APPENDIX F

Transportation and Environmental Benefits of Developing Unutilized Industrial Sites: *Brownfields*

Chris Hendrickson, Deborah Lange, Scott Matthews, Yeganeh Mashayekh

International Society of Industrial Ecology 2011, Berkeley, California

Agenda

- **Introduction**
- Methodology
- Results
- Discussion
- Conclusion

Brownfield Developments

View of Herr's Island in 1981 prior to its development (left) into Washington's Landing (below)

Photo credit: Urban Redevelopment Authority of Pittsburgh

Source: http://www.pittsburghgreenstory.org/html/brownfields.html#

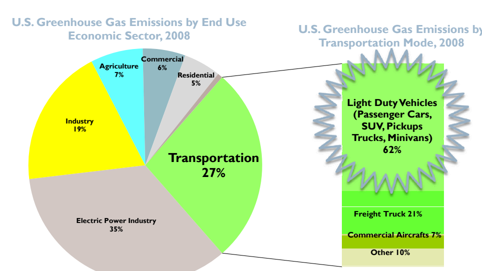
Brownfield Redevelopment - Barriers

- Cost of remediation and lack of funding
- Uncertainty over cleanup standards
- Concerns over liability
- Land assembly issues
- Reluctance to invest in distressed communities

Brownfield Redevelopment - Benefits

- Use existing infrastructure
- Keep green spaces intact
- Increase cost-effectiveness of transit (depending on the development location)
- Provide greater opportunities for physical activity
- Generate of local tax revenue
- Reduce vehicle miles traveled and the consequential emissions

Transportation System's Impact on Greenhouse Gas Emission



Source: U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 to 2008, April 2010

Transportation GHG Reduction Policy Goals

Energy Independence and Security Act 2007 – Section 1101(c)

Transportation System's Impact on Climate Change

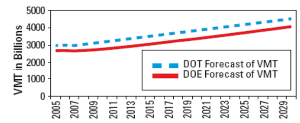
American Association of State Highway and Transportation Officials (AASHTO) Goal

Reduce rate of growth in VMT to approximately rate of population growth (about 1% per year)

Vehicle Miles Traveled (VMT)

37% Increase in VMT by light duty motor vehicles (1990 – 2008)
~15,000 miles/person

Forecasted VMT growth will outpace gains from improved fuel economy and alternative fuels.



Sources: U.S. DOE, *Annual Energy Outlook 2006*, Revised Early Release (March 2006)
FHWA, *2006 Conditions and Performance Report*

Motivating Questions

- Do Brownfield Developments reduce VMTs? What are the contributing factors for such reduction?
- Would the environmental cost savings resulted from VMT reduction offset the extra initial infrastructure development costs (i.e. remediation) of Brownfield Developments?

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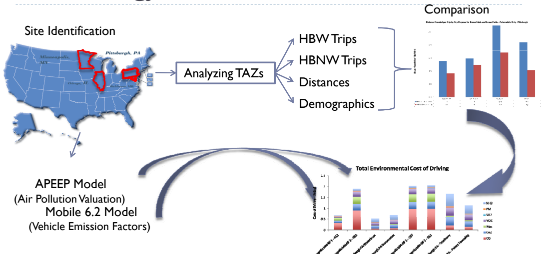
Methodology



