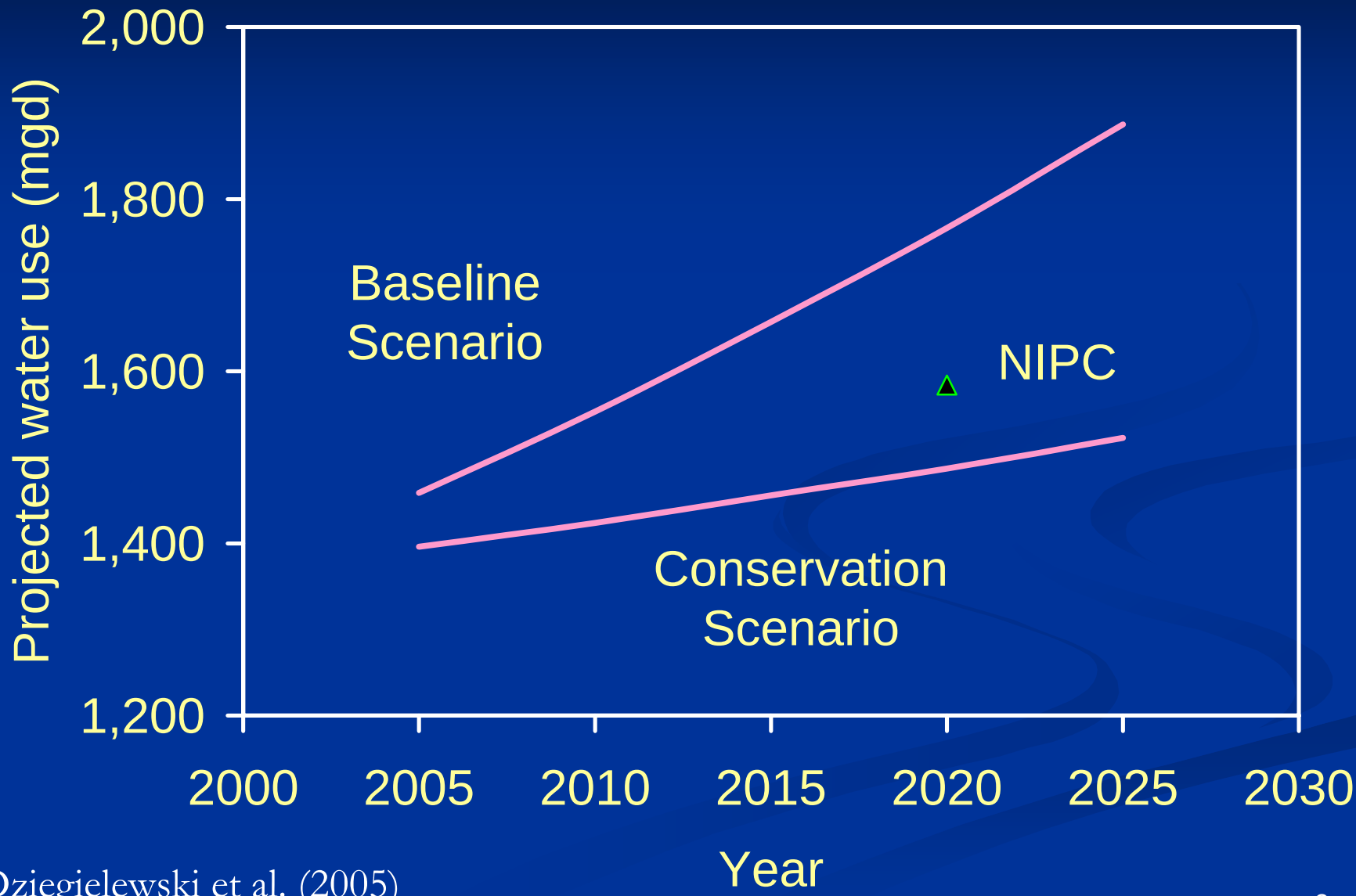
Multi-objective decision model for urban water use: Planning for a regional water reuse ordinance

