UNIVERSITY OF ALBERTA
SCHOOL OF PUBLIC HEALTH

Decision Tools for Alternatives to Septic Tank/Leachfield Systems

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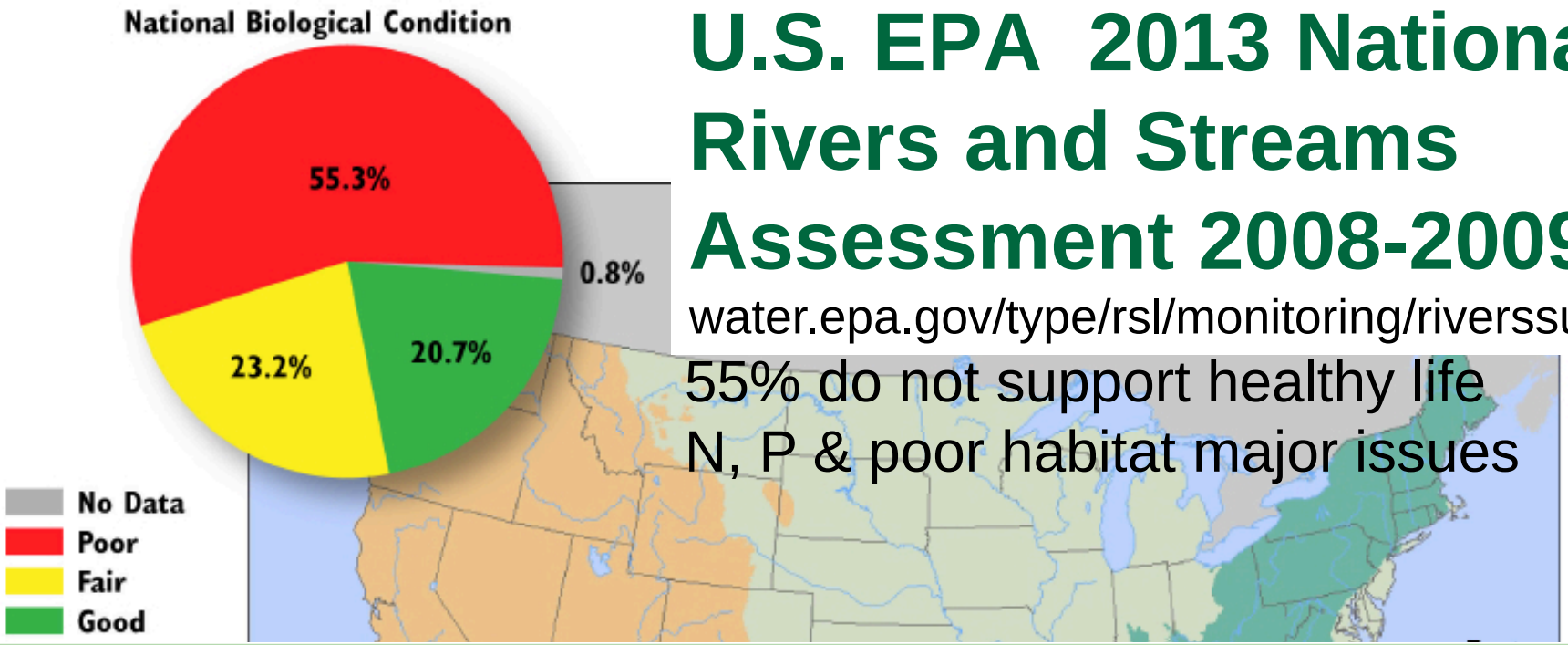
U.S. EPA 2013 National Rivers and Streams Assessment 2008-2009

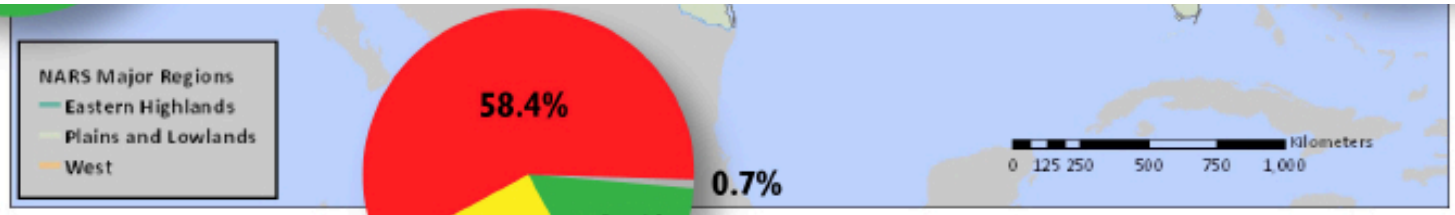
water.epa.gov/type/rsl/monitoring/riverssurvey

