District of Squamish
Integrated Flood Hazard Management Plan
Council Update #11

June 20, 2017

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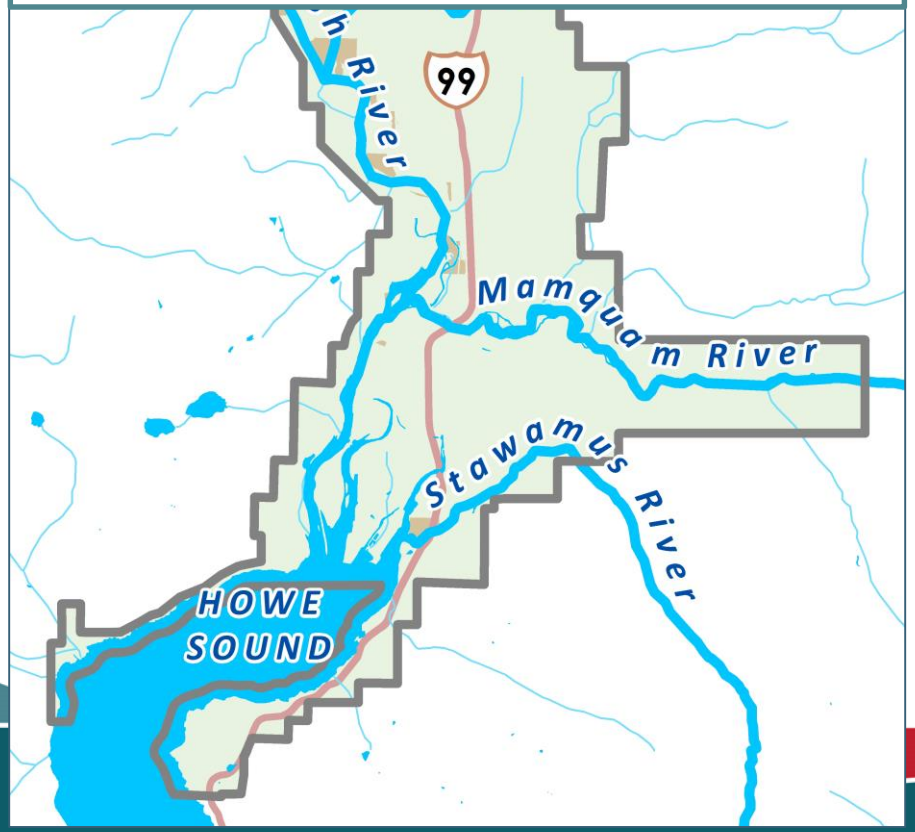
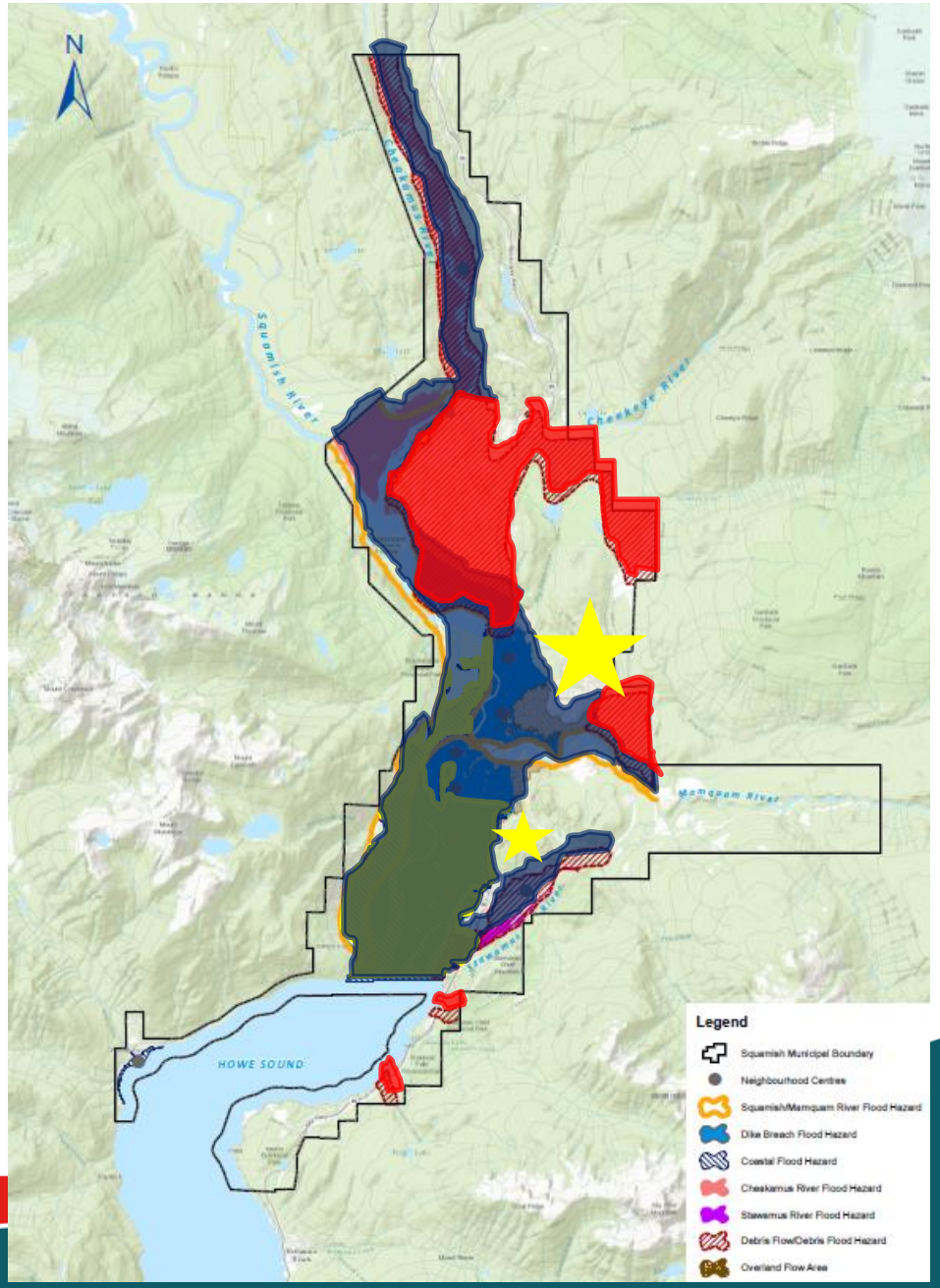
Squamish's Flood Hazards

Summary

- Nearly all of Squamish exposed to flood hazards
- Major flood would have significant community impacts
- Clear need for comprehensive mitigation plan





A History of Flooding

The recorded history of the Squamish community shows a constant struggle to protect human settlement from the natural forces that have frequently led to flooding. Over the past century, Squamish has experienced numerous floods as outlined below.

