Sustainability Research at CUNY as it Relates to the Big Picture of New York Infrastructure

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Sustainable Infrastructure in Practice
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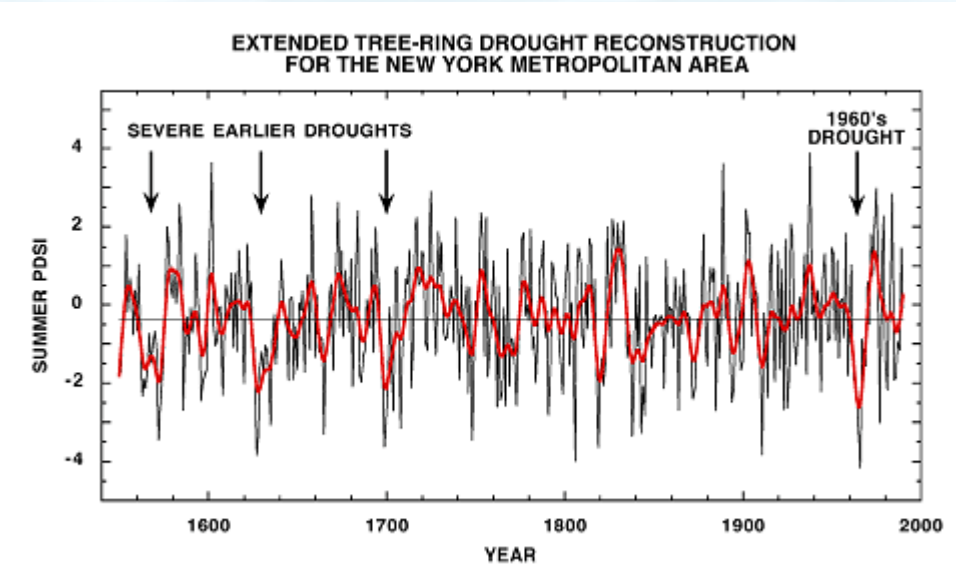
ASCE METROPOLITAN SECTION

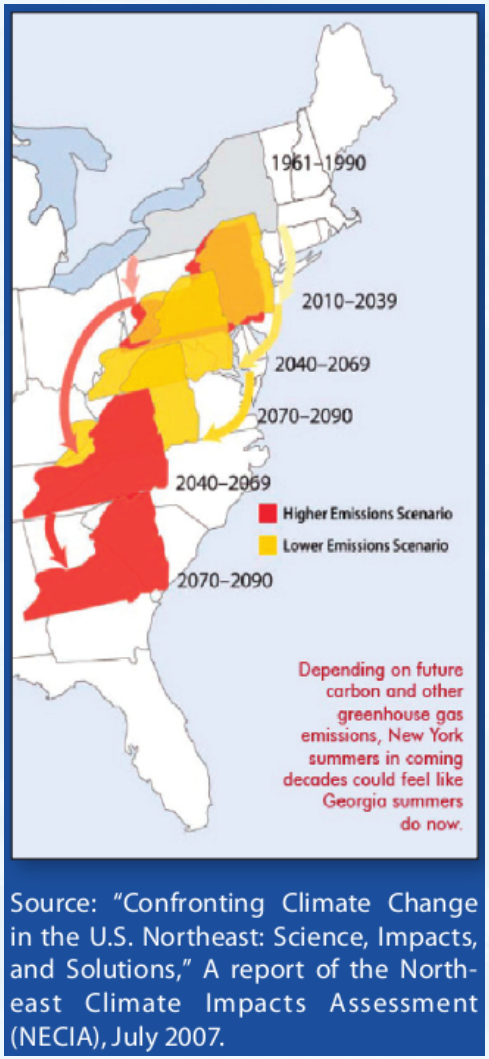
the City College of New York

Part 1: Some big-picture (climate) considerations

NYC climate: past and future

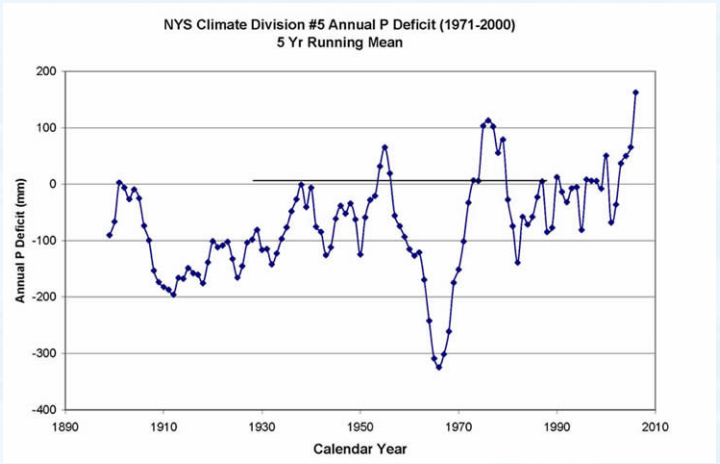


- Neither is well known, but both likely break the stability of recent decades



Source: "Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions," A report of the Northeast Climate Impacts Assessment (NECIA), July 2007.

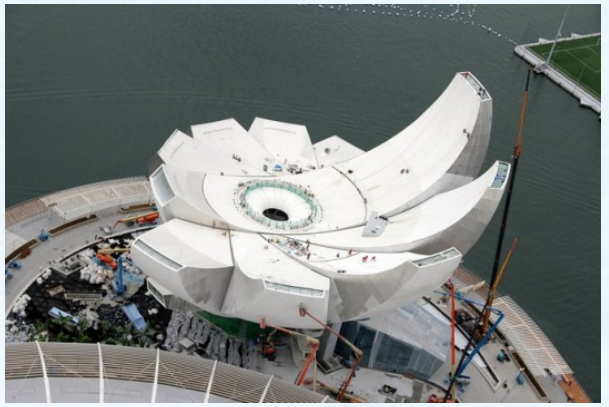
Is our water supply secure?



