



Three Earthquakes: Haiti, Chile, and Calexico

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May 14, 2010



Three Earthquakes

- Haiti, M_w 7.0, January 12, 2010
 - 230,000 dead, 6th most on record
 - Comparable to earthquake on Seattle Fault with an estimate of <2,000 fatalities
- Chile, M_w 8.8, February 27, 2010
 - 5th largest recorded earthquake
 - 452 dead
 - Comparable to Cascadia subduction earthquake
- Calexico, M_w 7.2, April 8, 2010
 - 2 dead
 - Water system damage

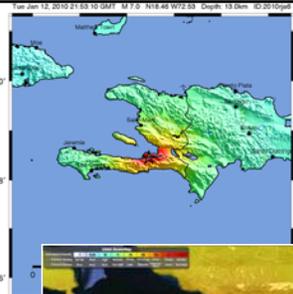


Acknowledgements

- ASCE Technical Council on Lifeline Earthquake Engineering (TCLEE)
 - Dave Plum – Haiti reconnaissance team
 - Brucely Joseph – Haiti reconnaissance team
 - John Eiding – Chile Preliminary Report
- Earthquake Engineering Research Institute
 - Background materials for Haiti and Chile
 - Colexico Earthquake EERI/UC San Diego Report
- Geo-Engineering Extreme Events Reconnaissance (GEER)
 - Chile Report



Haiti

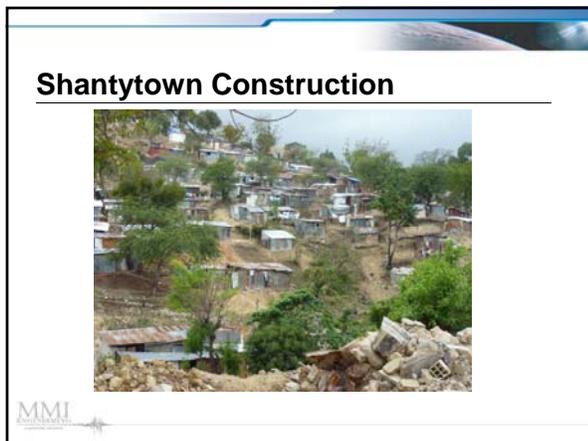
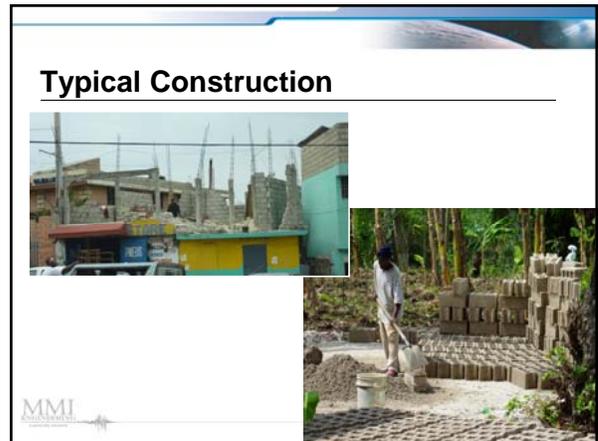
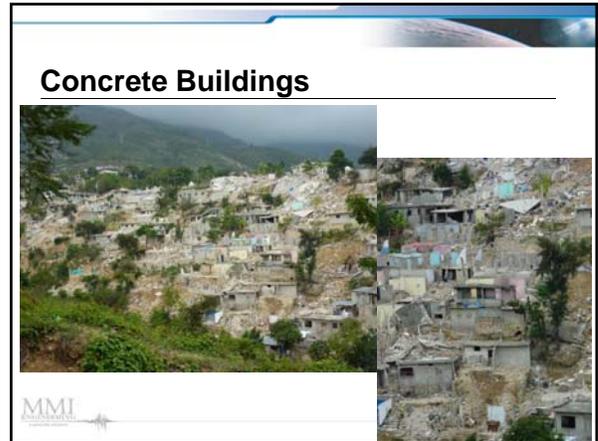
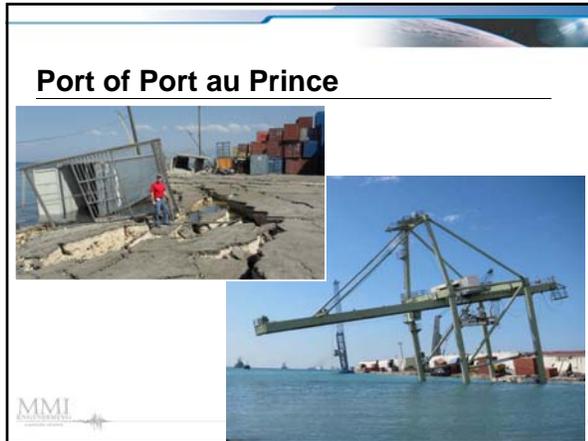