1890s
Squamish River
rst River Dike proposed

Sept 1906
Squamish River
"Many settlers were completely wiped out" (Myrtle Herndl)

Oct 1921
Mamquam River
Squamish River
Flood covered valley floor

Dec 1932
Howe Sound
Overtopping of the sea dike in Downtown

Oct 1940
Squamish River
Evacuations from Brackendale to Downtown

Oct 1950
Squamish River
Damage to roads and rail bridges

Dec 1951
Howe Sound
Sea dike was breached in two places

Oct 1955
Mamquam River
Mamquam Bridge washed out for 10th time in 28 years

Aug 1958
Cheekeye River
Major debris flow following a sudden rainstorm

Oct 1958
Squamish River
Four feet of water over the main road in Brackendale

Dec 1967
Howe Sound
Sea dike was overtopped & Downtown Squamish flooded.

Nov 1968
Mamquam River
Flooding damaged a trailer park, highways and the railway

Dec 1980
Squamish River
Cheakamus River
Mamquam River
Stawamus River
Logjams on 3 rivers led to damages to 200 homes and closure of Highway 99

Oct 1981
Squamish River
177 mm of rain in 48 hours

Oct 1984
Cheekeye River
Cheakamus River
Stawamus River
Log bridge across the Cheakamus River destroyed and damaged homes

Aug 1991
Squamish River
Cheakamus River
Cheekeye River
15 houses on Cheakamus I.R. No. 11 were flooded and the access road to Paradise Valley was washed out

Oct 2003
Cheakamus River
Largest flood in 50 years (369 mm in 4 days) caused District evacuations and damaged the BC rail line
Dikes were not overtopped

1890s 1900s 1910s 1920s 1930s 1940s 1950s 1960s 1970s 1980s 1990s 2000s 2010s

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Integrated Flood Hazard Management Plan

Phase 1
- Background/Gap Analysis

Phase 2
- Coastal Flood Mitigation Strategy

Phase 3
- River Flood Mitigation Strategy

Phase 4
- Integrated Flood Hazard Management Plan

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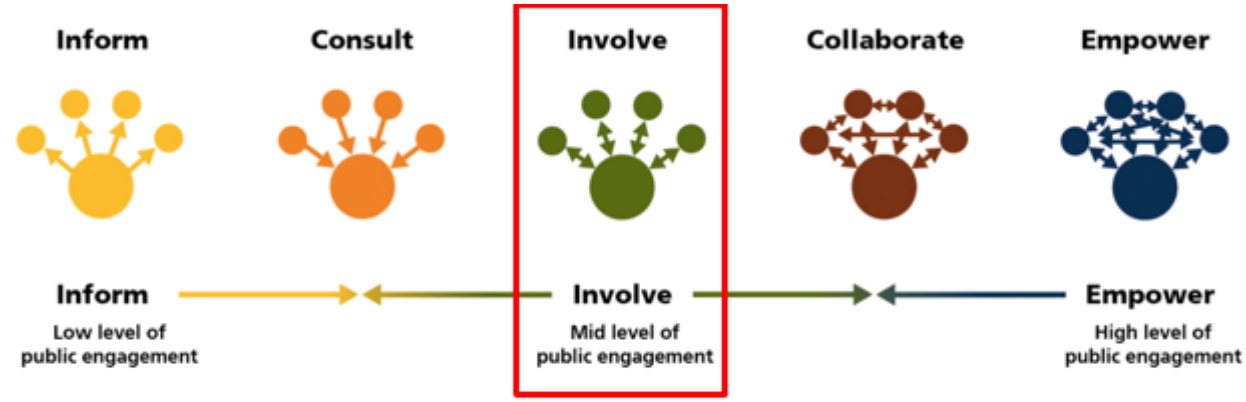
Community Consultation

Level of Engagement



IAP2 Spectrum of Public Engagement
Adapted from City of Burlington, 2013

Engagement Activities

Open Houses, online surveys, workshops, Council meetings, Squamish Nation meetings & more

Important note:

Consensus may not be possible due to conflicting objectives

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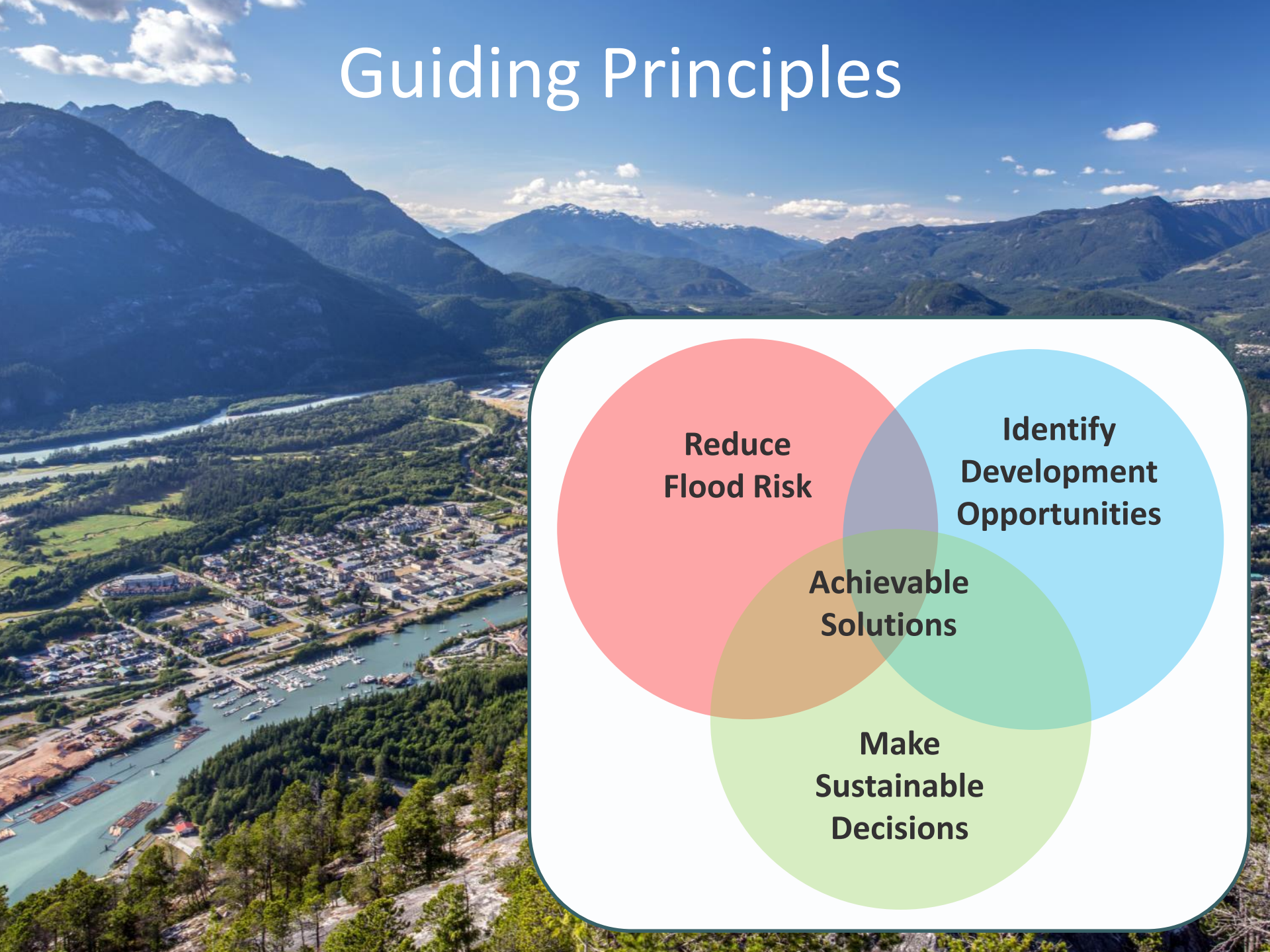
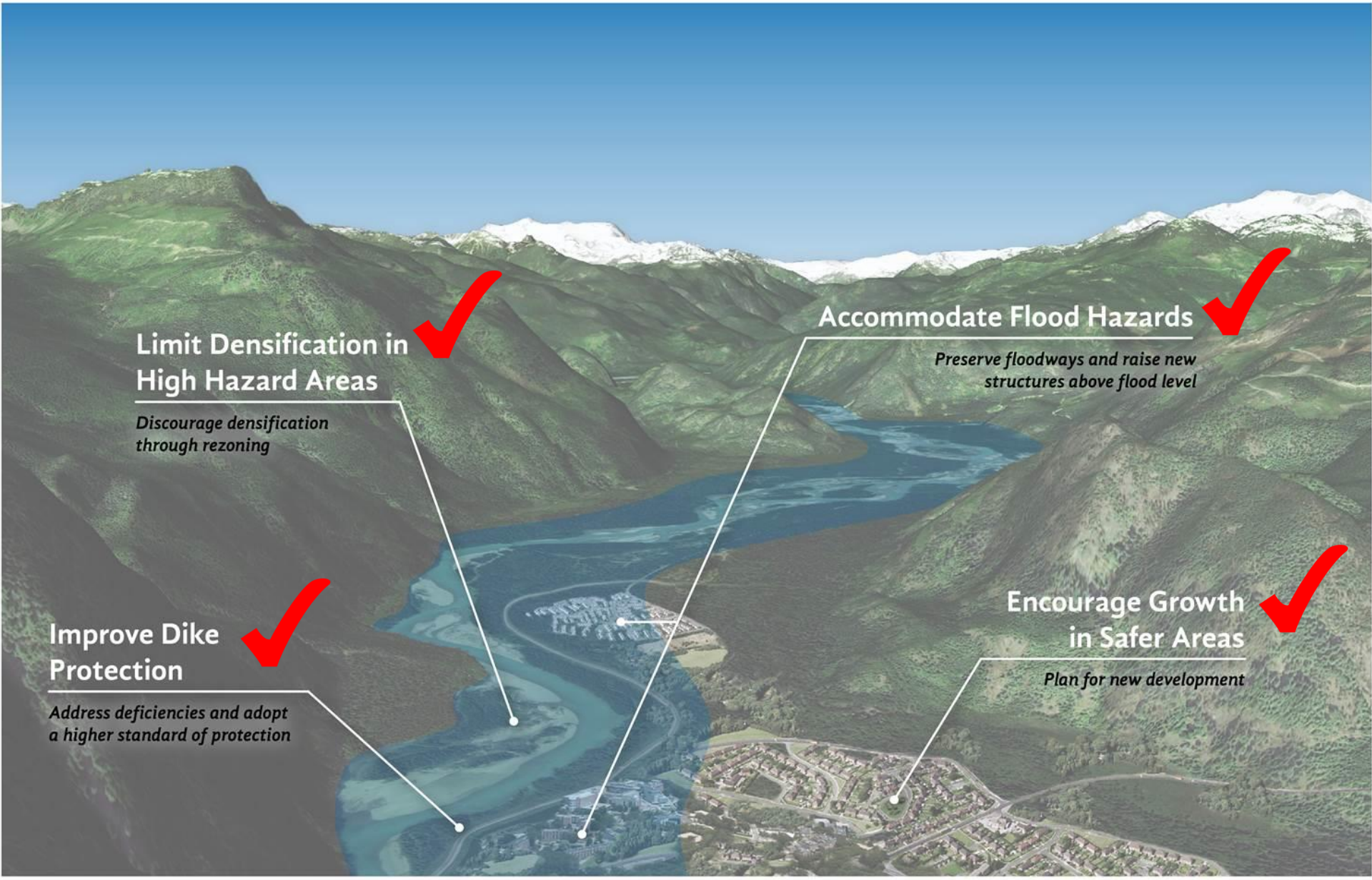
Guiding Principles



Mitigation Strategies



Unique Floodplains/Unique Mitigation

Table 5-2: Flood Risk Mitigation Strategies for Squamish

Flood Hazard Area	Flood Risk Mitigation Strategies				
	Protect	Accommodate	Avoid	Managed Retreat	Acceptable Risk
Squamish / Mamquam River	●	◓	◓	○	1 in 500 year
Cheakamus River	○	●	●	○	1 in 200 year
Stawamus River (Valleycliffe)	●	◓	–	–	1 in 200 year
"Connected" Coastal (Downtown)	●	◓	–	○	1 in 200 year
"Unconnected" Coastal	*site-specific based on development proposals*				1 in 200 year

