



Research Forum 2019 –
Impact of Super Typhoon Mangkhut

**Flood Attack during Mangkhut
and Our Challenges**

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Drainage Services Department

3 May 2019



Agenda

- Overview of Flooding Situation during Mangkhut
- Case Study – Tai O
- Our Challenges and Possible Way Out





Overview of Flooding Situation during Mangkhut

- Mild rainfall, about 30 – 40 mm/hr
- Flooding mainly due to storm surge and overtopping wave
- Majority at coastal / riverside locations, especially at low-lying areas





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Lei Yue Mun



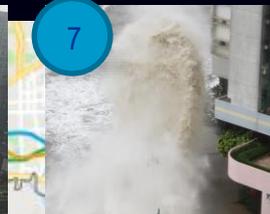
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Siu Sai Wan



6

Tung Chun Street / Chi Shin Street, Tseung Kwan O



7

South Horizons



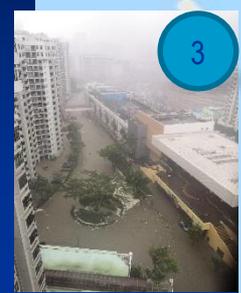
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Nam Wai, Sai Kung



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Shing Mun River, Shatin



3

Heng Fa Chuen



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Mui Wo



10

Plover Cove Road, Tai Po



11

Sam Mun Tsai, Tai Po



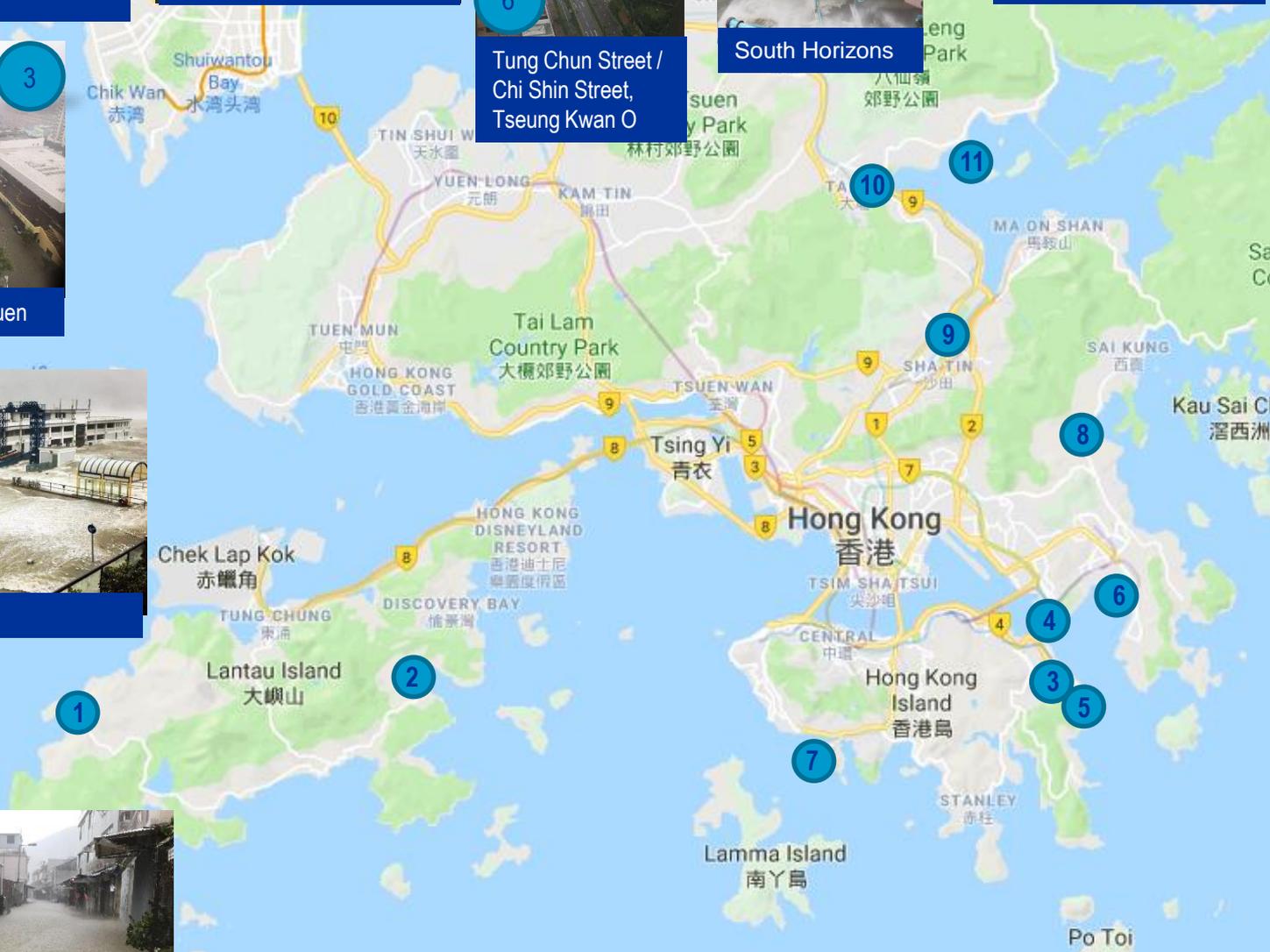
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Tai O



12

Shek Chung Au (near Sha Tau Kok Police Station)

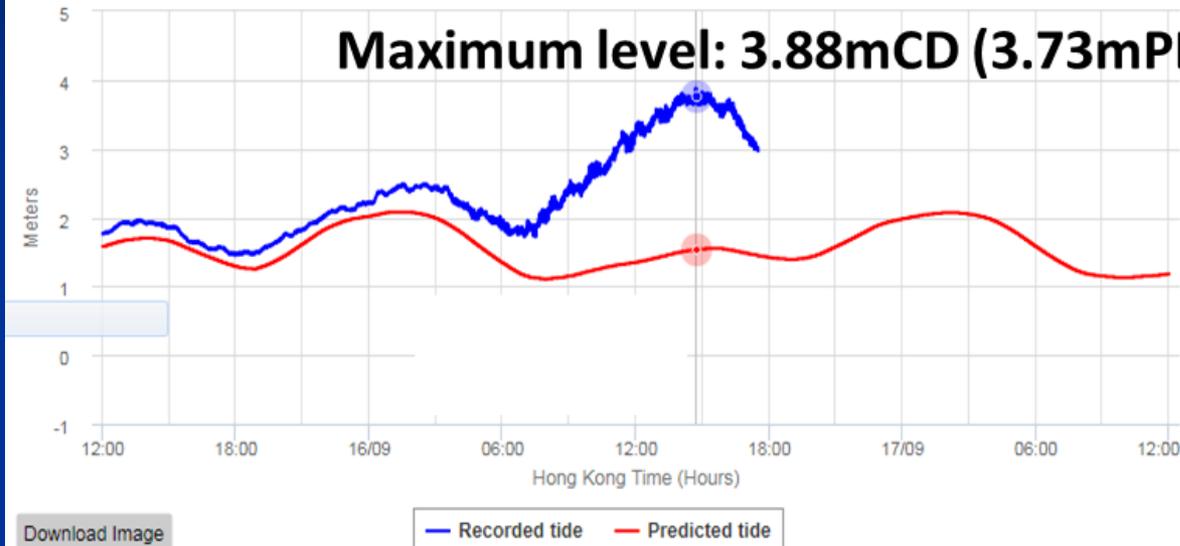


Major Flooding Incidents due to Mangkhut on 16 September 2018

Storm Surge Impact

Quarry Bay

Maximum level: 3.88mCD (3.73mPD)



Sea Level = AT + SS
AT = Astronomical Tide
SS = Storm Surge

Example:

3.88mCD =

1.53 mCD (AT) + 2.35m (SS)





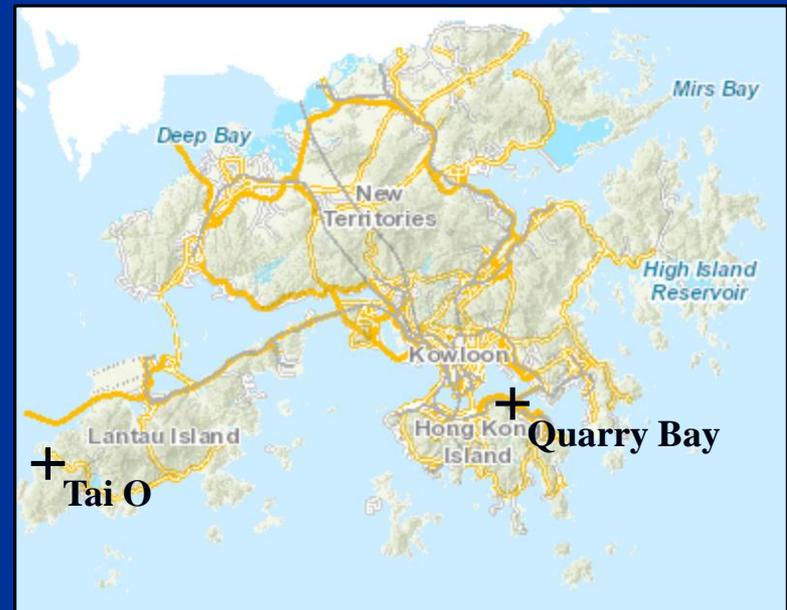
Design Extreme Sea Levels and Comparison with Wanda, Hato and Mangkhut (mPD)