Presidential Palace



Government Buildings





Port au Prince Water

- Public supply has 250,000 connections serving over 1 million people
- Houses have cisterns filled by public system, augmented with private trucked water
- Public distribution points where people fill own containers
- Rotating curtailments

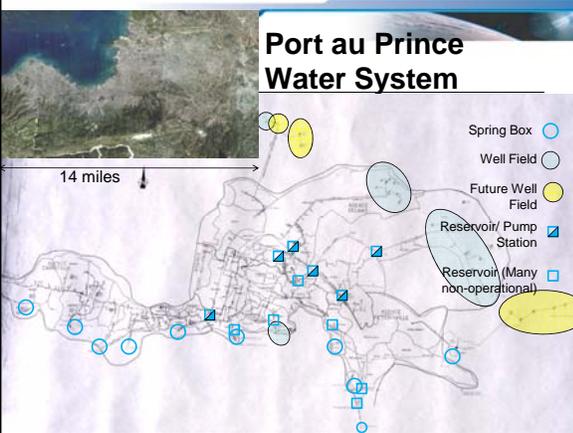


Port au Prince Water - continued

- 17 wells/spring box locations at higher elevations
- Each has storage and chlorination
- Maintaining chlorination is major ongoing issue
- Fiberglass tanks at many
- 12 larger concrete reservoirs counted on map; many not functional

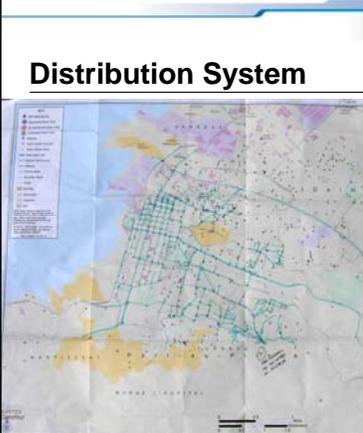


Port au Prince Water System



- Spring Box
- Well Field
- Future Well Field
- Reservoir/ Pump Station
- Reservoir (Many non-operational)

Distribution System



- Transmission system – up to 24" DIP
- Distribution 2" and 4" PVC
- 70 km pipe total
- Distribution system plumbed to government buildings, otherwise limited

Typical Supply at Turgeau




Earthquake Performance

- Port au Prince lost 5 employees
- Lost 50% of paying customers
- Isolated 8-10 (very low) breaks within 1 day; restored within 1 week.
- Many service line failures where buildings collapsed
- Appeared to be minor damage to other facilities
- Biggest issue serving 1 million people in temporary camps
 - Many emergency WTPs – US, Germany, France, Spanish
 - Drawing raw water from "public" system
 - Distributing by truck to local tanks and bladders at 500 sites



Emergency Treatment Plant at Turgeau



The image shows an emergency treatment plant at Turgeau. On the left, there is a row of white portable treatment units. On the right, a close-up view shows the internal components of one unit, including two large white cylindrical tanks and various pipes and electrical connections.

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Undamaged Reservoir/House Behind



The image shows an undamaged reservoir and a house behind it. The reservoir is a blue-lined concrete structure. The house behind it appears to be a simple structure with some damage to its roof and walls, but it is still standing.

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Collapsed Building at University Near Reservoir



The image shows a collapsed building at a university near a reservoir. The building is a large, multi-story structure that has completely collapsed, leaving a large pile of rubble. A white pickup truck is parked in the foreground, and a blue tarp is visible on the ground.

