# Health Impact Considerations: Brownfield Redevelopment

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# Making a (Public) Health Case for Reclaiming Brownfields

- Definitions: Regulatory Levels, Exposure Risk
- Washington County's Dirty Dozen Pollutants
- Health Risks from Environmental Contaminants
- Effect of Exposure Examples
- Washington County 2015 Community Health Assessment
- Cost of Exposure Examples
- Benefit of Redevelopment
  - From dealing with contaminants
  - From the redevelopment itself

# Where Health Impacts Originate

- Contaminants at redevelopment site
  - Children, animals investigate or play on empty spaces
- Effects from cleaning up and building at site
  - Stir up dust, track soil around, noisy
- Effects from choice of redevelopment
  - <u>These effects may be indirect</u>
    - Compact urban area reduces traffic driving distance which reduces air pollution
  - Positives – place to live or work, park or sports field, improved livability of surrounding areas

# Regulatory Levels

- EPA and DNR are aware that a balance must be found between exposure risks and economic reality
- Set at very conservative levels
- Vulnerable populations – children, elderly, pregnant or breastfeeding, immune compromised, chronic illness
- Not a sharp break as in "safe below" vs "hazardous above"
- EPA considers a substance a carcinogen if it is calculated to present a cancer risk of 1 case per 1 million population

# Cautions

- Just because you didn't test for it doesn't mean it isn't there…
  - …but if you get rid of the bad actors, you've gotten rid of the rest
- Just because you can see it doesn't mean you are exposed…
  - …you have to breathe it, eat it or get it on your skin, and…
  - …even then, your body has to be able to absorb it.

# Exposure Risk

- Compound and person must come in contact
- Compound must be absorbed by the body
  - All living things have internal processes to deal with toxins (enzyme pathways)
  - Certain man-made chemicals are activated and made toxic by those pathways
- Compound must reach the sensitive organ, tissues, or cells
- Compound must disrupt a key reaction or process

# Three Redevelopment Sites

- Germantown: Saxony Village
- Hartford: Northern Bookends
- Slinger: E. H. Wolf & Sons
- Common features
  - Bordered by active railroad track
  - Prior use as storage depot (petroleum, coal, ag chemicals, etc.), feed mill
  - Similar contaminants found at all three sites
    - Metals (lead, arsenic)
    - Petroleum hydrocarbons

# Washington County "Dirty Dozen"

- Arsenic
- Lead
- Benzo[a]pyrene (PAHs)
- Benzene (VOCs)
- Aroclor – 1254 (PCB)
- Aroclor – 1260 (PCB)

PAH – polycyclic aromatic hydrocarbon
VOC – volatile organic compound
PCB – polychlorinated biphenyl

- Tetrachloroethylene (PCE)
- Trichloroethylene (TCE)
- *Cis*-1,2-Dichloroethylene (DCE)
- Vinyl Chloride (VC)
- Asbestos (chrysotile, "white")
- Methane (explosion hazard)

# Dirty Dozen Health Effects

- Arsenic – Carcinogen
- Lead – Neurotoxin
- PAHs – Benzo[a]pyrene – Endocrine Disruption
- VOCs – Benzene – Anemia, Bone Marrow Carcinogen
- Chlorinated hydrocarbons – Auto-immune Conditions
- PCBs – Aroclors – Liver Damage, Neuro-behavioral Deficits
- Methane (explosion) – Physical Trauma

# (Dis)-Honorable Mentions

- Didn't make the Dozen, but still a hazard…

- Cyanide compounds
  - Sodium/potassium salts exposed to moisture in air can release minute amounts of hydrogen cyanide, exposed to acids produce considerable HCN
- Old pesticides (organophosphate/organochlorine)
- Priority Metals (other than lead & arsenic): antimony, beryllium, cadmium, chromium, copper, nickel, selenium, silver, thallium, zinc

# Health Risks

- Immediate toxic effects are rare
  - Would need to eat several pounds of contaminated soil daily to reach levels used in initial toxicity testing with lab animals
  - Exception – cyanide salts, strong acids or bases, or releases ammonia, chlorine or fluorine when exposed to air or moisture
- High-dose inhalation or ingestion signs often non-specific
  - Headache, eye/throat irritation, confusion, drowsiness, dizziness, nausea, rapid heartbeat, tremors, convulsions, death
- Combinations of contaminants can enhance each others' effects
  - Lead + arsenic, lead + cadmium, PAHs + lead