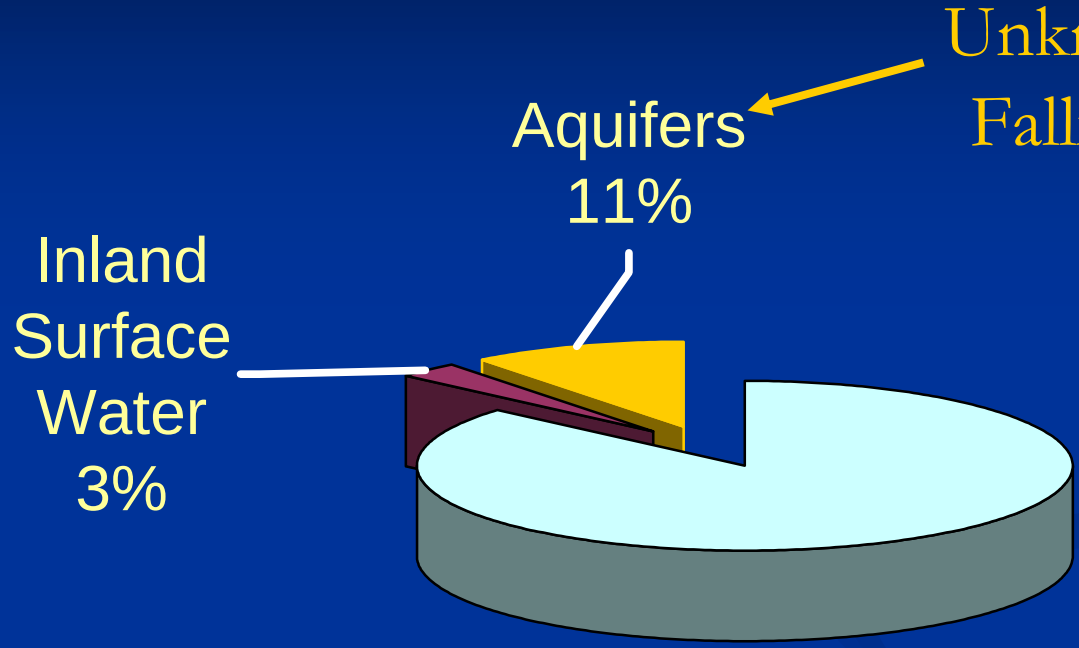
- Illinois Institute of Technology
- Illinois Waste Management Research Center
- Chicago Metropolitan Agency for Planning

NE Illinois: Growing demand for water



Dziegielewski et al. (2005)

NE Illinois: Limited water sources

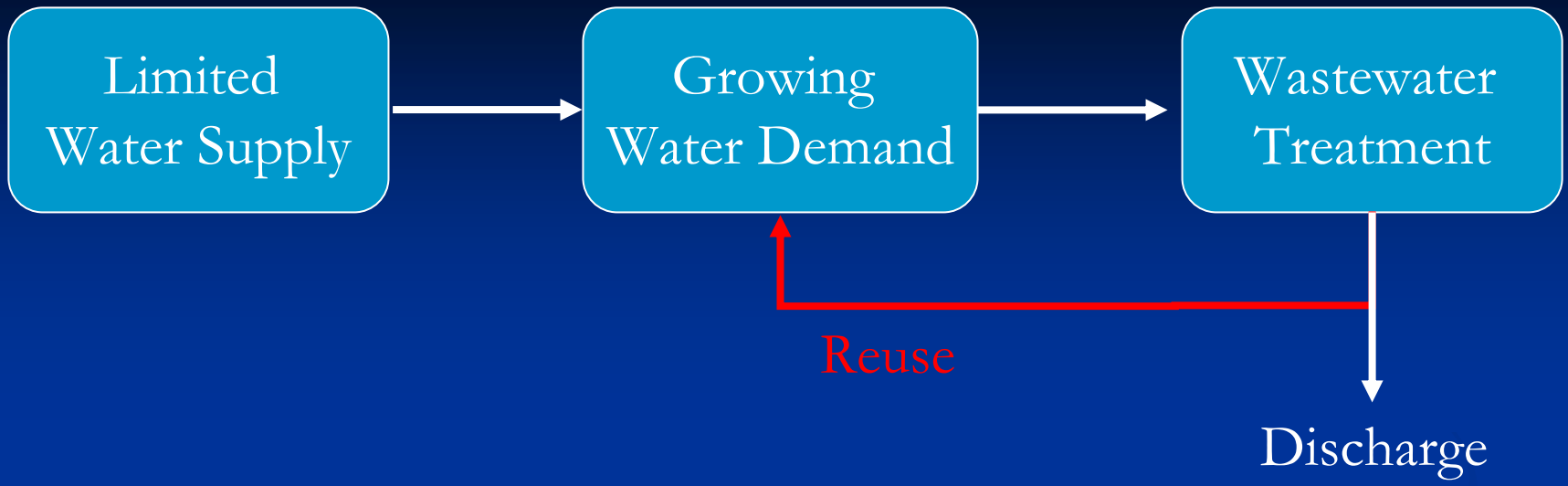


54% municipal
30% diverted runoff
16% direct diversion

Northeastern Illinois regional non-cooling water source allocation (NIPC, 2001)

Toward sustainable water resources planning

- Realize natural capital of treated wastewater
- Water reuse can be part of the solution
- Multi-objective decision model
  - Identify and balance competing issues:
    - Economics, technology, policy, regulations, human health and ecosystem risk, public perception



- Planning for water reuse
  - Identify industrial users (quality, volume)
  - Identify industrial clusters near WRP
    - Volume and location determine reuse cost
  - Minimize cost subject to constraints