Return Period (years)	North Point / Quarry Bay (1954 - 2017)	Tai O (1985 - 2017)
50	3.45	3.84
100	3.63	4.06
200	3.81	4.28
Wanda 1962	<div style="border: 1px solid red; padding: 2px;">1.77 (SS)</div> + 2.04 (AT) <div style="border: 1px solid orange; padding: 2px;">= 3.81 mPD</div> (3.96 mCD)	N.A.
Hato 2017	1.18 (SS) +2.24 (AT) = 3.42 mPD (3.57 mCD)	1.78 (SS) + 1.94 (AT) = 3.72 mPD (3.87 mCD)
Mangkhut 2018	<div style="border: 1px solid red; padding: 2px;">2.35 (SS)</div> +1.38 (AT) <div style="border: 1px solid blue; padding: 2px;">= 3.73 mPD</div> (3.88 mCD)	<div style="border: 1px solid red; padding: 2px;">2.33 (SS)</div> + 1.38 (AT) <div style="border: 1px solid blue; padding: 2px;">= 3.71 mPD</div> (3.86 mCD)

$$\text{Sea Level} = \text{AT} + \text{SS}$$

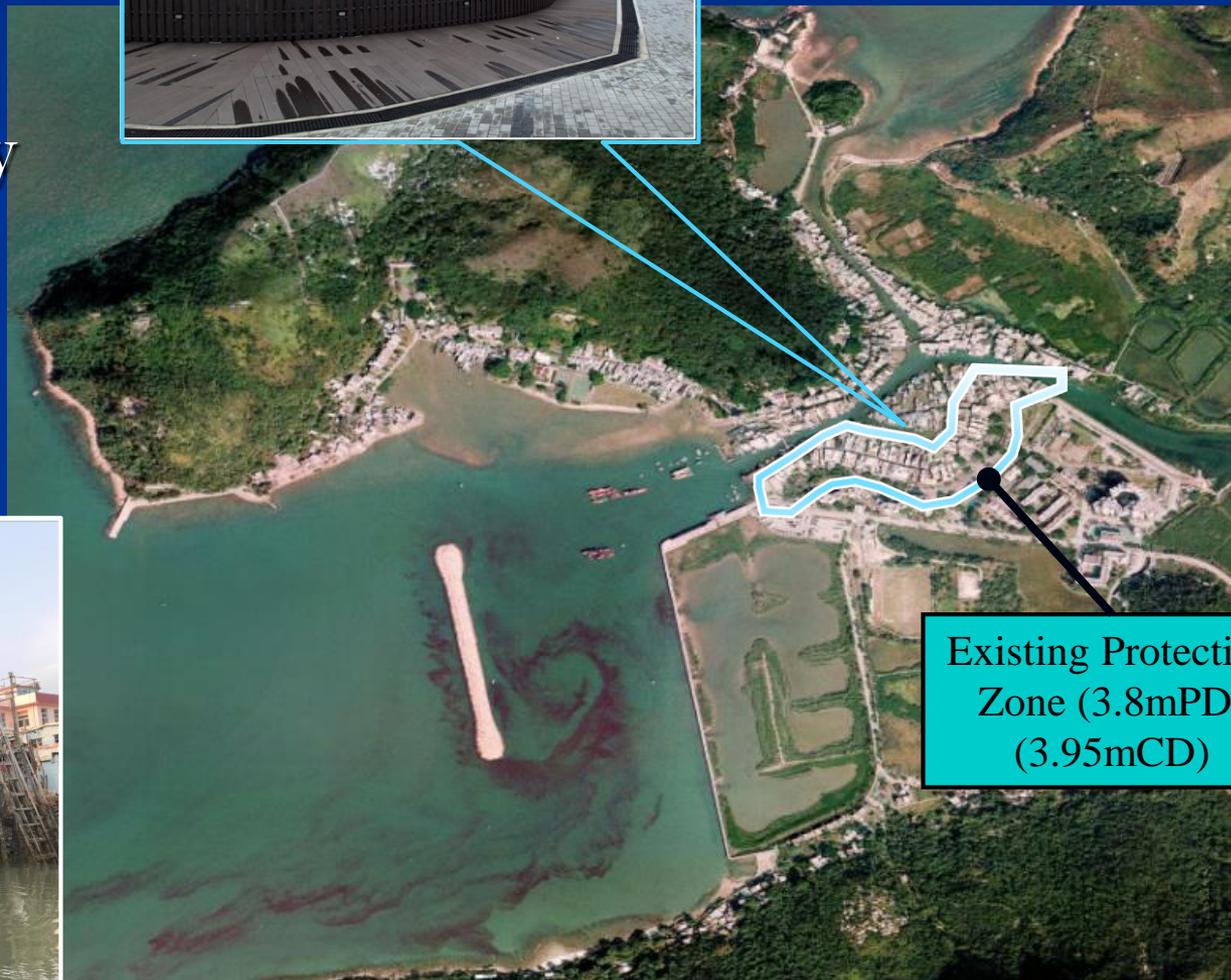
AT = Astronomical Tide

SS = Storm Surge



Case Study - Tai O

- Typical low-lying village
- Stilt houses
- Works successfully protected Tai O during Mangkhut



Existing Protection
Zone (3.8mPD)
(3.95mCD)



