable Nuisance is simply a dummy indicating any environmental nuisance including a pre-regulatory landfill, an active hazardous waste site, or an inactive hazardous waste site. See Table D1 in Appendix D for the complete regression output including fixed effects.

Table 5: Triple Difference Regression

| VARIABLES | (1)<br>Model 1 |
|---|---|
| Periphery | 0.151*** |
| | (0.0244) |
| Periphery*CityLimits | 0.120*** |
| | (0.0370) |
| Nuisance | -0.0336*** |
| | (0.00905) |
| Periphery*Nuisance | -0.0697* |
| | (0.0384) |
| Periphery*CityLimits*Nuisance | -0.0104 |
| | (0.0489) |
| Square Feet | 0.000261*** |
| | (5.96e-06) |
| Acres | 0.0622*** |
| | (0.00880) |
| Bathrooms | 0.0683*** |
| | (0.00529) |
| Rooms | 0.0427*** |
| | (0.00436) |
| Garage Square Feet | 0.000432*** |
| | (2.37e-05) |
| Constant | 9.924*** |
| | (0.125) |
| Observations | 30,170 |
| R-squared | 0.490 |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The coefficient on periphery is highly significant, but demonstrates the opposite of the expected result. It was anticipated that an unincorporated home just outside of city limits would have a lower value than a property inside the city, but these findings indicate that a house on the periphery sold for 15.1% more than one in the city. As briefly discussed earlier in this paper, the outskirts of a city offers a different living experience, with potentially more flexible rules and cheaper land, than the center of a town. Before homes on the periphery are annexed, they also have cheaper property taxes than those located within city limits. The positive coefficient on the variable periphery may embody these potential advantages, demonstrated through an increase in property value.

The highly significant double difference interaction between periphery and city limits, on the other hand, is the expected outcome. It represents the fact that, for properties on the periphery of a city, those that were sold after annexation (once the house was included within the new city limits) did so at a 12% higher amount than those that were never annexed. Although the periphery coefficient alone does not align with expectations at this point in time, the interaction term is an important finding in this regression. It can be taken to mean that, given a similar population and controlling for house attributes directly, property values on the periphery notably increased after properties were annexed in as part of a city. This value not only points in the same direction as the double difference result of 0.0673 found from the changes in averages methodology but pushes it over 5% higher, solidifying the finding and significance.

The coefficient on nuisance is as expected, highly significant and demonstrating a decrease in property value of approximately 3.4% for homes near a disamenity. The coefficient on the interaction between periphery and nuisance, while slightly less significant, is in the expected direction. It demonstrates an additional 7% decrease in property sale amount for homes on the periphery near a nuisance when compared to homes on the periphery not within the vicinity of a nuisance. While these do not have values to match up with from the changes in averages approach, they further point to the negative consequences of living near an environmental nuisance, especially when the property is unincorporated.

The three-way interaction triple difference indicator, which is the underlying outcome of interest, is the only variable not significant by any measure in this regression. Although this does not necessarily mean that there is no effect, there is not enough evidence from the data to prove its impact from this regression. While this alone cannot corroborate the intended story that annexation positively influences previously unincorporated homes on the periphery near a nuisance more than those not near a nuisance, the finding from the changes in the averages approach does. Because the sample population was manually created, it is relatively small; that fact, combined with the amount of covariates in the regression, may have precluded significance in this multi-step triple-difference. Results from the changes in the averages methodology illuminate a more concrete value of the triple-difference.

This also points back to the discussion on water access type examined at the beginning of the Data section. If the assumption that incorporation brings with it access to reliable city water is false, then it is much more difficult to measure the effect of perceived groundwater contamination risk through the regression methodology. As shown in Figures 1 and 2, the periphery of some cities may have already had access to piped city water before annexation took place. This would strongly reduce the significance of the triple difference interaction coefficient, as reliable water access would remain essentially unchanged before and after incorporation for homes on the periphery. Similarly, annexation only solidifies more consistent access to clean water with regard to nuisance effects; if main effects from the disamenities included air quality or smell, annexation does not help. This study does not control for these effects.

The rest of the variables in the equation are highly significant and demonstrate the expected tendencies. Each additional room in a house increases the value by approximately 4.3%, and each bathroom increases the value by approximately 6.8%. The total and garage square footage appear to have a small impact on property value, but the impact is likely absorbed by some of the other variables that increase alongside square footage, such as number of rooms and acres. The property value of a home increases just over 6.2% for each added acre. The $R^2$ value of this regression is 0.490, showing that the model explains nearly half of the variability in the outcomes.

