UBC Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

GNAM Global Network Week University of British Columbia:

Critical Infrastructure Interdependencies

Edgardo Flores, Yogesh Garg, Jillian Howell

University of British Columbia

BA 532

Themes: Community, Energy, Water

May 23, 2018

Disclaimer: *"UBC SEEDS Sustainability Program provides students with the opportunity to share the findings of their studies, as well as their opinions, conclusions and recommendations with the UBC community. The reader should bear in mind that this is a student research project/report and is not an official document of UBC. Furthermore, readers should bear in mind that these reports may not reflect the current status of activities at UBC. We urge you to contact the research persons mentioned in a report or the SEEDS Sustainability Program representative about the current status of the subject matter of a project/report".*

Executive Summary: Critical Infrastructure Interdependencies

As part of the GNAM Global Network Week: Urban Resilience and Inclusive Prosperity, the team of Edgardo Flores of Tecnologico Monterrey, Yogesh Garg of the Indian Institute of Management at Bangalore, and Jillian Howell of the Yale School of Forestry and Environmental Studies investigated critical infrastructure interdependencies at the University of British Columbia Vancouver. They sought to identify the components of UBC's critical infrastructure system that should be prioritized moving forward to make UBC more resilient in the face of potential acute shocks and longer term impacts. Using benchmark cities as case studies to identify relevant responses to shocks, the team recommended prioritizing electricity and water systems, and also implementing a resilience fund to address standard maintenance and repairs of infrastructure as well as disaster mitigation/preparation and responses/rebuilding efforts in the aftermath of a shock event.

GNAM Global Network Week
University of British Columbia

Critical Infrastructure Interdependencies

Edgardo Flores - Tecnologico de Monterrey
Yogesh Garg - Indian Institute of Management at Bangalore
Jillian Howell - Yale School of Forestry and Environmental Studies