55% do not support healthy life

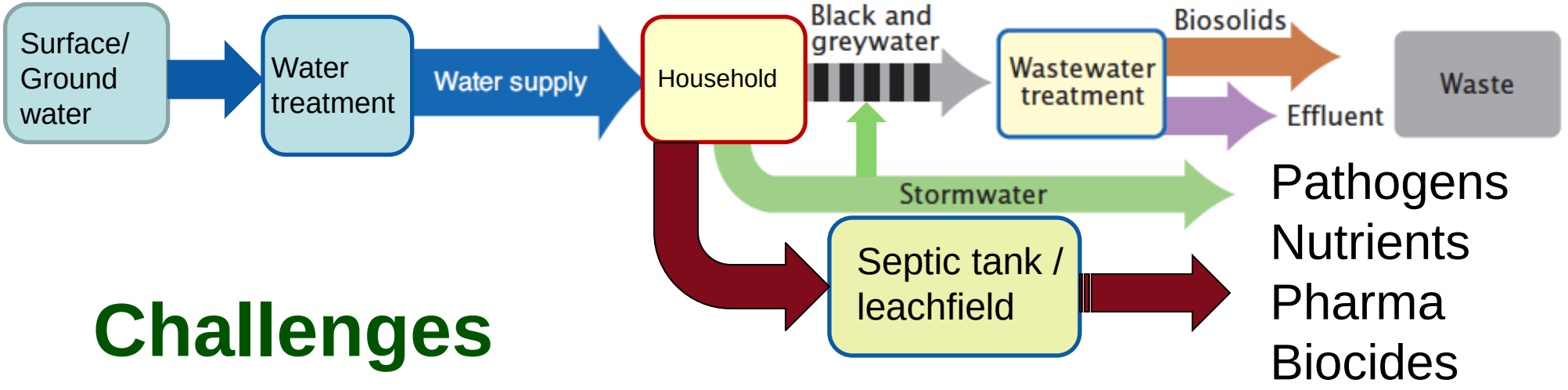
N, P & poor habitat major issues



Biological Indicators	Chemical Indicators	Physical Indicators	Human Health Indicators
■ Benthic macroinvertebrates ■ Periphyton (algae) ■ Fish community	■ Phosphorus ■ Nitrogen ■ Salinity ■ Acidity	■ Streambed sediments ■ In-stream fish habitat ■ Riparian vegetative cover ■ Riparian disturbance	■ Enterococci (fecal indicator) ■ Mercury in fish tissue



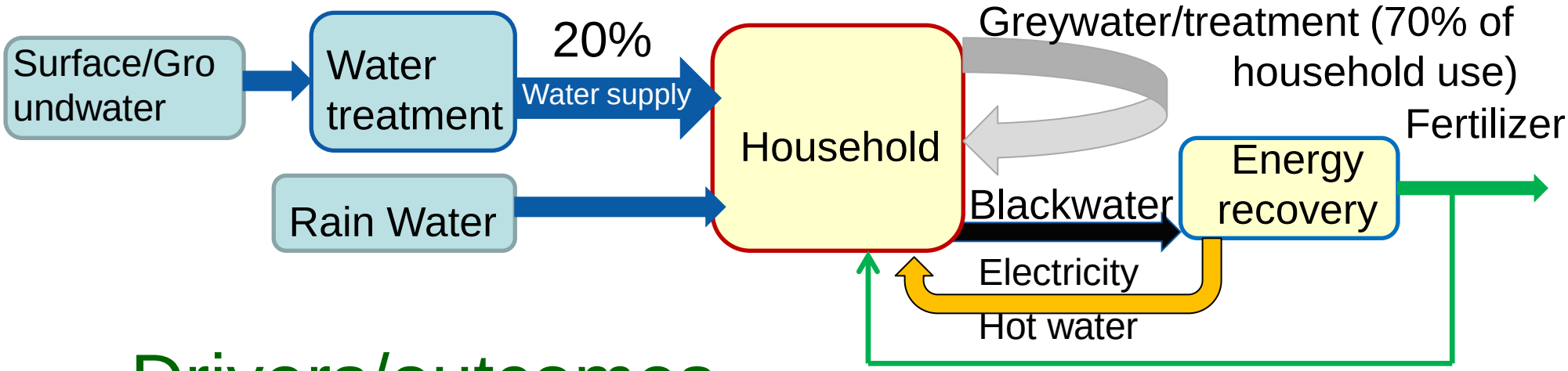
Current water service system



Challenges

- US water services utilize ~3-7% of nation's electricity
- Aging water and wastewater infrastructure $trillions to maintain
- Insufficient nutrient and energy recovery + 3% GHG
- Not climate nor demographic resilient

Hence, alternative system elements ‘One-water’ concept



Drivers/outcomes

- Need to reduce energy use plus GHG and nutrient emissions
  - ➢ Novel water, energy & nutrient recovery & management
- Climate & demographic resilient infrastructure
  - ➢ Decentralized, adaptable and antifragile

