

GIS: ANALYZING THE IMPACT OF GREEN INFRASTRUCTURE ON PROPERTY VALUES

PRESENTED BY

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About the Project

- Study began as an US EPA request for information local governments and sewerage/stormwater management districts throughout US
 - Milwaukee Metropolitan Sewerage District (MMSD)
 - Provide case studies and/or models to assess the \$ impact of GI projects on property values
- *What is the Financial/Fiscal Impact of Green Infrastructure (GI) projects on nearby or surrounding property values*
 - Estimates \$ impacts of other infrastructure ie roads, water/sewer lines, utilities on property values are well established
 - GI is relatively new, impacts are not established at this point
 - CBO wants to know what is the ROI for GI projects

What is Green Infrastructure?

- Bioretention facilities
- Wetlands
- Greenways
- Stormwater Trees/Vegetation
- Native Landscaping or Habitat Restoration
- Rain Gardens
- Green Roofs
- Bio-Swales
- Porous Pavement (Alleys/Streets/Parking Lots)
- Rain Barrels/Cisterns

Multi-purpose and multi-functional, all methods for reducing stormwater runoff

Step One: Hedonic Regression Analysis

- Standard method for real estate valuation modeling
- The value of a property is based upon its components:
 - Physical characteristics: square footage, lot size, number of bathrooms and bedrooms, number of units
 - Neighborhood quality: proximity to parks/rivers/lakes or other amenities, access to transit and transportation
 - Socio-Economic Characteristics: educational attainment, age, household size, household income
 - Other Characteristics: Presence of Business Improvement District or Tax Increment Finance District
 - *Proximity/adjacency to GI*
- Modeling determines the portion of the value contributed by GI

Step Two: Fiscal Impact Analysis and Return On Investment

- Regression models don't tell the whole story
- Estimating the amount of new property tax revenue created by the increase in property values
- Payoff of GI investment
- Comparing results of the models to the real world conditions

Hedonic Regression Modeling:

- Method of estimating pricing or value, and is THE standard method for real estate valuation modeling
- It deconstructs the item (in this case, each property) into its constituent characteristics (variables) and obtains estimates of the contributory value of each characteristic. This requires that the property being valued can be reduced to its constituent parts.
- Linear (multiple) regression equation

$$y = m_1x_1 + m_2x_2 + \dots + m_nx_n + b$$

where, y is the dependent variable; x_1 through x_n are the independent variables; m_1 through m_n are the coefficients of each independent variable and b is a constant

Hedonic Regression Modeling:

- Key Independent Variable (Presence/Absence of GI)
 - Which is impacted by a whole bunch of dependent variables
- Series of Dependent Variables for properties
 - Property Type/Use (Commercial, Industrial, or Residential)
 - Detailed property characteristics
 - Neighborhood characteristics and amenities
- Comparison of Study Group to a Control Group (apples to apples)
 - Identify all properties that are impacted/adjacent to the GI to all *similar* properties that are not adjacent to any GI
- Time Series Component
 - Study group properties compare/performance are compared to the control group properties over a given period of time
 - Key to the modeling is measuring Δ over time

Data all has a spatial component to it:

- GI data
 - GI types/uses
 - Locations
- Property data
 - Polygons
 - Parcel/Property Assessment data
- Socio-Economic/Demographic Data
 - US Census/American Community Survey
 - Census Tract level
- Other Neighborhood/City Data:
 - Distances to amenities (lakes, rivers)
 - Transportation (freeway entrances, bus stops)
 - Within development incentive areas (BIDs, TIFs)

Data Needs:

- Property Assessment data (Parcel Level)
 - \$ assessed value
 - Land use/property use
 - Building Area
 - Property Square footage
 - # Bedrooms
 - # Bathrooms
 - Age of structure/year built

Data Needs:

- Socio-Economic Demographic Data
 - All Census Tract level data
 - Median Household Income
 - % of population with Bachelors degrees
 - % of population in poverty
 - % black, % Hispanic
 - Population Density
- Other Economic/Development factors
 - Business Improvement Districts (BIDs)
 - Tax Increment Financing Districts (TIDs)
 - (Boundary polygons of BIDs and TIDs)

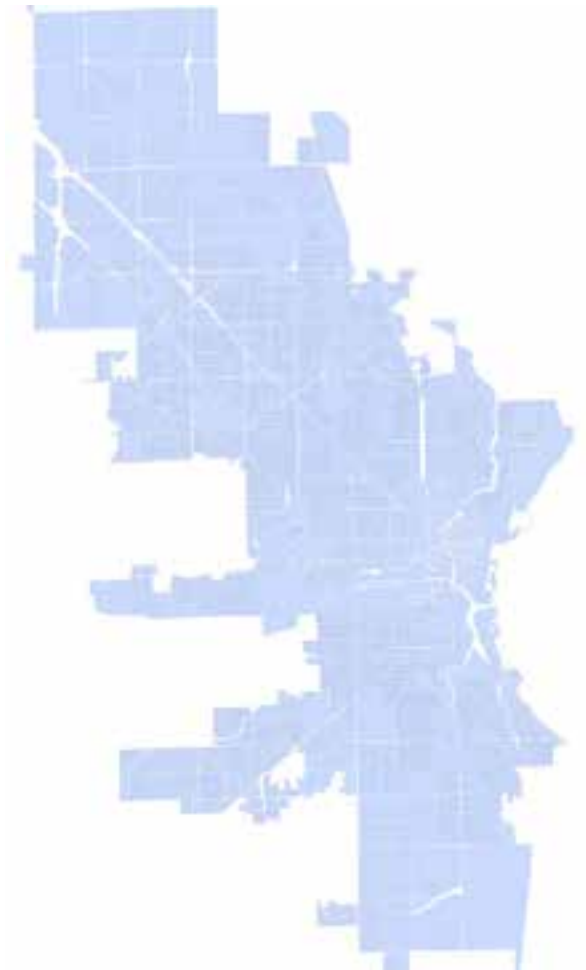
Data Needs:

- Proximity to other cultural/neighborhood amenities
 - Number of parks within 1,000 ft of property
 - Park Acreage within 1,000 ft of property
 - Distance to Lake Michigan
 - Distance to nearest river
- Proximity to Transit/Transportation
 - Distance to Bus Stops
 - Distance to nearest freeway on- and off-ramps
- Proximity to Blight
 - Number of Vacant Properties within 1,000 ft of property
 - Number of Brownfield Properties within 1,000 ft of property

Case Studies: Data and GIS

GIS:

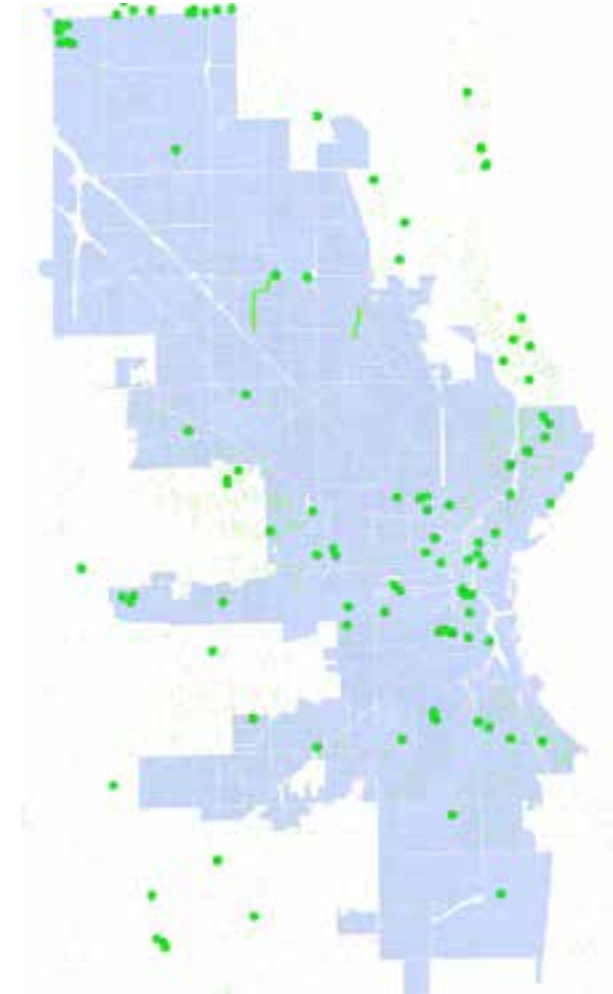
- Begin with City of Milwaukee Parcel Polygons
 - 165,000+ Parcel Polygons
 - Model is parcel polygon driven
- Tabular Property Assessment Data
 - Annual assessment data for all properties
 - In DBF or XML format (available 1970's to present)
 - One-to-One join with the parcel polygons



Case Studies: Data and GIS

GIS:

- Overlay/fix Green Infrastructure Shapefiles
 - Spatial join
 - Most located on publicly-owned parcels
 - Picked adjacent privately-held parcels – set criteria of
- Data processing to add all of the other variables
 - a significant amount of spatial joins
 - Census/ACS tract data (by year) assigned to each parcel
 - Distance/proximity calculations
- Culling Records



Case Studies: Data and GIS

GIS: Each parcel had a record for each year (so up to 12 records for 1 property)

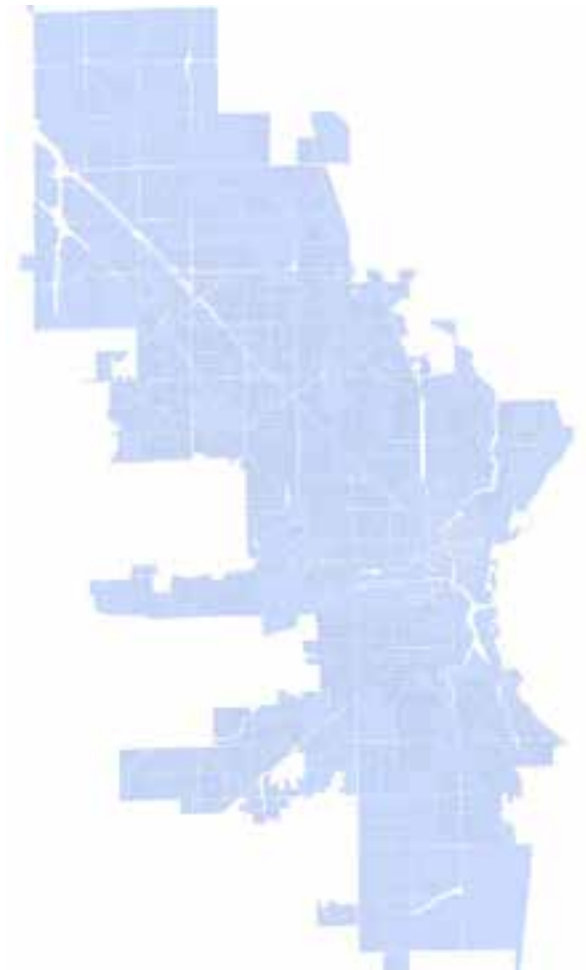
Year	GI?	Group	AsValue	Bldg Sq Ft	Md HH Income	#Bd rms	Povrty Rate	+ 50 VAR
2001	0	Study	99,000	1,786	39,782	3	.355	→
2002	0	Study	99,500	1,786	39,256	3	.363	→
2003	0	Study	99,750	1,786	40,156	3	.355	→
2004	1	Study	99,750	1,786	40,829	3	.342	→
2005	1	Study	101,000	1,786	40,782	3	.366	→
2006	1	Study	104,350	1,786	41,278	3	.357	→
2007	1	Study	112,420	1,786	41,768	3	.354	→
2008	1	Study	116,500	1,786	40,182	3	.397	→
2009	1	Study	115,400	1,786	39,291	3	.412	→
2010	1	Study	115,400	1,786	38,956	3	.428	→
2011	1	Study	115,750	1,786	39,287	3	.419	→