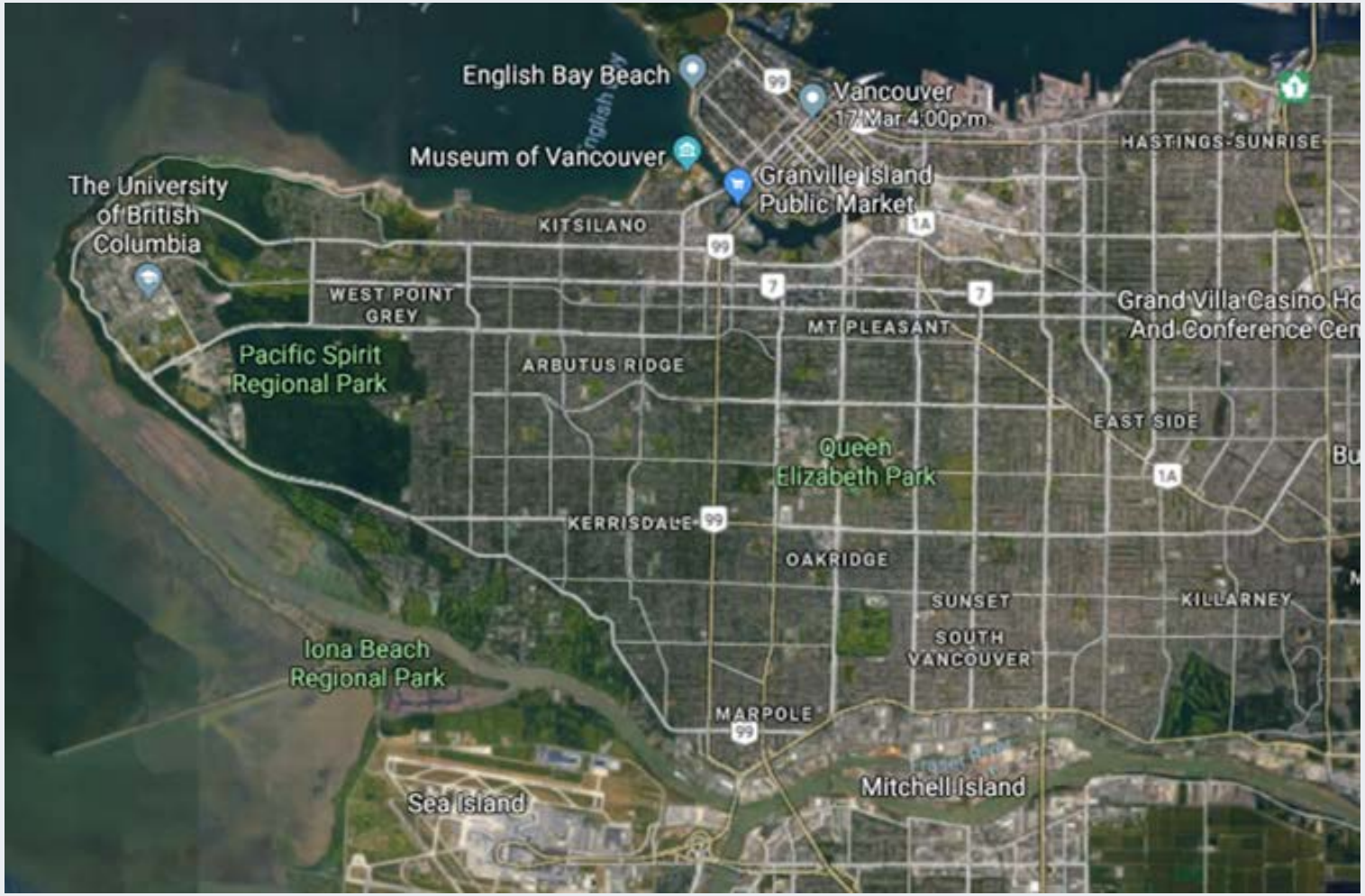
Outline

- Purpose and Methods
- UBC Background and Context
- Critical Infrastructure
- Interdependencies
- Acute Shocks and Other Potential Impacts
- Benchmark Cities and Responses
- Strategies and Recommendations
- Q & A

Purpose and Methods

- ***Objective*:** Identify the infrastructure area(s) of greatest need/importance
  - Which system, should it be disrupted, would have the greatest impact on the other infrastructure pieces and the UBC population?
- ***How?***
  - Understand Governance Structure and Stakeholders of UBC
  - Use Benchmark Cities to identify responses that could be replicated at UBC
  - Our team's greatest asset is diversity in experience, background and knowledge