## VI. Conclusion

Smith and Willse (2012) establish that North Carolina is "recognized as a leader in annexation activity within the United States," namely due to the state's recent legislative inclusion of both voluntary and involuntary annexation options. Residents of incorporated and unincorporated areas have access to a different variety of resources that can each be beneficial in their own manner. Moreover, the water infrastructure offered by a municipality, although coming with higher taxes, is more consistent and considered cleaner. Given that many environmental disamenities, such as landfills, are located just outside of city limits, this can put a disproportionate burden on unincorporated residents in the municipal fringe. This burden does not stem solely from proximity to the nuisance, but more so from increased risk of water contamination from a lack of access to a consistently clean water supply. Although the standard regression in this research does not find statistically significant results regarding perceived water contamination risk, the changes in the averages methodology does. Furthermore, both approaches illustrate an increase in property values for homes on the periphery that have been annexed into a city, compared to periphery homes that remain unincorporated. The triple-difference investigation into groundwater contamination risk in this paper could potentially be extended with more accurate and up-to-date geolocation maps of water access type. That extension would provide support to policy-makers and communities by helping to understand the value of access to piped water. Similarly, it contributes to the larger issue of environmental justice across the United States, such as the benefit of annexing communities near landfills or hydraulic fracturing that may be in danger of water contamination. On a broader level, the results found in this study play a part in the more general discussion of households on the municipal fringe, and how their value can vary with respect to their incorporation status.

## Appendix A: Data Cleaning Specifications

The purpose of this section is to specify the details of the data cleaning performed on the CoreLogic property information utilized in this research. Cleaning was executed in order to develop a data set that was both fully complete (i.e., no missing values) and free of extreme outliers. The following were performed after the property information was merged with the geospatial locations of the cities under consideration, such that no properties in other areas of North Carolina were included.

Table A1: Designations for Removing Observations from Analysis

| **Variable** | **Specification (Number of Observations Dropped)** |
|---|---|
| Property Square Feet | > 8,000 (194) |
| Property Acres | > 10 (835) |
| Total Rooms | > 10 (115) |
| Total Bathrooms | > 6 (124) |
| Garage Square Feet | > 1,000 (81) |
| Basement Square Feet | > 1,000 (59) |
| Total Rooms & Total Bathrooms | = 0 (267) |

Note: 233 observations were also dropped due to the fact that the properties were built during the same year that their respective areas were annexed into a city. These constructions likely occurred with prior knowledge of the annexation and therefore may not accurately reflect a change in price both before and after the annexation took place. Similarly, 14,352 observations had missing values for home square footage. In order to include these observations' other variables within the regression and summary statistics, the observations were not deleted; however, the missing values for square footage were not included in the final regression.