Likely trends / Implications

- **Climatic events / climate resilient infrastructure**:
  - More intense storms, sewer overflows, outages
    - Pressure sewers, off grid systems more resilient
  - Aging pop/tourists, more prone to diseases
    - e.g. legionellosis via water aerosols (etc.)
- **Energy & nutrient recovery / novel management**:
  - Utilize energy value within 'wastes' / energy-heat recovery
  - Revitalize agriculture / recycle of 'local' nutrients
- **Need to reduce greenhouse gases / source-sep**:
  - Move less water over long distances, i.e. recycle, especially reuse within homes/buildings with renewable energy

Core elements: water service sustainability

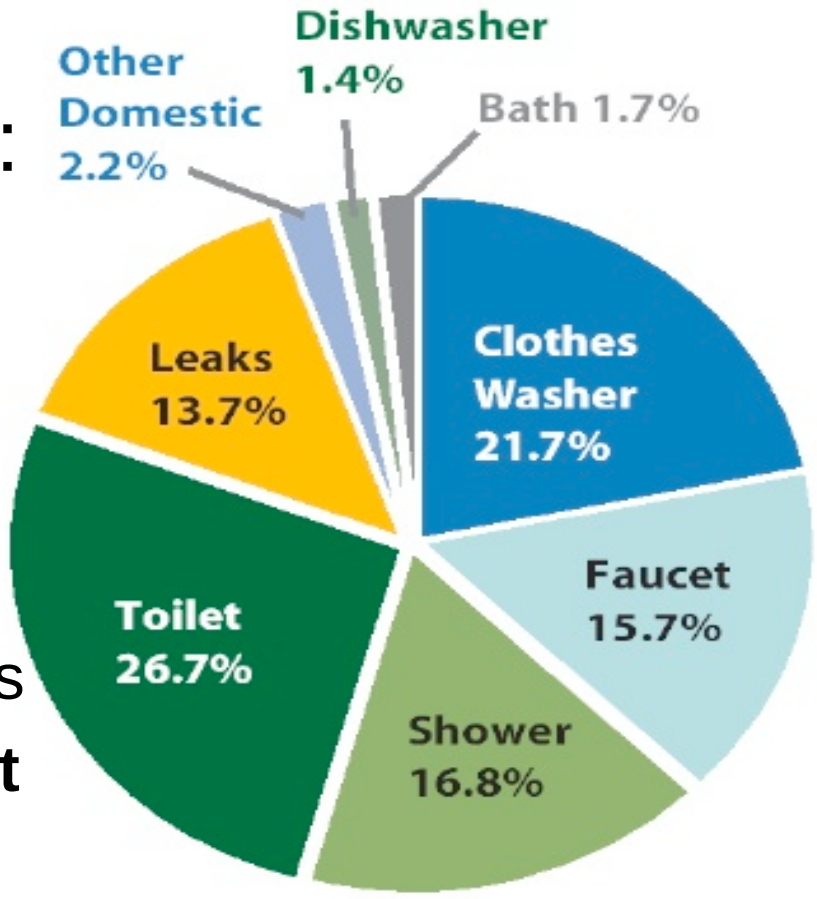
- We can not management the environment*, hence
  - The need for adaptive-resilient water services
- Ecosystem services are central societal needs
- Therefore, need to be framed water services that mimic nature, i.e.
  - Resource recovery for public health protection

*Social-ecological systems are so complex that understanding them is still a faint hope; If you cannot understand something, "managing" it is problematic & precautionary principle of little value