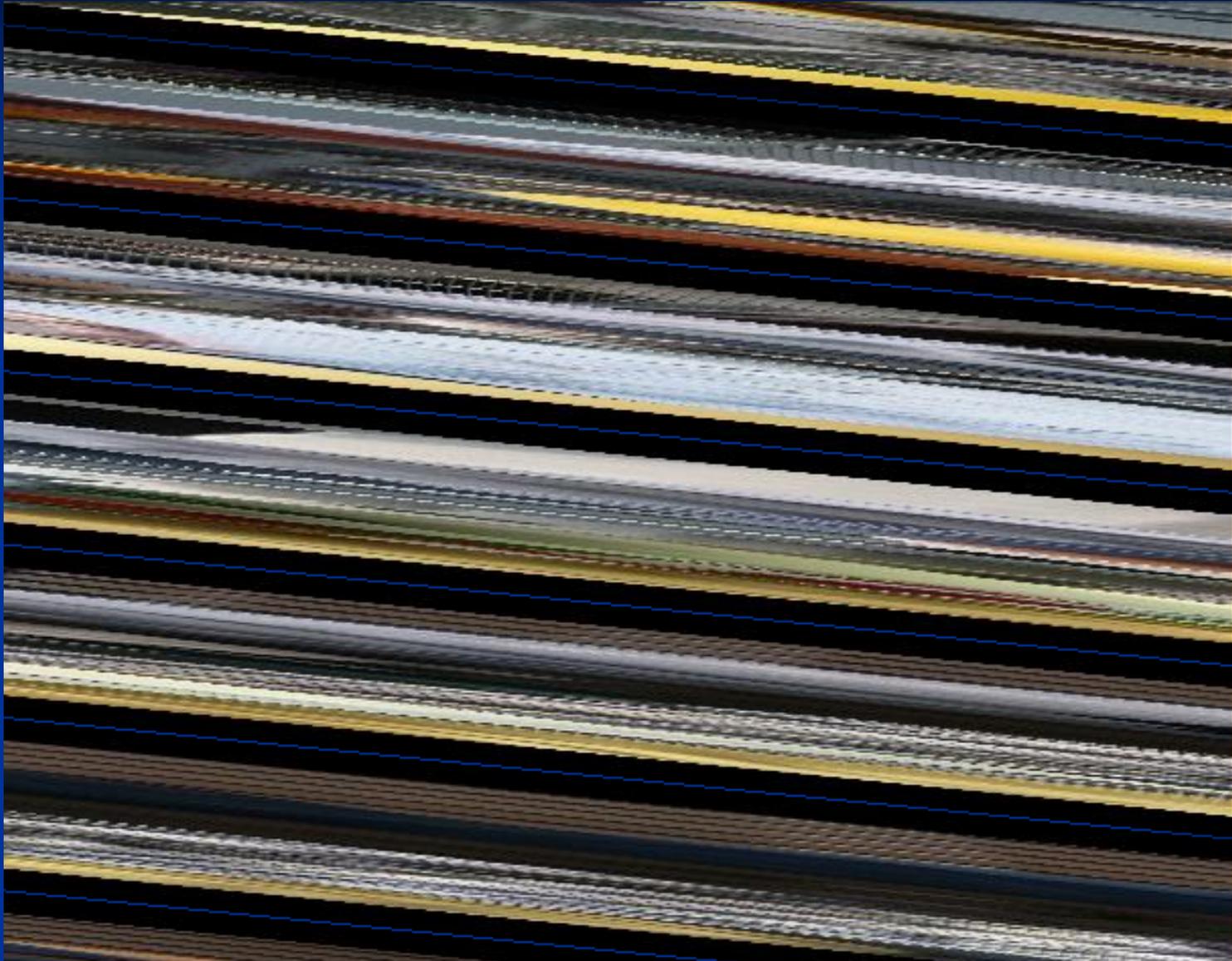


Aerial View of Tai O





Protection Scheme Completed in 2013





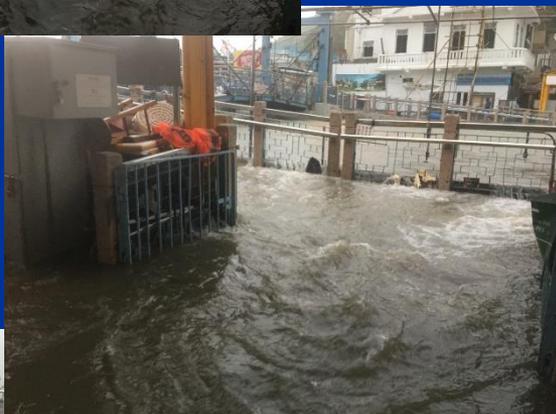
Current Contingency Plan at Tai O

- Early Alert System
 - HKO forecast sea level $> 3.3\text{mCD}$ (3.15mPD)
 - Alert residents & Gov to mobilize resources
- Evacuation and Rescue Plan
 - DSD real time monitor $> 3.0\text{mCD}$ (2.85mPD)





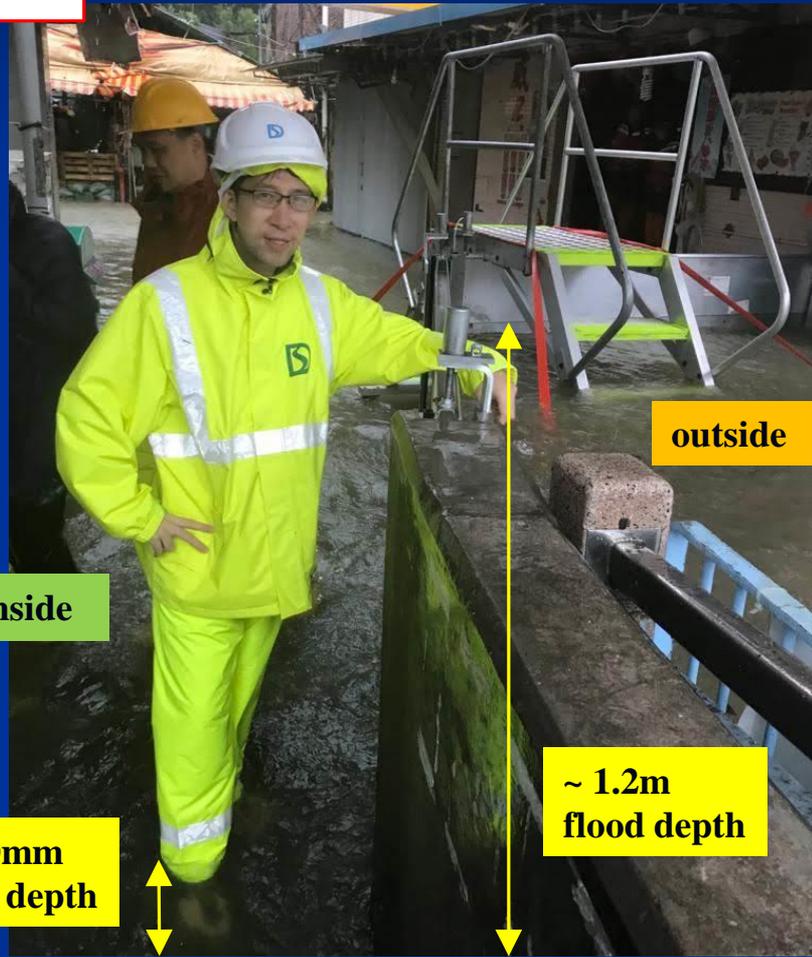
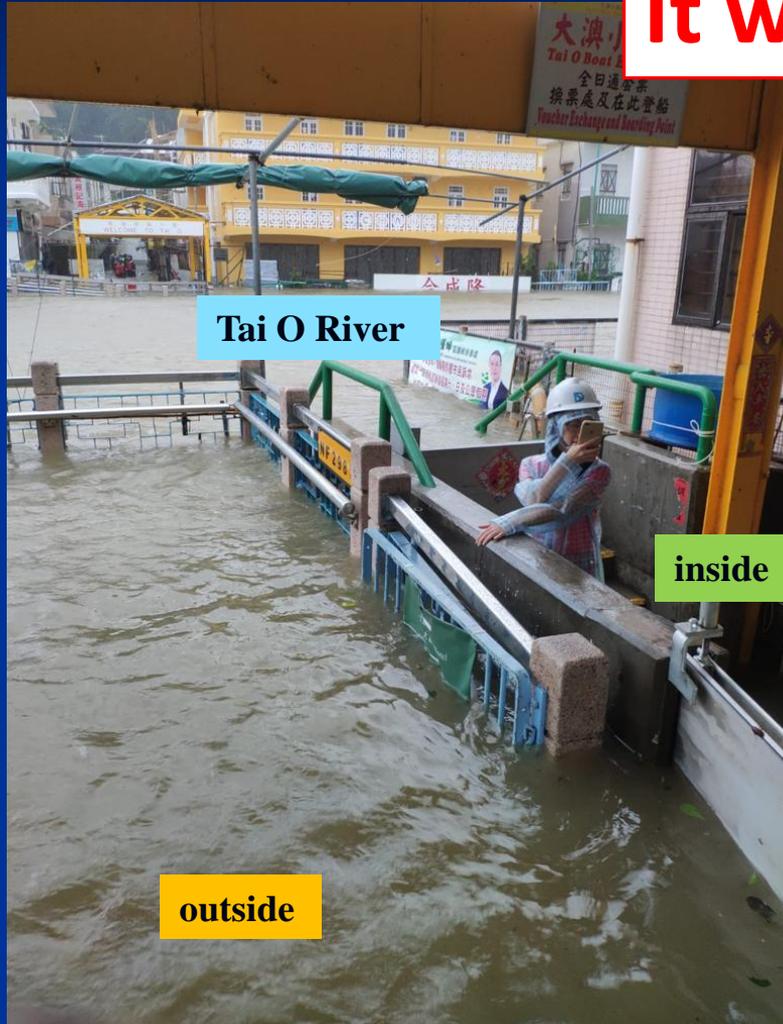
Situation during Mangkhut





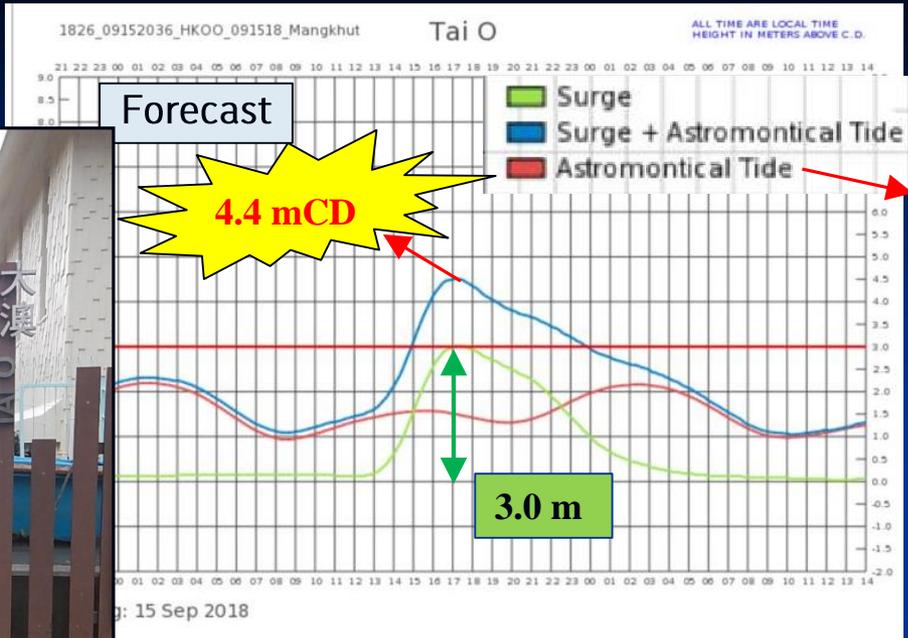
Performance of Protection Works

It works!