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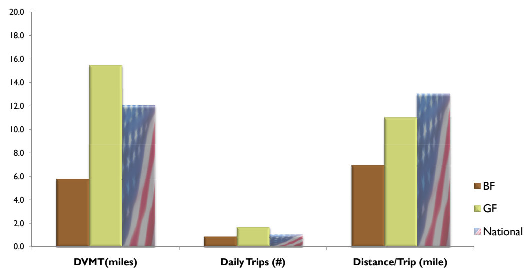
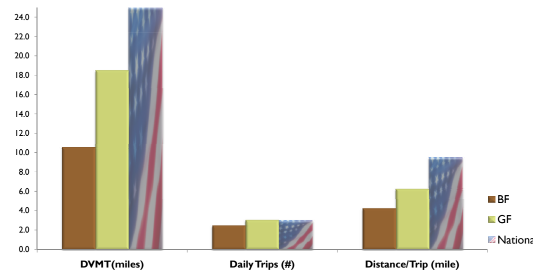
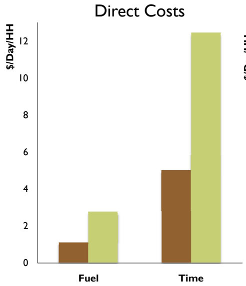
VMT Comparison Results
Brownfield and Greenfield Developments' Travel Pattern Comparisons
Home-Based Work Auto Trips per Household

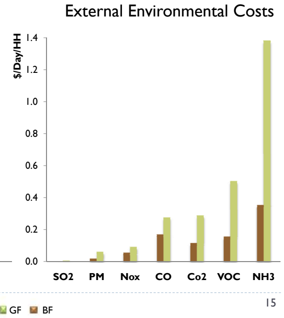


VMT Comparison Results
Brownfield and Greenfield Developments' Travel Pattern Comparisons
Home-Based Non-work Auto Trips per Household



Cost Comparison Results
Brownfield and Greenfield Developments





Annual Reductions per Household

	Greenfield Developments	Brownfield Developments	% Reduction
Vehicle Miles Traveled (miles)	8,800	4,200	52
Number of Trips	1,200	870	28
Direct Cost of Driving ($)	4,000	1,600	60
Environmental Cost of Driving ($)	680	230	66

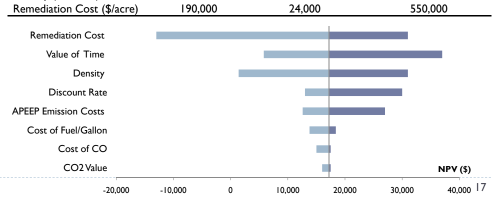
Remediation Cost of Brownfield Developments: $190,000/Acre*
Brownfield Unit Density: 65 Units/Acre

Initial Cost: $2,900 per Household
Benefit: $2,900 per Household per Year

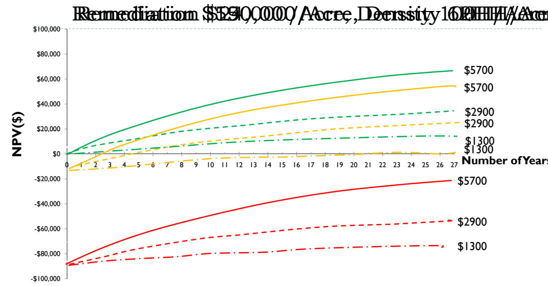
Source: Various Literature (mainly Chicago Brownfield Initiatives, R.S. Mean)

Uncertainty Analysis – 20 Year Period

	Base Case	Best Case	Worst Case
CO2 Value	$30/ton	$10/ton	$85/ton
Cost of CO ($/t)	520	1	1050
Cost fuel ($)/Gallon	2.80	Min (2008-2010)	Max (2008-2010)
APEEP Emission Costs	County Specific	Lowest County Costs	Highest County Costs
Discount Rate	7%	3%	9%
Cost of Time ($)	15.5	8.25	30.0
Density (HH/acre)	12	100	6
Remediation Cost ($/acre)	190,000	24,000	550,000



Net Present Value—Best Case Scenario—Remediation $24,000/Acre, Density 100 HH/Acre
Net Present Value—Worst Case Scenario—Remediation $550,000/Acre, Density 6 HH/Acre



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Brownfield vs. Other VMT Reduction Strategies