Parcel/
Taxkey X

Case Studies: Data and GIS

GIS:

- Criteria for Study Group
 - Major GI projects – like *uses*, including use and zoning codes, physical characteristics
 - Adjacent to or within 200 feet of Green Infrastructure
 - Needed to capture before and after installation of GI
- Criteria for Control Group
 - Same uses, physical char as study group
 - NOT within 1,000 feet of GI
 - Random sampling within ArcInfo

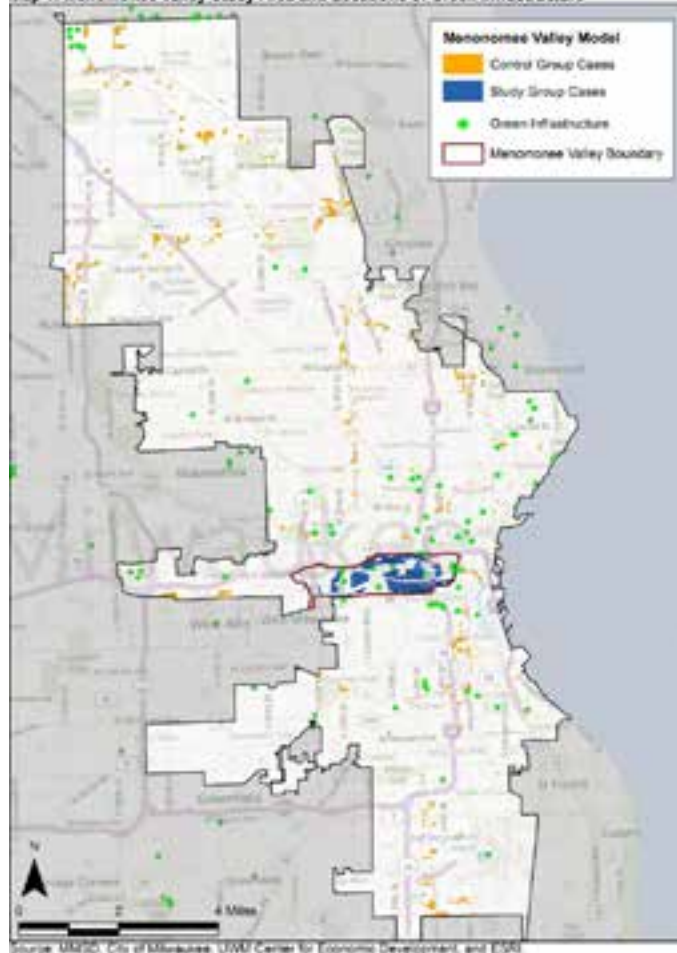


The Menomonee Valley Model

- Tax Increment Financed Redevelopment
 - Industrial Area - Significantly blighted
 - Four TIFs as mechanism to spur private redevelopment = \$31M
 - Brownfield cleanup and environmental/landuse planning
 - Major infrastructure projects - increasing connectivity and access, reducing stormwater runoff
- GI integrated into significant redevelopment project (stormwater runoff)
 - 12 GI projects including bioretention facilities, green roofs, green alleys/streets, porous pavement - the largest being a 3 acre stormwater park
 - Design contest for stormwater park (Wenk Associates and HNTB) – greater aesthetic appeal and recreational facilities
 - GI Costs = \$1.8M, with MMSD portion being \$835,000

Menomonee Valley Model

Map 1: Menomonee Valley Study Area and Locations of Green Infrastructure



Study Group = 117 industrial properties near GI
Control Group = 510 comparables
6,319 observations over a 9 year cycle
A Robust Sample

Case Studies: Results

The Menomonee Valley Model

Key Dependent Var = Total Assessed Value

$R^2 = .273$

Model performed very well (coefficients)

