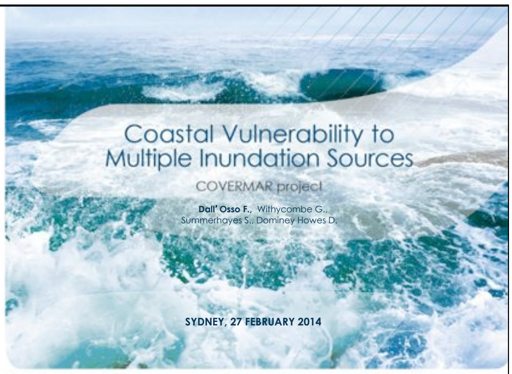


Coastal Vulnerability to Multiple Inundation Sources

COVERMAR project

Dall' Osso F., Withycombe G., Summerhayes S., Dominey Howes D.

SYDNEY, 27 FEBRUARY 2014

Coastal Inundation. COVERMAR Project 2012.

Overview

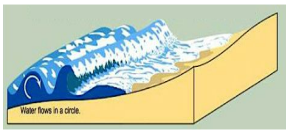
1. Storm surge and tsunamis
2. The aim of this project
3. Context and background
4. Hazard assessment
5. Vulnerability assessment
6. Results and conclusion
7. Acknowledgments

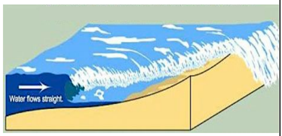
Extreme Inundations

"Inundation of coastal areas caused by the highest elevation reached by the sea during a given period" (IOC 2006)

STORM SURGES

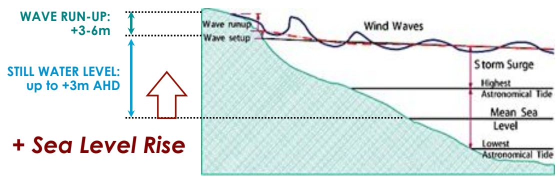
TSUNAMIS





Storm Surges

Storm Surge + Astronomical Tide = Storm Tide



+ Sea Level Rise

Storm Surges

Tsunamis

Tsunamis vs. Storm Surges

The Aim of COVERMAR

.. a tool to assess the VULNERABILITY OF COASTAL ASSETS
to MULTIPLE TYPES OF INUNDATION