Bromley (2012) Ecology & Society 17(3): 43-50

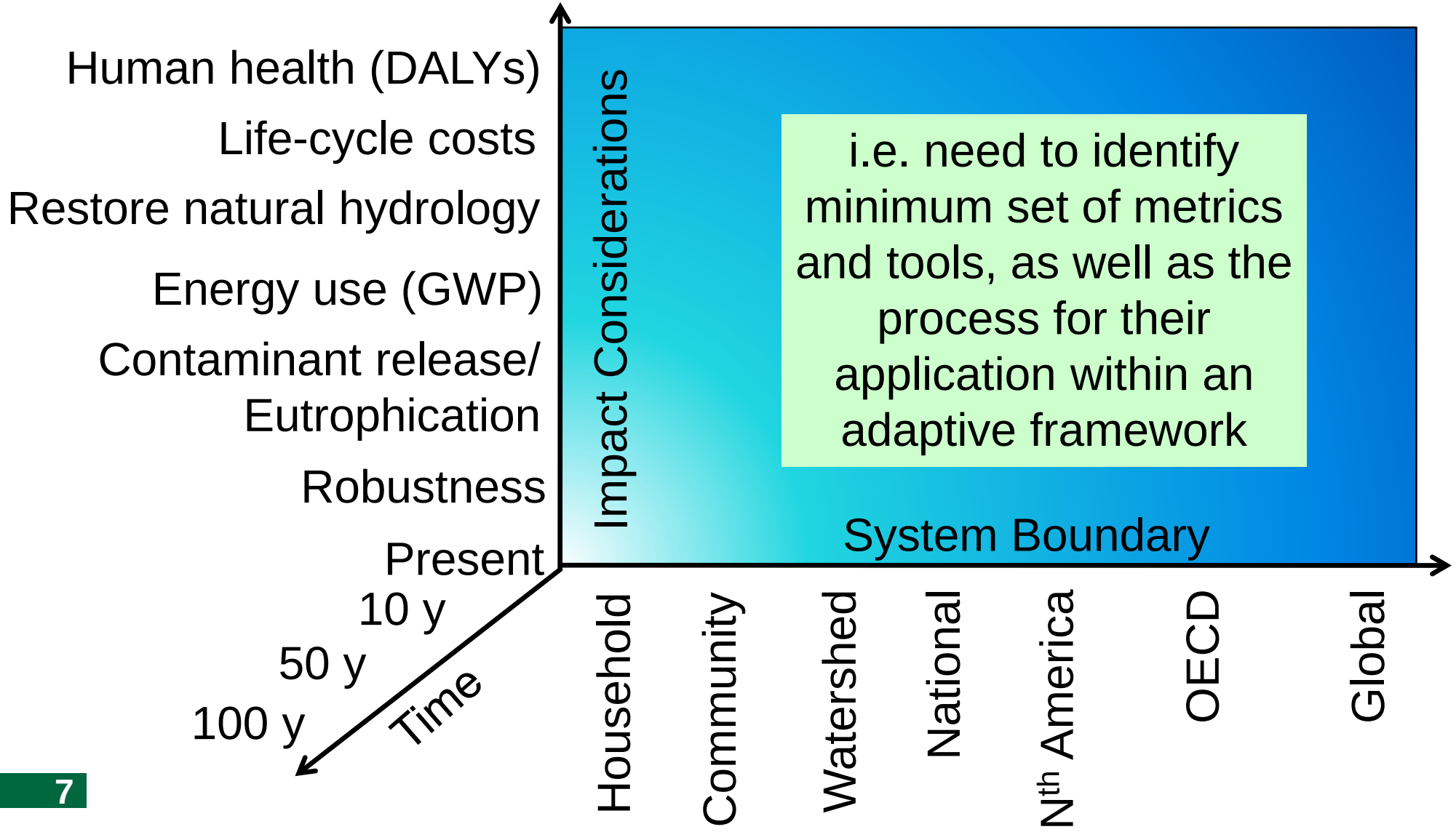
Global Issues: Water scarcity/climate change, urbanization & eco-service loss

- Tools to aid in decisions for:
  - Treating water so **fit-for-purpose**
  - Full cost accounting for water services to be driven by **resource recovery** (energy, water…) over system life-time
  - Health risks for any water exposures
  - **Adaptive planning & management of water infrastructure**

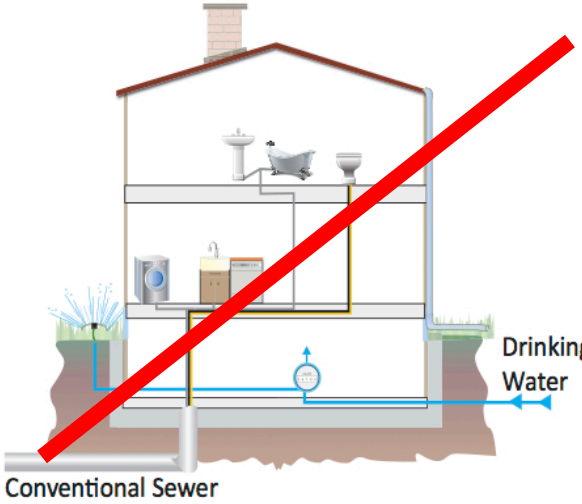


US Domestic water use (AWWA/AwwaRF)

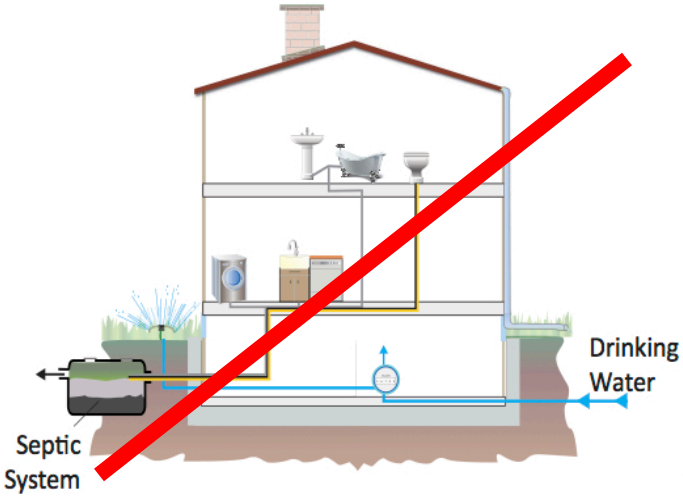
Systems Analysis of Water Infrastructure (to ID systems & policies to support them)