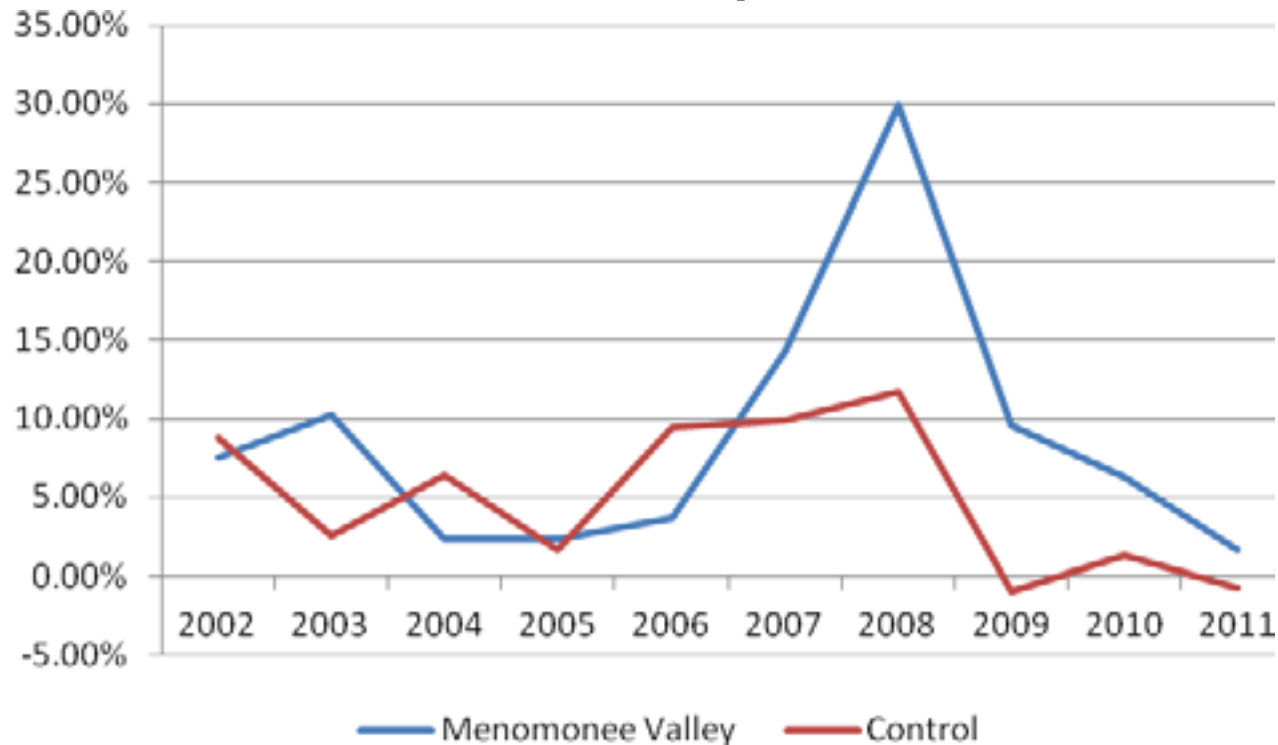
Variables	Coefficient	(Std. Error)	Sig. (P < z)
Green Infrastructure (Key Independent Var)	0.058	(0.022)	0.010**
Building Area (in square feet)	4.70E-06	(0.000)	0.000**
Parcel Area (acres)	1.74E-06	(0.000)	0.000**
Distance to Lake Michigan	3.92E-06	(0.000)	0.327
Distance to Closest River or Stream	-1.63E-04	(0.000)	0.000**
Distance to Nearest Freeway Ramp	-1.02E-05	(0.000)	0.453
Distance to Nearest Bus Stop	6.74E-05	(0.000)	0.318
Tax Increment Finance District (TID)	-0.088	(0.026)	0.001**
Business Improvement District (BID)	0.118	(0.018)	0.000**
Number of Brownfields within 1,000 feet	0.017	(0.004)	0.000**
Number of Vacant Properties within 1,000 feet	-0.001	(0.000)	0.121
Number of Parks within 1,000 feet	0.02	(0.009)	0.033**
Percent of Population with High School Diploma	2.232	(0.122)	0.000**
Percent of Population In Poverty	0.946	(0.108)	0.000**
Percent of Population Black	-0.112	(0.095)	0.242
Median Household Income (log)	0.415	(0.051)	0.000**
Population Density	0.007	(0.005)	0.199
Parking Lot (dummy variable)	-0.094	(0.035)	0.007**
Constant	5.826	(0.557)	0.000**

The Menomonee Valley Model

- Holding all other variables constant, in any give year, the assessed property values were 5.8 percent higher than they otherwise would have been without the GI/Redevelopment
- This translates into a \$13,317 increase in assessed value for the average industrial property in Milwaukee (which is about \$223,555 and is not in a TID or BID, nor is it a parking lot), which adds up to roughly \$1.56M in added assessed value for 117 properties.....
- BUT.....still some unanswered questions

The Menomonee Valley Return On Investment

Figure 1: Property Value Growth Rates in the Menomonee Valley and Control Group Areas, 2002-2011



Source: City of Milwaukee MPROP database and UWM-Center for Economic Development

Case Studies: ROI

Comparison of Assessed Values for the Study and Control Groups within the Menomonee Valley Model