Strategy	Cost Effectiveness: Implementation Cost ($/tonne CO_2e)	Cost Effectiveness: Net Included Benefit ($/tonne CO_2e)
This Study	14-16	260-750
VMT Fee	20-280	650-910
Pay As You Drive Insurance	30-90	920-960
Congestion Pricing	300-500	440-570
Cordon Pricing	500-700	530-640
Transit	1200-3000	(1000)-900
Non-Motorized Modes	80-210	600-700
Land Use	10	700-800
Tele-Working	1200-2300	180

Source: Department of Transportation, Report to Congress, April 2010

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In Summary…

- Brownfield Developments generate less VMT:
  - Shorter distances to city centers result in shorter distance/trip especially for commuters
  - Fewer trips, possibly due to better accessibility to transit
- Total cost of driving for Brownfield developments lower than for Greenfield developments
- Cost savings from Brownfield developments offset initial remediation costs in a short period of time (assuming median remediation cost and density)
- Brownfield developments can be a cost-effective strategy to reduce VMT in long term (depending on the nature of the stakeholders)

Stakeholders' Benefits and Costs of Brownfield Redevelopment

Who?	Potential Benefits	Potential Costs
Local Residents	Reduced Health Risks - Increased Home Values- Reduced Crime Rate	Increased Tax - Noise - Congestion
Brownfield Residents	Saved Time - Saved Fuel - Improved Health	Safety Concerns - Lower Quality of School
Developers	Existing Infrastructure - Zoning Differentiation - Funds and Subsidies	Remediation Cost - Timing Issues - Liability Concerns
Society at Large	Improved Health - Reduced Emission	Tax
The City	Property Tax - Employment Opportunities - Other Income	★
Government	Achieving Emission Reduction Goals - Various Fees	Funding - Subsidies
Transportation Authorities	Achieving VMT Reduction Goals - Increasing Cost Effectiveness of Transit	★

Policy Implications

Quantitative results should encourage MPOs, DOTs and transportation policy makers to consider Brownfield redevelopments as a VMT reduction strategy:

- Provide incentives and funding to other stakeholders
- Cooperate with other agencies such as EPA to select sites that would result in more VMT reduction (i.e. proximity to transit)
- Guide and provide incentives to developers and planners to implement smart growth principles (i.e. diversity and interconnectivity)
- Facilitate and encourage cooperation between agencies on a federal, state and local levels to work at cross purposes

Acknowledgments

- Dr. Chris Hendrickson, Dr. Scott Matthews, Dr. Deborah Lange
- Green Design Reading Group
- Steinbrenner Institute
- NSF Grant No. 0755672
- U.S. EPA Brownfield Training and Technical Assistance Grant
- The Southwestern Pennsylvania Commission
- Chicago Metropolitan Agency for Planning
- Baltimore Metropolitan Council
- Minneapolis Metropolitan Council

25

Thank You

Questions & Comments

26

Outstanding Issue – Future Work

- Expansion of the analysis to include more sites and especially those that will help with the combination of VMT reduction strategies
- Expansion of the analysis to include other aspects of Brownfield Developments including commercial and retail facilities
- Including congestion and transit environmental costs

27

Liability Issues

- Small Business Liability Relief and Brownfields Revitalization Act - mostly for Superfunds (2002)
- Economic Development Agency, Fiduciary and Lender Environmental Liability Protection Act (1995- Pennsylvania)
- Ohio and Illinois

28

The Paradox of Intensification

Ceteris paribus, urban intensification which increases population density will reduce per capita car use, with benefits to the global environment, but will also increase concentrations of motor traffic, worsening the local environment in those locations where it occurs.