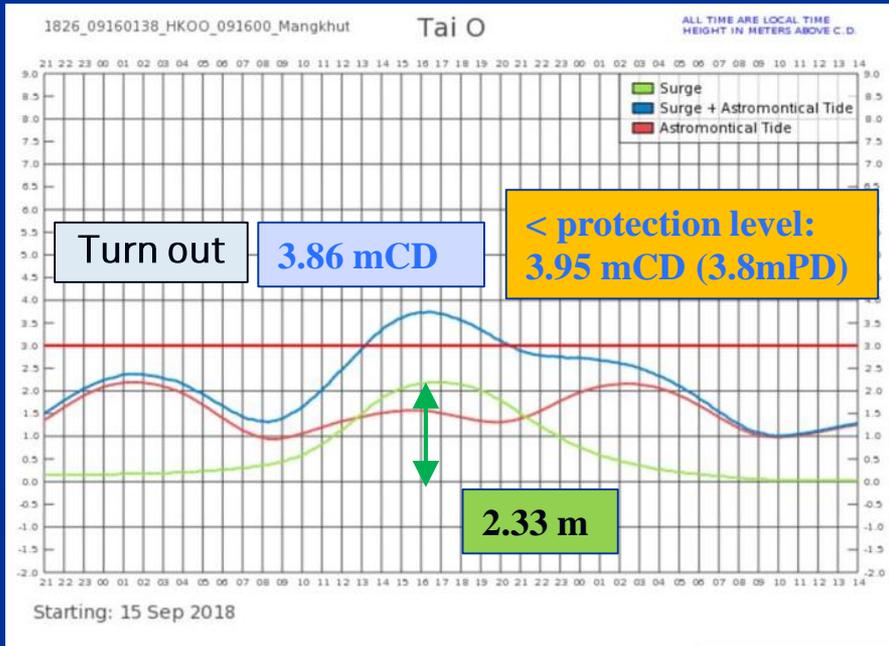




**But ... in fact ...
it may not work!**



HKO
將約
3.0米
約在
天文
分發

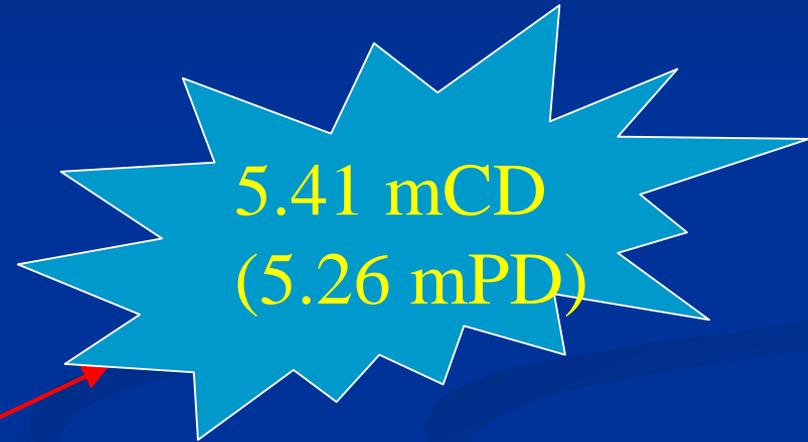




Storm Surge Forecast before Mangkhut

DAY HOUR (LOCAL)	STATION CODE							
	CLK	CCH	KLW	LOP	MAC	QUB	TAO	TP
1521	1.43	1.74	1.88	1.36	1.95	1.77	1.48	1.4
1522	1.68	1.98	2.05	1.59	2.22	1.98	1.76	1.4
1523	1.96	2.18	2.07	1.85	2.47	2.14	2.02	1.4
1600	2.16	2.26	2.07	2.05	2.65	2.20	2.21	2.4
1601	2.28	2.30	2.16	2.17	2.68	2.26	2.30	2.4
1602	2.29	2.29	2.24	2.16	2.69	2.25	2.30	2.4
1603	2.21	2.20	2.17	2.08	2.62	2.20	2.22	2.4
1604	2.02	2.05	2.03	1.92	2.51	2.05	2.06	1.4
1605	1.77	1.84	1.82	1.67	2.29	1.84	1.84	1.4
1606	1.50	1.63	1.66	1.37	2.03	1.64	1.55	1.4
1607	1.23	1.52	1.64	1.11	1.80	1.53	1.28	1.4
1608	1.06	1.52	1.76	.95	1.63	1.57	1.15	1.4
1609	1.00	1.70	2.11	.93	1.63	1.73	1.17	1.4
1610	1.09	2.01	2.49	.99	1.78	2.02	1.33	1.4
1611	1.30	2.45	2.87	1.18	1.99	2.46	1.60	1.4
1612	1.59	3.06	3.37	1.47	2.32	2.93	1.97	1.4
1613	1.98	3.72	3.85	1.85	2.82	3.46	2.53	1.4
1614	2.53	4.51	4.19	2.41	3.84	4.09	3.28	1.4
1615	3.37	4.94	4.18	3.23	6.01	4.50	4.24	1.4
1616	4.36	5.01	3.89	4.21	7.05	4.53	5.11	2.4
1617	4.95	4.74	3.39	4.76	7.19	4.19	5.41	4.4
1618	5.15	4.14	2.92	4.97	6.85	3.71	5.26	5.4
1619	4.86	3.49	2.50	4.62	6.15	3.10	4.91	5.4
1620	4.44	3.11	2.25	4.24	5.58	2.78	4.42	4.4
1621	3.97	2.90	2.24	3.78	5.02	2.65	3.95	4.4
1622	3.53	2.71	2.31	3.36	4.86	2.50	3.54	3.4
1623	3.19	2.51	2.21	3.03	4.70	2.33	3.21	3.4
1700	2.89	2.35	1.99	2.70	4.42	2.16	2.91	3.4
1701	2.64	2.31	1.89	2.47	4.13	2.16	2.68	3.4
1702	2.46	2.22	1.99	2.33	3.88	2.10	2.52	2.4
1703	2.29	2.12	1.99	2.16	3.67	2.05	2.35	2.4
1704	2.15	1.97	1.90	2.02	3.43	1.97	2.21	2.4
1705	1.94	1.79	1.69	1.81	3.17	1.77	1.99	2.4

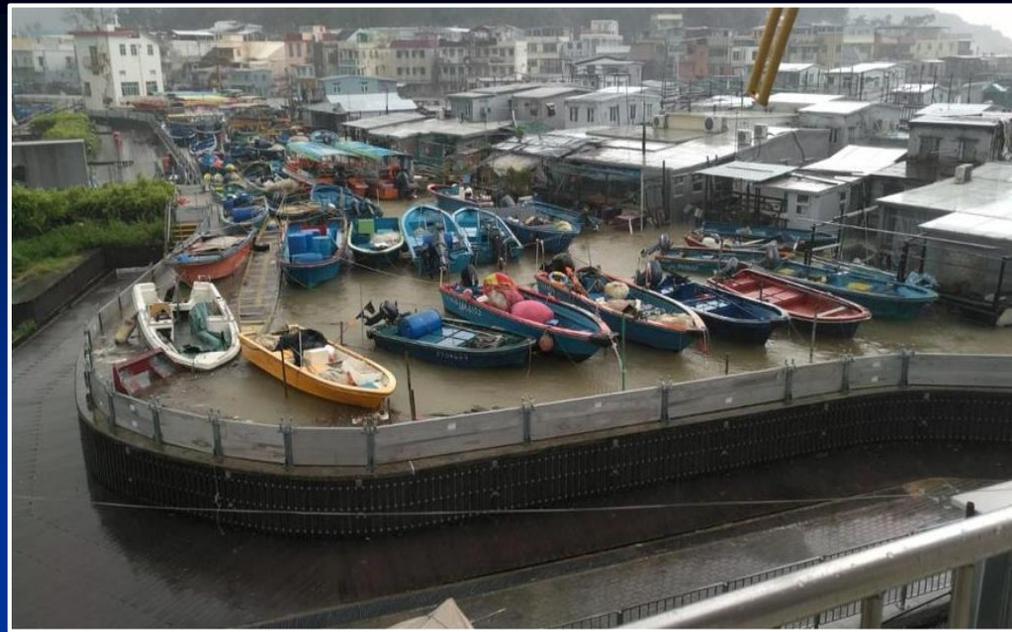
Under the worst scenario



- Exceeded protection level by about 1.5m
- Ground level ~ 3.0mCD
- General flood depth would be about 2.4m



- Further raise the protection level ?
- Extend the river wall?



Further measures are required.....



Would tidal barrier be applicable ?

- Cost-effectiveness
- Various impacts
- Public opinions



London



Tokyo



Singapore





Our Challenges and Possible Way Out

How about the whole Hong Kong?