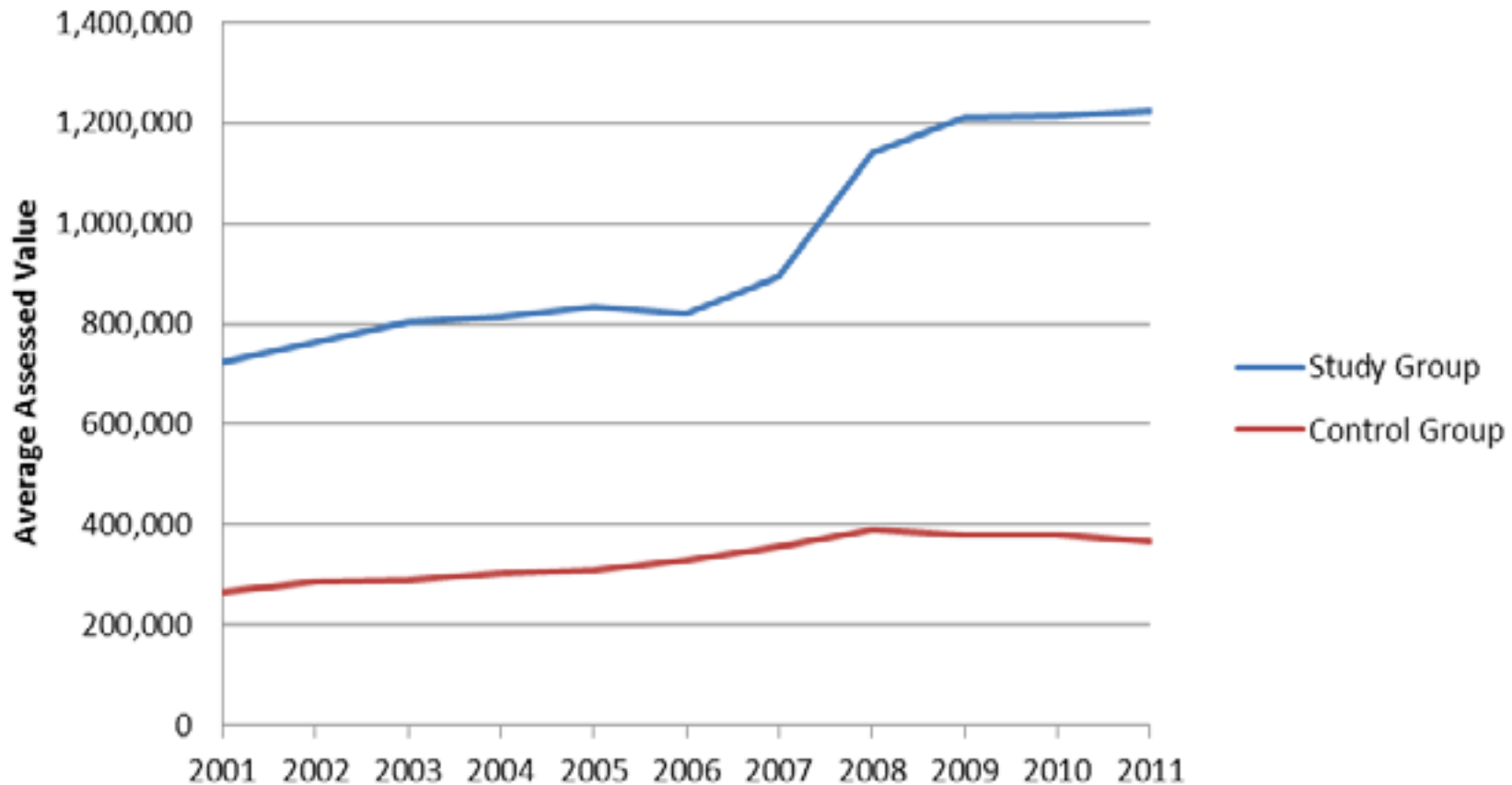
Year	Study Group				Control Group			
	Properties	Total Assessed Value*	Average Assessed Value*	Yr over Yr Growth Rate	Properties	Total Assessed Value*	Average Assessed Value*	Yr over Yr Growth Rate
2001	104	75,233,145	723,396	--	436	115,807,484	265,613	--
2002	106	80,886,664	763,082	7.5	440	125,930,508	286,206	8.7
2003	111	89,207,703	803,673	10.3	447	129,198,672	289,035	2.6
2004	112	91,241,883	814,660	2.3	454	137,486,387	302,833	6.4
2005	112	93,330,453	833,308	2.3	453	139,712,174	308,415	1.6
2006	118	96,813,589	820,454	3.7	466	152,952,429	328,224	9.5
2007	124	110,674,367	892,535	14.3	473	168,107,658	355,407	9.9
2008	126	143,790,214	1,141,192	29.9	481	187,855,065	390,551	11.7
2009	130	157,543,696	1,211,875	9.6	488	185,947,938	381,041	-1.0
2010	137	167,517,374	1,213,894	6.3	498	188,298,577	378,110	1.3
2011	140	170,256,000	1,224,863	1.6	509	186,818,348	367,030	-0.8

Note: Assessed values are adjusted for inflation to reflect 2011 dollars.

Source: City of Milwaukee MPROP database and UWM-Center for Economic Development

The Menomonee Valley Return On Investment

Figure 2: Average Assessed Value for Industrial Properties, 2001 to 2011



Note: Assessed values are adjusted for inflation to reflect 2011 dollars.