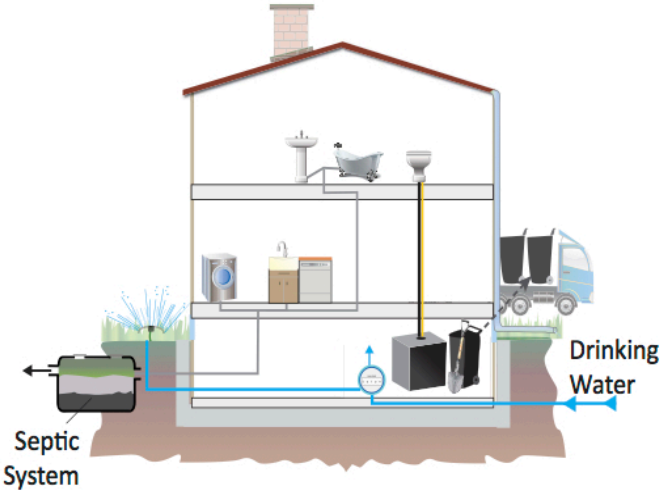
Alternatives to BAU-Septic/leachfield



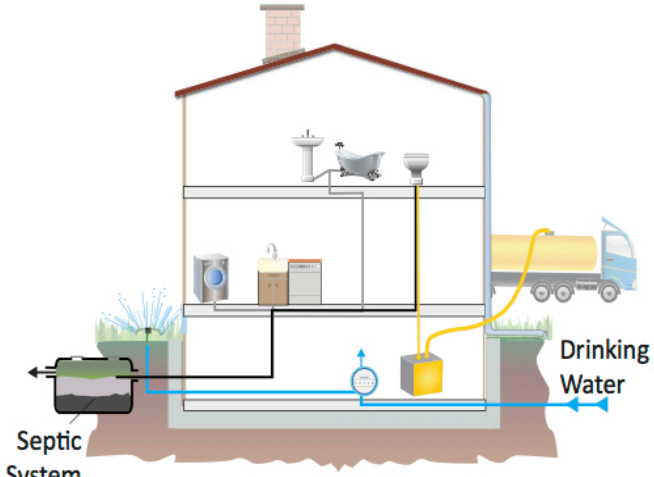
(BAU) Business as usual: Conventional municipal wastewater sewer & water supply



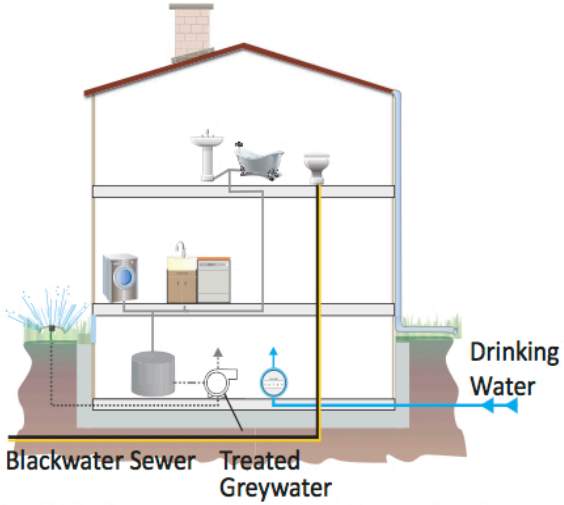
(BAU-SS) Business as usual: Conventional septic system & water supply



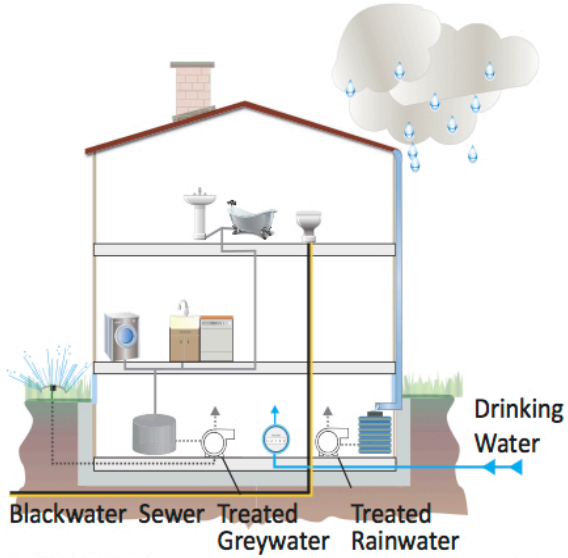
(CT-SS) Composting toilet w/ greywater-only septic system, municipal water supply



(UD-SS) Urine diversion toilet w/ blackwater & greywater septic system, municipal water supply



(BE-GR) Blackwater-only sewer w/ biogas electricity generation, treated greywater reuse for washing & irrigation



(BE-GRR) Blackwater-only sewer w/ biogas electricity generation, treated greywater & rainwater reuse for washing & irrigation

Tools – Human Health

- **Objective**
  - Characterize risk of disease from water-based exposure to chemical and pathogen hazards
- **Metrics & tools**
  - Risk assessment tools, using endpoints of:
    - Health adjusted life years (HALY)
    - Disability adjusted life years (DALYs)
  - So one metric for cancer, diarrhea, respiratory illnesses etc. following water exposure of hazard