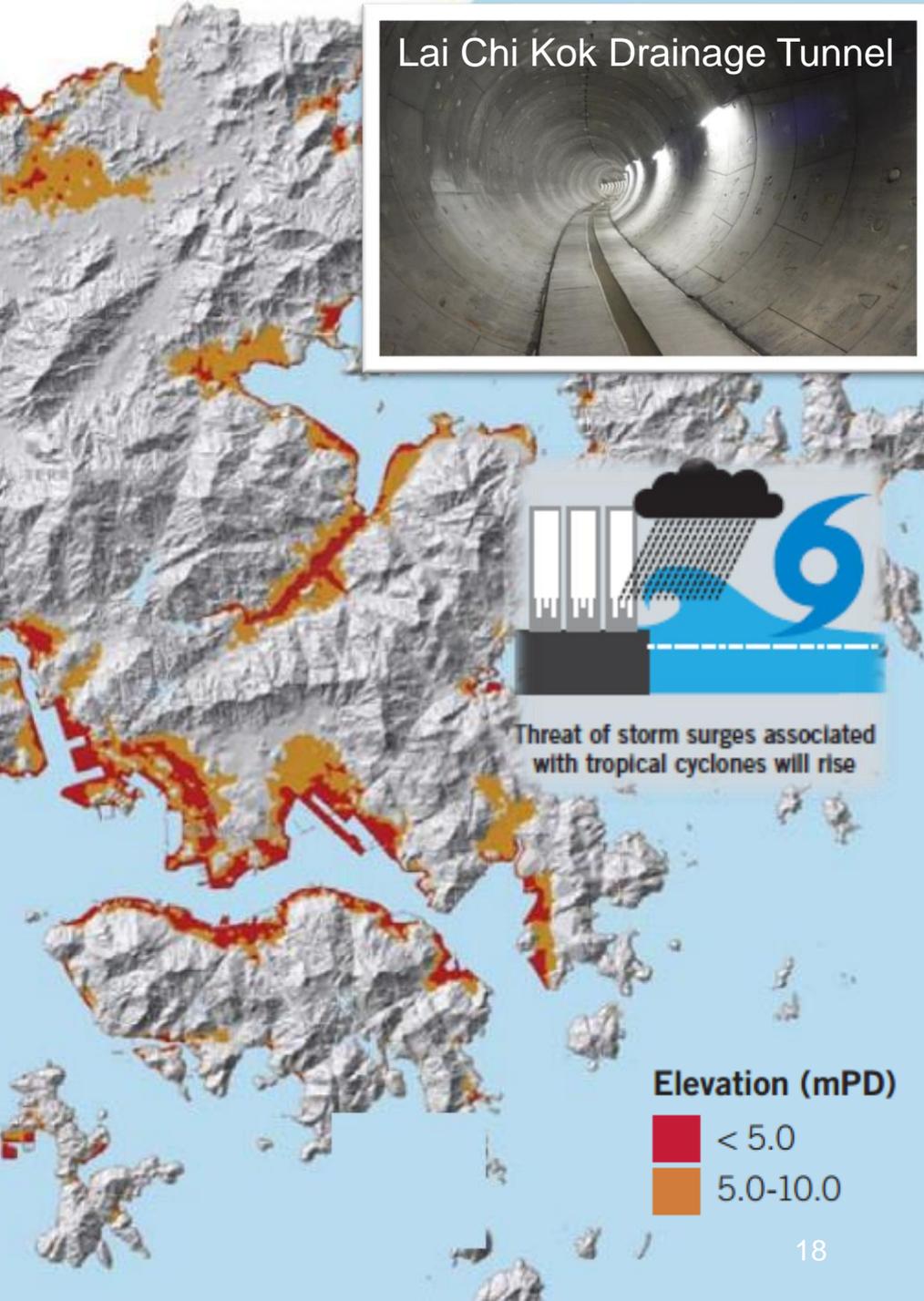
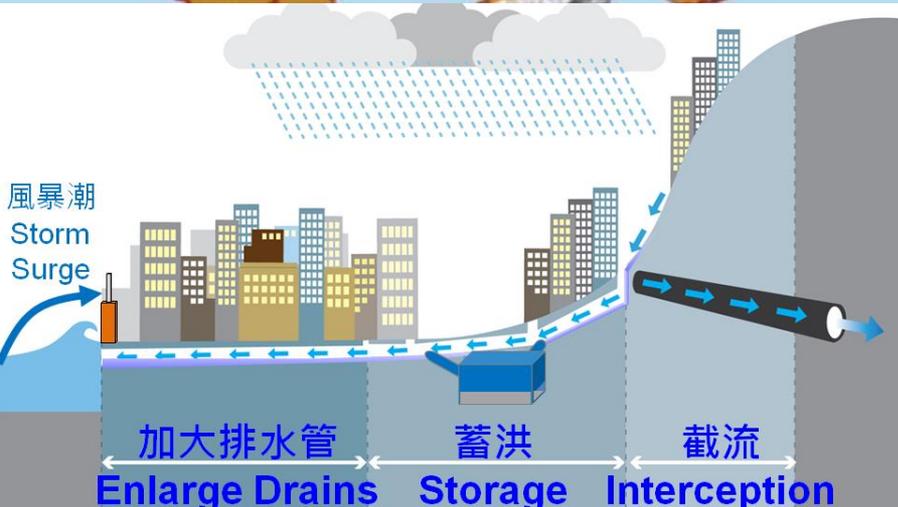
Happy Valley Underground Stormwater Storage Scheme



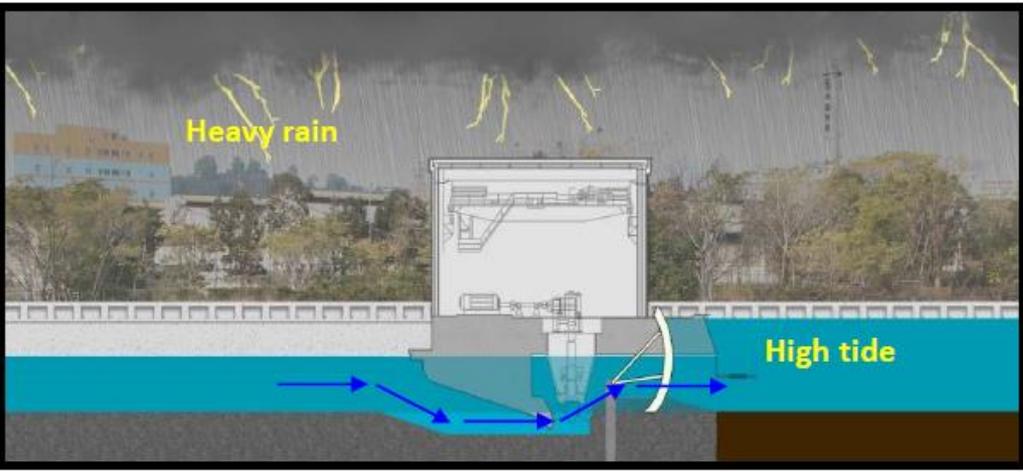
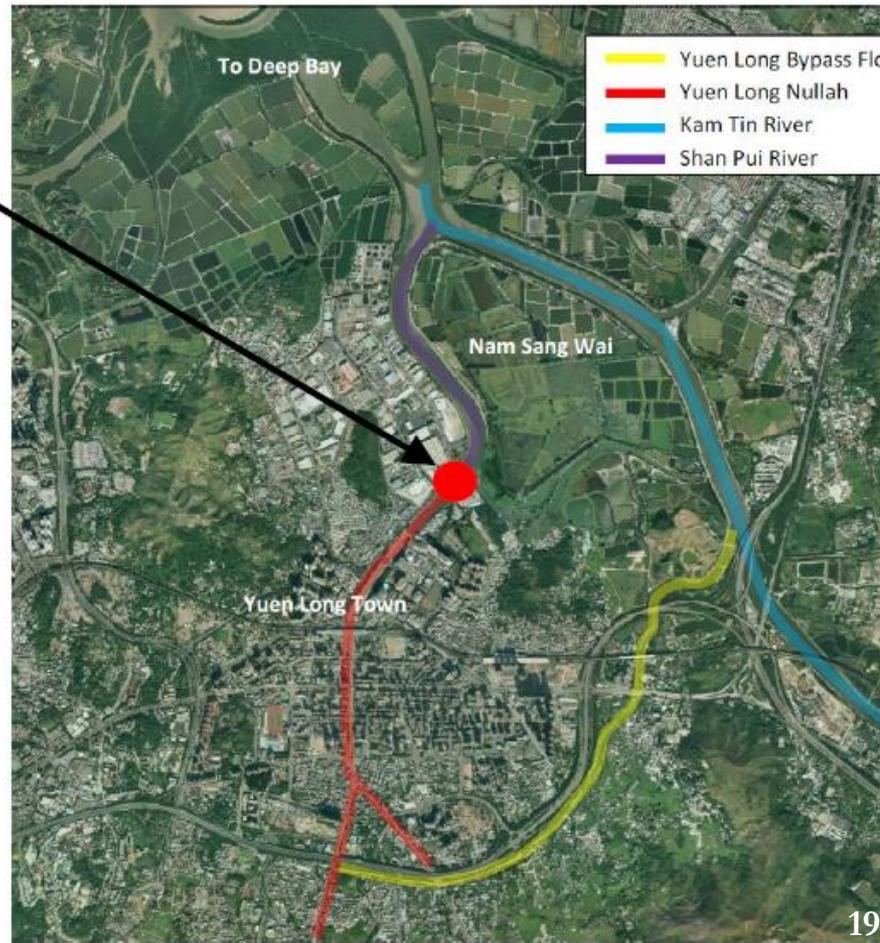
- Interception?
- Stormwater Storage?