Source: http://en.wikipedia.org/wiki/Compact_City

29

Remediation Cost Based on Various Documentations

Study	Remediation Cost ($/acre)	Note
Chicago 2003	25,000-530,000	Various Projects
Auld 2010	580,000	Pittsburgh
Lehr 2004	250,000-500,000	Capping
CUED 1999	57,000	-
R.S. Mean 2010	45,000	Capping (18")
Terry 1999	22,000	Phytostabilization
Terry 1999	56,000	Soil Capping
Terry 1999	65,000	Asphalt Capping

30

Brownfield and Greenfield Developments' Travel Pattern Comparisons

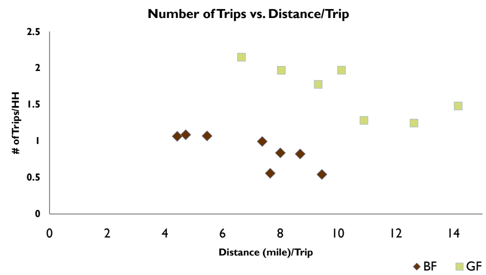
HBW

Type	Average VMT (mile/HH)	Average Distance (miles/trip)	Average # of Trips/HH
Brownfield (BF)	6.0	7.0	0.9
Greenfield (GF)	15.0	11.0	1.7
National	12.0	13.0	1.0
Reduction (GF to BF)	60%	36%	47%

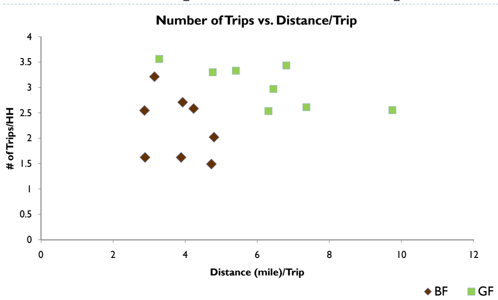
HBNW

Type	Average VMT (mile/HH)	Average Distance (miles/trip)	Average # of Trips/HH
Brownfield (BF)	11.0	4.2	2.5
Greenfield (GF)	19.0	6.3	3.0
National	25.0	9.5	3.0
Reduction (GF to BF)	42%	33%	17%

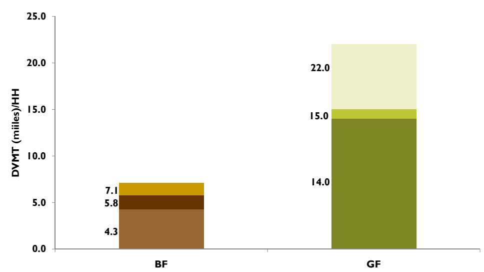
HBW Auto Trips – BF & GF Comparison



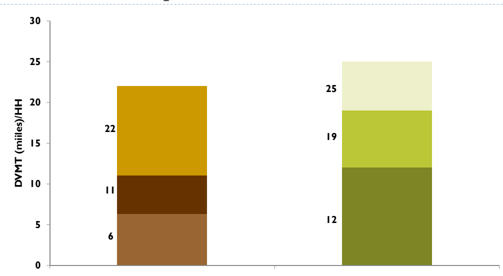
HBNW Auto Trips – BF & GF Comparison



DVMT/HH Range Comparison – BF & GF – HBW Auto Trips



DVMT/HH Range Comparison – BF & GF – HBNW Auto Trips



Comparison of Direct & Indirect Average Daily Costs/HH between Brownfield & Greenfield Sites

	Average Direct Costs ($/Day)		Average Indirect External Environmental Costs ($/Day)							
Area	Time	Fuel	CO_2	NO_x	VOC	CO	SO_2	PM	NH_3	Total
Brownfield (BF)	5.0	1.1	0.1	0.06	0.2	0.2	0.002	0.02	0.4	0.9
Greenfield (GF)	12.0	2.8	0.3	0.09	0.5	0.3	0.005	0.06	1.4	2.6
% Reduction (GF to BF)	60	60	60	40	70	40	60	70	75	67

Sources of Ammonia Emissions:

Agriculture is by far the biggest source of ammonia emissions.

Livestock farming and animal waste account for the biggest percentage of total ammonia emissions which are due to the decomposition of urea from large animal wastes and uric acid from poultry wastes.