# Health Risks from Long-Term Exposure

- Non-cancer
  - Developmental (baby in womb)
  - Neurological
    - Balance, sensation, muscle control
    - Behavior, learning ability, IQ
  - Endocrine (hormonal) disruption
    - Thyroid
    - Male and female reproductive
      - Estrogen
      - Testosterone
- Cancer related
  - Mutation (genetic)
  - Reading error (epigenetic)
  - Promotion (makes abnormal cells grow faster)

# Thinking ahead

- If it's not going to poison me, why worry about it?
- "In every deliberation, we must consider the impact on the seventh generation... even if it requires having skin as thick as the bark of a pine."
  - Paraphrased from Constitution of the Iroquois Confederacy

# Current state of science

- The danger of low-level environmental exposure is that people don't realize it is happening or has happened.
- Their descendants will be the ones affected
  - The effect appears as soon as the next generation, and sometimes not until the fourth generation.

# Effect of Exposure: Arsenic and the Human Body

- Skin – darkening, corn/callus type growths, loss of pigment
- Developmental – increased infant death, low birth weight, children exposed during mother's pregnancy prone to more severe or earlier-occurring lung disease, cardiovascular disease and cancers
- Nervous system – impaired intellectual function, motor function, neuropathy
- Respiratory – bronchiectasis, increased tuberculosis deaths
- Cardiovascular – coronary and ischemic heart disease, high blood pressure
- Immune – inflammation, frequent childhood illness
- Endocrine – diabetes, thyroid disruption, impaired glucose tolerance (preg)
- Cancer – lung, skin, liver, kidney, bladder

# Effect of Exposure: PCBs

- Reduced Intellectual Capacity in Children Exposed *in utero*
  - IQ deficit of 6.2 points in highest-exposure group
  - Reduction similar to blood lead levels of 1-30 mcg/dL in exposed children
  - No gross intellectual impairment except for one child with mental retardation
  - Notably six to twelve months behind peers in reading and verbal comprehension
  - Mothers were members of a Michigan study group looking at effects of consuming PCB-contaminated Lake Michigan sport fish


- Jacobson JL and Jacobson SW (1996). **Intellectual Impairment in Children Exposed to Polychlorinated Biphenyls *in utero***. *N Engl J Med* 335: 783-789.

# Washington County Community Health Assessment

- Environmental factors tracked by Washington Ozaukee Public Health Dept

- Air Quality (2015)
  - Average daily measure of fine particulates ($PM_{2.5}$) (micrograms/cubic meter)
    - County – 12.0 State – 11.5 National Benchmark – 9.5
  - 2.5 mcg/$m^3$ particulates reach the deepest parts of the lungs (alveoli) where oxygen/carbon dioxide exchange takes place

- Childhood Blood Lead Levels (2016)
  - 771 children tested, 21 with BLL over 5 mcg/dL (2.72% of tested children)

# Cost of Exposure: Lead & Cognition

- **Estimated costs of pediatric lead poisoning, United States, 1997.**
- Environmentally Attributable Fraction = 100%
- Main consequence = Loss of IQ over lifetime

- Mean blood lead level in 1997 among 5-year-old children = 2.7 µg/dL
- A blood lead level of 1 µg/dL = Mean loss of 0.25 IQ points per child
- Therefore, 2.7 µg/dL = Mean loss of 0.675 IQ points per child
- Loss of 1 IQ point = Loss of lifetime earnings of 2.39%
- Therefore, loss of 0.675 IQ points = Loss of 1.61% of lifetime earnings

- Economic consequences
- For boys: loss of 1.61% · $881,027 (lifetime earnings) · 1,960,200 = $27.8 billion
- For girls: loss of 1.61% · $519,631 (lifetime earnings) · 1,869,800 = $15.6 billion
- Total costs of pediatric lead poisoning = $43.4 billion

# Cost of Neurobehavioral Disorders

**Estimated costs, neurobehavioral disorders of environmental origin, United States, 1997,**

| Lifetime costs per case of developmental disabilities | Mental retardation | Autism | Cerebral palsy |
|---|---|---|---|
| Physician visits | $17,127 | — | $32,844 |
| Prescription drugs | $3,121 | — | $3,526 |
| Hospitalization | $26,434 | $4,437 | $17,335 |
| Assistive devices | $2,725 | $116 | $2,704 |
| Therapy and rehabilitation | $11,577 | $1,685 | $14,421 |
| Long-term care | $83,923 | $32,846 | $4,365 |
| Home and auto modifications | $810 | $571 | $1,847 |
| Special education services | $64,107 | $72,399 | $51,182 |
| Home care | $907,742 | $1,024,237 | $882,932 |
| Productivity losses due to morbidity | $563,869 | $472,740 | $467,753 |
| Total lifetime costs per case | $1,680,000 | $1,609,000 | $1,479,000 |
| Annual incident cases | 44,190 | 4,698 | 11,614 |
| Annual incident cases not attributable to lead | 43,085 | 4,698 | 11,614 |
| Total costs per annual cohort | $72.4 billion | $7.6 billion | $17.2 billion |
| Downward adjustment of costs for autism and cerebral palsy to account for co-existing mental retardation — | $72.4 billion (0) | $5.0 billion (–34%) | $14.6 billion (–15%) |
| Total environmentally attributable costs of neurobehavioral disorders | $9.2 billion (range $4.6–18.4 billion) | | |