## Appendix B: Detailed Eastern NC City Data

Table B1: Eastern NC Cities Included in Overall Research Study

| City | Population | % White | % Black | % Hispanic or Latino | Median Household Income ($) | # Annexations 2006-2016 Inclusive |
|---|---|---|---|---|---|---|
| Ahoskie | 4,976 | 31.1 | 62.2 | 4.1 | 25,024 | 12 |
| Alliance | 696 | 87.5 | 11.9 | 4.2 | 40,982 | 0 |
| Angier | 4,855 | 69.5 | 18.9 | 16.3 | 43,010 | 9 |
| Arapahoe | 498 | 79.7 | 11.6 | 7.4 | 47,321 | 0 |
| Atkinson | 378 | 90.2 | 6.3 | 7.9 | 38,750 | 0 |
| Atlantic Beach | 1,596 | 94.3 | 0.8 | 0.7 | 41,622 | 0 |
| Aulander | 785 | 31.6 | 68.3 | 1.7 | 25,179 | 0 |
| Aurora | 505 | 60.4 | 38.4 | 4.8 | 40,625 | 0 |
| Autryville | 426 | 100 | 0 | 0 | 23,500 | 2 |
| Ayden | 5,035 | 50.9 | 44.7 | 4.4 | 28,000 | 12 |
| Bald Head Island | 205 | 100 | 0 | 3.4 | 101,250 | 0 |
| Bath | 270 | 98.9 | 1.1 | 0 | 55,000 | 0 |
| Bayboro | 1,389 | 35.6 | 56.9 | 7.4 | 32,917 | 1 |
| Bear Grass | 137 | 100 | 0 | 0 | 43,125 | 0 |
| Beaufort | 4,153 | 74.7 | 19.6 | 2.5 | 33,701 | 8 |
| Belhaven | 2,000 | 42.8 | 55.6 | 5.5 | 27,241 | 0 |
| Belville | 2,437 | 76.4 | 13.9 | 7.7 | 62,632 | 4 |
| Bethel | 1,849 | 40.2 | 59.6 | 0 | 30,238 | 1 |
| Beulaville | 1,570 | 76.6 | 18.5 | 5.3 | 19,219 | 1 |
| Black Creek | 642 | 57.6 | 37.2 | 13.1 | 34,028 | 0 |
| Bladenboro | 1,875 | 63.5 | 30 | 12.7 | 21,587 | 2 |
| Bogue | 662 | 93.1 | 4.7 | 5.6 | 60,938 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Boiling Spring Lakes | 5,610 | 87.6 | 1.2 | 7.7 | 41,880 | 0 |
| Bolivia | 310 | 98.4 | 0 | 0 | 42,292 | 0 |
| Bridgeton | 304 | 93.8 | 6.3 | 2.6 | 73,214 | 14 |
| Burgaw | 4,011 | 47 | 44.8 | 6.9 | 28,794 | 7 |
| Calabash | 1,775 | 86.9 | 7.4 | 11.8 | 34,865 | 2 |
| Cape Carteret | 2,223 | 98.7 | 0.3 | 4 | 70,139 | 2 |
| Carolina Beach | 5,970 | 93.6 | 2.2 | 2 | 60,057 | 0 |
| Carolina Shores | 3,549 | 98.1 | 0.3 | 0.4 | 49,024 | 9 |
| Caswell Beach | 387 | 89.9 | 0 | 2.6 | 82,250 | 0 |
| Chadbourn | 2,169 | 31 | 62.1 | 2.4 | 25,871 | 1 |
| Chocowinity | 936 | 61.6 | 32.2 | 6.1 | 24,375 | 6 |
| Columbia | 795 | 41.1 | 36.6 | 29.8 | 27,083 | 9 |
| Edenton | 4,942 | 47.1 | 50.9 | 0.1 | 25,601 | 6 |
| Elizabeth City | 18,111 | 43.5 | 53.8 | 7.1 | 30,803 | 38 |
| Elizabethtown | 3,610 | 43.9 | 49.4 | 4.6 | 23,544 | 0 |
| Elm City | 1,630 | 34.3 | 47.2 | 9.4 | 35,208 | 0 |
| Emerald Isle | 3,708 | 98.1 | 0.3 | 4 | 62,331 | 0 |
| Faison | 1,107 | 64.8 | 16 | 42 | 37,083 | 0 |
| Falkland | 59 | 44.1 | 25.4 | 30.5 | N/A | 0 |
| Farmville | 4,755 | 57.4 | 40 | 2.8 | 33,595 | 7 |
| Fremont | 1,147 | 48.6 | 41.2 | 5.1 | 29,375 | 0 |
| Garland | 674 | 51.8 | 43.6 | 4.9 | 20,625 | 0 |
| Gatesville | 403 | 87.3 | 10.4 | 0.2 | 52,250 | 0 |
| Goldsboro | 35,952 | 38.1 | 54.4 | 5.7 | 34,598 | 58 |
| Grifton | 2,576 | 52.6 | 42.8 | 6.4 | 34,336 | 5 |
| Grimesland | 421 | 53.2 | 40.1 | 7.1 | 31,875 | 5 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Lewiston Woodville | 846 | 9.2 | 85.1 | 0.9 | 42,639 | 0 |
| New Bern | 30,218 | 56.5 | 32.1 | 5.4 | 41,148 | 29 |
| Pantego | 222 | 73.9 | 25.2 | 5 | 35,536 | 0 |
| Snow Hill | 1,847 | 49.5 | 45.4 | 11 | 28,947 | 2 |
| Tarboro | 11,292 | 47.7 | 45 | 6.8 | 33,349 | 1 |

Source: American Community Survey Data Profiles (2015)

Note: The list of cities in Table B1 is all-encompassing. Certain cities were not included in the final regression due to unavailable property information from their respective properties.