Livestock – contributes more than 50% of all emissions

Fertilizer application

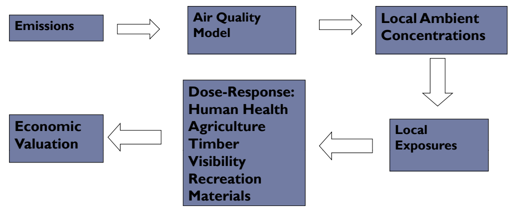
Oceans

Vegetation

Biomass burning

Source: http://www.tropical-rainforest-animals.com/Air-Pollutants.html

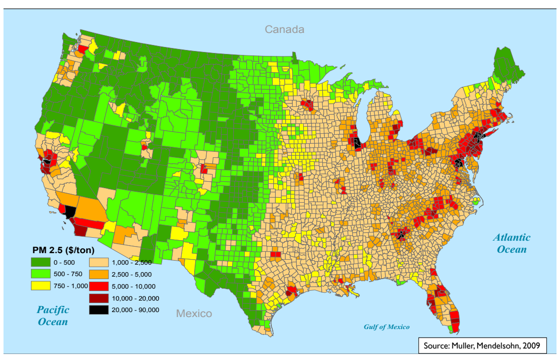
Non-Climate Damages via Air Pollution Emissions Experiments and Policy Analysis Model (APEEP)



Uses NEI - All emissions of NH_3, $PM_{2.5}$, PM_{10}, SO_2, NO_x, VOC in the contiguous U.S.

Source: *National Research Council Report , Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*
Presentation by Dr. Jared Cohon and Dr. Scott Matthews, Carnegie Mellon University, Departments of Civil & Environmental Engineering / Engineering & Public Policy

APEEP Marginal Damages ($/ton): $PM_{2.5}$ Area Sources



Source: Muller, Mendelsohn, 2009

VMT Reduction – Other Strategies

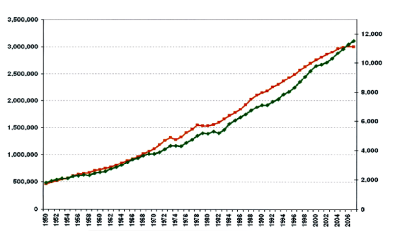
Strategy	Typical Reduction %*
Commute Trip Reduction Programs	10-30%
Congestion Pricing	10-20%
Pay as you Drive	10-12%
Transit and Rideshare Improvements	10-30%
Walking and Cycling Improvements	5-15%

**Transportation Emission Reduction Strategies, Todd Litman, July 2010*

Correlation does not prove causation!

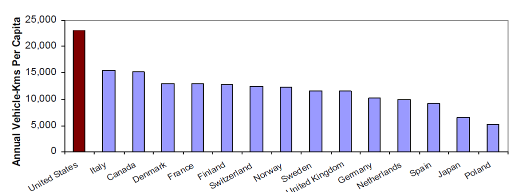
Vehicle Miles Traveled (VMT) and Gross Domestic Product (GDP) are extremely closely correlated:

Since 1950, the cumulative correlation rate between VMT and Real GDP, calculated using Pearson's R, is .9946. This is an extraordinarily strong correlation even when calculating the R-square value of 98.9% which indicates the predictive value between the two variables (VMT or GDP).



Source: HUA 2009

Per Capita Annual Vehicle Travel Per Country



Wealthy countries such as Switzerland, Norway and Sweden drive half as much as U.S. due to policies and planning practices that increases transport system efficiency!

Source: OECD 2009

Typical Steps in the Redevelopment Process

Source: Anatomy of Brownfield Redevelopment, EPA 2006

Mode Share Depending on Distance from Public Transit Stop

	From station: home distance/work distance Subgroups 3C 1 mi/1mi (%)	 2B 0.5 mi/0.5 mi (%)	 1A 0.25 mi/0.25 mi (%)
Walk	6	8	9
Bike	3	4	3
POV	58	45	40
CTA/Pace Bus	8	10	9
CTA Train	11	17	27
Metra Train	10	12	9
Other	4	4	3