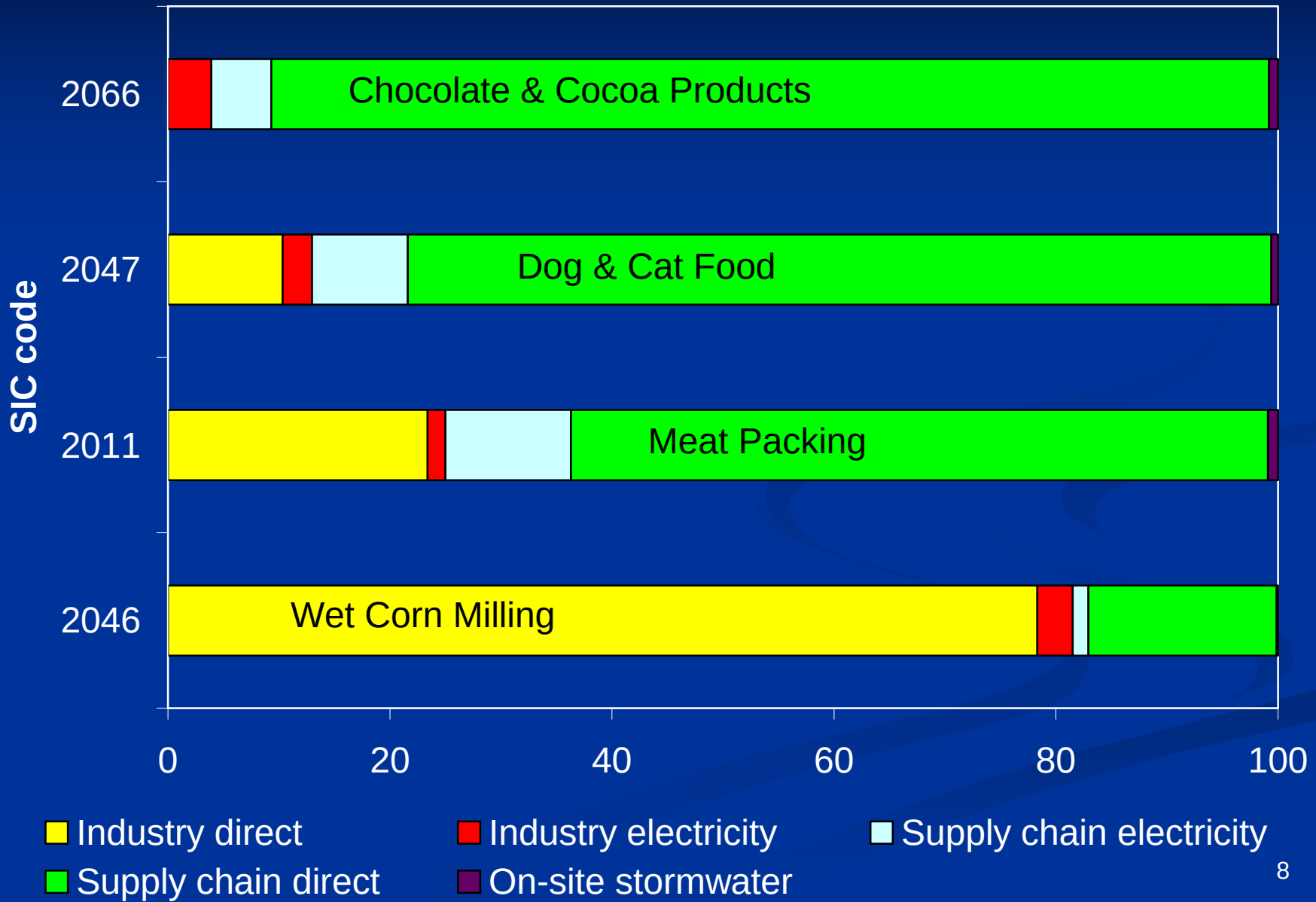
Water reuse priorities

- Industrial
  - Process/cooling
- Commercial/Domestic
  - Car wash
  - Toilet flush
  - Firefighting
- Irrigation
- Groundwater recharge
- Potable water