Table B2: Eastern NC Cities Not Included in Overall Research Study

| **City** | **Population** | **% White** | **% Black** | **% Hispanic or Latino** | **Median Household Income ($)** | **# Annexations 2006-2016 Inclusive** |
|---|---|---|---|---|---|---|
| Greenville | 88, 598 | 54.8 | 37.8 | 4.1 | 34,435 | 189 |
| Jacksonville | 68,315 | 65.7 | 21.3 | 14.9 | 40,918 | 65 |
| Rocky Mount | 56,642 | 31 | 63.4 | 3.4 | 36,088 | 47 |
| Wilmington | 111,998 | 76.5 | 18.9 | 5.6 | 42,128 | 14 |
| Wilson | 49,478 | 42.4 | 47 | 9.1 | 38,497 | 122 |

Source: American Community Survey Data Profiles (2015)

Note: Greenville, Jacksonville, Rocky Mount, and Wilmington were not included because their population was over 50,000. Cities of this size potentially have different characteristics, and they were removed to sustain consistent and similar cities for analysis in this study. Wilson was removed from consideration because of its abnormally large number of annexations; the time required to manually add each annexation was not feasible given the time constraints of this paper.

## Appendix C: Further Analysis of Property Sale Amounts

Table C1: Property Sale Amounts for Eastern NC within 2 Km Nuisance Buffer

| | Observations | Mean | Min | Max | St. Dev. |
|---|---|---|---|---|---|
| Pre-Regulatory Landfill (In City Limits) | 6,359 | $169,587 | $10,000 | $840,000 | $153,543 |
| Pre-Regulatory Landfill (On Periphery) | 91 | $165,146 | $10,000 | $600,000 | $144,798 |
| Active Hazardous Site (In City Limits) | 13,315 | $184,326 | $10,000 | $842,500 | $149,355 |
| Active Hazardous Site (On Periphery) | 1,413 | $203,722 | $12,000 | $821,000 | $124,631 |
| Inactive Hazardous Site (In City Limits) | 10,542 | $168,812 | $10,000 | $842,500 | $139,425 |
| Inactive Hazardous Site (On Periphery) | 85 | $165,651 | $12,000 | $600,000 | $127,339 |

## Appendix D: Complete Regression Output

Table D1: Triple Difference Regression Including Fixed Effects

| | (1) |
|---|---|
| VARIABLES | Model 1 |
| | |
| Periphery | 0.151*** |
| | (0.0244) |
| Periphery*CityLimits | 0.120*** |
| | (0.0370) |
| Nuisance | -0.0336*** |
| | (0.00905) |
| Periphery*Nuisance | -0.0697* |

| | |
|---|---|
| | (0.0384) |
| Periphery*CityLimits*Nuisance | -0.0104 |
| | (0.0489) |
| Square Feet | 0.000261*** |
| | (5.96e-06) |
| Acres | 0.0622*** |
| | (0.00880) |
| Bathrooms | 0.0683*** |
| | (0.00529) |
| Rooms | 0.0427*** |
| | (0.00436) |
| Garage Square Feet | 0.000432*** |
| | (2.37e-05) |
| | |
| Alliance | 0.0162 |
| | (0.139) |
| Angier | 0.480*** |
| | (0.0444) |
| Arapahoe | 0.00703 |
| | (0.126) |
| Atkinson | -0.217*** |
| | (0.0829) |
| Atlantic Beach | 1.352*** |
| | (0.0433) |
| Aulander | -0.158 |
| | (0.136) |
| Autryville | 0.170 |
| | (0.273) |
| Ayden | 0.223*** |
| | (0.0472) |
| Bald Head Island | 1.320*** |

| | |
|---|---|
| | (0.0472) |
| Bayboro | -0.108 |
| | (0.0811) |
| Bear Grass | 0.155 |
| | (0.209) |
| Beaufort | 1.103*** |
| | (0.0431) |
| Belville | 0.773*** |
| | (0.0474) |
| Bethel | 0.205** |
| | (0.104) |
| Beulaville | 0.306*** |
| | (0.0542) |
| Black Creek | -0.106 |
| | (0.109) |
| Bladenboro | -0.108 |
| | (0.0989) |
| Bogue | 0.666*** |
| | (0.0608) |
| Boiling Springs Lake | 0.590*** |
| | (0.0426) |
| Bolivia | 0.374*** |
| | (0.145) |
| Bridgeton | 0.351*** |
| | (0.115) |
| Burgaw | 0.418*** |
| | (0.0398) |
| Calabash | 0.530*** |
| | (0.0486) |
| Cape Carteret | 0.902*** |
| | (0.0463) |