- NYC's reservoirs hold about a year's worth of supply, 74% depleted in 1960s
- Aqueducts and tunnels are old and vulnerable to natural or human-caused disaster

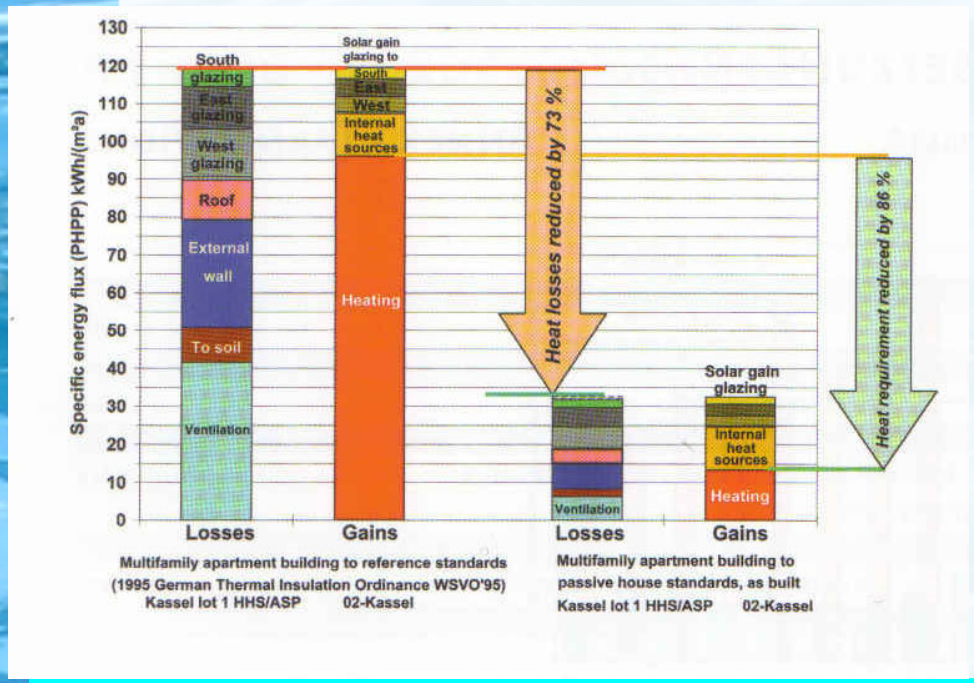
Some possible solutions

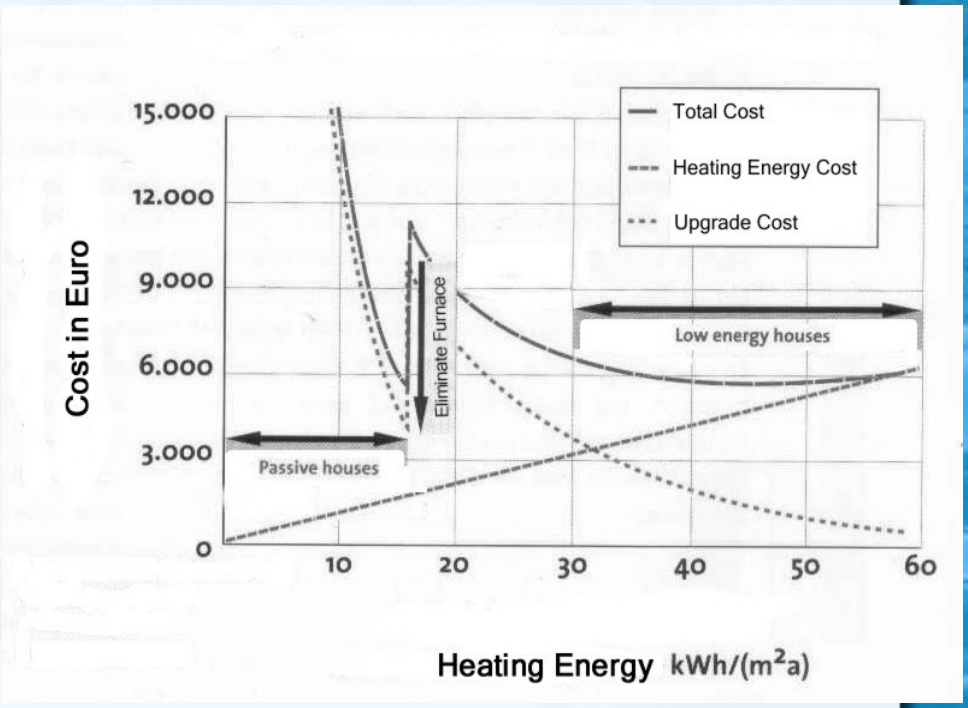
At Kokugikan sumo wrestling arena in Tokyo, Japan, rainwater collected from the arena's 8,400 square meter rooftop is used for non-potable purpose.



- Supply: Tunnel No. 3; more pond/aquifer storage in city; diversify sources through rainwater collection, like Singapore
- Demand: water use reduced 30% in last 30 y despite population growth