Pathogens: key public health issue

- CDC estimate waterborne disease costs > $970 m/y
  - Addressing giardiasis, cryptosporidiosis, Legionnaires' disease, *otitis externa*, and non-tuberculous mycobacterial infections, causing over 40 000 hospitalizations per year,
  - ✦ >$780 m/y from gastrointestinal pathogens (incl. some via water)

Disease	**$ /** hospitalization	**Total cost**
Cryptosporidiosis	**$16 797**	**$45 770 572**
Giardiasis	**$9 607**	**$34 401 449**
Legionnaires' disease	**$33 366**	**$433 752 020**
NTM infection/Pulmonary	**$25 985 / $25 409**	**$425 788 469/ $194 597 422**

Collier *et al.* (2012) Epidemiology & Infection 140:2003-2013

Human Health RA

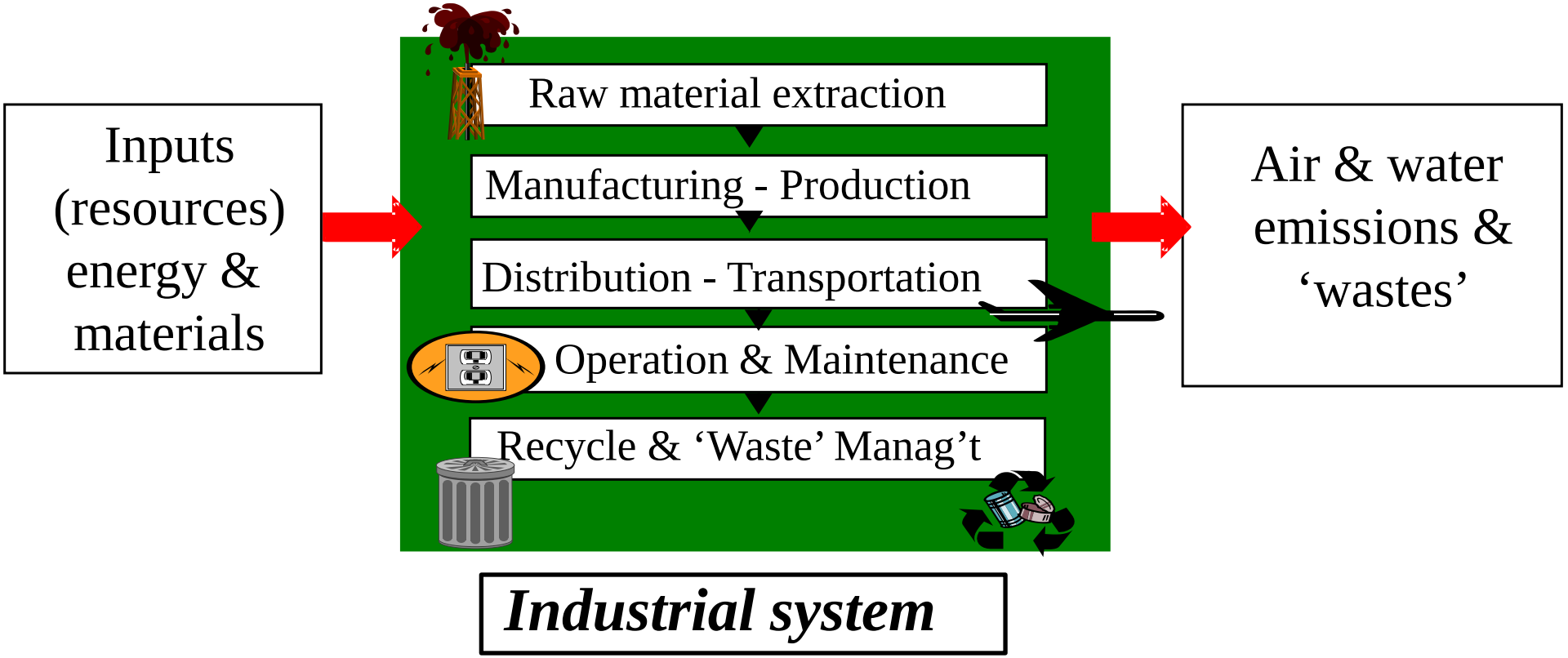
- **Pathogens**
  - Three reference pathogens selected for Cape Cod: Human norovirus, *Campylobacter, & Cryptosporidium*
  - Dose estimates: household & recreational exposure routes
  - Infection risks to disability-adjusted life years (DALYs)
- **Disinfection by-products (DBPs)**
  - The highest-risk class of chemicals associated with water & urban living (bladder cancer)
  - Focus on chloroform & bromodichloromethane
- Key human health risk trade-off:
  - Use of rainwater with no DBP via hot water, but increased potential risk from pathogens