| | |
|---|---|
| Carolina Beach | 1.249*** |
| | (0.0409) |
| Carolina Shores | 0.888*** |
| | (0.0423) |
| Caswell Beach | 1.495*** |
| | (0.0533) |
| Chadbourn | -0.197*** |
| | (0.0685) |
| Columbia | 0.0925 |
| | (0.156) |
| Edenton | 0.406*** |
| | (0.0421) |
| Elizabeth City | 0.122 |
| | (0.430) |
| Elizabethtown | 0.440*** |
| | (0.0543) |
| Elm City | -0.186*** |
| | (0.0616) |
| Emerald Isle | 1.472*** |
| | (0.0422) |
| Faison | -0.0140 |
| | (0.105) |
| Falkland | -0.147 |
| | (0.253) |
| Farmville | 0.176*** |
| | (0.0470) |
| Fremont | 0.322*** |
| | (0.0908) |
| Garland | -0.216* |
| | (0.128) |
| Gatesville | 0.434** |

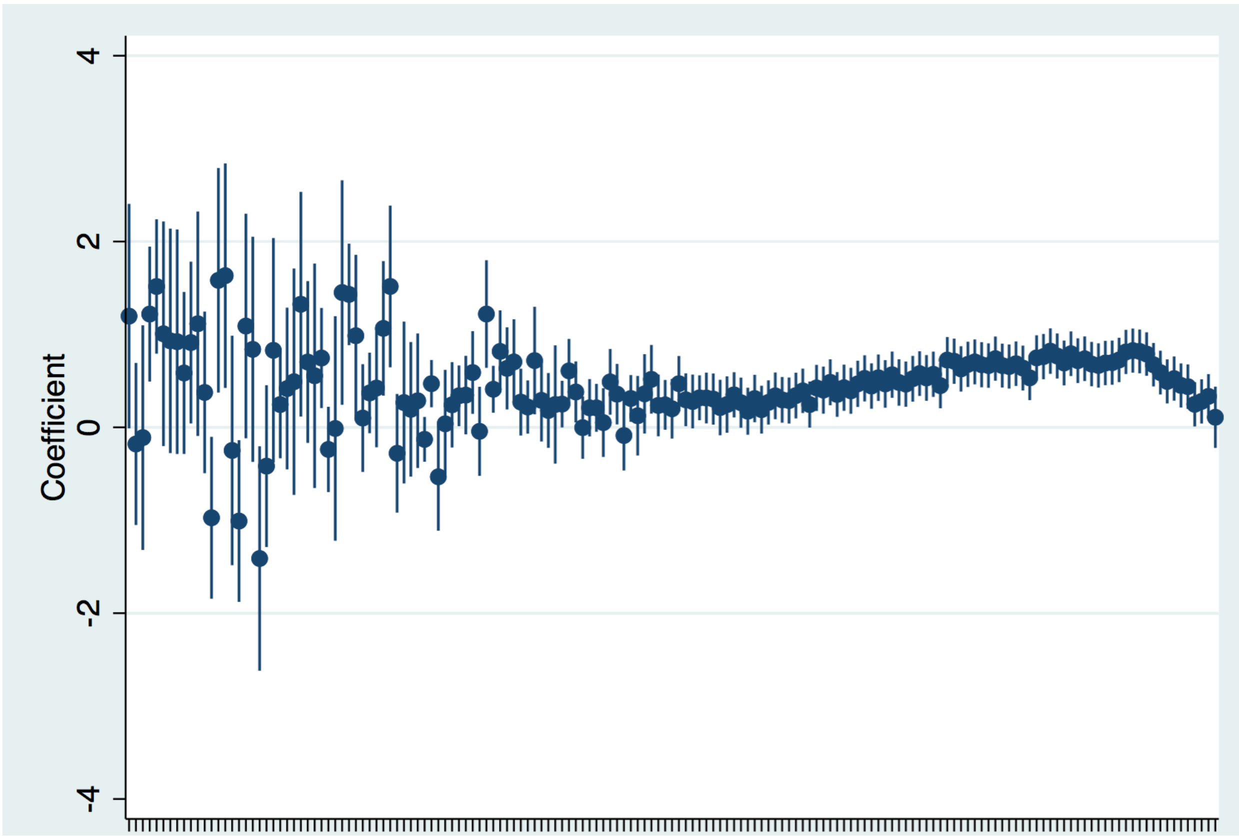
| | |
|---|---|
| | (0.196) |
| Goldsboro | 0.346*** |
| | (0.0403) |
| Grifton | 0.0286 |
| | (0.0567) |
| Grimesland | -0.256** |
| | (0.112) |
| Lewiston Woodville | -0.392*** |
| | (0.0961) |
| New Bern | 0.433*** |
| | (0.0320) |
| Snow Hill | 0.0792 |
| | (0.0578) |
| Tarboro | 0.272*** |
| | (0.0432) |
| | |
| 2007.year_sold | 0.00796 |
| | (0.0147) |
| 2008.year_sold | 0.0103 |
| | (0.0159) |
| 2009.year_sold | -0.0616*** |
| | (0.0160) |
| 2010.year_sold | -0.0792*** |
| | (0.0157) |
| 2011.year_sold | -0.151*** |
| | (0.0162) |
| 2012.year_sold | -0.139*** |
| | (0.0157) |
| 2013.year_sold | -0.156*** |
| | (0.0153) |
| 2014.year_sold | -0.144*** |