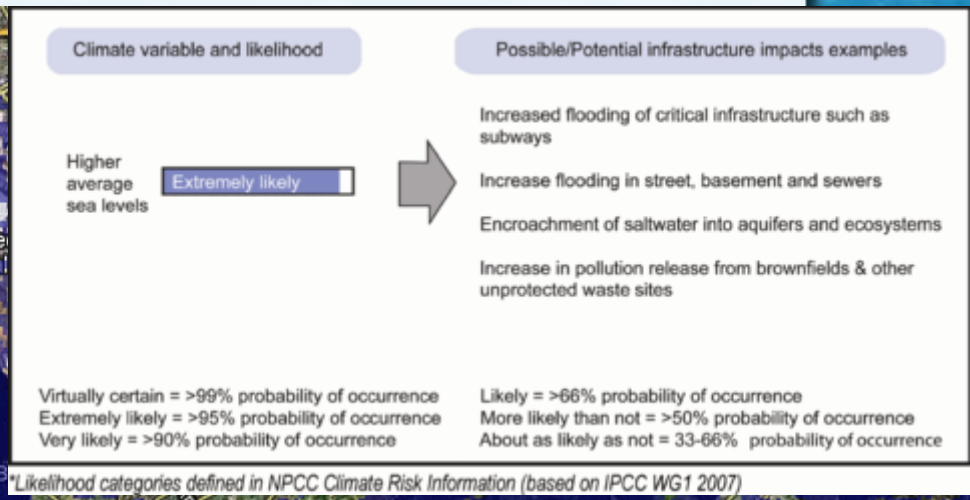
Temperature comfort

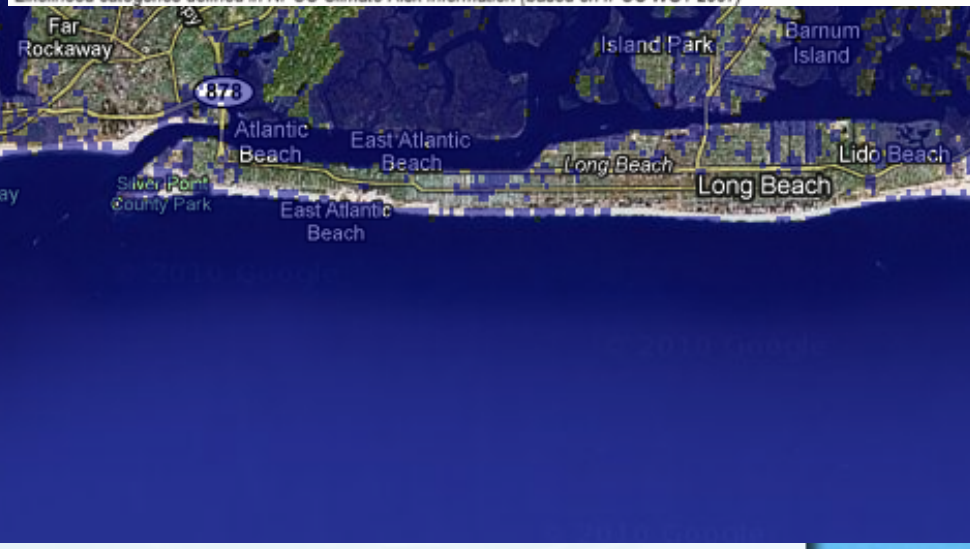




- NYC uses 13 GW natural gas and fuel oil for heating, cooking, etc. → $4 billion/year at current wholesale
- Need research and policy developments to scale deep energy reduction approaches such as PassivHaus to retrofits of high-rise buildings

Flooding





- JFK airport under 2 m sea level rise – storm/tsunami surge or, in decades to centuries, ice melt

Can NYC be flood-proofed?

- “The potential 30-foot storm surge accompanying a Category 3 hurricane would flood large swaths of south Brooklyn, parts of Queens, Staten Island, and Manhattan below Canal Street ... floodwater might pour into the city's tunnels and subway system ... The city's wastewater treatment plants ... could back up, sending raw sewage into basements and bathrooms citywide.”
- A Dutch ASCE workshop idea is a barrier across the Verrazano Narrows – price tag: $6.5 billion
- Barriers are usually built *after* major floods
- Are there small steps for some resiliency in the short term?

A spectrum of adaptation responses

Coastal adaptation (IPCC CZMS, 1990)	Adaptation objectives (Klein and Tol, 1997)	Adaptation responses (after Cooper et al., 2002; Defra, 2001)	Example
Protect	Increased robustness	Advance the line	Land claim; empoldering Estuary closure
		Hold the line	Dyke; beach nourishment
Accommodate	Increased flexibility		'Flood proof' buildings Floating agricultural systems
Retreat	Enhanced adaptability	Retreat the line	Managed realignment
		Limited intervention	Ad hoc seawall
		No intervention	Monitoring only
	Reversing maladaptive trends	Sustainable adaptation	Wetland restoration
	Improved awareness and preparedness	Community-focussed adaptation	Flood hazard mapping; flood warnings

"We're going to have to do something," [Stony Brook University oceanography professor Malcolm] Bowman said. "Or else you retreat, and that's inconceivable. How are you going to retreat from New York City?"