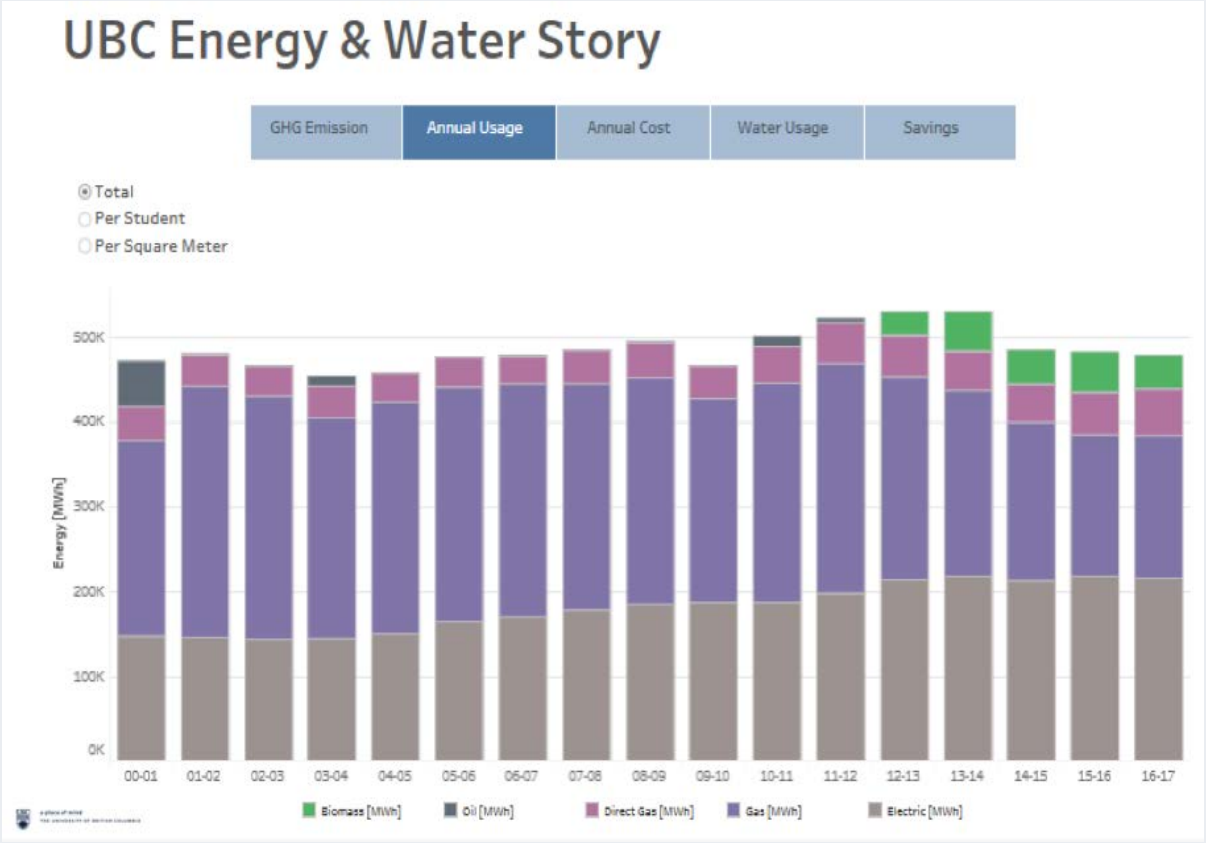
UBC Context


English Bay Beach
Vancouver
17 Mar 4:00 p.m.
Museum of Vancouver
Granville Island
Public Market
The University of British Columbia
KITSILANO
WEST POINT GREY
MT PLEASANT
HASTINGS-SUNRISE
Grand Villa Casino
And Conference Cen
Pacific Spirit Regional Park
ARBUTUS RIDGE
EAST SIDE
Queen Elizabeth Park
KERRISDALE
OAKRIDGE
SUNSET
KILLARNEY
SOUTH VANCOUVER
Iona Beach Regional Park
MARPOLE
Mitchell Island
Sea Island

CANADA
WASHINGTON
OREGON
Pacific Plate
Juan de Fuca Plate
North American Plate
Mantle upwelling
Subducting plate
Hydrous melting zone

Critical Infrastructure: Electricity

- Electricity provided by BC Hydro via 2 transmission lines
- UBC owns & operates 2 sub-stations:
  - North Campus sub-station
  - South Campus sub-station
- Stakeholders: UBC staff and students, neighborhood residents, BC Hydro



Critical Infrastructure: Electr. Back-Up

- Diesel-Fueled Back-Up Generators
  - 50,000 Liters of accessible diesel fuel
  - 300,000 Liters near former steam plant
  - Power capability range depends on the time of year
    - E.g., Temperature, campus capacity
  - Deep storage
  - Seismically vulnerable
  - No mechanism of distribution
  - Supply chain problem

Critical Infrastructure: Buildings

- Residential Housing
- Institutional Buildings
  - Facilities include major structures such as the UBC library, Museum of Anthropology, Beaty Biodiversity Museum, Thunderbird Sports Centre
- Stakeholders
  - UBC
  - Students, faculty, researchers
  - Residents
  - Donors

Critical Infrastructure: Transportation

- Transportation
  - Roads: limited access into and out of UBC via bus or personal vehicles
  - Sea: Coast guard and sea evacuation cited as a possible route of evacuation in case of emergencies

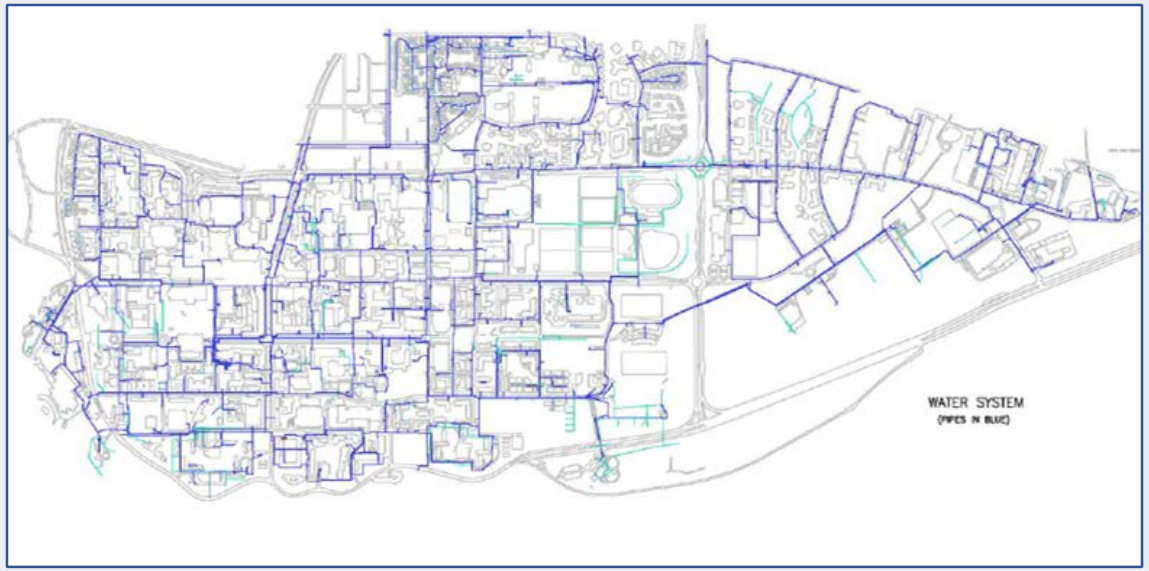
http://farm6.staticflickr.com/5228/5650828243_e8a5dcc467_z.jpg