Source: Relationship between proximity to transit and ridership for journey-to-work trips in Chicago
Marshall Lindsey, Joseph L. Schofer, Pablo Durango-Cohen, Kimberly A. Gray
Transportation Research Part A, July 2010

Sample Calculations

$$FU_{(a)} = (FE_i * DVMT_{i(a)}) + (FE_j * DVMT_{j(a)})$$
$$FC_{(a)} = (FU_{(a)} * P)/C$$

$FU_{(a)}$ = Fuel use for site a (MJ/day);
FE = Fuel energy (MJ/Mile);
$FC_{(a)}$ = Fuel cost for site a ($/day);
P = Price of gas ($2.8/gallon);
C = 121.3 MJ/gallon of gasoline
$DVMT_{(a)}$ = Daily vehicle miles traveled for site a (mile/day);
i and j represent freeway and arterial respectively.

$$C_{i(a)} = DVMT_{(a)} * EF_i * C_i$$

$C_{i(a)}$ = Cost of pollutant i for development a ($/day);
$DVMT_{(a)}$ = Daily vehicle miles traveled for development a (mile/day);
EF_i = Emission factor for pollutant i (gram/mile); and
C_i = Cost factor for pollutant i ($/1000gram).

Direct Cost

$$FU_{(a)} = (FE_i * DVMT_{i(a)}) + (FE_j * DVMT_{j(a)})$$
$$FC_{(a)} = FU_{(a)} * P$$

Where:
- $FU_{(a)}$: Fuel use for site a (MJ/day);
- FE: Fuel energy (MJ/Mile);
- $FC_{(a)}$: Fuel cost for site a ($/day);
- P: Price of gas ($2.8/gallon);
- $DVMT_{(a)}$: Daily vehicle miles traveled for site a (mile/day); and
- i and j represent freeway and arterial respectively.

External Environmental Cost

$$C_{i(a)} = DVMT_{(a)} * EF_i * C_i$$

Where:
- $C_{i(a)}$: Cost of pollutant i for development a ($/day);
- $DVMT_{(a)}$: Daily vehicle miles traveled for development a (mile/day);
- EF_i: Emission factor for pollutant i (gr/mile); and
- C_i: Cost factor for pollutant i ($/kg).

Strategies to Reduce Greenhouse Gas Emissions of Transportation Sector

- Type of Fuel (Low–Carbon)
- Fuel Economy (Increase)
- Improving Transportation Efficiency (Management and Operations)
- Reducing Travel Activity (Vehicle Miles Traveled)

Components

- Site Selection Criteria:
  - Metropolitan Areas
  - Relatively Large Developments
  - Developed in the Past 20 Years
  - At Least 100 Housing Units
- Residential Developments Only
- 2010 TDM Models
- Only Automobile Trips
- Arterial vs. Freeway Miles: TTI Urban Mobility Report (2009)
- Speed: Freeways (65mph); Arterials (35mph)
- Distances are based on shortest paths.

Strategy	Key Assumptions	Cost Effectiveness Implementation Cost ($/tonne CO_2e)	Net Included Cost ($/ tonne CO_2e)
This Study	Explained throughout this presentation	14-16	260-750
VMT Fee	VMT fee of 2 to 5 cents per mile	20-280	650-910
Pay As You Drive Insurance	Require states to permit PAYD insurance (low)/Require companies to offer (high)	30-90	920-960
Congestion Pricing	Maintain level of service D on all roads (average fee of 65 cents/mile applied to 29 percent of urban and 7 percent of rural VMT)	300-500	440-570
Cordon Pricing	Cordon charge on all U.S. metro area CBDs (average fee of 65 cents/mile)	500-700	530-640
Transit	2.4-4.6% annual increase in service; increased load factors	1200-3000	(1000)-900
Non-Motorized Modes	Comprehensive urban pedestrian and bicycle improvements implemented	80-210	600-700
Land Use	60-90% of new urban growth in compact, walkable neighborhoods (4,000+ persons/sq mi or 5+ gross units/acre)	10	700-800
Tele-Working	Doubling of current levels	1200-2300	180