Source: City of Milwaukee MPROP database and UWM-Center for Economic Development

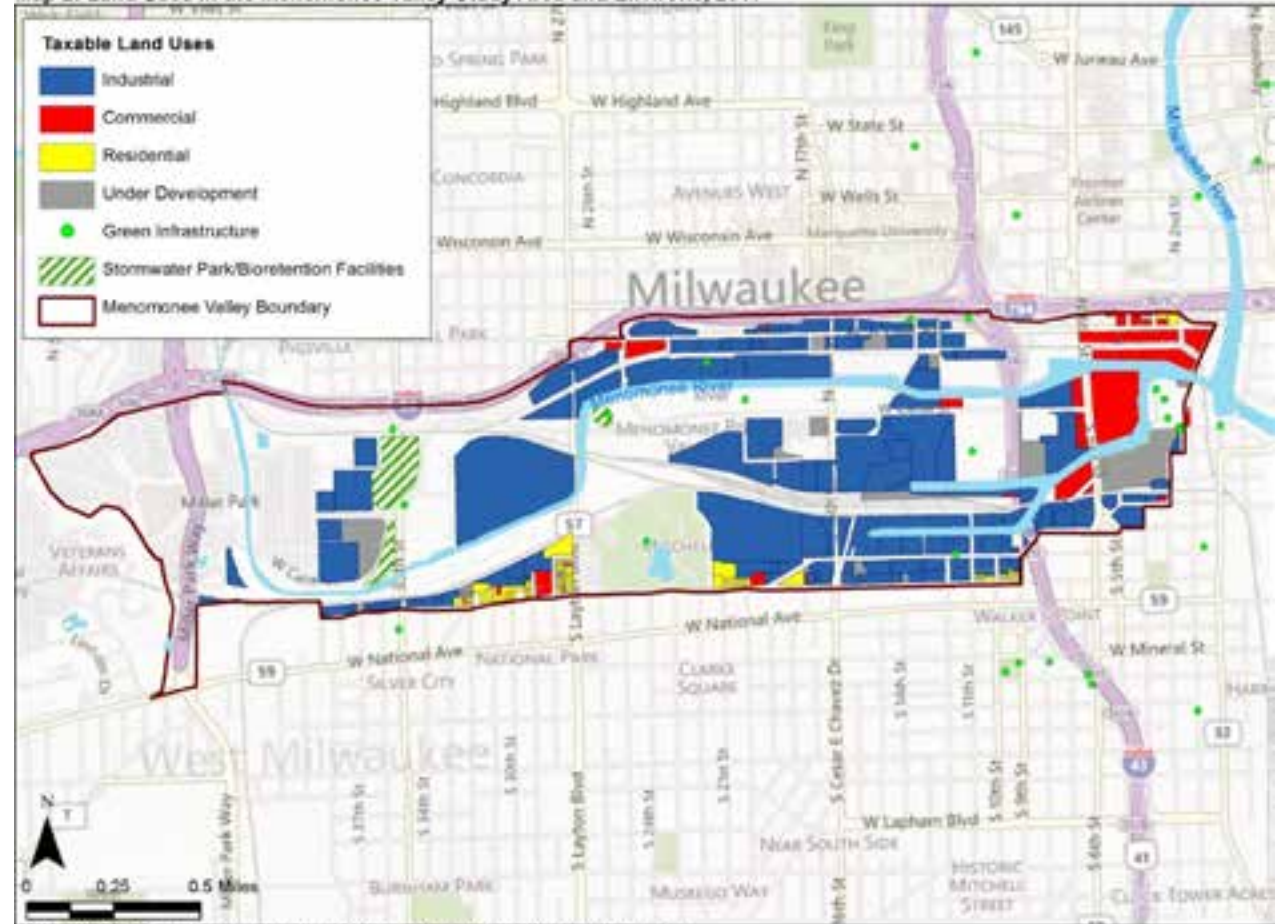
Case Studies: ROI

Table 3: Non-Industrial Land Uses and Assessments in the Menomonee Valley, 2011

Land Use Type	2011	
	Number of Parcels	Total Assessed Value
Commercial	35	52,025,300
Residential	163	40,485,600
Under Development ¹	24	8,061,100
SUBTOTAL	222	100,572,000
Industrial Properties	140	170,256,000
TOTAL	362	270,828,000

¹ A total of 24 properties within the Valley study area were identified as under development in 2011. These properties will likely add additional assessed value upon completion.
 Source: City of Milwaukee MPROP database and UWM-Center for Economic Development

Map 2: Land Uses in the Menomonee Valley Study Area and Environs, 2011



Source: MMSD, City of Milwaukee, UWM Center for Economic Development, and ESRI.