Critical Infrastructure: Comms

- Emergency Communication Systems
  - Two systems of notification of incidents using voice messaging, email and text messaging to Electoral Area A.
    1. University of British Columbia operates an emergency notification system available to the residents of the Campus and University Neighborhood
    2. Both systems are voluntary, require residents to provide contact info

Critical Infrastructure: Water

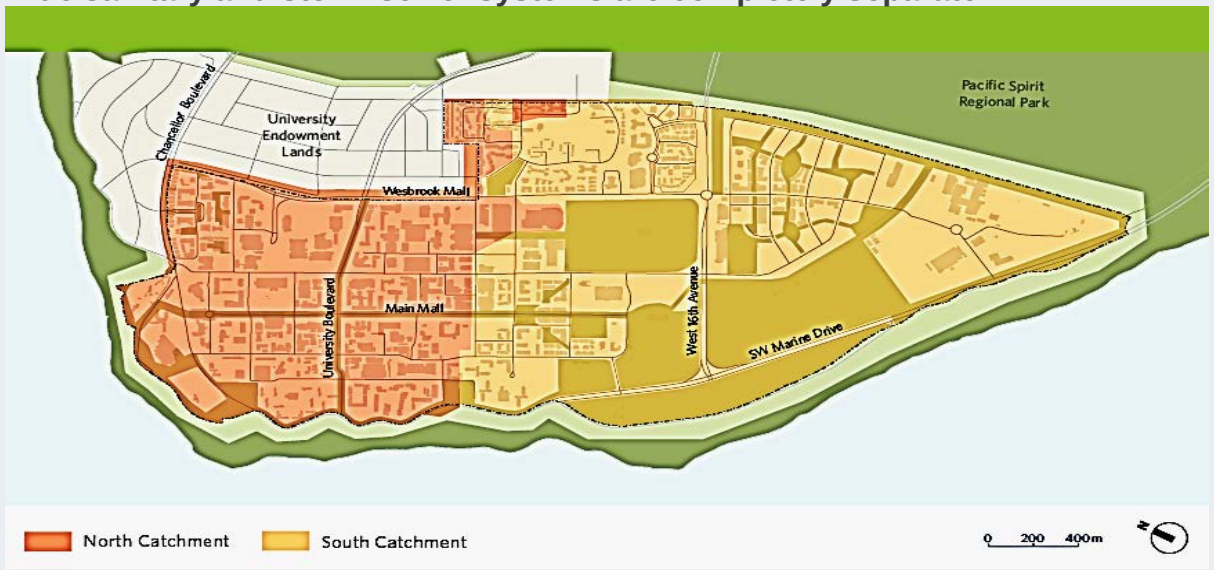
- Potable water provided by Metro Vancouver via 2 water lines from a reservoir in Pacific Spirit Park:
  - University Boulevard supplies UBC's pumping stations which distributes to the high pressure zone
  - West 16th Avenue (supplies low
  - pressure zone only)
- UBC owns and operate the campus-wide water system and is responsible for maintenance
- Risk in terms of redundancy



Critical Infrastructure: Sanitary Sewer

Responsibility	Own and Operates
Customers	Academic, Neighborhood
Funding	Academic - UBC pays commodity Neighborhood - 85% of metered water consumption
Decision Maker	Metro Vancouver decides on supply and commodity cost
Stakeholders	Metro Vancouver, Academic, Neighborhood
Risks	• Uncertainty over cost • Uncertainty over infrastructure ownership

Sanitary sewer is discharged into Metro Vancouver sewer system. Campus-wide sanitary and storm sewer systems are completely separate.



Facts

- ❑ *Total Consumption* 85% of water
- ❑ *Neighborhood Consumption* 85% of water
- ❑ *Total Commodity Cost* $1.46m
- ❑ *Commodity Cost Recovery*
- ❑ $1.48m ($0.45m from neighborhoods)

Critical Infrastructure: Stormwater

Responsibility	Own and Operates
Customers	Academic, Neighborhood
Funding	Academic UBC funds operation and maintenance. Infrastructure Impact Charges fund new infra Neighborhood UNA's pays for operations and maintenance
Decision Maker	Metro Vancouver decides on supply and commodity cost
Stakeholders	Metro Vancouver, Academic, Neighborhood
Risks	• Uncertainty over long-term replacement costs • Metro Vancouver contribution to 'spiral drain' storm infrastructure • Cliff erosion • Lack of regulatory framework

Stormwater discharges into 4 catchment areas which then drain into the ocean. Campus-wide sanitary and storm sewer systems are separate.