● Very Important ◓ Important ○ Use Carefully – Not Recommended

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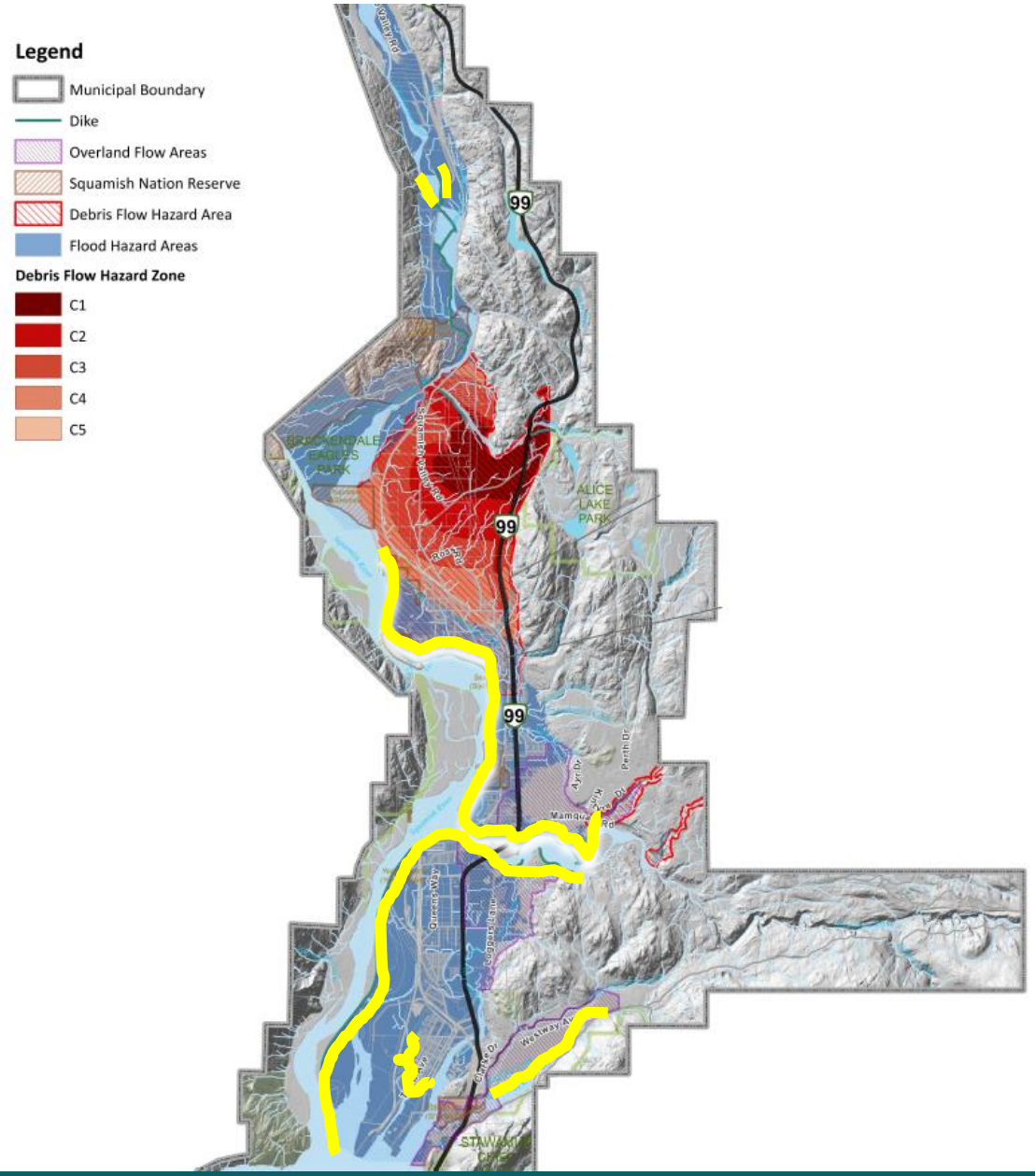
Improve Dike Protection

Summary

1) Correct existing dike deficiencies

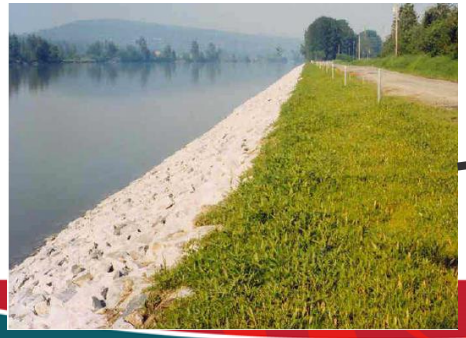
- Dike below 1:200 yr level
- Lack of land tenure
- No access
- Oversteepened slopes
- Too narrow
- Missing erosion protection
- Vegetation overgrown
- Etc

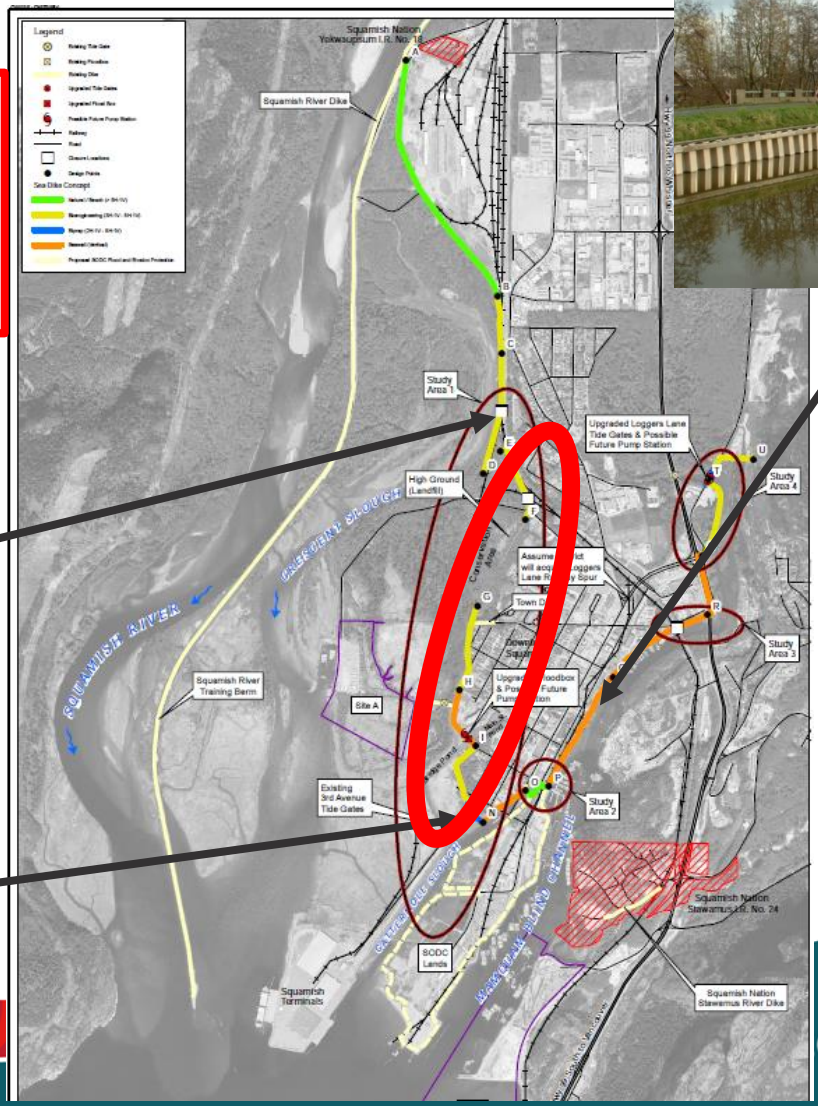


Improve Dike Protection

Summary

1) Correct existing dike deficiencies
2) Build Sea Dike
    - ‘Town Dike’ option recommended based on Truck Route Study