# Cost of exposure: Lead Relationship to Crime


- Childhood lead exposure before 2 years of age is the most damaging to the brain
- Calculation using average blood lead level, number of children born in a year and crime statistics from one year allowed researcher to estimate the number and cost of criminal activities that can be traced to childhood lead exposure.
- Switch to unleaded gasoline preceded an overall reduction in crimes 20 years later
- Major exposure now comes from lead-based paint dust, lead water service lines, and lead contaminated soil.

# Cost of Exposure: Lead Connection with Crime

- **Lead and crime, United States, 2009.**

| Crime | All crimes per 100,000 residents (no.)*a* | Lead-linked crimes per100,000 residents (no.)*b* | Total lead linked crimes (no.) | Direct costs per crime ($)c | Total direct costs ($)c |
|---|---|---|---|---|---|
| Burglaries | 1335.7 | 38.7 | 116,541 | 4,010 | 467,329,410 |
| Robberies | 213.7 | 0.83 | 2,499 | 22,871 | 57,154,379 |
| Aggravated assaults | 352.9 | 17.9 | 53,904 | 20,363 | 1,097,628,286 |
| Rape | 37.6 | 1.39 | 4,186 | 28,415 | 118,945,567 |
| Murder | 8.3 | 0.238 | 717 | 31,110 | 22,305,512 |
| Totals | | | 177,847 | | 1,763,363,153 |

- ***a***Calculated using crime incidence data from the Federal Bureau of Investigation (2006).
- ***b***Data from Nevin (2006). ***c***Data from the Bureau of Justice Statistics (2004); inflated to 2006 USD.

# Cost of Exposure: Air Pollution Particulates & Asthma

**Estimated costs of pediatric asthma of environmental origin, United States, 1997.**

- Medical costs — U.S. dollars
- Hospital care
  - Inpatient — 634 million
  - Emergency room — 323 million
  - Outpatient — 154 million
- Physicians' services
  - Inpatient — 54 million
  - Outpatient — 625 million
- Medications — 2.81 billion
- Subtotal: medical costs — 4.6 billion

- Indirect Costs — U. S. dollars
- School days lost — 1.78 billion
- Premature deaths — 193 million
- Subtotal: indirect costs — 2.0 billion
- Total costs of pediatric asthma — 6.6 billion
- EAF 30% (range 10–35%)
- Environmentally attributable — 2.0 billion

- Total costs of pediatric asthma (range $0.7–2.3 billion)

# Cost of Exposure: Air Pollution Particulates & Preterm Birth

- **2010 data, Lower-48 United States**
- Total Births – 3,963,694
- Preterm Births – 475,368 (12%)
- $PM_{2.5}$ Attributable Preterm Births – 15,808 (3.32%)
- Average IQ Point Reduction due to Prematurity – 11.9
- Lost Productivity - $4.33 billion
- Additional Medical Care Cost - $760 million

- **Wisconsin** –
- For each 10 mcg/$m^3$ over reference level 8.8 mcg/$m^3$ the estimated effect is
- PTBs due to air pollution - 286 (3.85%)
- Lost Lifetime Economic Productivity - $78.4 million
- Additional Medical Care Cost - $13.7 million

# Three Redevelopment Sites

- Flexibility is an Asset: Saxony Village
  - Large area, but main contaminant hazard localized to small area
  - Re-orient planned development to avoid digging up contaminant
- Complexity in a Small Space: Northern Bookends
  - History of residential, commercial and industrial activities in close proximity
  - Residential and commercial redevelopment planned
- Ideal Situation: E. H. Wolf and Sons
  - Site considered an opportunity from the start
  - Site history known to be industrial, re-use also industrial
  - Proactively plan for high likelihood of contamination