Facts

- ❑ *Total Pipe Length: 185,808 meters (incl 56,009m of field/building drain tile)*
- ❑ *Neighborhood Pipe Length: 11,603 meters*
- ❑ *Spiral Drain System 70-80 years old*

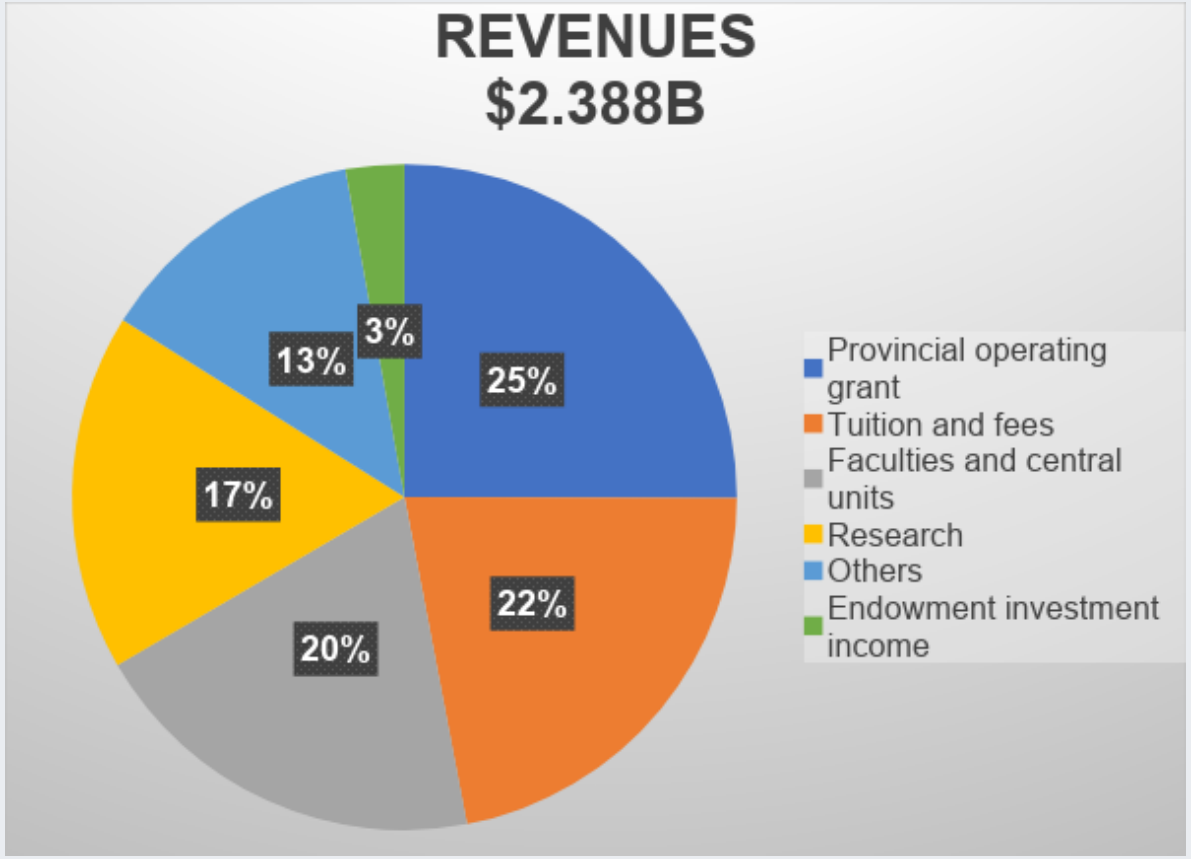
Critical Infrastructure: Natural Gas

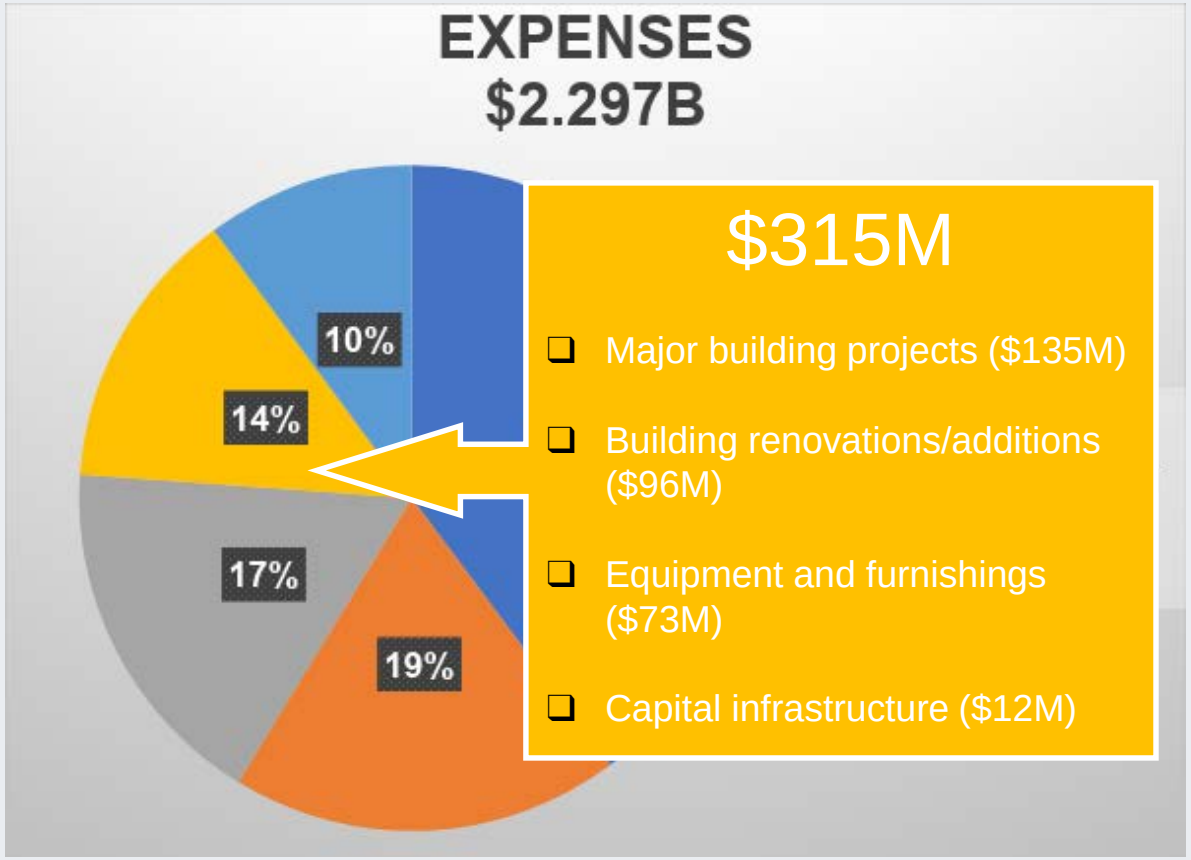
Responsibility	Distribution
Customers	Academic, Neighborhood(3 areas) Fortis BC provides natural gas to 3 other neighborhood areas