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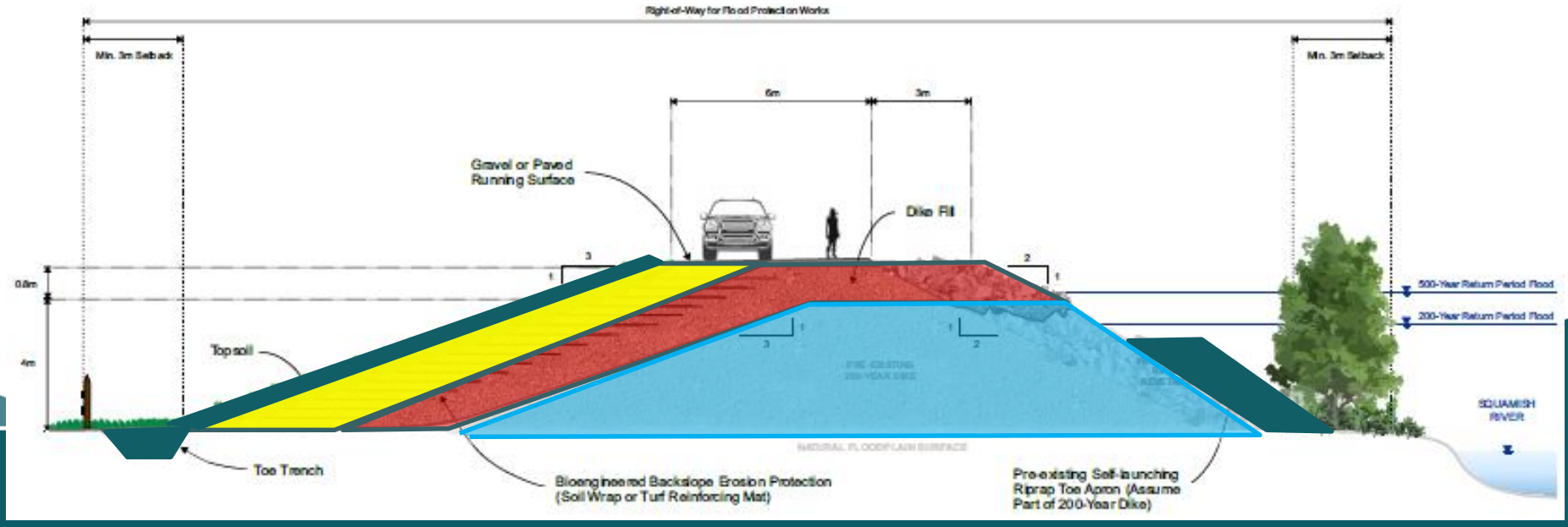
Improve Dike Protection

Summary

1) Correct existing dike deficiencies
2) Build Sea Dike according to implementation plan
3) Long-term: Adopt higher standard of protection for Squamish & Mamquam River South dike

- Justified by high consequence of failure (cost/benefit analysis)
- Higher, wider, stronger than Provincial Standard



Dike Funding

- Long-term Costs > $80M
- Strategies:
  - Prioritize & phase work
  - Be opportunistic
    - Development
    - Pursue grant funding
- Potential Funding Sources:
  - Provincial/Federal grants
  - Municipal Funding
  - Other options: Flood Protection Utility, Local Area Service, Developer Contributions