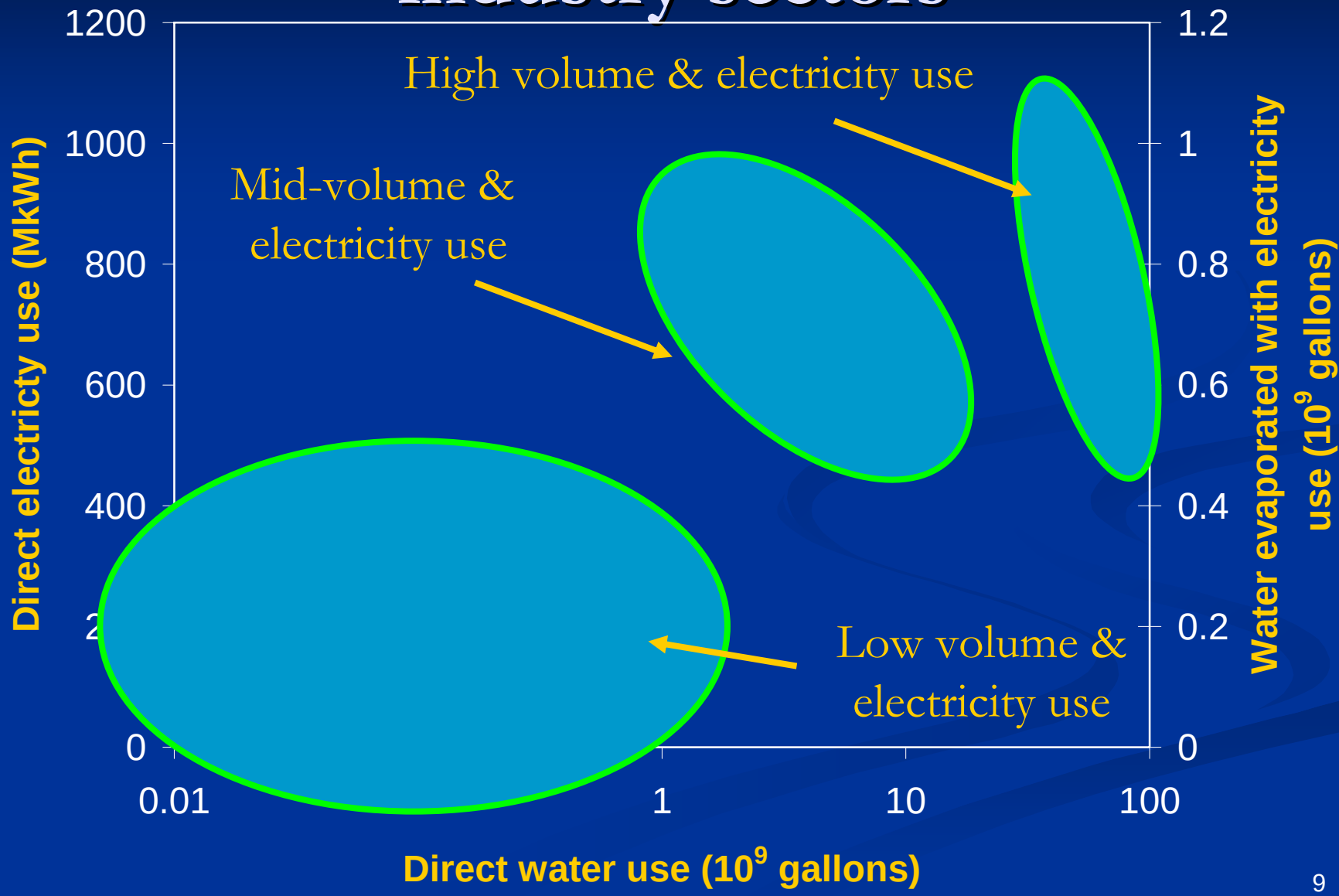
Industrial hydrologic footprints

- Measure of industry interaction with water
  - Conventional direct water use
  - Evaporative loss associated with electricity use
  - Stormwater runoff from industry property
  - Supply chain direct water use
  - Supply chain evaporative loss with electricity
- Consider 50 largest volume water dischargers
- Supply chain data from eiolca.net
- Data normalized to economic activity (gal/$)

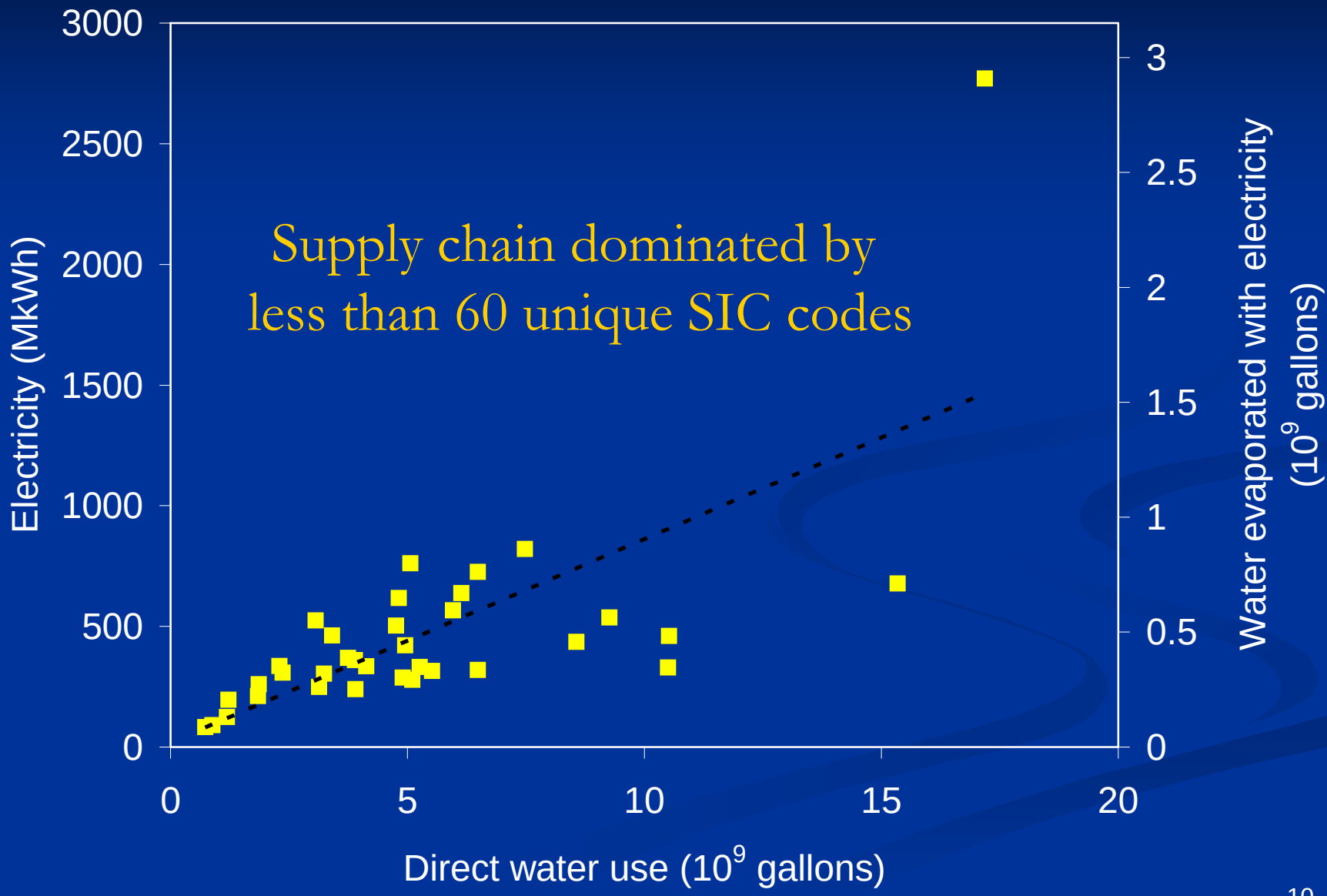
Hydrologic footprints for four SIC codes