Tools – Environment

- **Objective**
  - Characterize depletion of water, land & other natural resources, energy use, global warming …
- **Metrics & tools**
  - Life-cycle assessment, using key metrics
    - Water use index, including reuse, natural hydrology
    - Global warming potential (GWP) & energy use
    - Eutrophication potential
  - Over the life-time of infrastructure/green solution

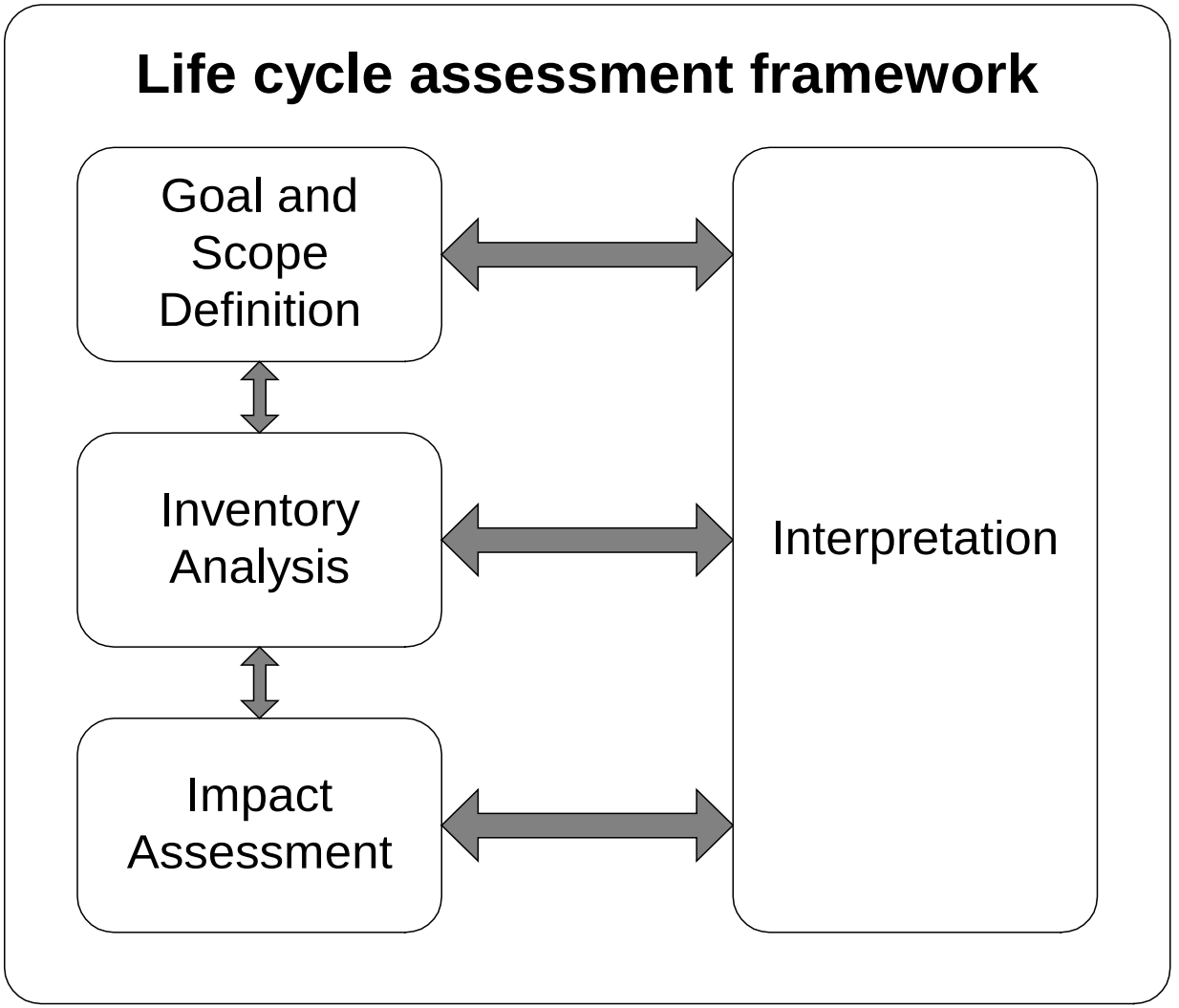
Life-cycle assessment (LCA)

LCA is the systematic analysis of environmental impacts from products/services during their entire life-time