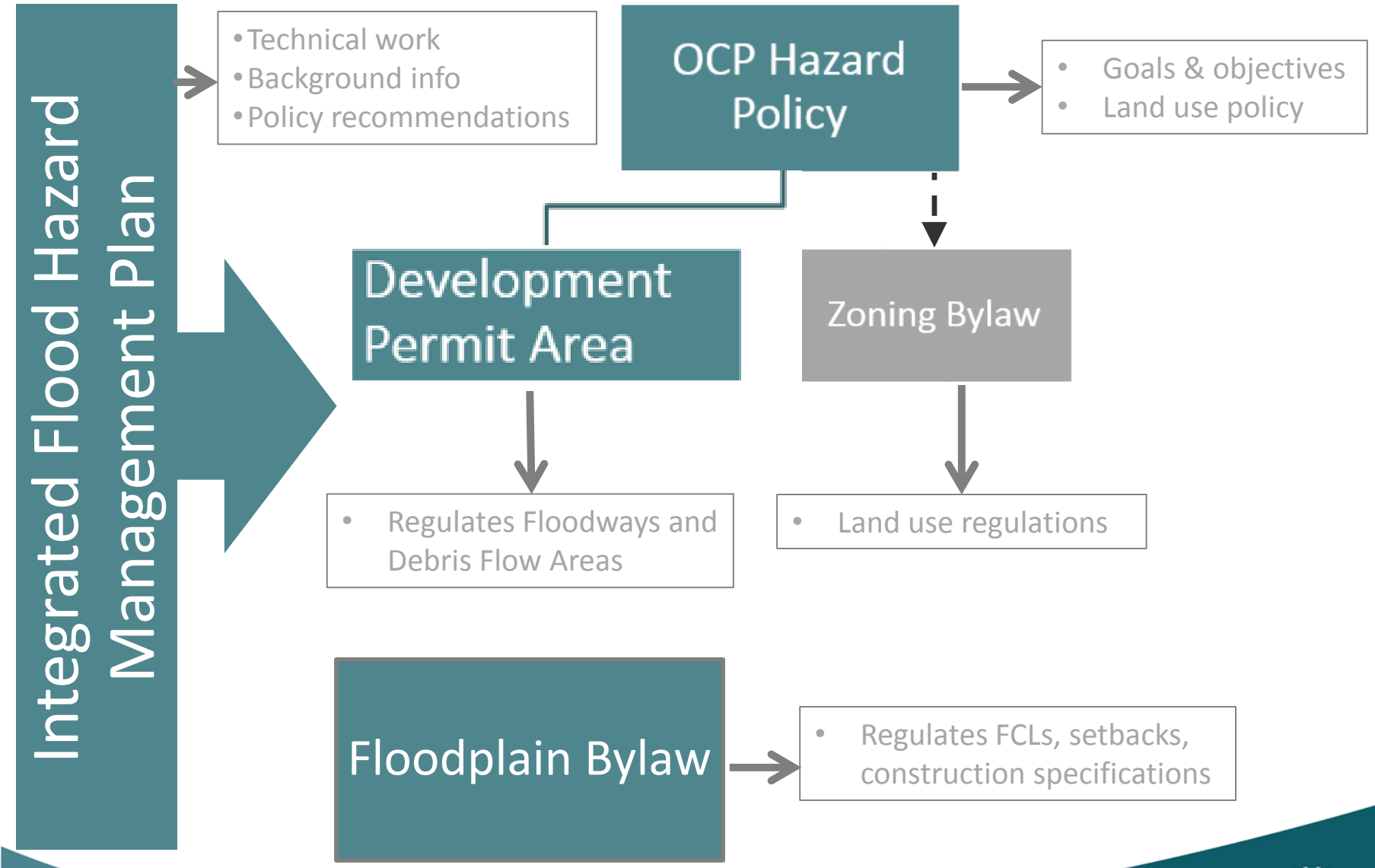
Improve Dike Protection

Prioritization

- Projects prioritized based on risk:
  - Likelihood of failure
  - Consequence of failure
  - Cost-weighted

Priority	External Funding Required?	Dike / Area	Action
1	No	All	Condition inspection for all penetrations and flow control gates, upgrades at priority problem spots
1	No	Mamquam / Downtown	Implement stockpiling and deployment plan for dike closures at CNR, Hwy 99, and sea dike
1	No	All	upgrade / secure penetrations and flapgates identified as high-risk during inspection
1	No	All	Inspect erosion protection and identify priority problem spots (eg u/s Judd Slough PS)
1	Yes	Upper Squamish	Judd Slough standard dike improvements (includes removal of deactivated culvert)
1	No	Lower Squamish	Replace flap gate and CCTV broken culvert on lower Squamish River dike and slipline as required
2A	No	Squamish	Obtain engineering opinion on unauthorized fill
2A	No	Stawamus	Complete riprap to dike crest on upper Stawamus River dike
2A	Yes	Lower Squamish	Widen Squamish River dike at the Fish (standard dike)
2A	Yes	Downtown	temporary sea dike upgrades to 3.3 m on perimeter (Lot 1 downtown plus local areas on reaches 2, 4, 5)
2A	Yes	Upper Squamish	Eagle Run toe berm at Cheema / McIntosh and standard dike improvements
2B	No	All	complete seismic assessment of critical dike sections where a flow slide would require major realignment
2B	No	Upper Squamish	Work with Squamish Nation to re & re gabion backslope on Seaichem I.R. No. 16
2B	Yes	Upper Squamish	Brackendale standard dike upgrades, Judd Slough PS to Seaichem I.R. No. 16 (incl gates and SROW verification)
2B	Yes	Downtown	sea dike to 4.0 m (reaches 3-4-5)
2B	Yes	All	Upgrade riprap protection and add toe at prioritized locations (assume incremental implementation)
3A	Yes	Upper Squamish	Judd Slough superdike upgrades
3A	Yes	Lower Squamish	Raise / widen Squamish River dike from the Fish to the Railway Museum dike access (superdike standard)
3A	Yes	Mamquam	Review Mamquam dike downstream of Brennan Intake against superdike standard and address deficiencies
3A	Yes	Paradise Valley	Upgrade Bailey Bridge Training Works and accept responsibility for Dike 5C
3A	Yes	Downtown	Implement Reach 2 sea dike to 4.0 m elevation
3A	No	Mamquam	Upgrade Mamquam North dike and riprap upstream of Government Road
3B	No	Mamquam	Mamquam River south standard dike upgrade upstream of Reunion Intake
3B	No	Upper Squamish	Harris Slough standard dike upgrades
3B	Yes	All	upgrade / secure balance of flapgates
3B	Yes	Lower Squamish	Raise / widen Squamish River dike from the Railway Museum dike access to Fortis ROW (superdike standard)
3B	Yes	Upper Squamish	Brackendale superdike upgrades
3B	Yes	Upper Squamish	Eagle Run superdike upgrades
3C	Yes	Stawamus	Stawamus River dike upgrades for debris flood design event (pending debris flood study)
3C	Yes	Mamquam	Mamquam north (golf course) standard dike upgrades
3C	Yes	Upper Squamish	Harris Slough superdike upgrades

Flood Policy Overview



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OCP: Flood Hazard Policy

1. Broad Goals and Objectives

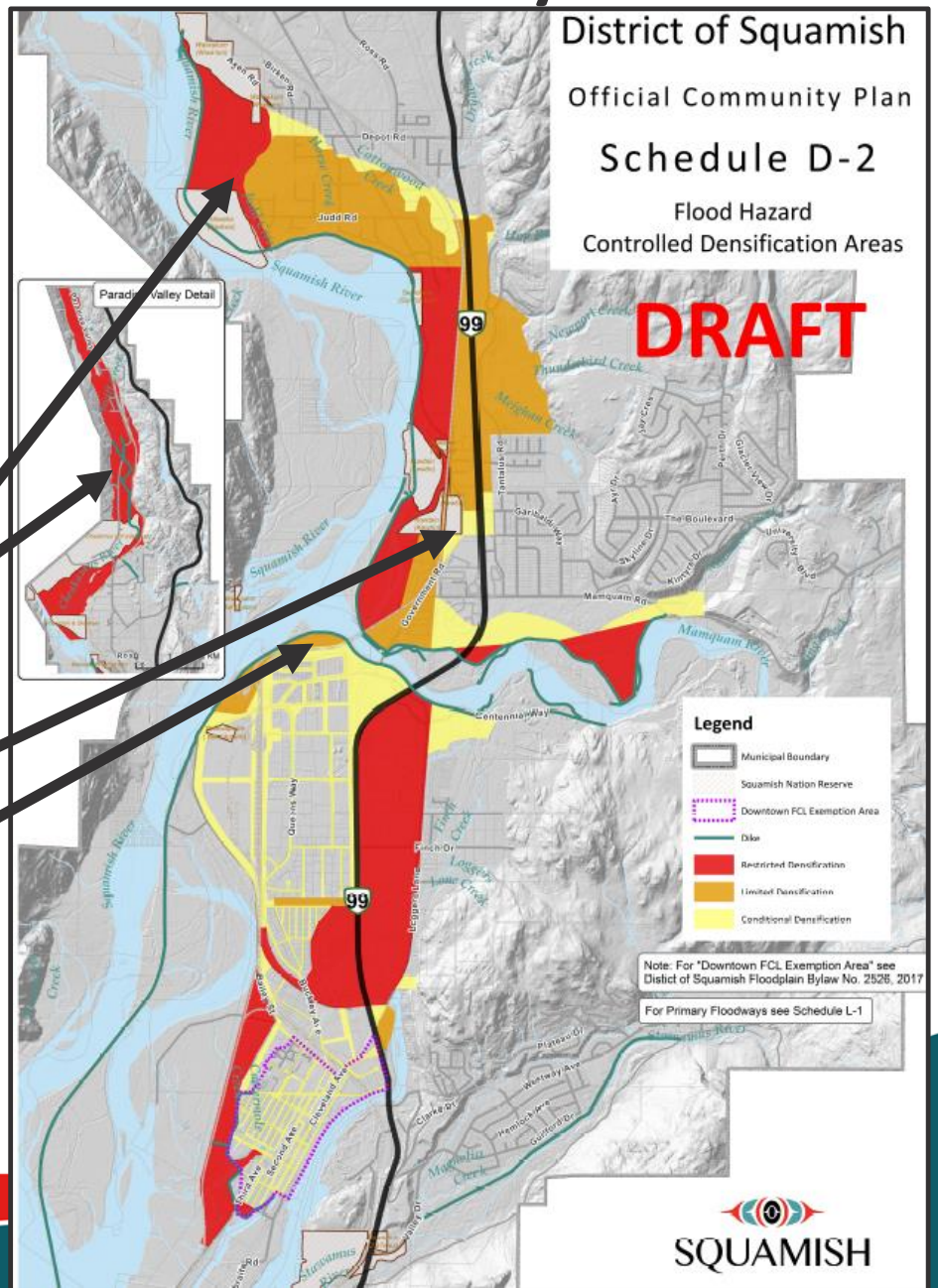
- Manage flood risk with new development
- Encourage growth in low risk areas
- Adopt risk tolerance criteria
- Many more