Part 2: Some relevant projects at CCNY

Nitrogen Removal from Wastewater

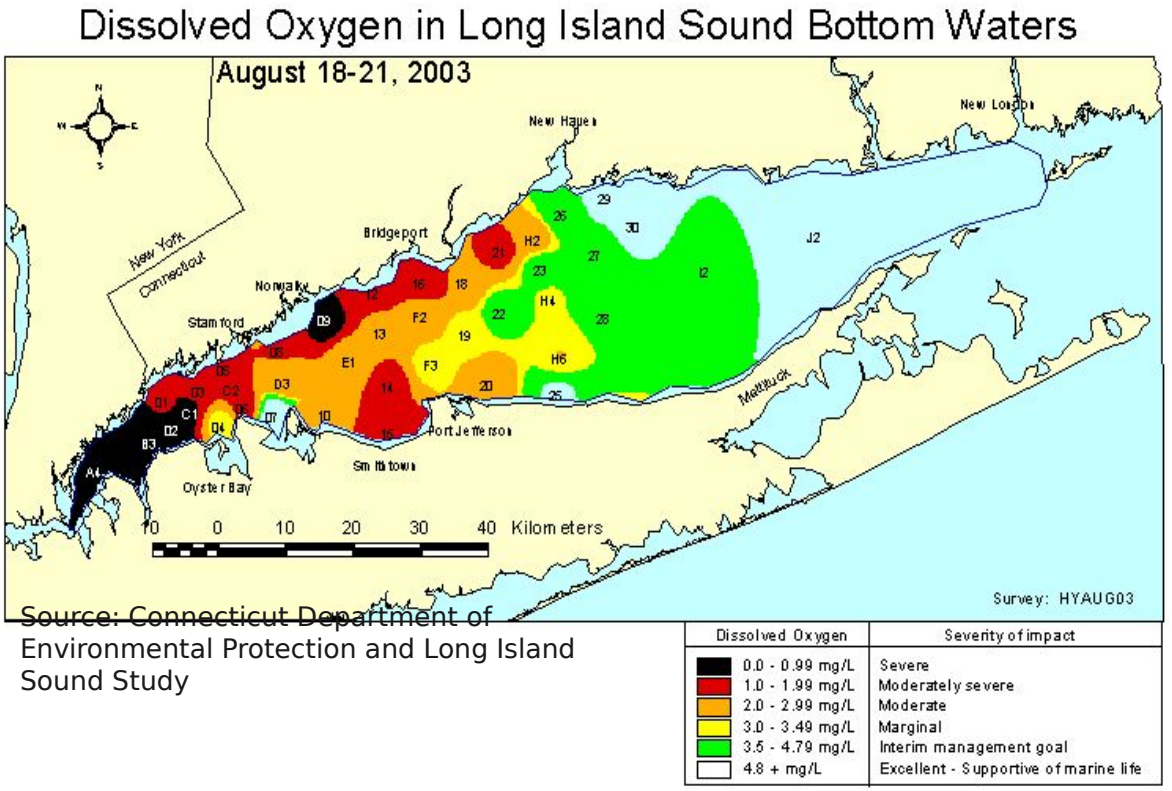
The removal of nitrogen from wastewater is a focus of research at CCNY (Prof. Fillos, DEP contract)

$$N_{organic}$$
$$NH_3$$
$$NO_2^-$$
$$NO_3^-$$
$$\rightarrow N_2$$

Why is it necessary to remove nitrogen from wastewater ?

Environmental Consequences

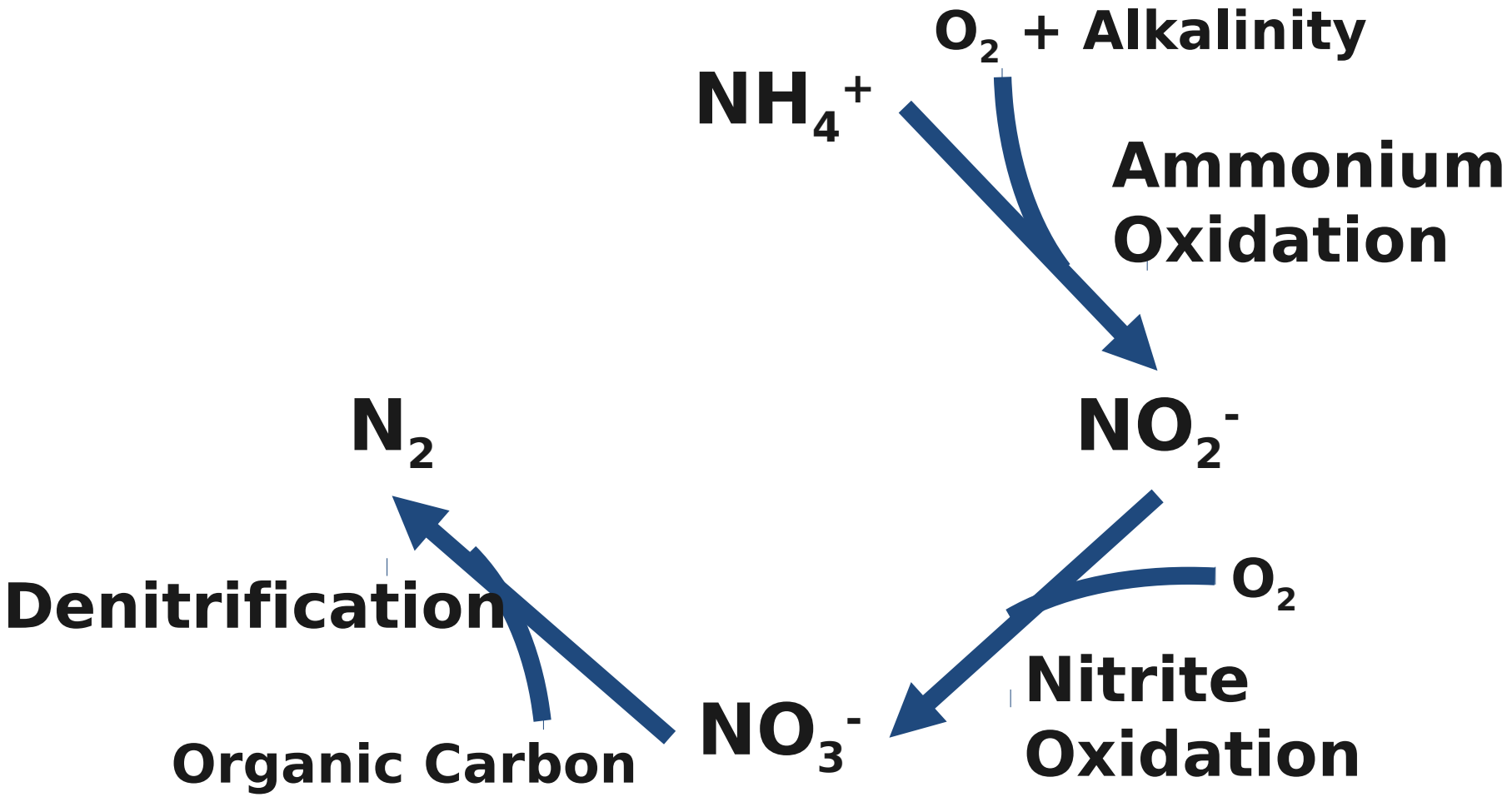
- Nitrogen discharge into coastal waterbodies increases algae growth.
- The decomposition of organic matter (dead algae) creates hypoxic conditions on the ocean floor.