# Benefit of Redevelopment: Halt Spread or Remove Contaminants

- Remediation accomplished several ways
  - Dig up and remove contaminated material
  - Cap contaminated soil (clean soil, concrete or asphalt, built structure)
  - Ventilate soil (aeration wells for volatiles)
  - Draw-off wells (change underground water flow, treat removed water)
  - *In situ* Remediation (used in groundwater) – inject chemicals and/or specific microbes to break down contaminants to non-toxic products

# Benefit of Redevelopment: Reduction of "Health Concern"

- 2016 Roanoke, VA rail corridor, survey of 200 citizens
  - Participants asked what concerns they would have for people in general living near brownfield sites
    - Greatest - Physical hazard to children, chemicals in drinking water, lead poisoning
    - Medium – Asthma, cancer, eye and skin disease
    - Moderate – Birth defects, premature birth, infant death
  - Industrial and unkempt sites automatically suspect, even if not contaminated
  - Preconceived ideas of opportunity allowed some participants to "see through" an otherwise unappealing view (run-down building, rough vegetation)


- Kim, Eujin Julia and Miller, Patrick (2016). **Residents' Perception of Local Brownfields in Rail Corridor Area in the City of Roanoke: The Effect of People's Preconception and Health Concerns Factors.** *Journal of Environmental Planning and Management* 60(5): 862-882.

# Benefit of Redevelopment: General Health in Area

- 2014 study reports "strong, significant, small-area-level (voting ward), independent association between brownfield land and morbidity (illness and long-term disability) in England."
  - Scale of 100 to represent an average proportion of brownfields and an average morbidity and mortality rate – values over 100 represent more brownfields or more illness
  - 20.2 unit increase "not good health", 13.8 unit increase in long-term illness and 23.8 unit increase in mortality for brownfield area (over 250 units) versus minimum brownfield area (under 28)
  - Correcting for socioeconomic and demographic variables, left average rates higher than expected (15.4 units "not good health" and 14.3 units long-term illness, mortality difference no longer significant)
  - "These findings suggest that In England the relative proportion of brownfield land is associated with health outcomes at ward level independently of the age, sex, and sociodemographic profiles of the areas. The association with health is independent of other measures of socioeconomic and environmental deprivation."


- Bambra, Clare, et al (2014). **Healthy Land? An Examination of the Area-Level Association Between Brownfield Land and Morbidity and Mortality in England.** *Environment and Planning A* 46: 433-454.

# References – Environmental Contaminants


- Agency for Toxic Substances and Disease Registry (www.atsdr.cdc.gov/)
  - ToxFAQs
  - Toxicological Profiles
  - Interaction Profiles
- US Environmental Protection Agency (www.epa.gov/)
- Stantec Consulting Services, Inc.
  - Phase I and II Environmental Site Assessments, Site-Specific Sampling and Analysis Plans for Washington County Redevelopment Sites

# References – Societal Costs of Contamination


- Muir, Tom and Zegarac, Mike (2001). **Societal Costs of Exposure to Toxic Substances: Economic and Health Costs of Four Case Studies that are Candidates for Environmental Causation**. *Environ Health Perspect* 109(suppl 6): 885-903.
- Landrigan, et al, (2002). **Environmental Pollutants and Disease in America's Children: Estimates of Morbidity, Mortality, and Costs for Lead Poisoning, Asthma, Cancer, and Developmental Disabilities**. *Environ Health Perspect* 110: 721-728.
- Gould, Elise (2009). **Childhood Lead Poisoning: Conservative Estimates of the Social and Economic Benefits of Lead Hazard Control**. *Environ Health Perspect* 117: 1162-1167.
- Muennig, Peter (2009). **The Social Costs of Childhood Lead Exposure in the Post-Lead Regulation Era**. *Arch Pediatr Adolesc Med* 163(9): 844-849.
- Trasande, Leonardo and Liu, Yinghua (2011). **Reducing the Staggering Costs of Environmental Disease in Children, Estimated at $76.6 Billion in 2008**. *Health Affairs* 30(5): 863-870.
- Perera, et al (2014). **Prenatal Exposure to Airborne Polycyclic Aromatic Hydrocarbons and IQ: Estimated Benefit of Pollution Reduction**. *J Public Health Policy* 35(3): 327-336.
- Attina, et al (2016). **Exposure to Endocrine-Disrupting Chemicals in the USA: a Population-Based Disease Burden and Cost Analysis**. *Lancet Diabetes Endocrinol* 4(12): 996-1003.
- Trasande, et al (2016). **Particulate Matter Exposure and Preterm Birth: Estimates of U. S. Attributable Burden and Economic Costs.** *Environ Health Perspect* 124(12): 1913-1918.