2. Land Use Policy

#1 - Restricted Densification Areas (red)

#2 – Conditional Densification Areas (yellow)

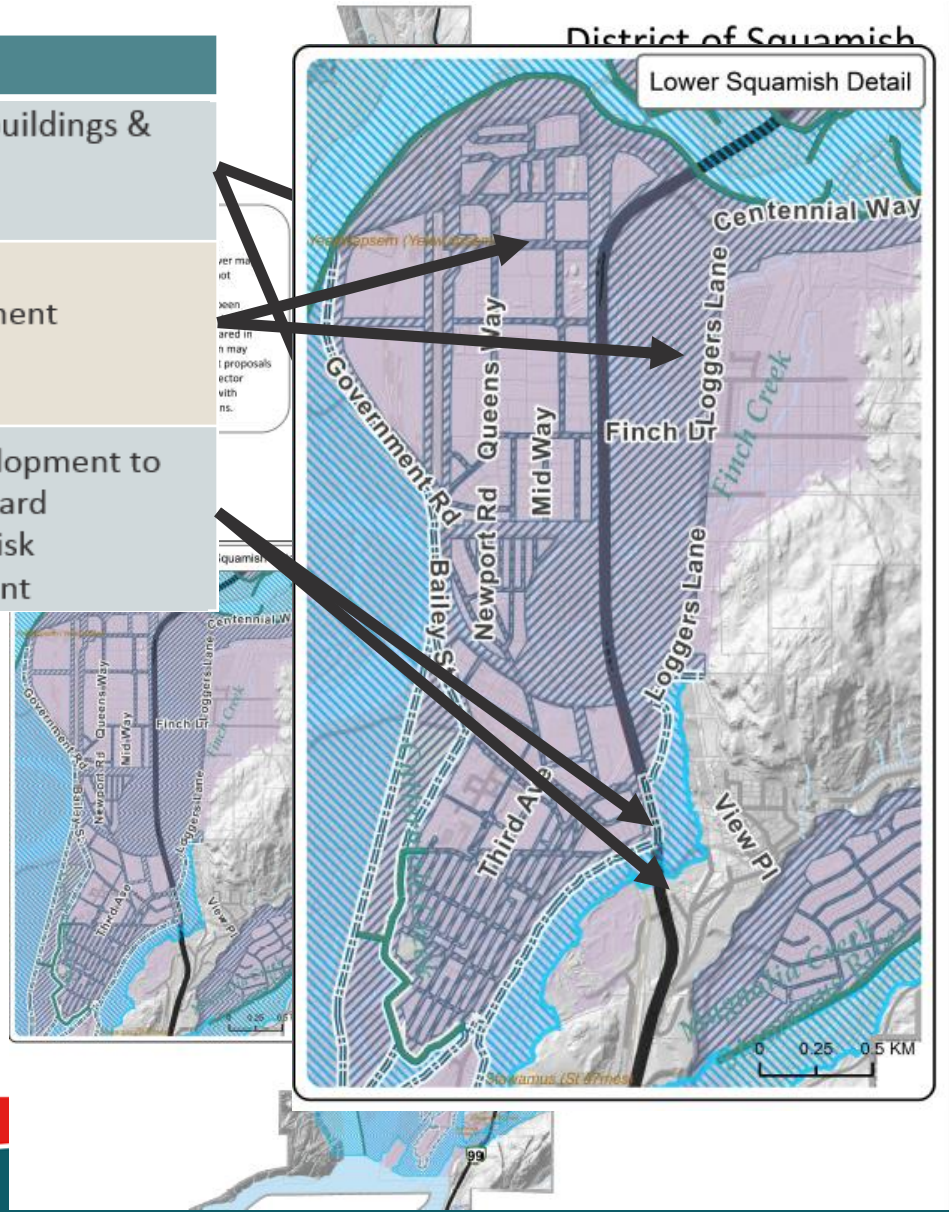
#3 – Limited Densification Areas (orange)