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Emergency WTP from Germany



The image shows an emergency water treatment plant (WTP) from Germany. It features two large blue cylindrical tanks mounted on a metal frame. A German flag is visible in the background.

- German lab found positive coliform and high HPCs in public supply

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Private Supply (WTP Failed)



The image shows a private water supply system. On the left, there is a stainless steel water filtration unit. On the right, there is a white truck with a large blue tank on the back. The tank has the text "DLO PAW" and "LIVRAISON D'EAU" on it. A sign on the truck lists services: "Eau d'acier", "Eau pour usage industriel", "Eau pour usage agricole", and "Eau pour usage domestique".

- Private companies distribute treated water by truck, 5 gal bottles (\$1.50 ea)

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National Stadium/ Emergency Water Supply



The image shows a national stadium and an emergency water supply station. The stadium is a large, open-air structure with a blue roof. The water supply station is a large, open-air structure with several large blue tanks and pipes. People are standing around the water supply station, and a white truck is parked nearby.

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Elevated Concrete Tank Damaged



Drainage and Waste Disposal

- Septic systems (10-30%) – large modern buildings
- Cesspools/Latrines (30%)
- Balance to drainage system
- Only WWTP in country at National Hospital and was inoperable before earthquake



Drainage System Needs Cleaning



Drainage System

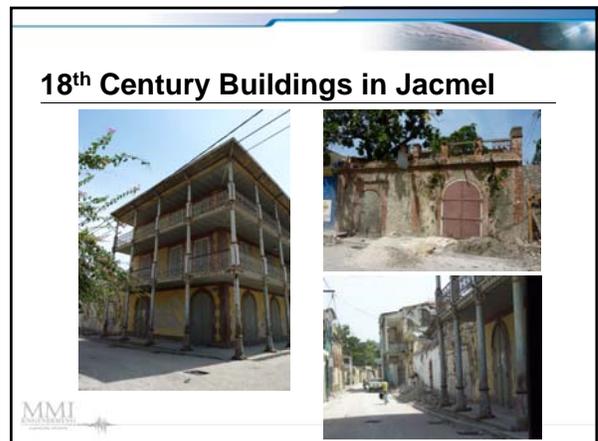
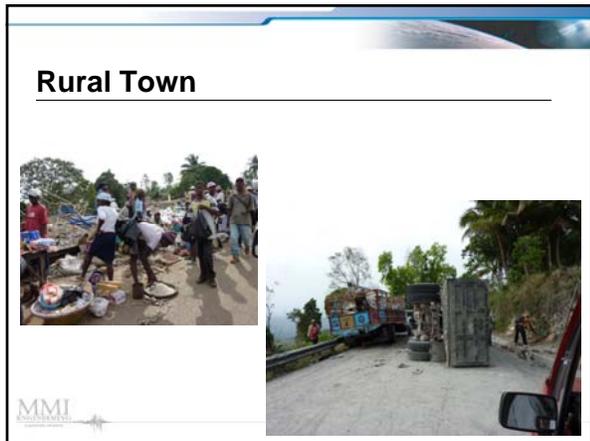
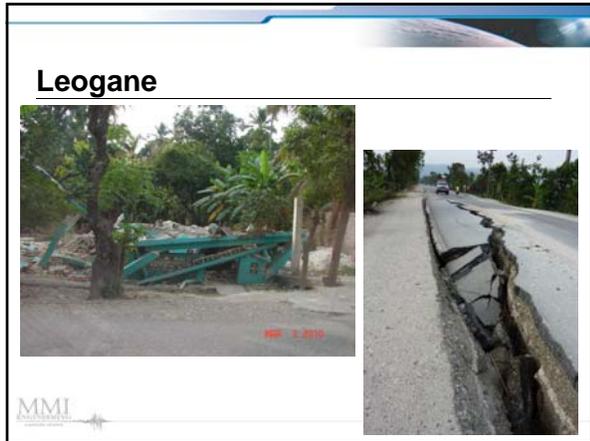