| | |
|---|---|
| | (0.0154) |
| 2015.year_sold | -0.108*** |
| | (0.0152) |
| 2016.year_sold | -0.0840*** |
| | (0.0193) |
| | |
| Constant | 9.924*** |
| | (0.125) |
| | |
| Observations | 30,170 |
| R-squared | 0.490 |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Figure D1: Mean and Standard Deviation of Coefficients from Triple Difference Year Built Fixed Effects




Year Built, Increasing from 1730 - 2015

Note: Year built fixed effects were removed from the regression above because of the inordinate amount of pages they took up. Figure D2 is included instead. It illustrates that increasingly newer homes generally have a positive effect on property value, with the results becoming much more significant and in more recent time periods. This is likely due to larger numbers of observations in recent years.

# Appendix E: Complete Results from Changes in the Averages

Table E1: Annexation-Specific Data on Average Log of Sale Amounts Before and After Incorporation Occurs

| **Annexation** | **Properties Within 2Km of Nuisance?** | **Average Change in Log of Property Values Across City Limit Boundaries [seen in Figure 8 as: $\triangle P(B)_{0,1}$ - $\triangle P(A)_{0,1}$]** |
|---|---|---|
| Ahoskie Annexation 1/9/07 | Yes | N/A |
| Autryville Annexation 4/20/11 | Yes | N/A |
| Ayden Annexation 5/14/07 | No | N/A |
| Ayden Annexation 8/25/08 (02) | No | 0.04065 |
| Ayden Annexation 8/25/08 (03) | No | 0.83264 |
| Ayden Annexation 9/11/06 | Yes | N/A |
| Beaufort Annexation 10/10/11 | Yes | N/A |
| Beaufort Annexation 10/11/10 | Yes | 0.32168 |
| Beaufort Annexation 2/11/13 (02) | Yes | -0.11394 |
| Beaufort Annexation 5/8/17 | Yes | N/A |
| Beaufort Annexation 8/9/10 | Yes | N/A |
| Belville Annexation 7/29/09 (01) | No | N/A |
| Burgaw Annexation 1/9/07 | No | N/A |
| Burgaw Annexation 11/12/13 | Yes | N/A |
| Burgaw Annexation 5/9/06 (02) | No | N/A |
| Calabash Annexation 12/9/08 | No | N/A |
| Calabash Annexation 6/10/08 | No | 0.15939 |
| Carolina Shores Annexation 3/6/07 | Yes | -0.02584 |
| Carolina Shores Annexation 5/7/15 | Yes | -0.01109 |
| Columbia Annexation 7/2/07 | Yes | N/A |
| Edenton Annexation 6/23/08 (01) | No | -0.43038 |