Funding	Academic UBC funds operation, maintenance and long-term replacement costs Neighborhood Residents pay UBC at Fortis BC market rates
Decision Maker	Fortis BC decides on supply and commodity cost
Supplier	Shell Energy North America
Risks	• UBC's system is also reaching supply capacity

Facts

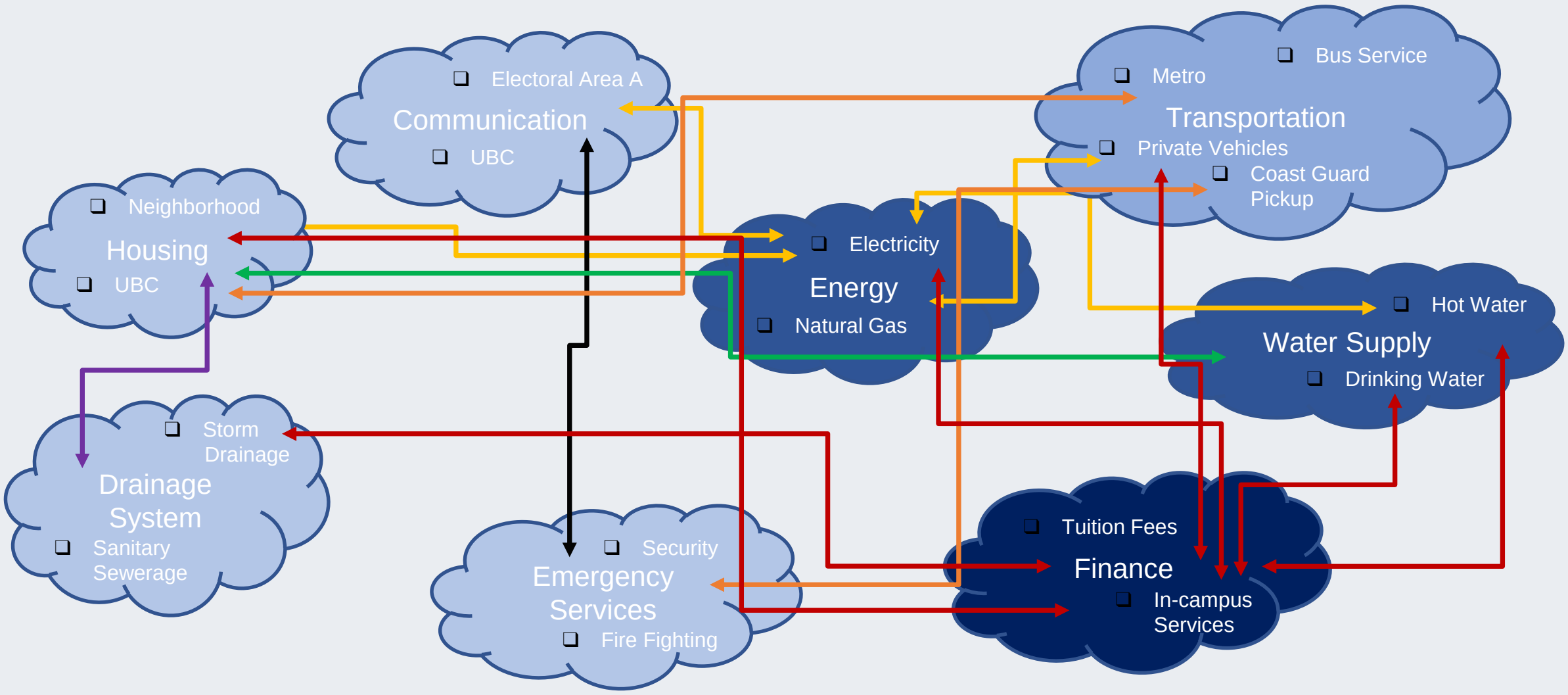
- *Total Consumption (where UBC provides service) 247,648 GJ*
- *Neighborhood Consumption (where UBC provides service) 14,250 cu ft*
- *Total Commodity Cost: $1.72m*
- *Commodity Cost Recovery $1.37m ($0.16m from neighborhoods)*