Water & electricity use for 31 industry sectors

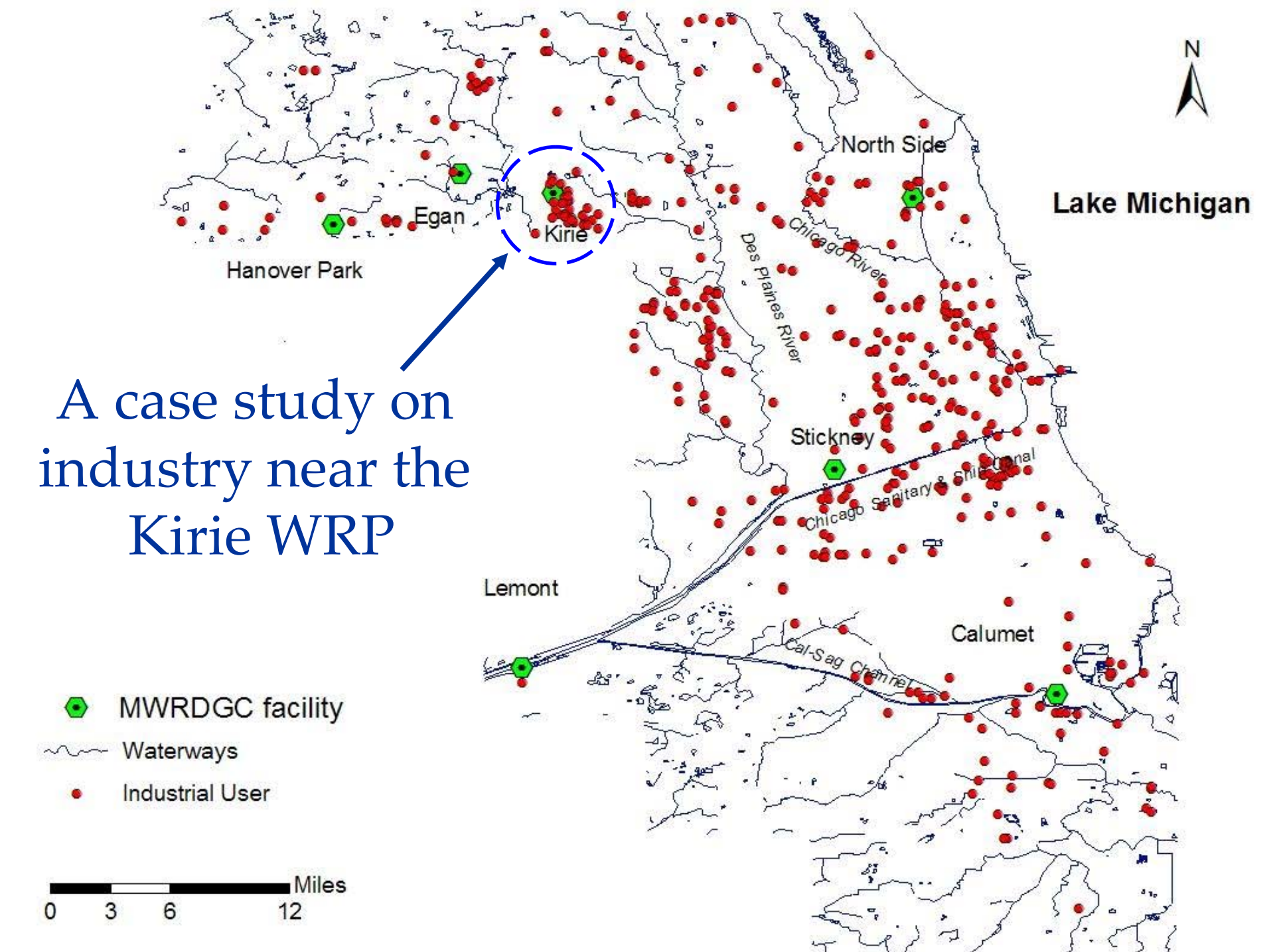


Supply chain water & electricity use



Hydrologic footprint summary

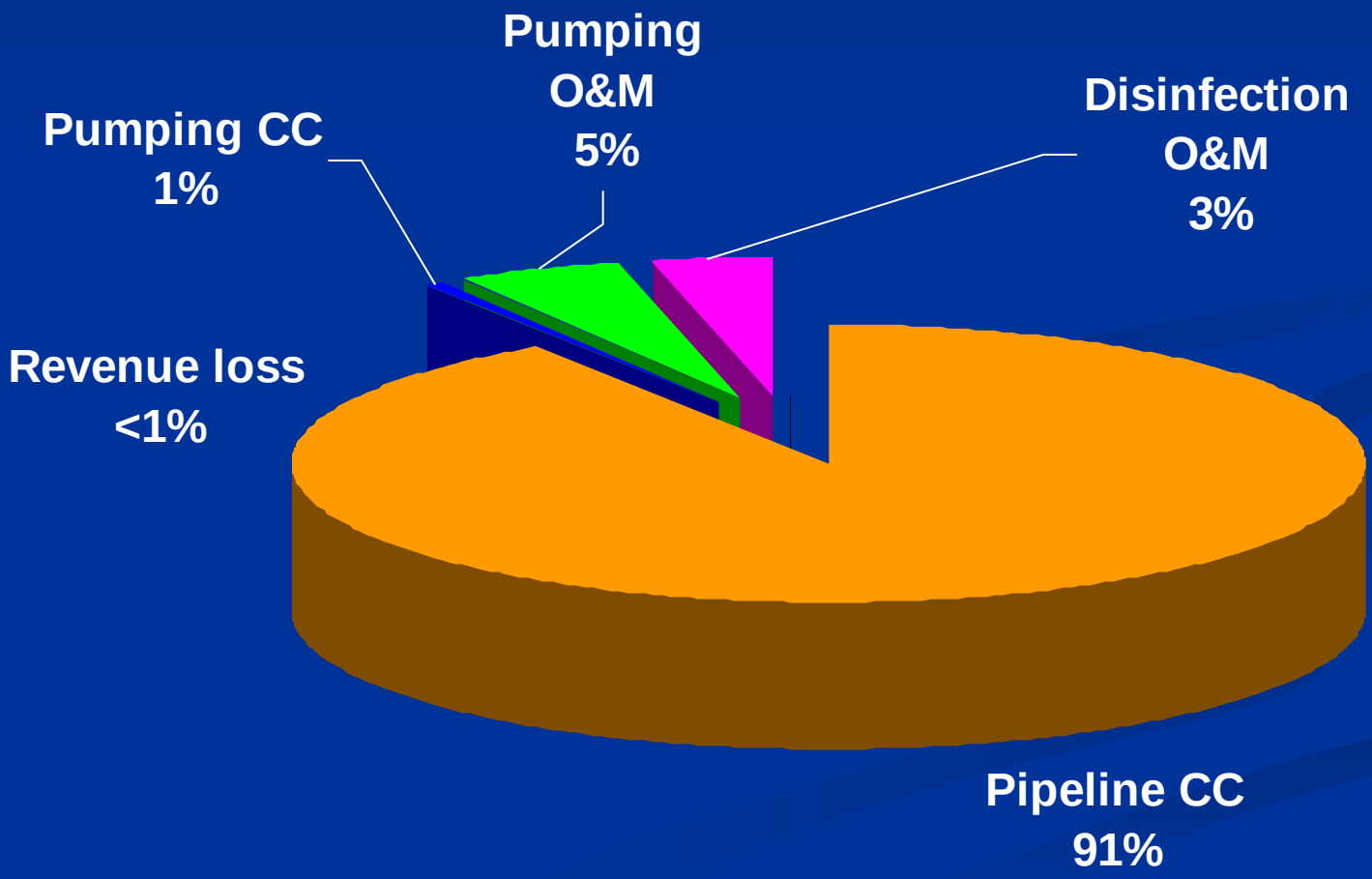
- Indirect use (stormwater, electricity) are small
- Direct use (industry or supply chain) dominates
- Supply chains are often important
- Supply chains dominated by a few industries
- 10% have relatively big footprints (gal/$)
  - Is reuse cost-effective for these industries?