Threat of storm surges associated with tropical cyclones will rise



Adaptation (Structural Measure) — Yuen Long Barrage Scheme





But how about Harbour Area?

Ground level along coastline at ~4 mPD

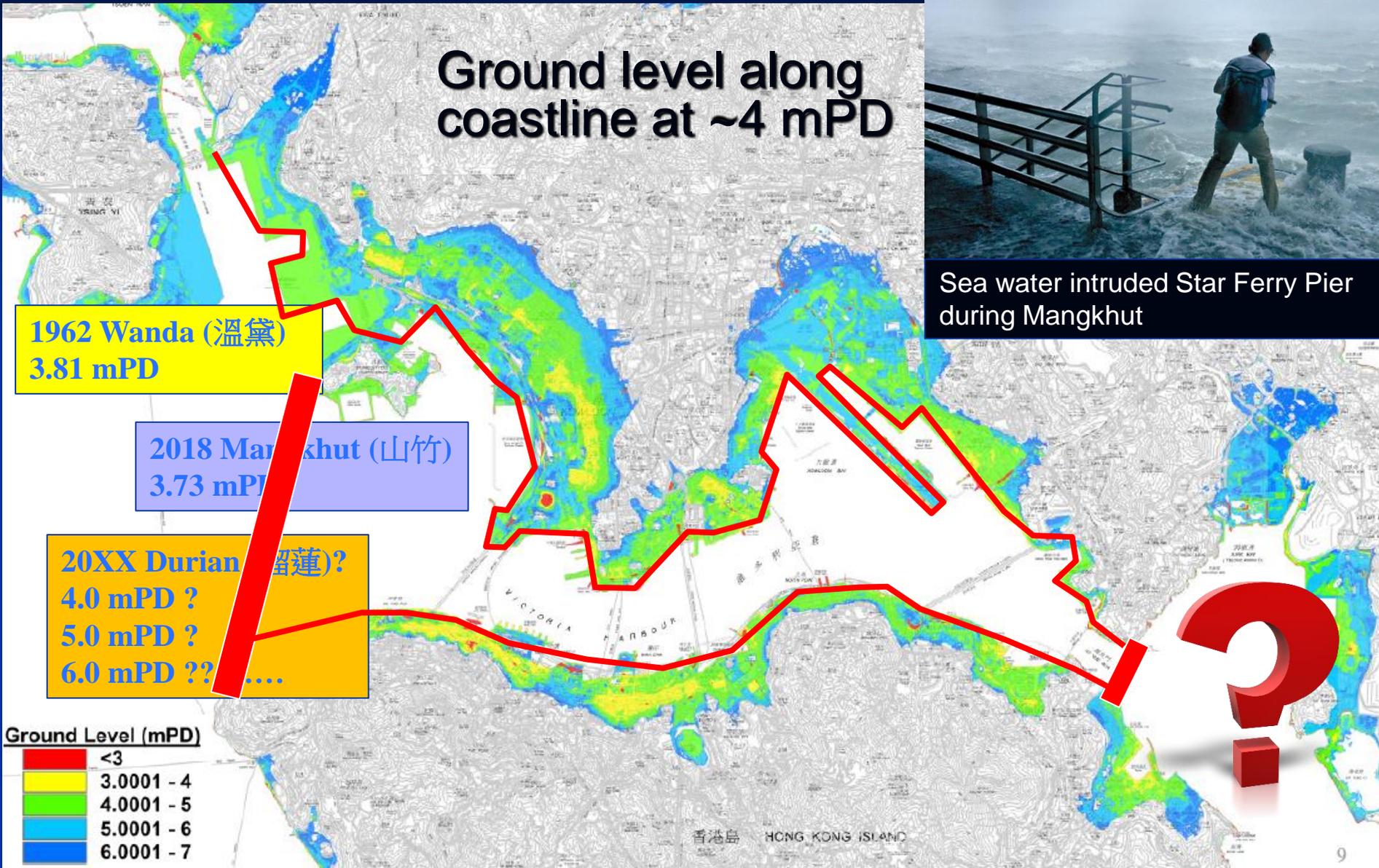


Sea water intruded Star Ferry Pier during Mangkhut

1962 Wanda (溫黛)
3.81 mPD

2018 Mangkhut (山竹)
3.73 mPD

20XX Durian (榴蓮)?
4.0 mPD ?
5.0 mPD ?
6.0 mPD ??





More Adaptive & Resilient Design



渠務署
Drainage Services Department

如何減少水浸損失 HOW TO REDUCE FLOOD LOSS

此小冊子旨在簡要闡明下列要點

- 現時政府的防洪對策
- 居住在易受水浸影響樓宇的居民應注意事項
- 介紹減少水浸損失的方法供市民參考

Non-structural Measures

Raising community awareness



Prepare for emergencies



Contingency funding



Recovery Plan

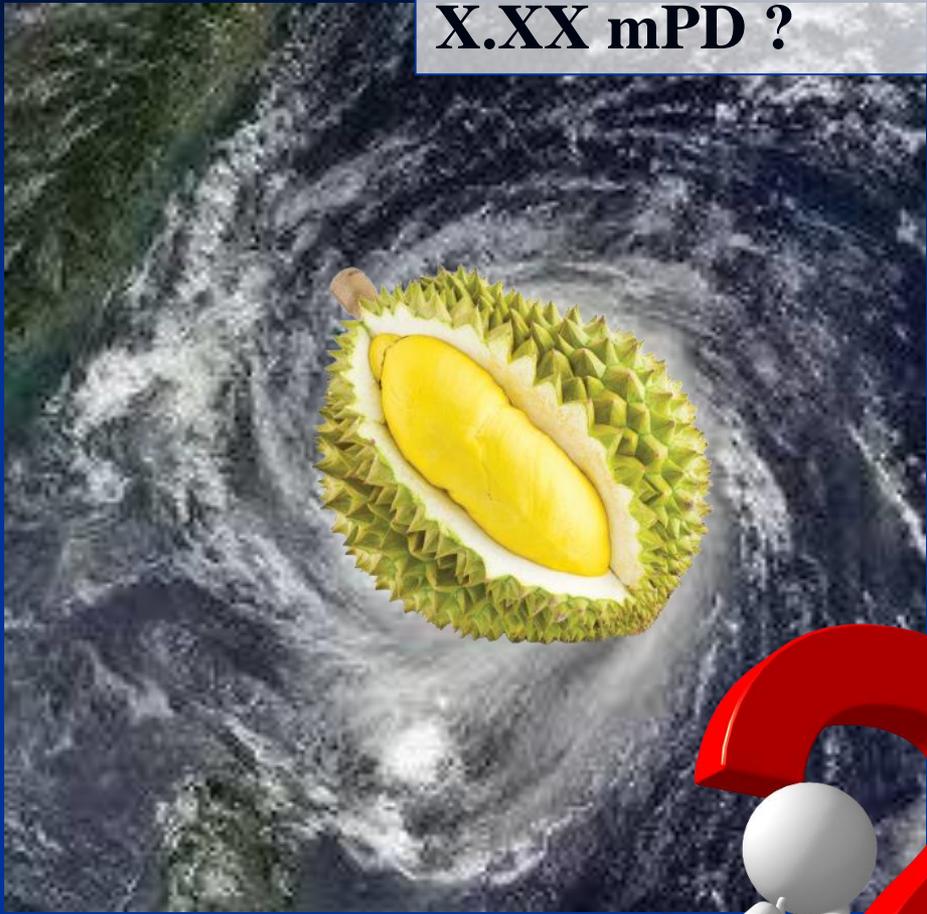




20XX Durian ?
X.XX mPD ?



2018 Mangkhut
3.73 mPD



Thank You!