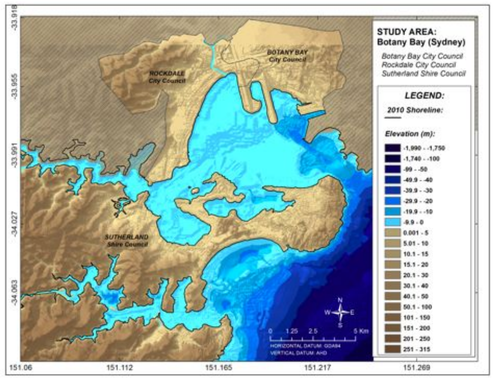
HIGH VULNERABILITY ⟷ LOW VULNERABILITY

Study Area Selection

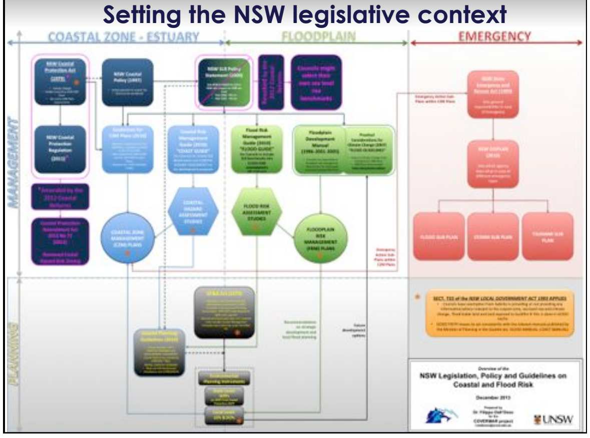
COVERMAR ADVISORY COMMITEE

SELECTION CRITERIA →	TSUNAMI EXPOSURE W.Av. over 2 scenarios in 2100HT + infrastr.	STORM SURGE EXPOSURE Avg. number of properties over 3 scenarios	STORM SURGE EXPOSURE NSW Erosion Hot Spot	SIGNIFICANCE critical infrastructure or strategically important sites	POPULATION DENSITY within the exposed areas	BUILDING TYPE VARIATION	SOURCES OF CASCADE EFFECTS	COMMUNITY RESILIENCE	FINAL SCORE (out of 5)
Criteria Weight →	0.8	0.9	0.48	0.66	0.9	0.62	0.8	1	
CASE STUDY OPTIONS									
Council 1	1	2	1	5	2	2	3	4	[illegible]
Council 2	1	2	1	2	2	1	1	3	[illegible]
Council 3	1	1	1	3	2	4	3	2	[illegible]
Council 4	2	2	1	4	4	3	1	3	[illegible]
Council 5	1	1	1	3	3	3	1	3	[illegible]
Council 6	1	1	1	4	3	2	1	2	[illegible]
Council 7	4	5	5	3	3	2	1	2	[illegible]
Council 8	1	1	1	4	2	1	1	2	[illegible]
Council 9	2	4	1	4	3	3	1	2	[illegible]
Council 10	5	2	1	4	3	5	4	3	[illegible]
Council 11	3	2	1	5	5	3	2	2	[illegible]
Council 12	1	2	3	3	2	1	1	2	[illegible]
Council 13	1	1	1	4	1	1	1	5	[illegible]
Council 14	1	1	1	2	1	1	1	2	[illegible]
Council 15	2	2	1	4	4	2	1	3	[illegible]

Study Area Selection



Setting the NSW legislative context



Previous work: the 2009 SCCG Tsunami Project

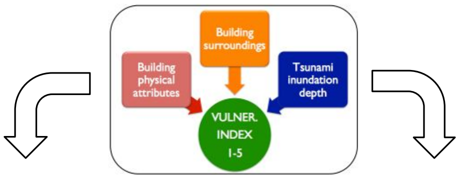
UNSW
MED INGEGNERIA

A METHOD FOR ASSESSING
THE VULNERABILITY OF BUILDINGS TO CATASTROPHIC
(TSUNAMI) MARINE FLOODING

August 2009

http://www.sydneycoastalcouncils.com.au

Previous work: the 2009 SCCG Tsunami Project



Previous work: the 2009 SCCG Tsunami Project

COVERMAR Inundation Scenarios

1. Multi-Hazard Approach

STORM SURGES	TSUNAMIS

COVERMAR Inundation Scenarios

2. Future Sea Level Conditions

	STORM SURGES	TSUNAMIS
TODAY (2010 msl)		
2050 (+34cm) ?		
2100 (+84cm) ?		

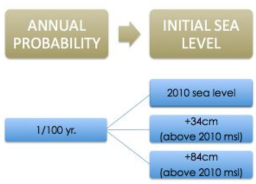
COVERMAR Inundation Scenarios

3. Probabilistic Inundation Hazard Assessments

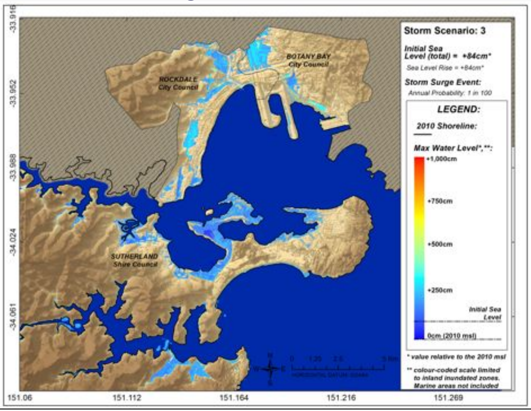
	STORM SURGES	TSUNAMIS
TODAY (2010 msl)	1 in 100 yr.	1 in 100 yr. 1 in 1,000 yr. 1 in 10,000 yr.
2050 (+34cm) ?	1 in 100 yr.	1 in 100 yr. 1 in 1,000 yr. 1 in 10,000 yr.
2100 (+84cm) ?	1 in 100 yr.	1 in 100 yr. 1 in 1,000 yr. 1 in 10,000 yr.