Source: Connecticut Department of Environmental Protection and Long Island Sound Study

Nitrogen discharge has emerged as one of the greatest pollution problems in the coastal waters of the U.S.

Current NYC N removal bio-pathway

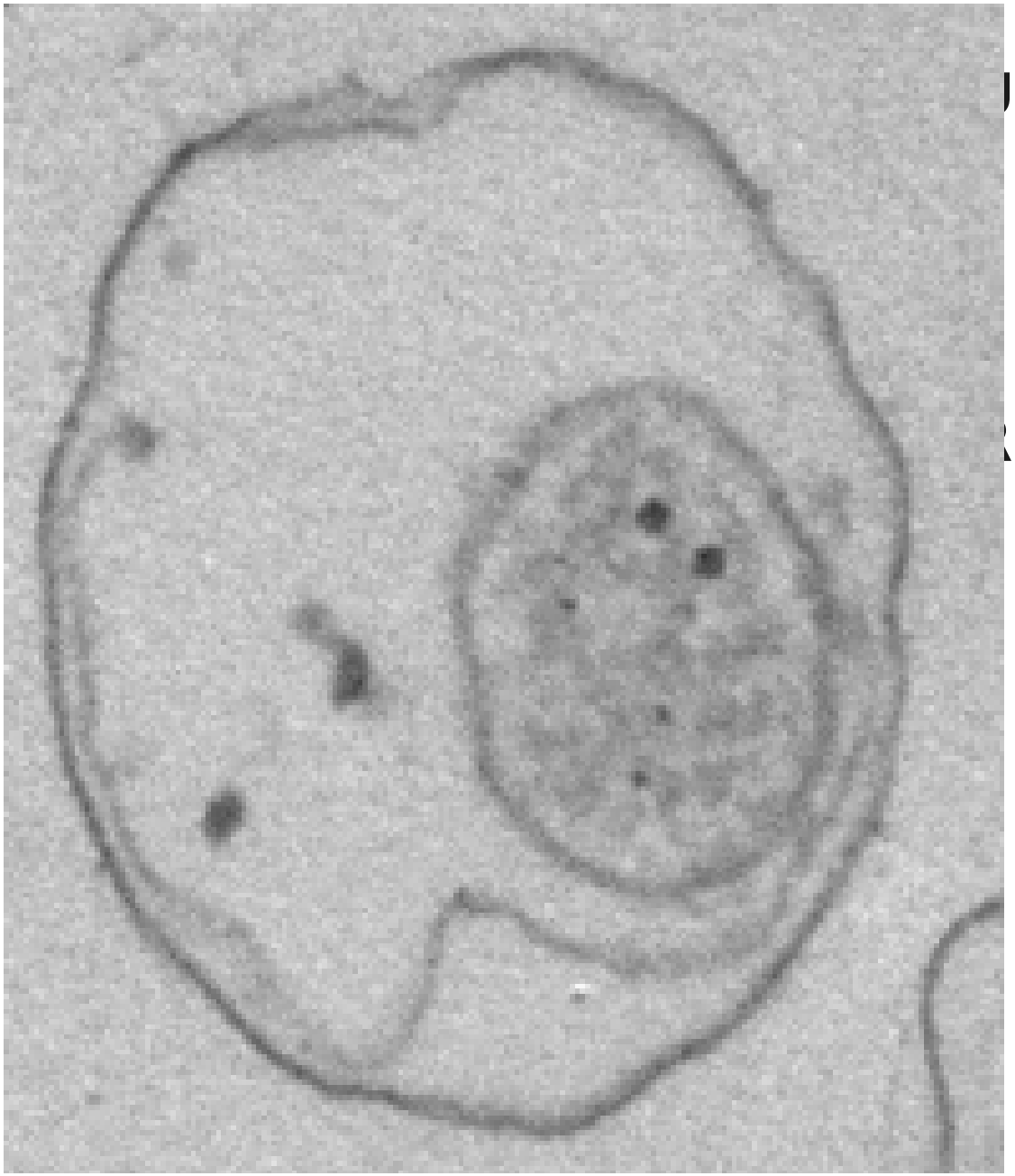


The quantities of alkaline chemicals, organic carbon, and aeration energy make nitrogen removal a very expensive process

The Discovery of Anammox
(ANaerobic AMMonium OXidation)

Unexplained nitrogen losses discovered at a WWTP in the Netherlands in 1990

Revealed to be an entirely new microorganism with a unique metabolic strategy



Micrograph of Anammox Cell by Helen Markewich

Anammox metabolism
(ANaerobic AMMonium OXidation)

NH_4^+ and NO_2^- react directly to form N_2

A small fraction of NO_2^- reacts to form NO_3^- ,
which allows biomass to form from inorganic carbon.