Comparison between Hato and Mangkhut



flooded

Hato in 2017

It works!



protected

flooded

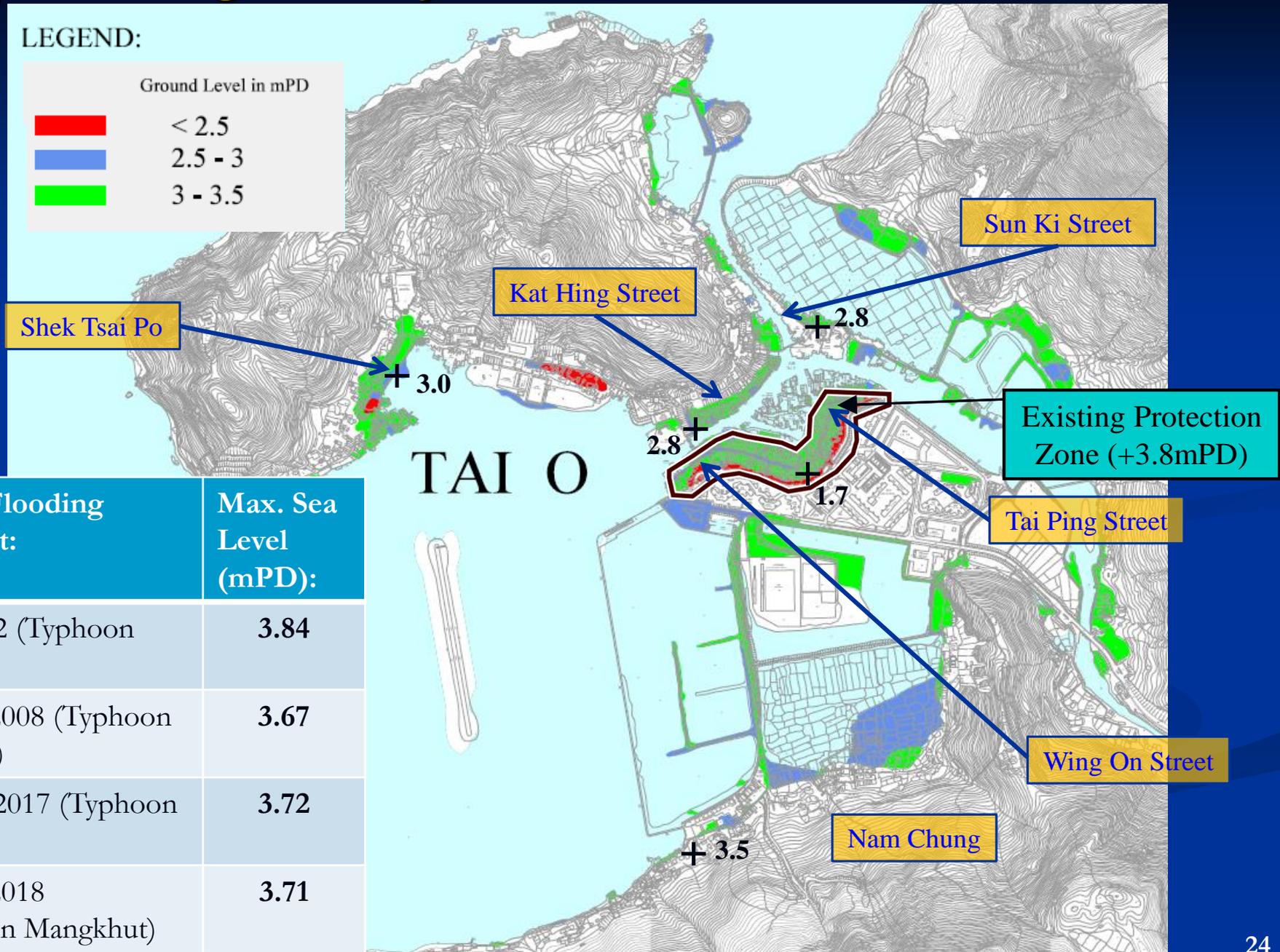
Mangkhut in 2018



Flooding History of Tai O

LEGEND:

Ground Level in mPD	
█	< 2.5
█	2.5 - 3
█	3 - 3.5

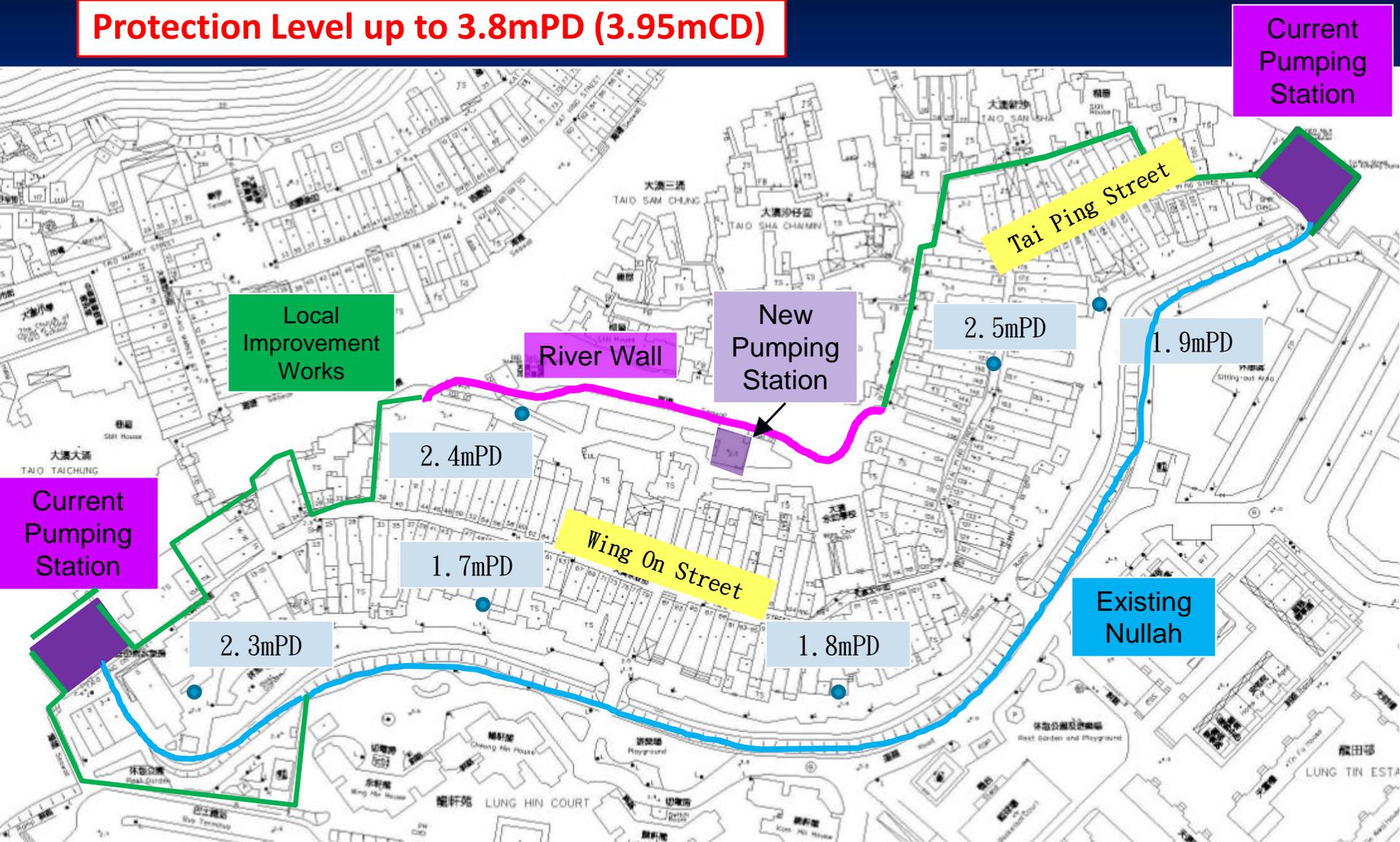


Major Flooding Incident:	Max. Sea Level (mPD):
Sep 1962 (Typhoon Wanda)	3.84
23 Sep 2008 (Typhoon Hagupit)	3.67
23 Aug 2017 (Typhoon Hato)	3.72
16 Sep 2018 (Typhoon Mangkhut)	3.71