Storm Surge Hazard Assessment

2012 SCCG-CSIRO Project:
"Mapping and Responding to Coastal Inundation"
http://www.sydneycoastalcouncils.com.au



Storm Surge Hazard Assessment



Tsunami Hazard Assessment

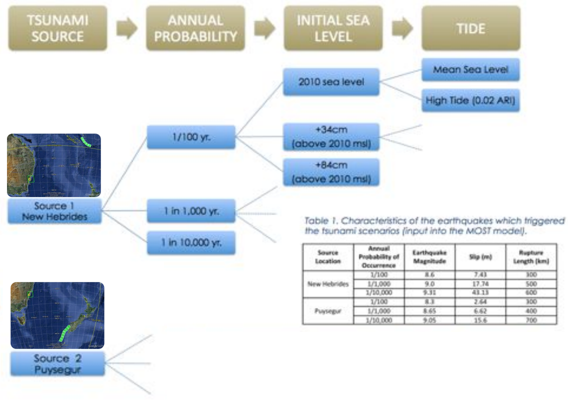
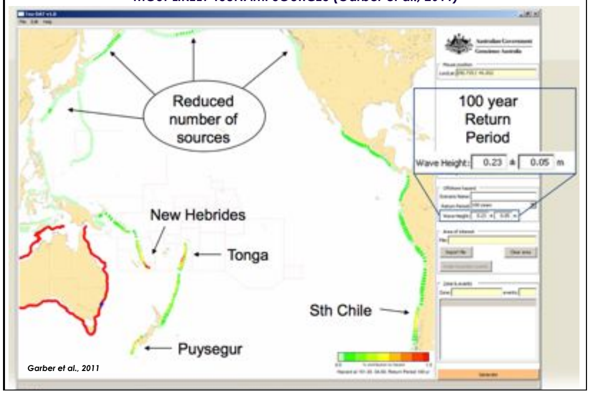


Table 1. Characteristics of the earthquakes which triggered the tsunami scenarios (input into the MOST model).

Source Location	Annual Probability of Occurrence	Earthquake Magnitude	Slip (m)	Rupture Length (km)
New Hebrides	1/100	8.6	7.43	300
	1/1,000	9.0	17.74	500
	1/10,000	9.31	43.13	600
Puysegur	1/100	8.3	2.64	300
	1/1,000	8.65	6.62	400
	1/10,000	9.05	15.6	700

Tsunami Hazard Assessment

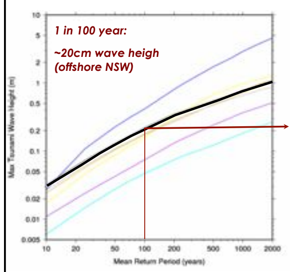
✓ *MOST LIKELY TSUNAMI SOURCES (Garber et al., 2011)*

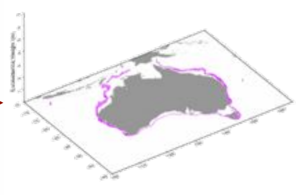


Garber et al., 2011

Tsunami Hazard Assessment

✓ *PROBABILISTIC ESTIMATES (Burbidge et al., 2008)*





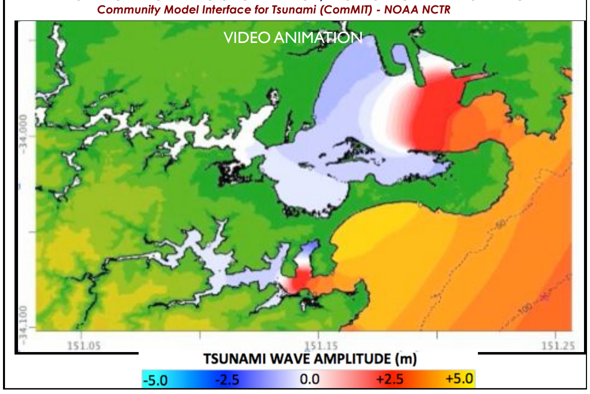
Offshore wave amplitude caused by a 1/100 year tsunami

Maximum offshore tsunami wave amplitude against various return times, for different Australia States. NSW is the black line

Burbidge et al., 2008

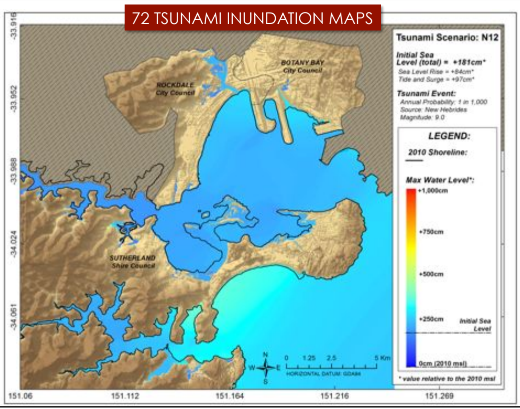
Tsunami Hazard Assessment

✓ *NUMERICAL MODELLING OF GENERATION, PROPAGATION AND INUNDATION*
Community Model Interface for Tsunami (ComMIT) - NOAA NCTR