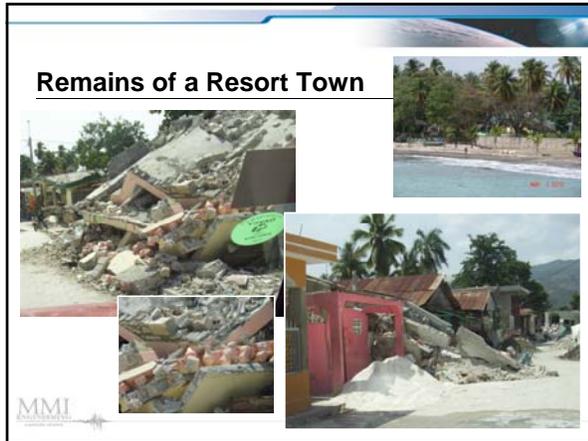
Waste Disposal



Leogane - Jacmel

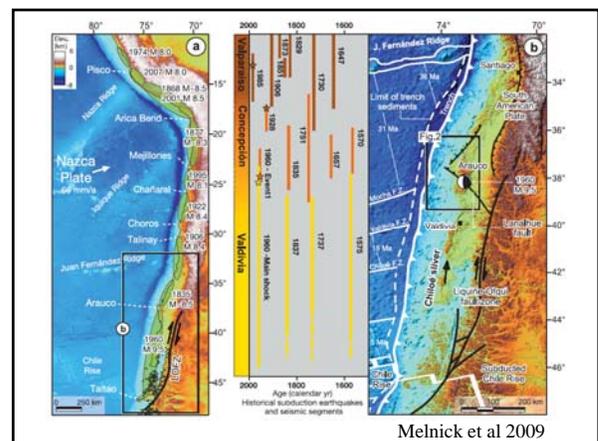
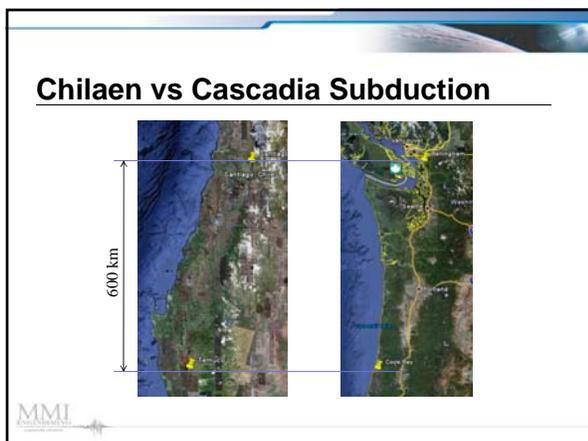
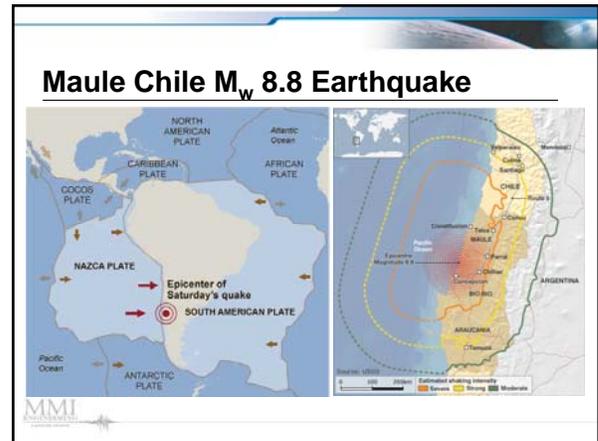