The Menomonee Valley Return On Investment

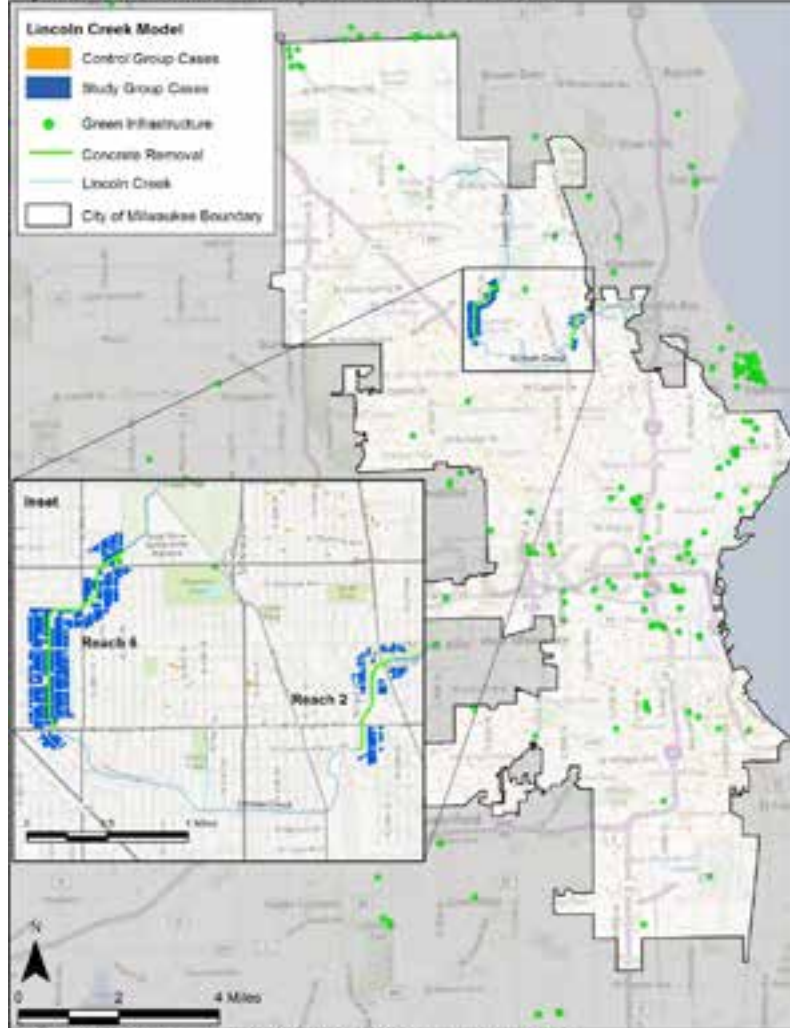
- Based on a Total Assessed Value of \$270.8M in 2011 (was \$168M in 2001, adjusted to 2011 dollars):
 - MMSD should anticipate receiving about \$400,825 in annual tax revenues generated from all taxable properties within the value
 - Based on MMSD's \$834,711 initial investment, payoff would be in 3 years, assuming that all of the revenues generated are directed to payoff the investment
 - Estimate does not include any additional user charges nor any costs that were likely to accrue had the GI not been developed

Lincoln Creek

- Residential
 - Multiphase project –removal of concrete channels
 - Stormwater and flooding
 - Infrastructure was significantly blighted
- Redevelopment was entirely GI
 - Limited this model to 2 reaches (otherwise number of cases within model would have been unwieldy)
 - GI Costs = \$10.95M
 - Widen/deepen creek
 - Concrete removal
 - Grading and erosion control
 - Adding low flow habitat
 - Bridge revetments, culvert

Lincoln Creek

Map 5: Lincoln Creek Model and Locations of Green Infrastructure



Map 6: Land Uses in the Lincoln Creek Study Area and Environs, 2011



Case Studies: Results

Lincoln Creek

Dependent Var =

Total Assessed Value

R² = .754

Model performed
 very well
 (coefficients)

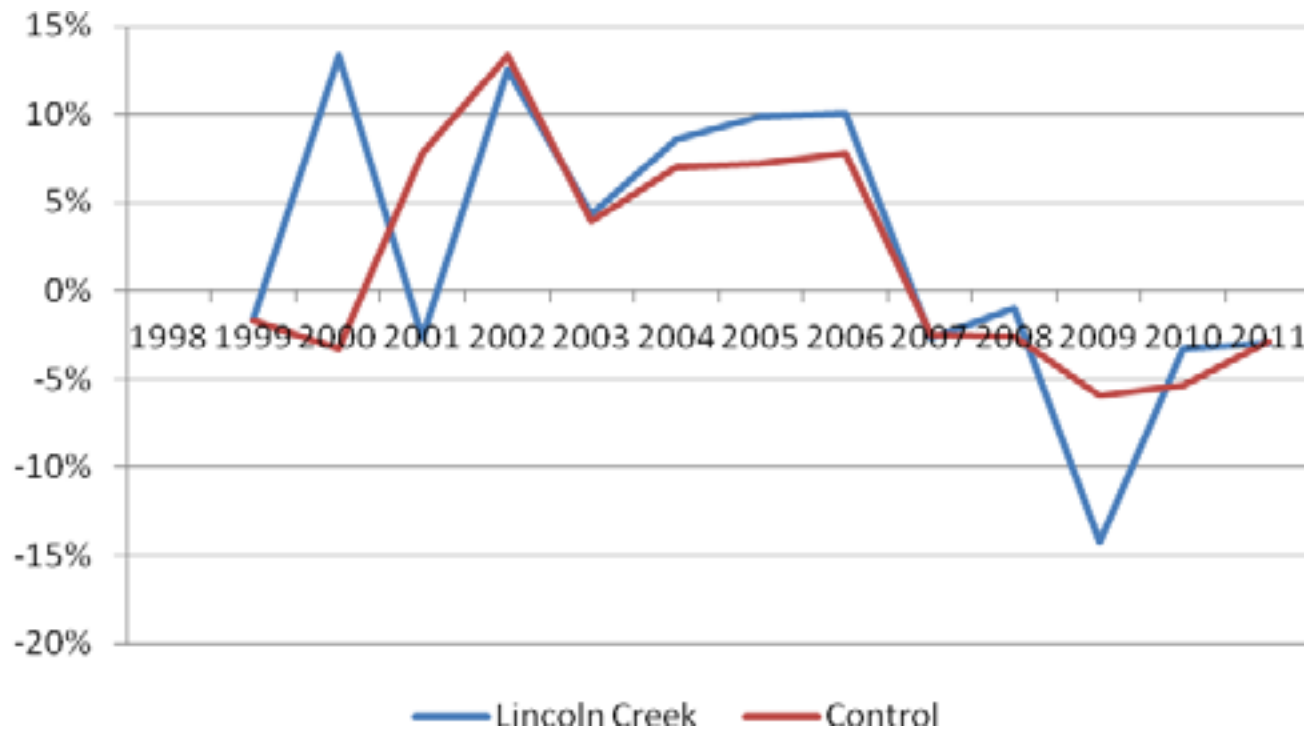
Variables	Coefficient	(Std. Error)	Sig. (P < z)
Green Infrastructure (Key Independent Var)	0.204	(0.003)	0.000**
Building Area (square feet)	4.102E-04	(0.000)	0.000**
Parcel Area (square feet)	1.690E-05	(0.000)	0.000**
Age	-4.387E-03	(0.000)	0.000**
Age ²	2.630E-05	(0.000)	0.000**
Bedrooms	0.267	(0.015)	0.000**
Bedrooms ²	-0.039	(0.002)	0.000**
Baths	0.099	(0.007)	0.000**
Distance to Lake Michigan	4.890E-06	(0.000)	0.000**
Distance to Closest River or Stream	7.300E-06	(0.000)	0.005**
Distance to Nearest Freeway Ramp	9.800E-06	(0.000)	0.000**
Distance to Nearest Bus Stop	1.930E-05	(0.000)	0.027**
Number of Brownfields within 1,000 feet	0.015	(0.002)	0.000**
Number of Vacant Properties within 1,000 feet	-0.0070	(0.000)	0.000**
Number of Parks within 500 feet	-0.0671	(0.005)	0.000**
Number of Parks within 1,000 feet	0.0500	(0.004)	0.000**
Percent of Population In Poverty	0.7305	(0.026)	0.000**
Percent of Population: Black	-0.2601	(0.013)	0.000**
Percent of Population: Hispanic	1.1105	(0.026)	0.000**
Percent of Population: High School Graduates	2.4755	(0.028)	0.000**
Median Household Income (log)	0.1624	(0.013)	0.000**
Population Density	-0.010	(0.000)	0.000**
Constant	6.691	(0.154)	0.000**