Internationally standardized framework

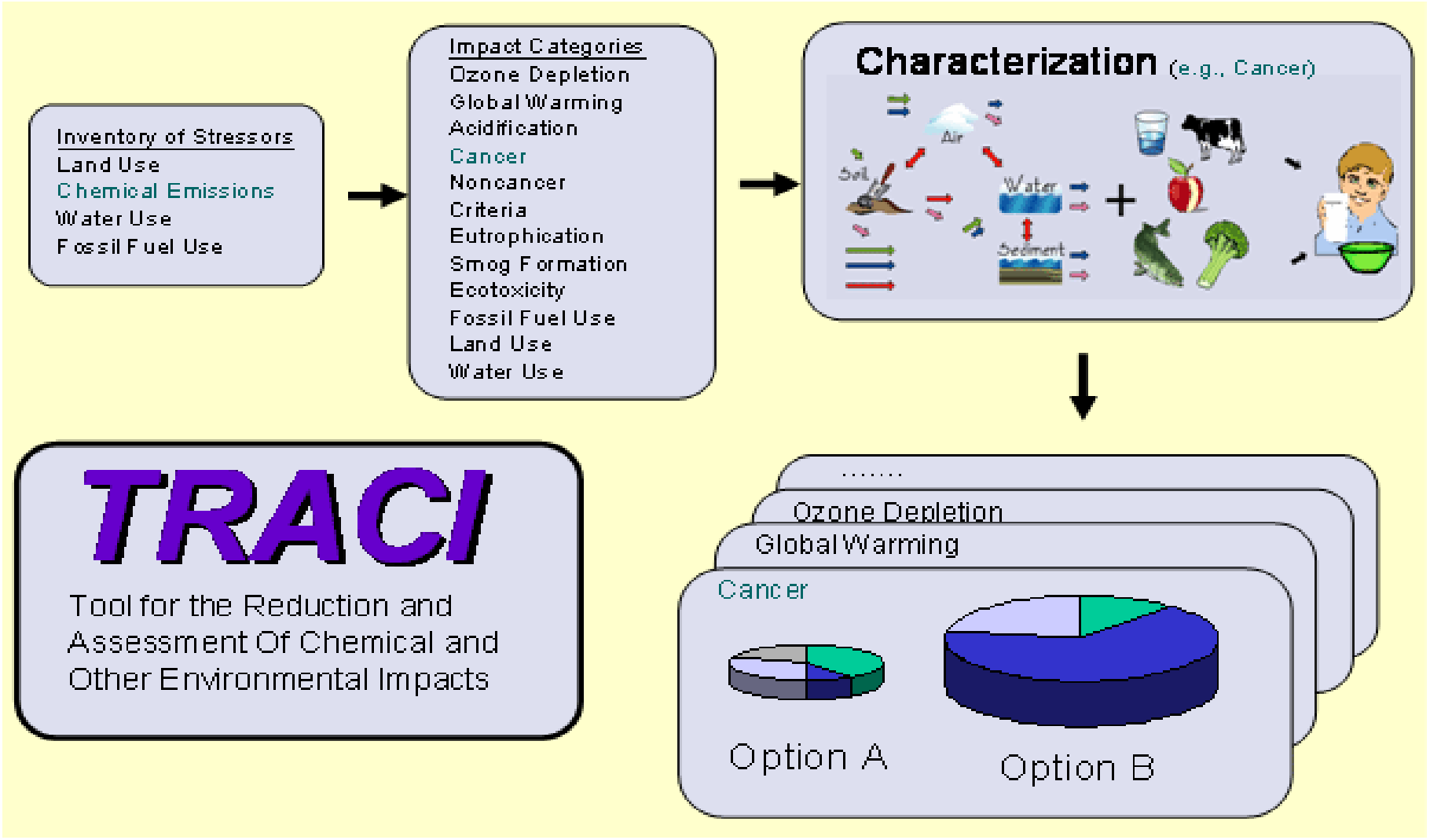
- ISO 14040
- “Flexible standard”
  - Life-cycle inventory (LCI)
  - Life-cycle impact assessment (LCIA)



Life Cycle Inventory (LCI)

Unit processes	Data sources
Water services including water extraction, treatment and supply	water utility datasets, ecoinvent database, peer reviewed articles
Composting toilet, low-flush toilet, urine-diversion toilet	pilot studies, peer reviewed articles
Blackwater collection, digestion and energy recovery	ecoinvent database, EPA Coeat Model, peer reviewed articles
Graywater collection, treatment and reuse	ecoinvent database, peer reviewed articles
Rainwater harvest and use	ecoinvent database, peer reviewed articles

Life-Cycle Impact Assessment (LCIA)



Data and software tools

USDA

TRACI

Tool for the Reduction and Assessment Of Chemical and Other Environmental Impacts

openLCA

GaBi

Product Sustainability Performance

eco invent Centre

Swiss Centre for Life Cycle Inventories

Associated needs when considering alternatives

- Central financing entity that owns and maintains decentralized water services / with users' tax breaks
- Owners have options for type of service, which may include:
  - Urine storage &/or septic retro and pump-out – fertilizer payment
  - Greywater treatment on-site using PV power for use in garden, toilets, clothes washing
  - Blackwater sewer connection – with community useable hot-water heating and/or energy credits
- Municipally-owned reactive barriers for enhanced denitrification for groundwater N removal & phosphorus sorption

Summary

- Sustainable water services = resilient & adaptable systems
- Based on resource recovery (so economically driven change)
- Need new metrics for robustness
- Systems, life-cycle approach recommended when comparing options

Acknowledgements

Xiaobo Xue, Troy Hawkins, Mary Schoen (EPA)