Development Permit Area Policy

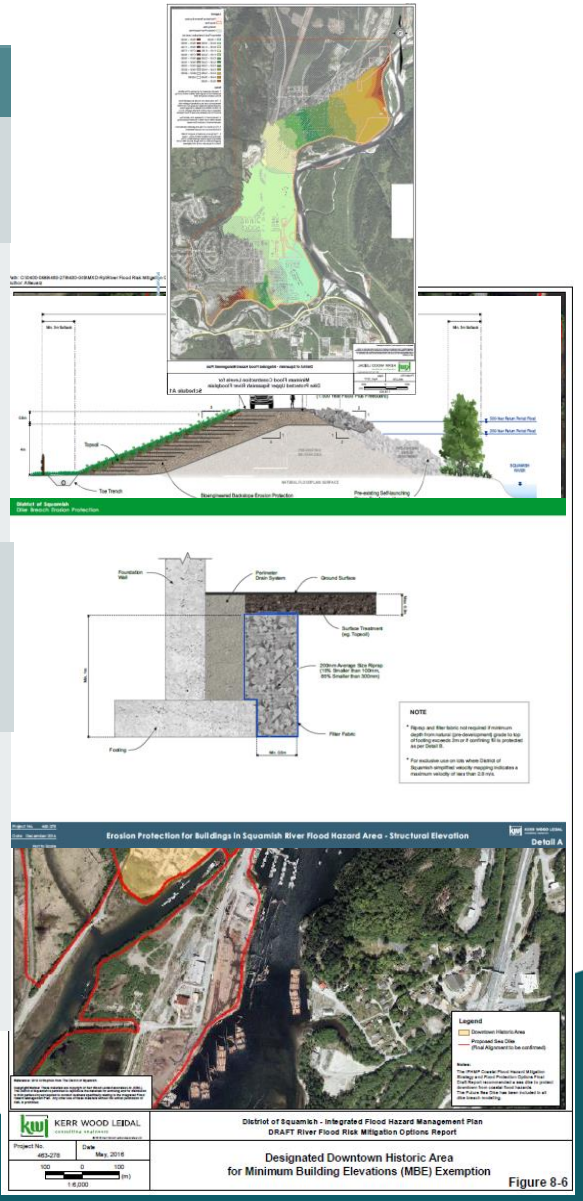
Policy Area	Objectives	Policy
Primary Floodways	• Allow 'room for the river' • Maintain flood conveyance • Avoid increasing flood levels	• Restrict buildings & fill
Secondary Floodways	• Maintain flood conveyance • Avoid increasing flood levels	• Regulate development
Debris Flow Hazard Areas	• Reduce risk to people and property	• Site development to avoid hazard • Require risk assessment

*Excludes Cheekeye Fan (covered under OCP Policy)



Floodplain Bylaw

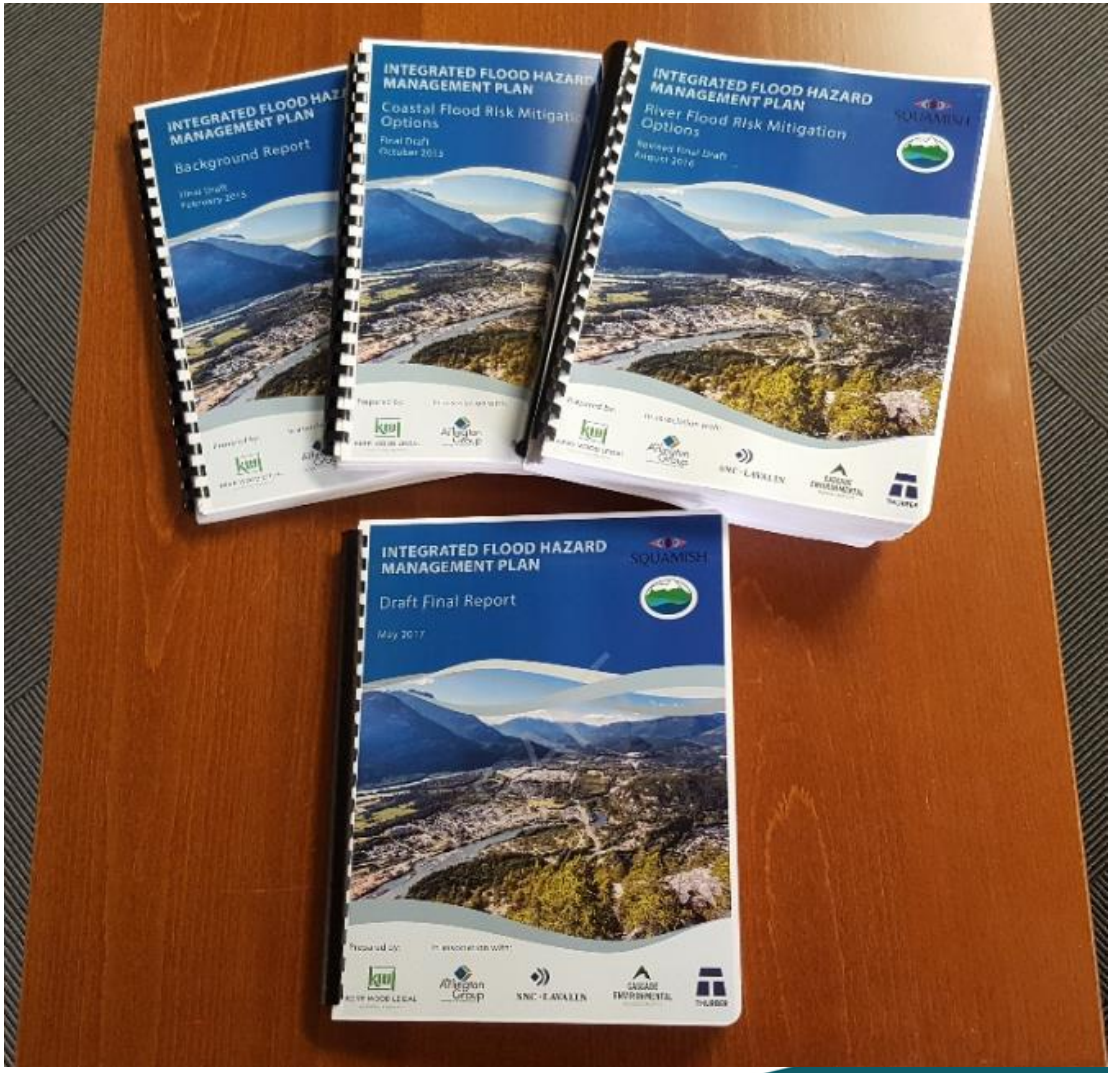
Policy Item	Objectives	Policies
• Designate Floodplains	• Identify hazard areas	• Regulate development
• Establish FCLs, setbacks	• Keep new development safe • Maintain floodways • Maintain space for diking	• Specify setbacks from watercourses & dikes
• Establish Floodplain Specifications	• Keep development safe	• Specify erosion, scour protection
• Establish Exemptions	• Exempt non-critical building elements • Allow flexibility in cases of hardship	• General exemptions • Local Area exemptions • Site-specific



Summary

- 3 year groundbreaking project

- Comprehensive, long-term plan to manage community flood risk including:
  - Prioritized capital plan
  - Robust policy framework



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Next Steps

- June - Complete Community Engagement
- July - Come back to Council with Final IFHMP
- Fall - Implement recommendations (adopt policies)

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Questions/Discussion