Critical Infrastructure: Finance





Interdependencies



Responses from Benchmark Cities

- Examined responses from other cities during times of acute shocks and other impacts
  - City Criteria: chosen locations have already suffered an acute shock and are contexts we are familiar with
  - Draw conclusions and co-opt relevant, successful responses
- Mexico City, Mexico
- Surat, India
- Boston, USA

Benchmark City: Mexico City, Mexico

- Acute Shock: Earthquake
  - Densely populated urban area
  - Damage to infrastructure, loss of life
- Mexico City law and guidance for natural disasters
  - “Ley del Sistema de Protección Civil del Distrito Federal”
    - Guidelines
    - Public organizations
    - Responsibilities
    - Actions

Benchmark Cities: Surat, India

- Acute Shock: Flooding
- Affected nearly 90% of households
- Crippled the economy

<u>Resilience Strategy Pillars</u>

- Connectivity/mobility services & regulations
- Affordable housing
- Water availability and quality
- Employment and economic dependency
- Ecosystem and environmental regulations
- Upscaling of public health
- ***Social cohesion***

Benchmark Cities: Boston, USA

- Acute Shock: Terrorism and Security Threats
  - Boston Marathon Bombing April 2013
- Response to the event was well-coordinated and organized, with local and state authorities taking the lead and federal agencies providing support and resources

Acute & Long Term Shocks

- Acute Shocks
  - Natural Disaster
    - Wildfire, storm events
  - Financial Breakdown
  - Cyber Attack
  - Security Threats/Terrorism

- Long Term Impacts from Climate Change
  - Sea Level Rise
  - Water Shortage
  - Flooding

Strategies and Recommendations

1) **Energy and Electricity**: Critical to essential UBC functions
2) **Water:** Lack of redundancy and necessary for sustaining the population
3) **Resilience Fund:** Identify channels to divert resources for standard maintenance and repair, but also mitigation/preparation efforts and disaster response

4) Create detailed, event specific evacuation and emergency plan: Focus on detailed logistics, identify most vulnerable populations, look at exit/entry strategies and safe UBC locations
5) Use resilience lens for all campus Improvements and developments
6) Create social cohesion: many distinct populations within the UBC community, focus on commonalities
7) Reinforce Cyber Security/IT Infrastructure

Questions?

Resources

- UBC Energy and Water Departament – Energy Annual Usage Story. https://public.tableau.com/views/UBCEnergyStoryExtracted/UBCCampusEnergyStory?:embed=y&:display_count=yes&:toolbar=no&:showVizHome=no
- The University of British Columbia – 2016/17 UBC Annual Report https://annualreport.ubc.ca/
- Forbes México **-** ¿Por qué el costo de los sismos de 2017 no se compara al de 1985?. https://www.forbes.com.mx/por-que-el-costo-de-los-sismos-de-2017-no-se-compara-al-de-1985/
- UBC Point Grey Campus Service Delivery, July 2016
- UBC Financial Report 2016 and 2017
- Surat Resilience Strategy - http://www.100resilientcities.org/strategies/surat/
- https://sustain.ubc.ca
- http://energy.ubc.ca/ubcs-utility-infrastructure
- https://www.suratmunicipal.gov.in/