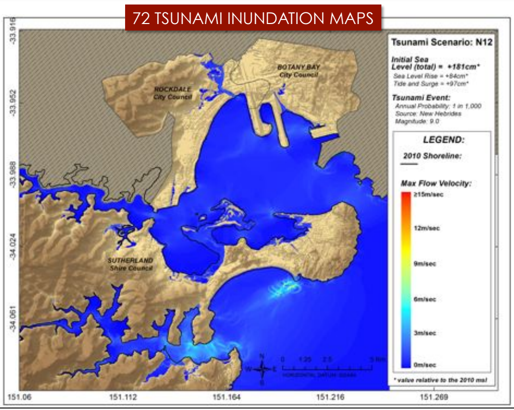
Maximum Tsunami Water Depth

72 TSUNAMI INUNDATION MAPS



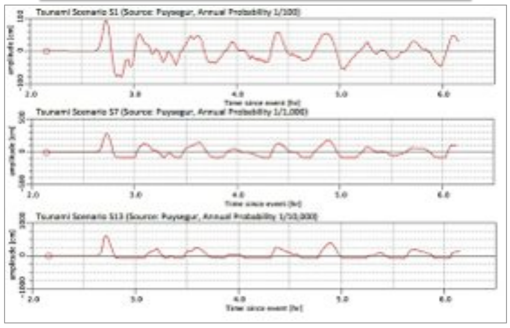
Maximum Tsunami Flow Velocity

72 TSUNAMI INUNDATION MAPS



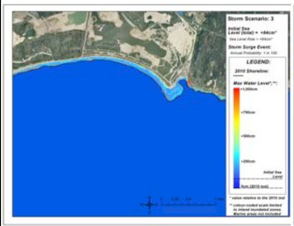
Tsunami Hazard Assessment

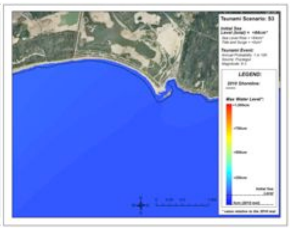
✓ TSUNAMI ARRIVAL TIME, WAVES NUMBER, DURATION



FROM PUYSEGUR: ~2.5 hr. FROM NEW HEBRIDES: ~ 4 hr.

Tsunami vs Storm Surges





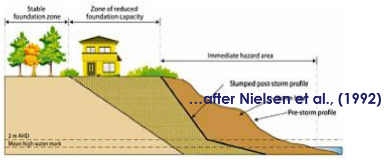
1/100 yr. storm surge >>> 1/100 yr. tsunami

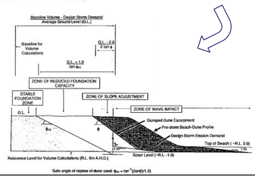
tsunami flow velocity >>> storm surge flow velocity

Puysegur tsunamis would reach Sydney in only 2h30'

Storm Surge Vulnerability Assessment

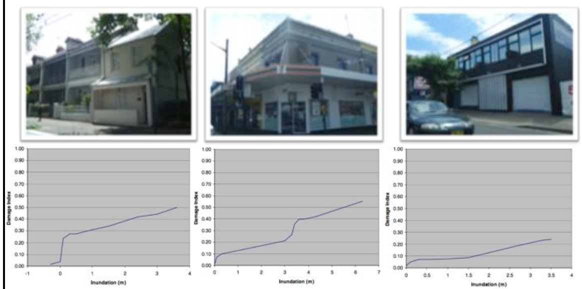
1. Damage given by wave scouring under building foundations
   - *Within the COVERMAR study area, only beaches and coastal structures would be affected*





Storm Surge Vulnerability Assessment

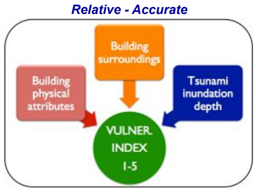
2. Damage given by tidal inundation
   - *Flood vulnerability curves for 20 typical Australian buildings (Maqsood et al., 2013)*



Tsunami Vulnerability Assessment

lack of observations of tsunami damage to Australian buildings

1. Index-Based Methods
   Relative - Accurate



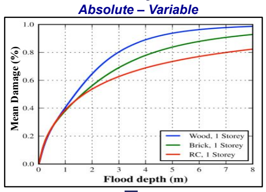
⇩

PTVA-3 Model improved

⇩

Building Vulnerability Maps

2. Vulnerability Functions
   Absolute – Variable



⇩

Functions from the 2011 Japan Tsunami adapted to Sydney's building types

⇩

Economic Loss (PML)

Data Acquisition

4083 buildings exposed to storm surges or tsunamis

1. Remote Sensing Survey

2. Field Validation

Data Acquisition

4083 buildings exposed to storm surges or tsunamis

3. Building Classification

24 building classes,
117 subclasses, based on:
- construction material
- number of storeys
- use
- garage-basement
- ground floor type

4. GIS Construction

Results:

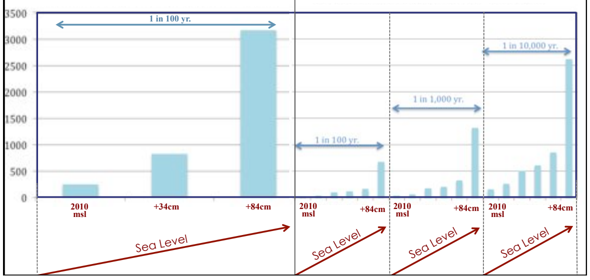
1. *Exposure Estimates*
2. *Building Vulnerability Maps*
3. *Economic Loss (PML)*

Results: Exposure

Number of Buildings Inundated

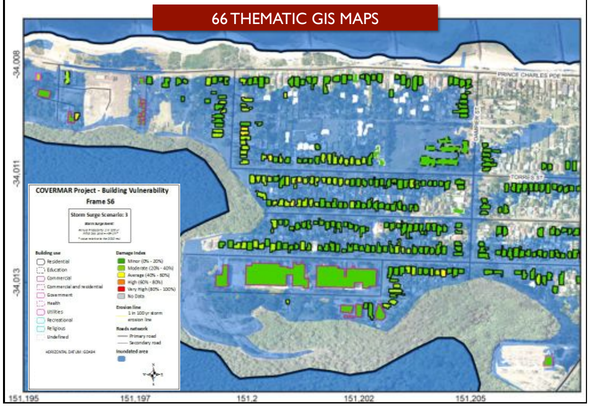
STORM SURGES

TSUNAMIS

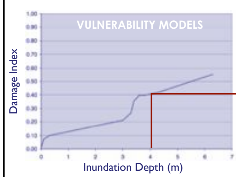


Results: Vulnerability Maps

66 THEMATIC GIS MAPS



Results: Economic Loss (PML)



Damage Index = 0.4 = Incurred Damage ($) / Construction Cost ($)

a. **BUILDING NEEDS REPAIR:**
Repair Cost = (Damage Index) x (Construction Cost) x (Repair Contingency)

b. **BUILDING NEEDS REPLACEMENT:**
Replacement Cost = (Construction Cost) + (Demolition Cost)

Results: Economic Loss (PML)

	STORM SURGES		TSUNAMIS					
	1 in 100 yr.		1 in 100 yr.		1 in 1,000 yr.		1 in 10,000 yr.	
2010 msl	$26 M	248	$29 M	132	$55M	212	$171M	609
+34cm	$64 M	829	$45 M	184	$90 M	325	$257M	919
+84cm	$264 M	3,173	$169 M	911	$294 M	1,304	$728M	2,623

In Summary (1 of 2)

1. ***Tsunamis triggered in New Zealand would reach the study area in about 2.5 hours.***
2. *The exposure to 1/100 yr. storm surges is significantly higher than the exposure to all simulated tsunami events.*
3. ***Sea level rise has a strong influence on exposure and damage.***
4. *Kingsford Smith Airport and Port Botany would be heavily inundated only by the most severe scenarios.*
5. ***Storm erosion is currently a threat only to beaches, coastal structures and transport infrastructure.***

In Summary (2 of 2)

6. ***The average economic loss per building caused by a 1/100 yr. tsunami is three times higher than that caused by a 1/100 yr. storm surge.***
7. *The total economic loss for building impacts caused by tsunamis and storm surges having an annual probability of occurrence of 1/100 yr. is comparable.*
8. ***If all buildings of the study area had a raised ground-floor (+30 cm above ground level), the total PML would decrease by 44.6% (storm surge) and 29.6% (tsunami).***
9. *Hotspots representing the most vulnerable locations are listed against each LGA. This includes an area that may become isolated for most inundation scenarios.*
10. ***Some potential sources of 'cascading effects' have been identified.***

Conclusion

1. *COVERMAR is the first multi-hazard tool to assess the risk from extreme inundations in Australia.*
2. *The methodology is consistent with the current NSW legislation on coastal risk.*
3. *COVERMAR provides data to support balanced inundation risk reduction measures.*
4. *We recommend applying the COVERMAR tool to other NSW coastal locations.*

Acknowledgments

- *The NSW Minister for Police and Emergency Service*
- *The COVERMAR Advisory Committee*
- *Geoff Withycombe (SCCG) and the SCCG staff*
- *Stephen Summerhayes, the project Manager (SCCG)*
- *Prof. Dominey-Howes (University of Sydney)*
- *the Hazards Research Group (University of Sydney)*

Coastal Inundation. COVERMAR Project 2012

Coastal Inundation. COVERMAR Project 2012