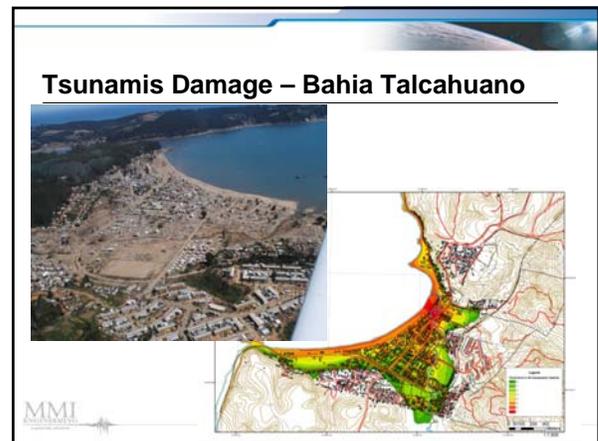
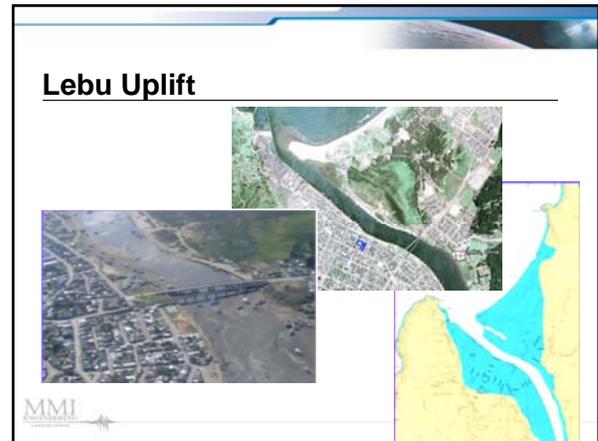
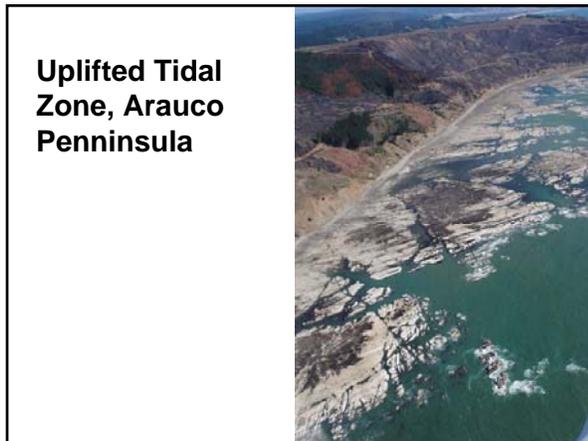
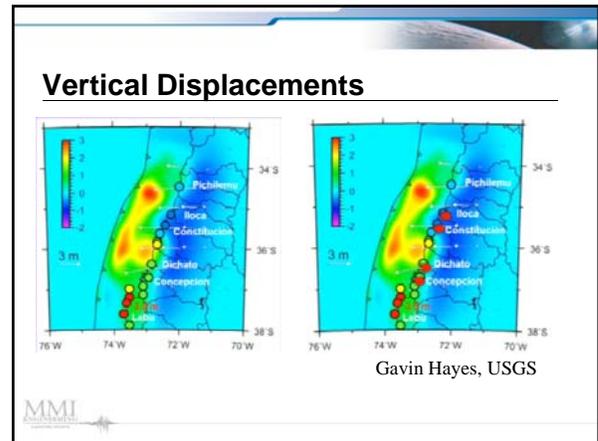
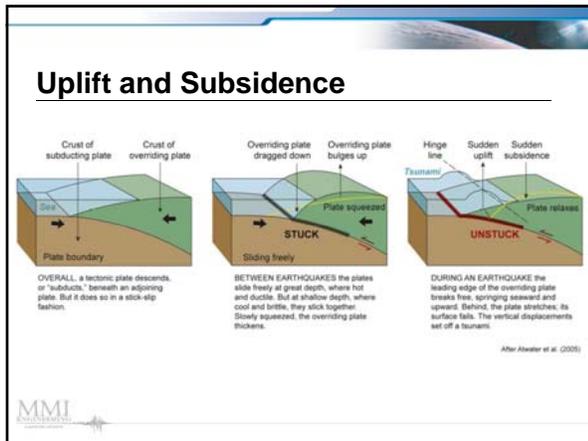