Resources

- Walls RM, Zinner MJ. The Boston Marathon response – why did it work so well? *JAMA* (2013) **309**(23):2441–2. doi:10.1001/jama.2013.5965
- Biddinger PD, Baggish A, Harrington L, d'Hemecourt P, Hooley J, Jones J, et al. Be prepared – the Boston Marathon and mass casualty events. *N Engl J Med* (2013) **368**:1958–60. doi:10.1056/NEJMp1305480
- Hanfling D (2014) Boston bombings and resilience – what do we mean by this? *Front. Public Health* **2**:25. doi: 10.3389/fpubh.2014.00025
- https://censusreporter.org/profiles/16000US2507000-boston-ma/
- http://www.100resilientcities.org/cities/boston/
- http://www.metrovancouver.org/services/regional-planning/PlanningPublications/ElectoralAreaAEmergencyManagementPlan.pdf

Appendices

The following slides include additional research into Benchmark Cities not included within the March 16, 2018, presentation.

Benchmark City: Mexico City

- Acute Shock: Earthquake
  - The earthquakes are principals problems of the city that combined with overpopulation and without control in development infrastructure have high risk
  - 1985: 8.1 earthquake in the Richter scale
  - 2017: 7.1 earthquake in the Richter scale
- Consequences
  - Cost lives (more than 10 thousand – 355)
  - Infrastructure (4 – 1.6 billions of dollars)
  - Damage in houses and buildings (757 – 38 buildings)
  - Psychological damage

Benchmark City: Boston

- 100 Resilient Cities: Released its Resilience Strategy on July 13, 2017.
- Population: 672,840, greater Boston 4.8 million
- 48.4 square miles land situated on the Atlantic Ocean
- Official elevation is 19 ft (5.8 m) above sea level.
  - The highest point 330 feet (100 m) above sea level, and the lowest point is at sea level.
- Academic institutions, transportation and cultural hub
- Why? Emergency response and climate are located

Benchmark City: Boston

Long Term Shock: Climate Change

- Boston is a coastal city: climate change presents significant shocks and stresses, including flooding
- In 2013, the Organization for Economic Co- operation and Development (OECD) ranked Boston the eighth-highest metropolitan area worldwide in expected annual economic losses due to coastal flooding.
- Major impact potential to critical infrastructure such as Logan International Airport, MBTA stations, the Boston Convention and Exhibition Center, and the Seaport World Trade Center, primary data center, central fleet maintenance, six neighborhood emergency shelters, and Boston Police Department's telephone and computer communications.
- Boston has experienced 21 weather-related events that triggered federal or state disaster declarations since 1991.

Benchmark City: Surat, India

- The Surat city released its Resilience Strategy on April 18, 2017.
- Population: 4,467,797(4.4 million)
- Area: 326.515 km2,
- Density: 14,000/km2
- On the banks of the river Tapi
- Serves as a trade link between India and the Gulf countries
- Altitude: 13 meters (m.) above mean sea level
- Highest growth rates in the country and a 10-fold population rise

Benchmark City: Surat

Acute Shock: Sea level rise and flooding

- Nearly 90 per cent of the households were affected
- Crippled the economy

Benchmark City: Surat, India

Resilience Strategy - Organized around seven key pillars

1. CONNECTIVITY & MOBILITY SERVICES AND REGULATION

Implement an efficient traffic management system and move towards ensuring an adequate public transport system

2. AFFORDABLE HOUSING

Improve outlook and maintenance of affordable housing, and use engineering and technology to better provide it

3. WATER AVAILABILITY AND QUALITY

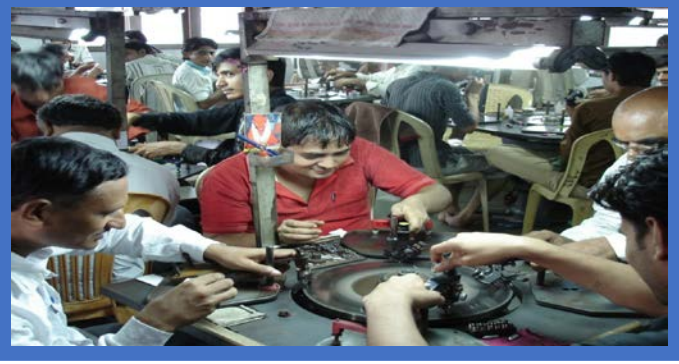
With a growing population, Surat must act to meet future water demand

Benchmark City: Surat, India

Resilience Strategy - Organized around seven key pillars

4. DOMINANT SECTORS OF EMPLOYMENT & ECONOMIC DEPENDENCY

Diversify Surat's industry and develop skills to strengthen the city's economy.



5. ECOSYSTEM & ENVIRONMENTAL REGULATION

Growth in industry and population density threatens to harm Surat's natural ecosystem and its people

7. UPSCALING OF PUBLIC HEALTH

Support healthier citizens to create a healthier city

6. SOCIAL COHESION

A city vulnerable to floods and other challenges must have strong social capital