Lincoln Creek Model

- Holding all other variables constant, in any give year, the assessed property values were 20.4 percent higher than they otherwise would have been without the GI/Redevelopment
- This translates into a \$19,174 increase in assessed value for the average residential property in Milwaukee (which is \$90,253 single family home with 3 bedrooms)
- This adds up to roughly \$18.33M in added assessed value for study area properties

Lincoln Creek Return On Investment

Property Value Growth Rates in Lincoln Creek and Control Group Areas, 1999-2011



Source: City of Milwaukee MPROP database and UWM-Center for Economic Development

Case Studies: ROI

Comparison of Assessed Values for the Study and Control Groups within the Lincoln Creek Model

Year	Study Group				Control Group			
	Properties	Total Assessed Value	Average Assessed Value	Yr Over Yr Growth Rate	Properties	Total Assessed Value	Average Assessed Value	Yr Over Yr Growth Rate
1998	959	58,248,826	60,739	--	1,193	111,163,714	93,180	--
1999	958	57,323,088	59,836	-1.5	1,195	109,255,756	91,427	-1.9
2000	958	64,951,010	67,799	13.3	1,195	105,703,368	88,455	-3.3
2001	957	63,230,130	66,071	-2.5	1,196	113,901,821	95,236	7.7
2002	958	71,184,495	74,305	12.5	1,199	129,096,419	107,670	13.1
2003	958	74,249,642	77,505	4.3	1,197	134,126,591	112,052	4.1
2004	960	80,598,302	83,957	8.3	1,202	143,472,795	119,362	6.5
2005	960	88,553,413	92,243	9.9	1,201	153,853,368	128,104	7.3
2006	960	97,480,808	101,543	10.1	1,205	165,910,313	137,685	7.5
2007	959	94,862,660	98,918	-2.6	1,205	161,841,232	134,308	-2.5
2008	959	93,929,775	97,946	-1.0	1,205	157,657,314	130,836	-2.6
2009	959	80,507,676	83,950	-14.3	1,205	148,303,668	123,074	-5.9
2010	960	77,835,773	81,079	-3.4	1,206	140,358,096	116,383	-5.4
2011	961	75,500,500	78,565	-3.1	1,207	136,347,600	112,964	-2.9

Lincoln Creek Return On Investment

Table 8: Land Uses and Assessments within the 600 Foot Buffer Boundary in Lincoln Creek Reaches 2 and 6, 2011

Land Use Type	2011	
	Number of Parcels	Total Assessed Value
Commercial	30	6,622,300
Industrial	11	2,070,300
Under Development ¹	33	102,600
Residential Properties Not in Study Group ²	343	34,914,100
SUBTOTAL	417	43,709,300
Residential Properties in Study Group	961	75,500,500
TOTAL	1,378	119,209,800

¹ A total of 33 properties within the Lincoln Creek study area were identified as under development in 2011. These properties will add additional assessed value upon completion.

² Non-single family home residential properties.

Lincoln Creek Return On Investment

- Based on a Total Assessed Value of \$119.2M in 2011:
 - MMSD should anticipate receiving about \$176,430 in annual tax revenues generated from all taxable properties within the value
 - Based on MMSD's \$10.95M initial investment, payoff would be in 62 years, assuming that all of the revenues generated are directed to payoff the investment
 - Estimate does not include any additional user charges nor any costs that were likely to accrue had the GI not been developed, nor the negative impact on property values given the history of flooding and basement backups within the study area

Thanks for your input!

Questions and Comments:

Draft report is available online at CED's website!

- <https://www4.uwm.edu/ced/>

Please contact Kate Madison at cmadison@uwm.edu or by phone at (414) 229-6155