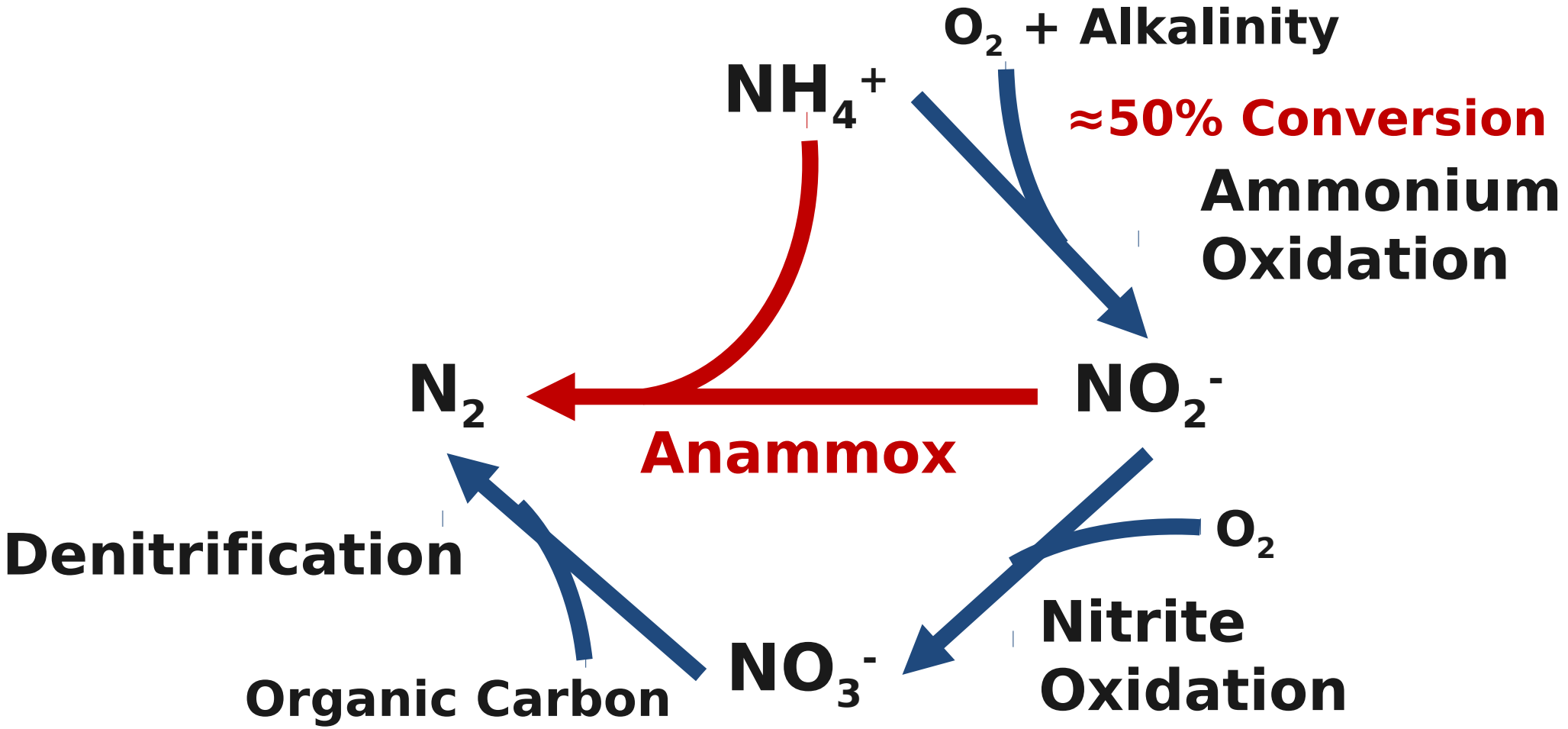
Stoichiometry:

$1\ NH_4^+ + 1.32\ NO_2^- + .066\ HCO_3^- + .13\ H^+ \rightarrow$

$1.02\ N_2 + .26\ NO_3^- + .066\ CH_2O_{0.5}N_{0.15} + 2.03\ H_2O$

Compared to current all-aerobic process:
- Only need to oxidize part of ammonium to nitrite, and then remaining nitrate
- Needs much less aeration
- Needs much less organic matter (methanol) addition