A case study on industry near the Kirie WRP
N
North Side
Lake Michigan
Egan
Kirie
Hanover Park
Des Plaines River
Chicago River
Stickney
Chicago Sanitary & Ship Canal
Lemont
Calumet
Cal-Sag Channel
MWRDGC facility
Waterways
Industrial User
Miles
0
3
6
12

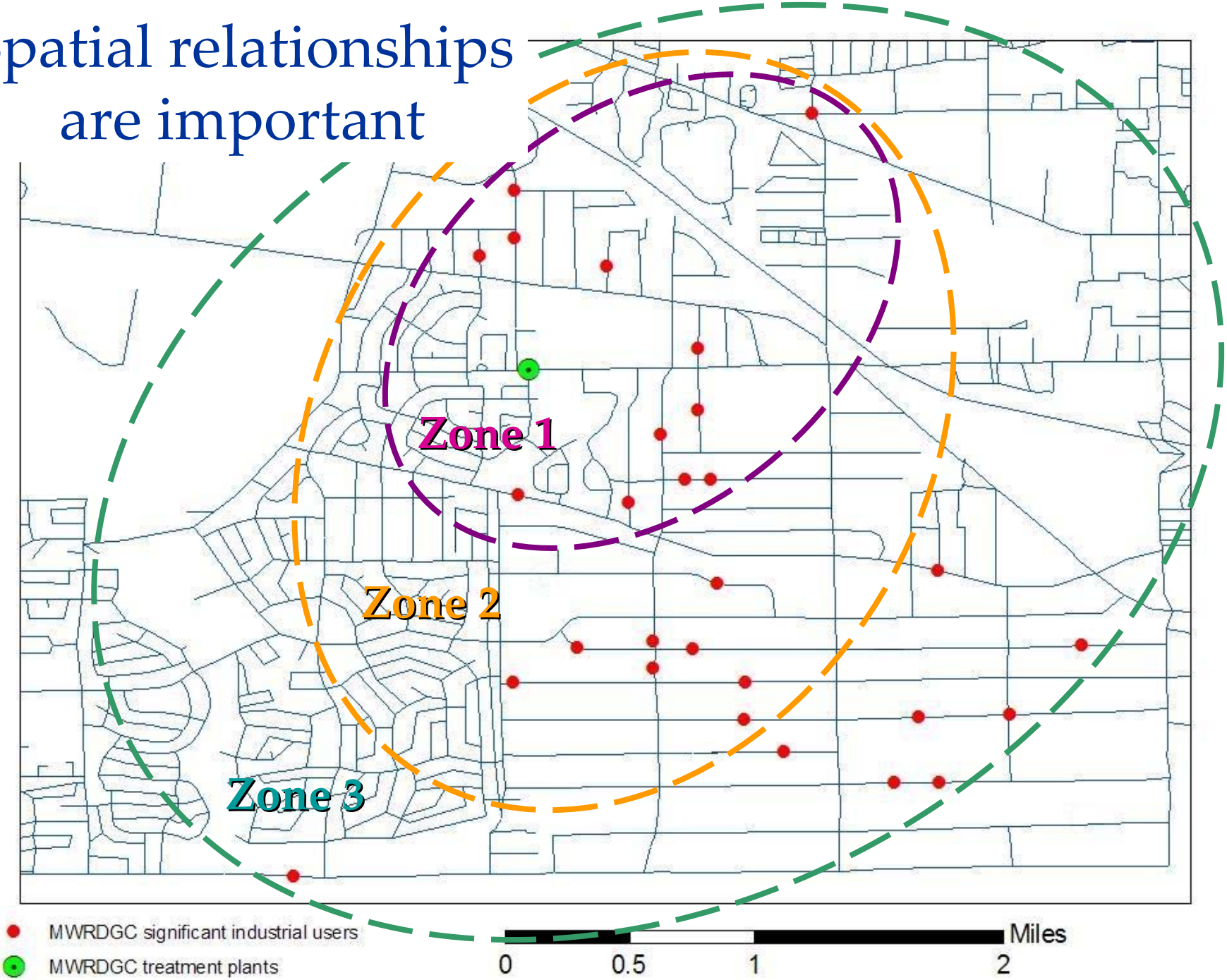
Is wastewater reuse economical?

- Objective:
  - Minimize cost
- Constraints:
  - Demand
  - Mass balance
  - Capacity
  - Water withdrawal
  - Water quality