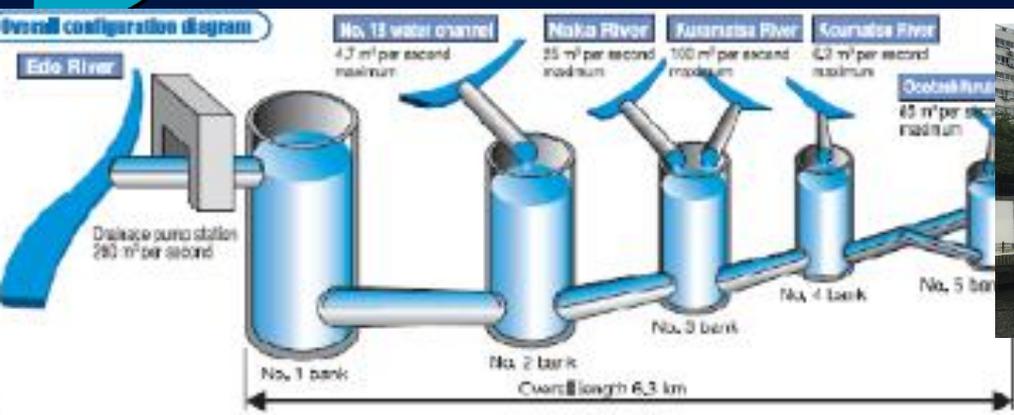


Protection Scheme completed in 2012

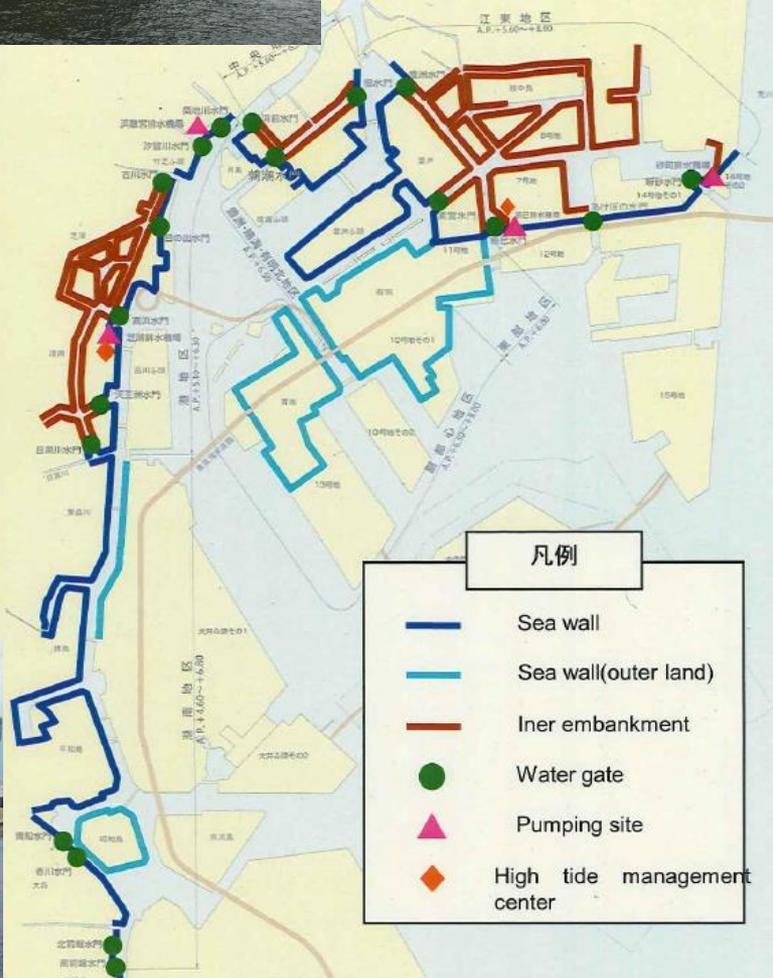
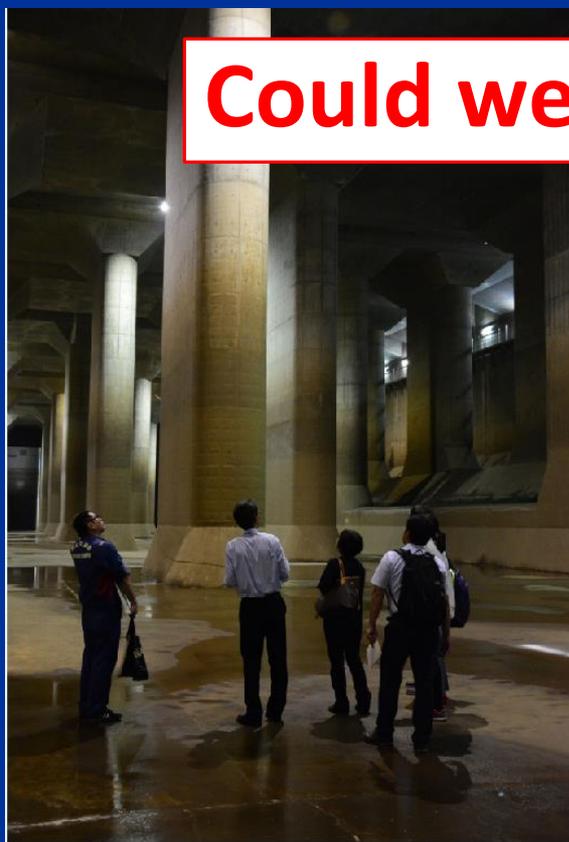
Protection Level up to 3.8mPD (3.95mCD)



Outer Underground Discharge Channel in Tokyo



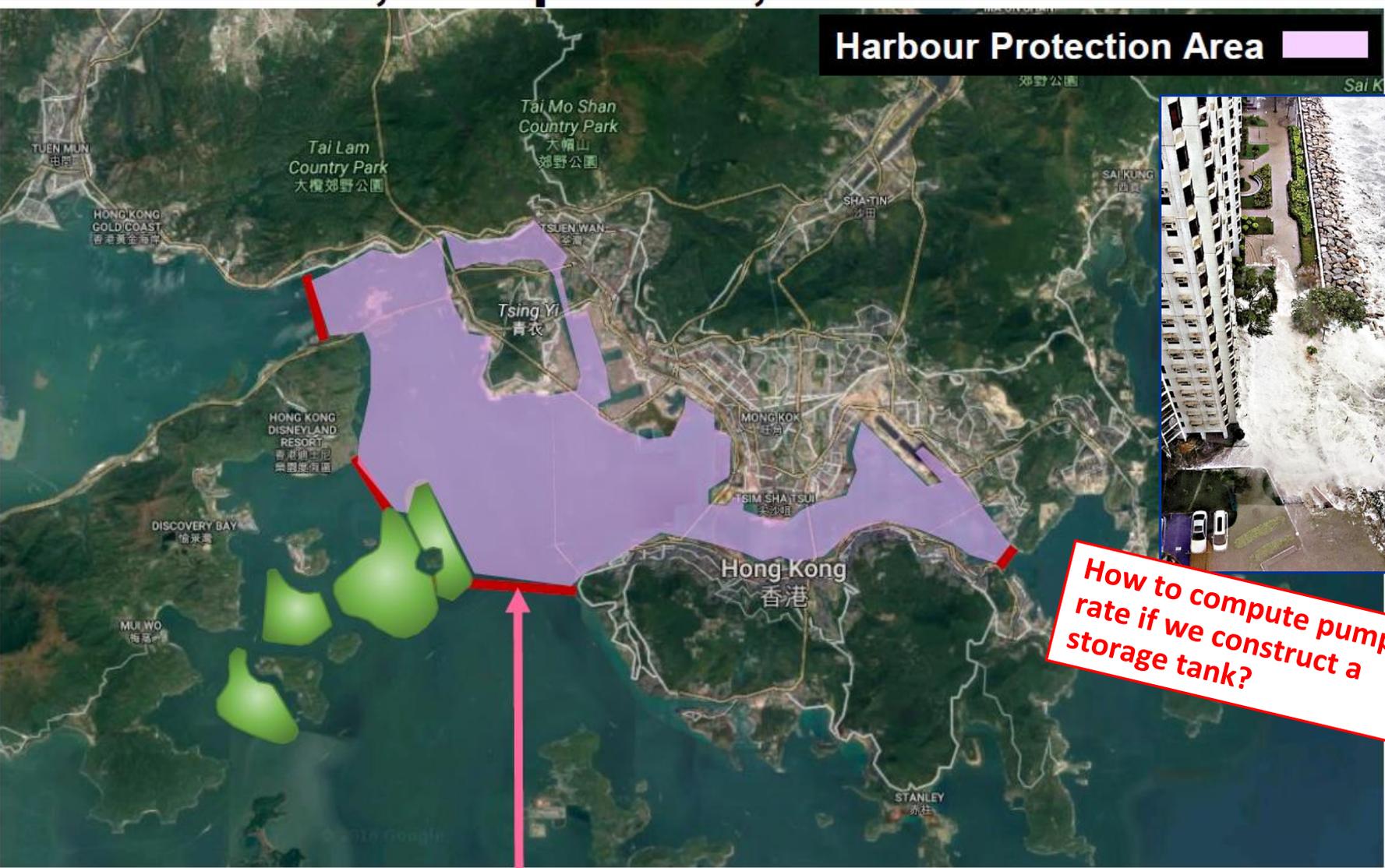
Could we?





Barrage scheme to protect our Harbour Area?

Harbour Protection Area 



How to compute pump rate if we construct a storage tank?

Opportunity for Road, Railway, Tidal Barrier and other co-use functions

Living with Water ?

Resilience in Venice