A Shortcut Through Conventional Denitrification

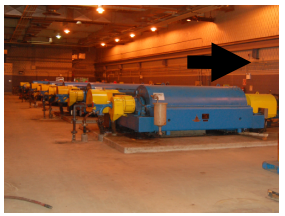


Anammox at CCNY

Primary Sludge

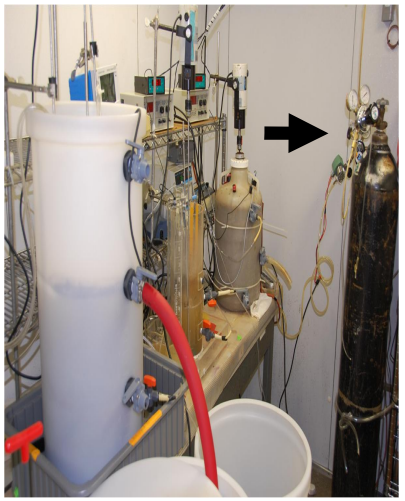
Waste Activated Sludge

Anaerobic Digestion



Centrifugation

$NH_4^+ + O_2 \rightarrow NO_2^-$



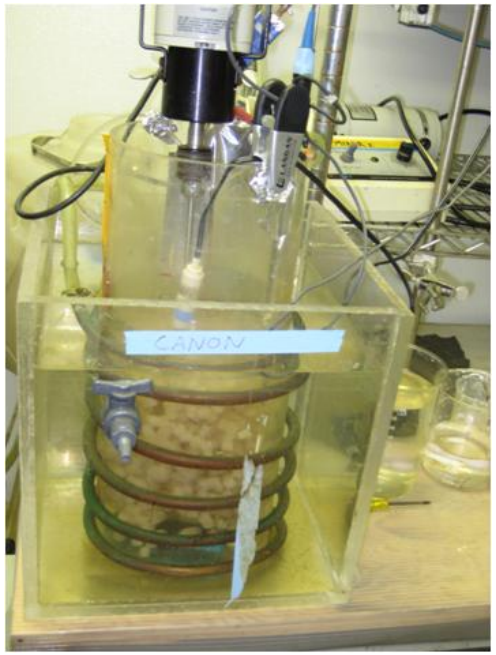
Partial Nitritation

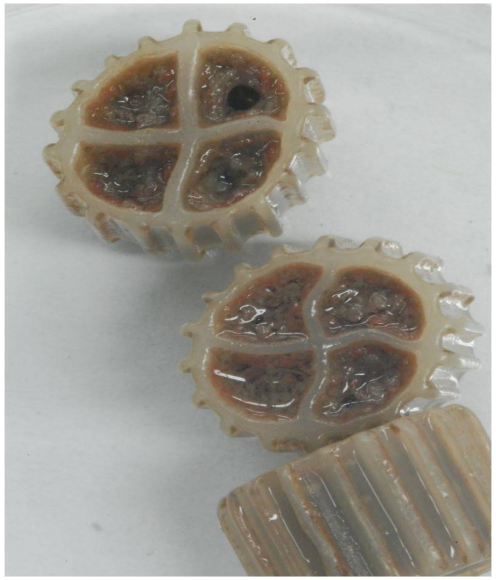
$NH_4^+ + NO_2^- \rightarrow N_2$

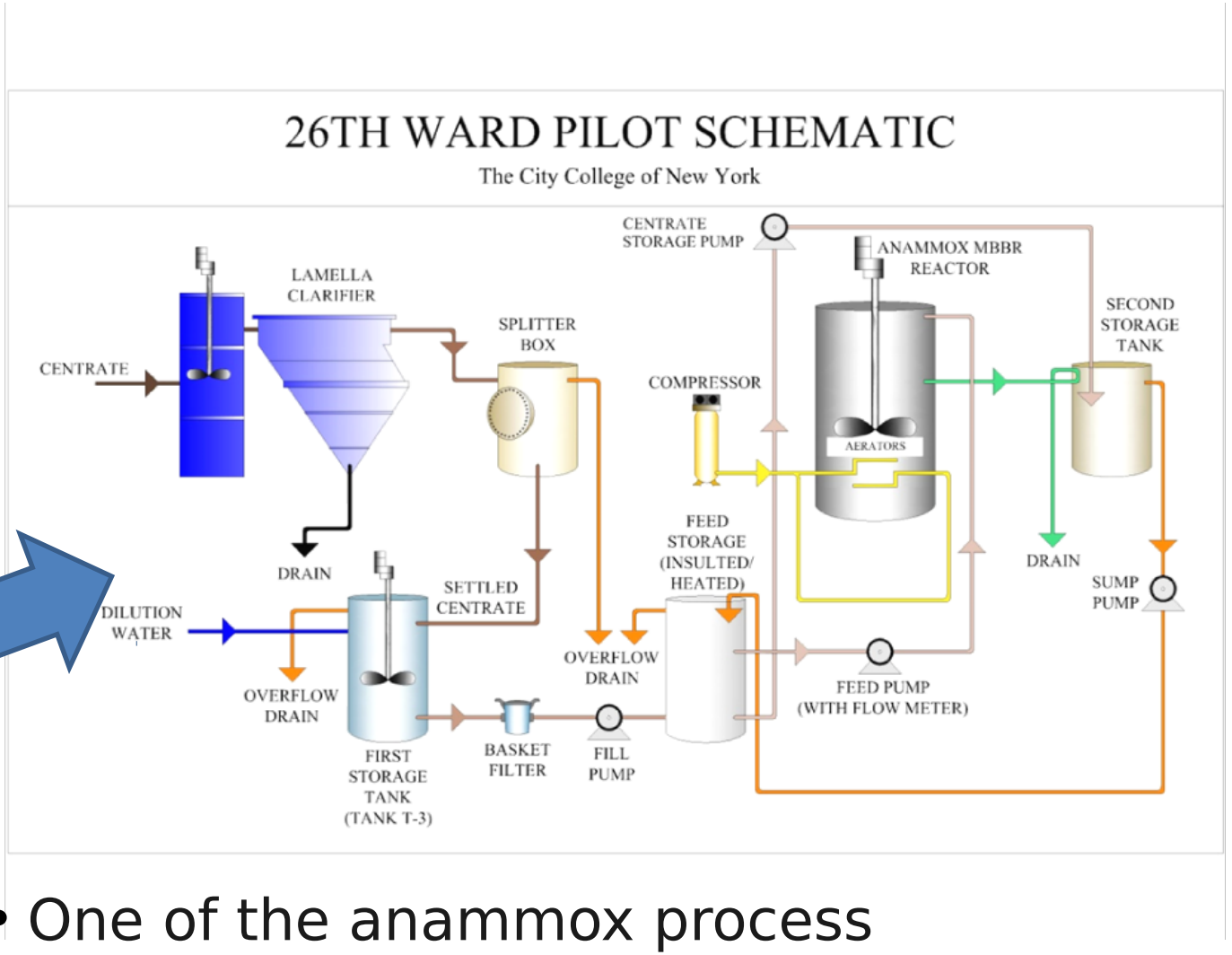
Anammox

- At CCNY, nitrogen removal is achieved in multiple laboratory scale anammox reactors since January 2008.
- The past three years of research focused on the physiology and growth kinetics of anammox biomass grown in a real New York City waste stream.

Anammox Pilot Demonstration







- One of the anammox process configurations evaluated at CCNY is currently being scaled up to an 1100 gallon demonstration reactor at the 26th Ward WPCP (Brooklyn).

CR3MUS

CENTER FOR RECLAMATION REUSE AND RECYCLING OF MATERIALS FOR URBAN SUSTAINABILITY

A Multidisciplinary Research Center at CCNY exploring the tangible and intangible benefits of Reclamation, Reuse and Recycling of natural and manmade materials in sustainable urban environments.

PI: Prof. Vasil Diyamandoglu

CR3MUS

Research Interests of Associated CCNY Faculty Members

Industrial and commercial solid waste reuse.
Effects of single and multi-cycle reuse on material properties.
Short and long term life/service implications.
Modeling of time dependent material deterioration.
Reliability of reusable materials.
Certification procedures of reused material properties.
Electronic wastes – recovery, reuse and disposal issues
Construction and demolition wastes
Economic analysis of implementation of materials reuse
Environmental impact assessment of materials reuse and recycling
Societal impact of materials reuse.