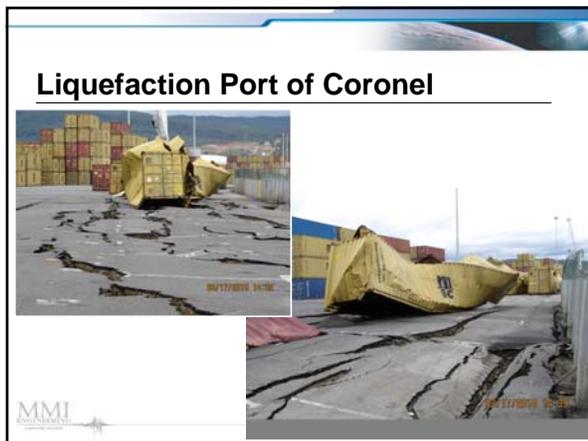
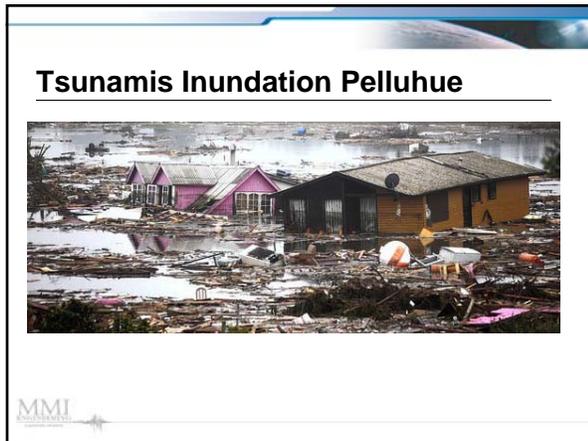


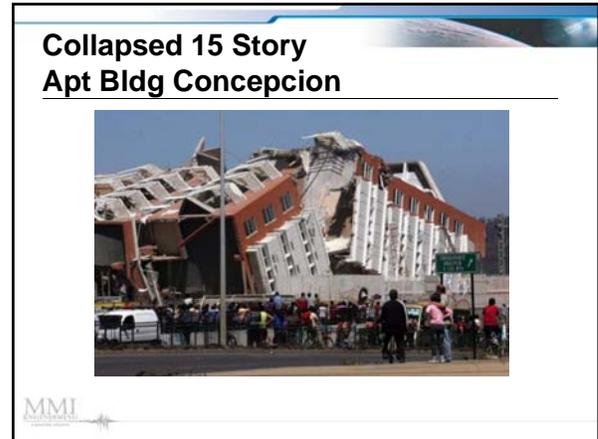
Jacmel Water

- 1 spring box cracked
- CIP transmission system OK
- Canadian military replacing valves, had not identified any leaks; 4" clamps in short supply
- New rural systems using HDPE with heat fused joints (similar to gas systems)









Chile Water System Limitation of Use of Photos and Information

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Concepcion Water System Damage

- Concepcion and Talcahuano most heavily damaged
- Concepcion – Mochita WTP, 57 MGD
 - PGA – 25-30%g
 - Pumps raw water from Bio Bio River
 - Trash rack – 1 ft lateral spread differential mvt
 - Pump station – extensive structural damage
 - 4 flocculator/clarifiers; filters, chlorination
 - Center column, baffles, and tube settlers damaged
 - Filters OK; gallery piping OK
 - Computer monitors and computers fell and broke
 - 1/3 lab counter top equipment fell and broke
 - Onsite piping broke



Collapsed Wall Mochita WTP PS



Photo by Eiding



Clarifier Under Repair, Mochita WTP



Photo by Wang



Concepcion Water Pipelines

- Total 1,200 km of pipe
- Treated water transmission lines leaving plant
 - 500-1,000 mm diameter – 72 failures
- Distribution 6" – 12"
 - Cast iron-oldest areas; AC-intermediate; PVC and HDPE used now (no failures)
 - 1,000 pipeline failures (most PGD); 2,000 service failures
- 40% unaccounted for water before; 60% after
- Restoration issues:
 - Loss of cellular telephone service
 - Loss of offsite power (had gen sets at WTP and larger PSs)



Damaged Welded Steel Pipe



Photo by Eiding



Rural Water Systems

- Groundwater with submersible pumps
- Small steel elevated tanks ~ 10,000 gallons
 - 73 tanks of 420 exposed to strong shaking collapsed
 - PVC distribution





Wastewater Systems

- Concepcion
 - Main collector pipe broke resulting in discharge to the Bio Bio River
 - Primary clarifier baffles broke
- Los Angeles
 - Large diameter pipe broke resulting in discharge to the Quilque River