Pipeline costs dominate

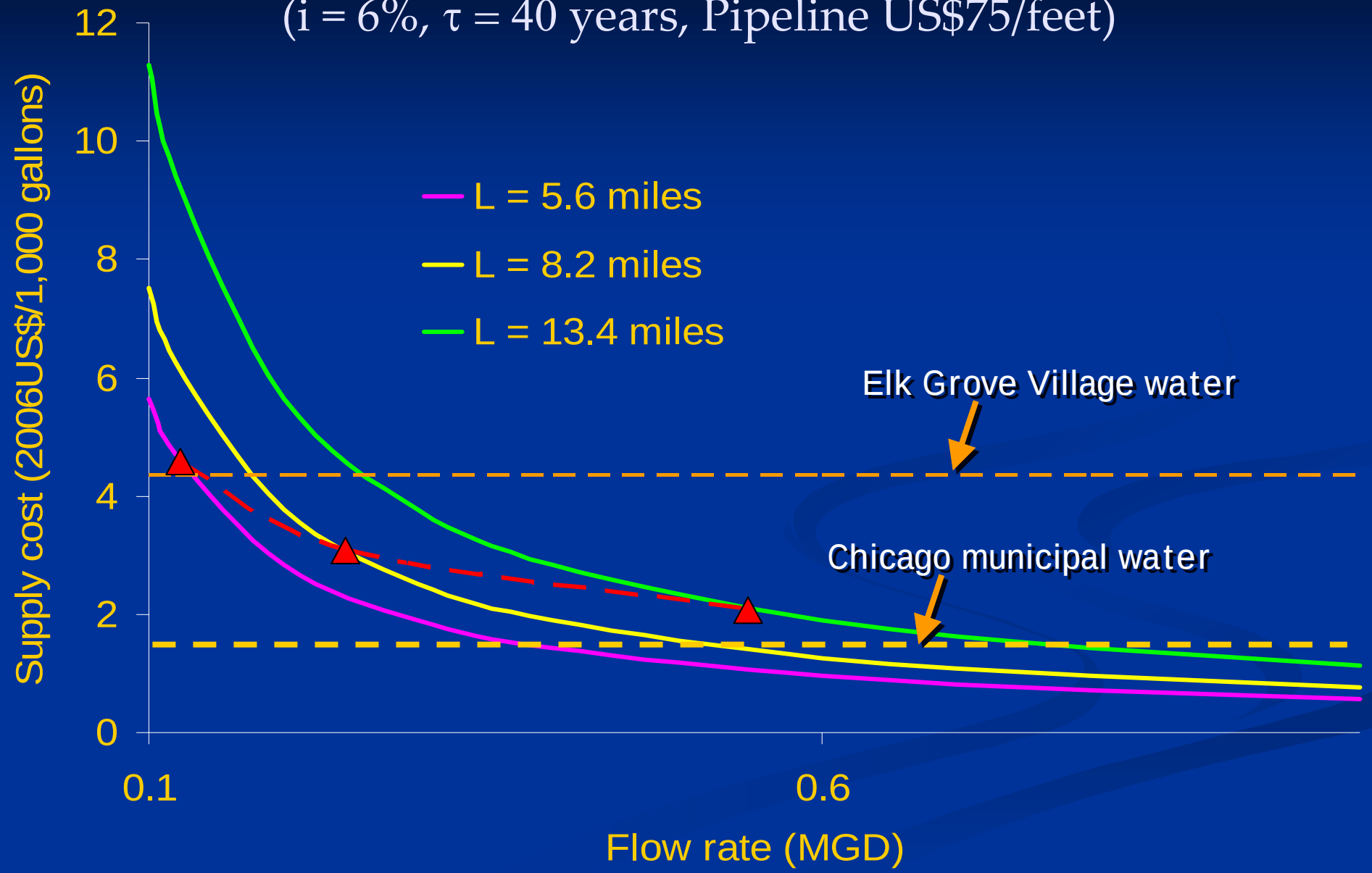


Spatial relationships are important



Cost depends on volume & distance

(i = 6%, τ = 40 years, Pipeline US$75/feet)



Chicago reuse study summary

- Pipeline installation costs dominate
- Spatial relationship affects supply cost
- Reuse can be cost effective
- Chicago is an unusual case study:
  - Municipal water is very cheap
  - MWRDGC has little incentive for reuse
  - Successful water conservation efforts

What about Wayne's World?

- Aurora, IL - 40 miles west of Chicago
- 2nd largest city in Illinois
- Rapidly growing area
- Municipal water
  - Groundwater supplies uncertain
  - Surface water up to 35% treated effluent

Aurora study advantages

- Recent severe drought
- $4.81 / 1000 gallons
- WRD exploring marketing effluent
- Experience with heat pump

Aurora study issues

- No industrial clusters
- Potential non-industrial users:
  - Park district, golf course
  - Limited seasonal demand
- Water quality requirements for recharge?

Surprising results

- "…implement a policy before there is a need…"
- Little economic incentive in Chicago
  - MWRDGC funding: Property tax
  - Chicago municipal water: $1.38/1,000 gal
- Change is hard
  - Public perception: Water is plentiful
  - Industry is risk averse: Why change?

Update on partners

- Current partners
  - Chicago Metropolitan Agency for Planning
  - Waste Management and Research Center
- New partners
  - Fox Metro Water Reclamation District study
- Potential partners
  - Other water reclamation districts
  - Suburban municipalities

Benefits of CNS funding

- Current collaborators
  - ILWMRC, CMAP, Fox Metro WRD
- Potential collaborators
  - IL Regional Water Supply Planning Group
  - Chicago Waste-to-Profit Network
  - Professor Fan, Hungkuang University (Taiwan)

Feedback, questions, and contacts

- Great Lakes and Eastern US applications?
- Industry water quality requirements?
- US DOE water & energy integrated efforts?
- US DOC industrial water use survey?
- International (Taiwan) cooperation?
- Water quality limits for recharge & irrigation?