Travel Demand Models

- Step 1 • Trip Generation
- Step 2 • Trip Distribution
- Step 3 • Mode Choice
- Step 4 • Assignment

Comparison of VMT and GHG Reductions with Various Studies

Study	Geographic Area	Type of Land-Use	Average Reduction in VMT	Range of Reduction in VMT	Range of Reduction in GHG & Air Pollutants
This Study	Baltimore, Pittsburgh, Chicago, Minneapolis	Brownfield	52%	38% - 63%	35%- 75%
EPA 2010a	Seattle, Minneapolis, St. Paul, Emeryville, Baltimore, Dallas	Brownfield	47%	32% - 57%	32% - 57%
EPA 2001a, EPA 2002, EPA 1999, NRDC 2003, Schroeer 1999, IEC 2003	12 cities: Atlanta, Baltimore, Boston, Charlotte, Denver, Dallas, Nashville, Sacramento, San Diego, Montgomery, Wes Palm Beach, BCD	Brownfield	61%	39% - 81%	-
US Conference of Mayors (USCM), 2001	Baltimore and Dallas	Brownfield	-	23% - 55%	36%-87%
EPA 2006	Atlantic Station, Atlanta	Brownfield	73%	14%-52%	-
CSI 2009,	U.S.	Compact	40%	20%-60%	20%-60%
NCR 2010	U.S.	Compact	-	5%-25%	5%-25%
Ewing 2008,	U.S.	Compact	30%	20%-40%	18%-36%

Travel Time Comparisons with National Averages – Auto Only

	TAZ Based		Census Based*		Survey Based **		NHTS 2009
	BF	GF	BF	GF	BF	GF	
HBW Travel Time (min)	12.0	16.0	20.0	24.0	15.0	17.0	24.0
HBNW Travel Time (min)	19.0	26.0	-	-	-	-	18.0

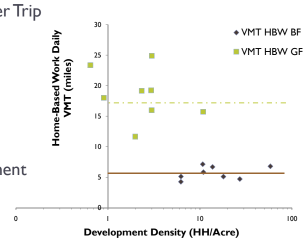
**Commuting from US Brownfield and Greenfield Residential Development Neighborhoods, Amy Nagengast, Chris Hendrickson and Deborah Lange*
***A Life Cycle Assessment Case Study of a Brownfield and a Greenfield Development: Cranberry Heights and Summerset Pennsylvania, Ronell Auld, Chris Hendrickson, and Deborah Lange*

Brownfield Sites - Facts

- 450,000 Brownfield sites in the U.S.
- Abandoned or underutilized
- Desirable real estate resources from social perspective:
  - Increase jobs
  - Improve tax base
  - Impact land value positively
  - Improve health

Contributing Factors to VMT Reductions

- Distance to City Center:
  - Shorter Distances per Trip
  - Fewer Trips
- Design:
  - Walkability
  - Access to Transit
- Diversity:
  - Mixed-use Development
- Density:
  - High vs. Low



55

APPENDIX G

PDC'S PROPERTY PROFILE

Complete on per property - fill in as much information as possible.

GENERAL INFORMATION Date: ____________________

Name and title of person completing the profile: ____________________

Name of organization: ____________________

Address: ____________________ Phone number: ____________________

E-mail: ____________________

PROPERTY OWNER

Name of site (if applicable): ____________________

Address: Street: ____________________

City: ____________________ Zip: ____________________

County: ____________________ E-mail: ____________________

Is the owner open to redevelopment options? Yes___ No___ Not sure___

SITE INFORMATION

Name of site (if applicable): ____________________

Address: Street: ____________________

City: ____________________ Zip ____________________

County ____________________

Municipality: ____________________

Tax parcel ID# ____________________ Tax millage rate: ____________________

Are there any tax liens currently on the property? Yes___ No___ Not sure___