CR3MUS

Programs Funded by the New York City Department of Sanitation
Bureau of Waste Prevention Reuse and Recycling

NYC Materials Exchange Development Program

Strengthening NYC's materials exchange and reuse sector

www.nycmedp.org

MEDP helps New York City businesses save money and improve the Environment by diverting "reusables" from the solid waste stream

NYC WASTE MATCH

www.wastematch.org

NYC's free commercial on-line materials exchange program

CR**3**MUS - Externally Funded Activities

NYC Materials Exchange Development Program

Strengthening NYC's materials exchange and reuse sector

Research and Development -

Commercial solid waste in NYC is 4-5 times as large as household waste, yet mostly goes unnoticed. Develop methodologies to track and reduce this solid waste source.

Donation Referrals through NYC WasteMatch -

NYC WasteMatch is the only public on-line materials exchange and reuse service, free to the entire NYC commercial sector.

www.nycwastematch.org

Educational Opportunities -

Materials Exchange and Reuse Certificate Program. Consists of eight 3-hour seminars held at CCNY and at facilities around NYC.

Technical Assistance and Workshops

Annual Materials Reuse Conference

Held at CCNY in mid-November of each year. 2011 will be the fourth conference.

NYC Materials Exchange Development Program

Strengthening NYC's materials exchange and reuse sector

MEDP Member Reuse organizations in NYC (over 100)

Computers

- Computers for Youth
- Lower East Side Ecology Center
- Non-Profit Computing
- Per Scholas

Furniture

- Furnish a Future
- Green Office Systems
- Tools for Schools

Clothing

- Goodwill Industries of Greater NY and NJ
- Bottomless Closet (NYC)
- NYC Clothing Bank

Building Materials

- Build it Green
- Demolition Depot
- Rebuilding Source

Used and surplus materials handled by NYC WasteMatch include

- Building Materials
- Computers, Electronics, Office Equipment
- Containers & Packaging
- Furniture
- Medical Equipment & Supplies
- Metals, Glass, Plastics
- Office Supplies & Art Supplies
- Paper & Cardboard
- Surplus Food
- Textiles, Fabric & Leather

Since April 1998, NYC Waste Match Activities Produced

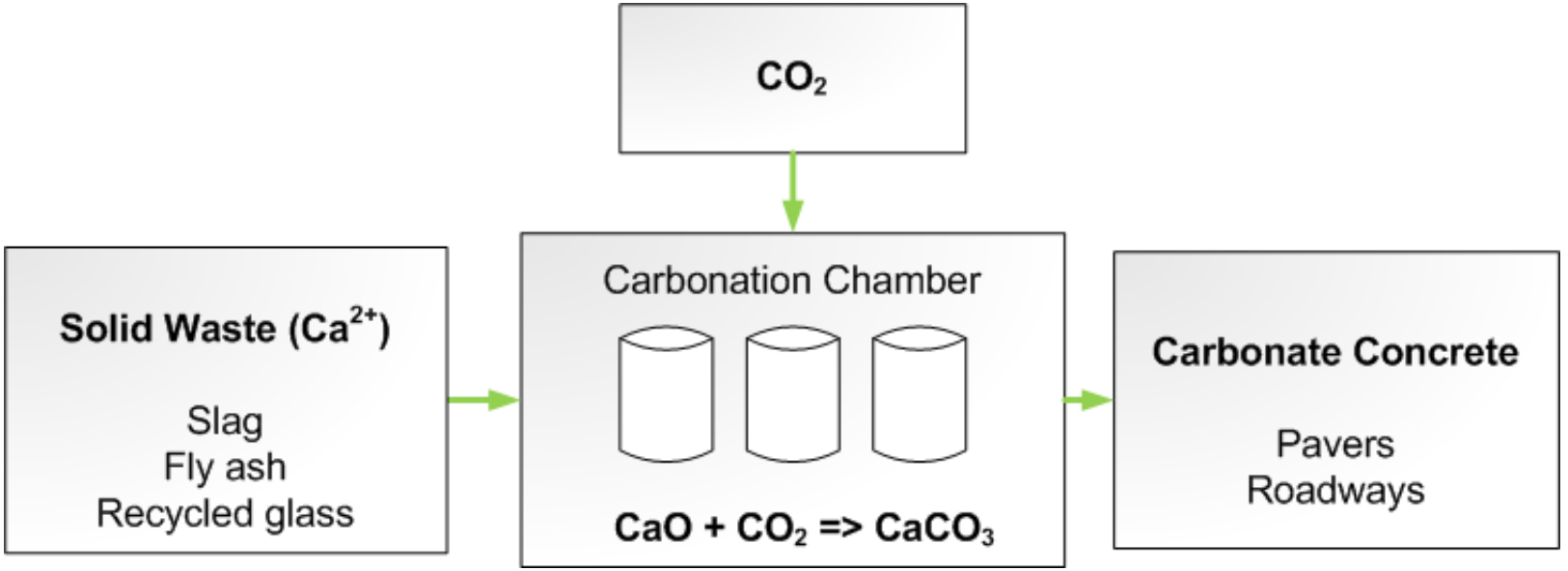
Number of Transactions / Exchanges: 4035
Tons of Waste Diverted: 1,123,413
Total Cost Savings: $5,189,037

Sustainable Materials Research at CCNY

Green Building Materials

Chemical Sensing

Carbon Sequestering Infrastructure Materials



Weihua Jin, CCNY; Collaborator: Masoud Ghandehari, NYU-Poly

Green Concrete for the CCNY Concrete Canoe

Weihua Jin, CCNY; Collaborator: Christian Meyer, Columbia University

Green Concrete for Buildings and Architecture

Weihua Jin, CCNY; Collaborator: Baogui Zhang

Chemical Sensing for Healthy Infrastructure

Weihua Jin, CCNY; Collaborator: Masoud Ghandehari, NYU-Poly