| | | |
|---|---|---|
| Elizabeth City Annexation 1/12/09 | Yes | 0.35394 |
| Elizabeth City Annexation 1/23/06 (01) | Yes | N/A |
| Elizabeth City Annexation 11/10/08 | No | -0.28619 |
| Elizabeth City Annexation 2/23/09 | No | N/A |
| Elizabeth City Annexation 3/12/07 (01) | Yes | 0.20832 |
| Elizabeth City Annexation 3/12/07 (02) | No | -0.04221 |
| Elizabeth City Annexation 3/12/07 (03) | Yes | N/A |
| Elizabeth City Annexation 3/28/16 | Yes | N/A |
| Elizabeth City Annexation 4/14/08 (01) | Yes | 0.44389 |
| Elizabeth City Annexation 4/26/10 | No | -0.97891 |
| Elizabeth City Annexation 6/24/13 (01) | Yes | N/A |
| Elizabeth City Annexation 8/11/08 (02) | No | N/A |
| Elizabeth City Annexation 9/24/07 (01) | No | N/A |
| Farmville Annexation 5/6/08 | Yes | N/A |
| Farmville Annexation 6/24/14 | Yes | N/A |
| Farmville Annexation 7/7/09 | Yes | N/A |
| Farmville Annexation 8/1/06 | Yes | N/A |
| Farmville Annexation 9/5/06 | Yes | N/A |
| Goldsboro Annexation 1/23/12 | Yes | -0.87285* |
| Goldsboro Annexation 1/3/11 | No | -0.01171* |
| Goldsboro Annexation 1/7/13 | Yes | N/A |
| Goldsboro Annexation 10/1/07 (01) | No | -0.49817 |
| Goldsboro Annexation 10/15/12 (01) | Yes | 0.87951 |
| Goldsboro Annexation 10/2/06 | Yes | N/A |
| Goldsboro Annexation 10/20/14 | No | N/A |
| Goldsboro Annexation 10/5/09 | No | N/A |
| Goldsboro Annexation 11/15/10 | No | 0.54877* |
| Goldsboro Annexation 11/2/09 | Yes | N/A |
| Goldsboro Annexation 3/20/06 | Yes | N/A |

| | | |
|---|---|---|
| Goldsboro Annexation 3/6/06 | Yes | N/A |
| Goldsboro Annexation 4/21/14 | No | 0.58201 |
| Goldsboro Annexation 4/3/06 | Yes | N/A |
| Goldsboro Annexation 5/3/10 (01) | Yes | 0.11009 |
| Goldsboro Annexation 6/7/13 | Yes | N/A |
| Goldsboro Annexation 6/26/17 (02) | No | N/A |
| Goldsboro Annexation 6/7/10 | Yes | N/A |
| Goldsboro Annexation 7/10/06 | Yes | N/A |
| Goldsboro Annexation 7/19/10 | No | N/A |
| Goldsboro Annexation 8/16/10 | Yes | N/A |
| Goldsboro Annexation 8/21/06 (02) | Yes | N/A |
| Goldsboro Annexation 9/17/12 | Yes | 0.10123 |
| Grifton Annexation 12/11/07 (01) | No | N/A |
| New Bern Annexation 1/23/07 (02) | No | N/A |
| New Bern Annexation 1/24/06 | Yes | N/A |
| New Bern Annexation 10/24/06 | No | N/A |
| New Bern Annexation 12/11/12 | Yes | -0.11842 |
| New Bern Annexation 2/14/12 (01) | No | 0.11601 |
| New Bern Annexation 2/14/17 | No | N/A |
| New Bern Annexation 2/27/07 (01) | No | 0.7462 |
| New Bern Annexation 5/26/15 | Yes | N/A |
| New Bern Annexation 6/26/06 (01) | No | N/A |
| New Bern Annexation 6/26/06 (02) | No | N/A |
| New Bern Annexation 6/27/06 | No | N/A |
| New Bern Annexation 8/25/09 | No | -0.33141 |
| Snow Hill Annexation 2/9/15 (01) | Yes | N/A |

Note: Only 23 of the above annexations had sufficient information for this analysis. Of these, 11 had properties near a nuisance and 12 had properties not near a nuisance. In order to compare changes before and after annexation, there had to be recorded property sales from both before and after the annexation occurred. If these were not present, the annexation was removed from this secondary methodology. These are represented in the table above with an N/A in the right-hand column. Furthermore, the three annexations with values in the right-hand column that have an asterisk (*) only had one property sale during either their before or after annexation period. As this is likely unrepresentative of an average, they were removed from consideration as well.

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