MEASUREMENTS OF GROUNDWATER CONTRIBUTIONS TO OKANAGAN LAKE FROM THE KELOWNA AREA

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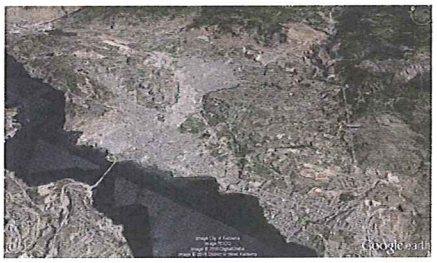
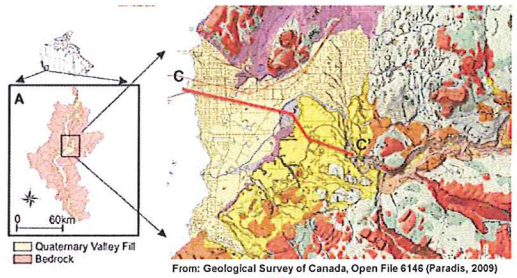
a place of mind THE UNIVERSITY OF BRITISH COLUMBIA

OUTLINE

BACKGROUND
METHODS
RESULTS
DISCUSSION
CONCLUSIONS
NEXT STEPS



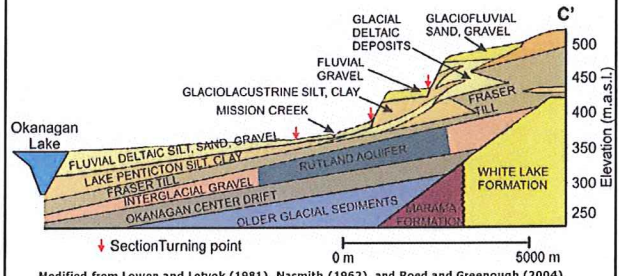
BACKGROUND



From: Geological Survey of Canada, Open File 6146 (Paradis, 2009)

glaciolacustrine glacio-fluvial terrace bedrock glacial till alluvial fan

BACKGROUND



Modified from Lowen and Letvek (1981), Nasmith (1962), and Roed and Greenough (2004).

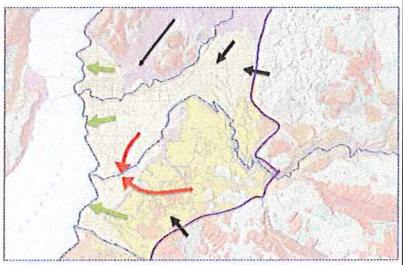
BACKGROUND

Groundwater

Main Ins:
Precipitation Recharge
Losses from Creeks
Inputs from Bedrock
Irrigation Returns
Leakage

Main Outs:
Discharge to Lake
Discharge to Surface Water
Pumping

Or: Storage Change



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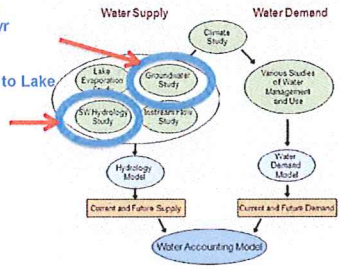
glaciolacustrine glacio-fluvial terrace bedrock glacial till alluvial fan

BACKGROUND

Okanagan Basin Water Board's Supply and Demand Study

Total GW Flow
~32 x 10^6 m^3/yr

GW Discharge to Lake
4 x 10^6 m^3/yr

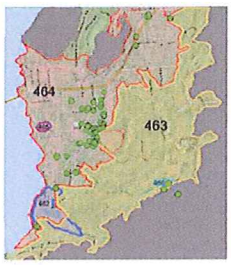


Phase 2 completed in 2010

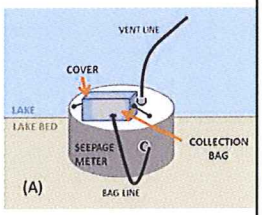
Modified from: OBWB Phase II Summary Report

PURPOSE

1. Directly measure groundwater discharge from the Kelowna aquifers to Okanagan Lake
   - Spatial/temporal, high flow areas, confined aquifer discharge
2. Investigate the potential implications of the observed groundwater discharge volume and patterns
   - Other studies, other parameters, regional context



METHODS



SEEPAGE METERS

74 point measurements

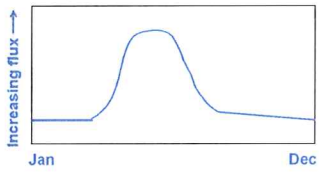
11 control measurements

POINT MEASUREMENT ISSUES: Time | Space | Confined aquifer

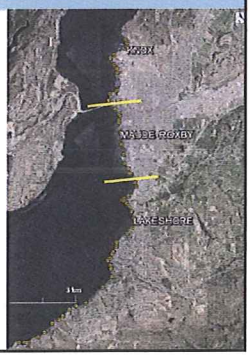
METHODS

ISSUE: Variation over Time

Eg: Conceptual expected GW outflow over one year

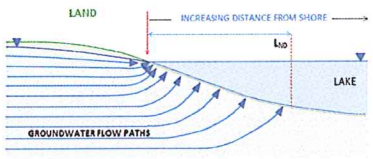


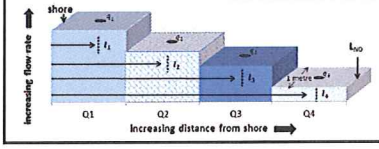
Solution: 3 long-term stations



METHODS

ISSUE: Variation in Outflow with Distance From Shore

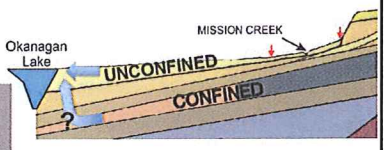


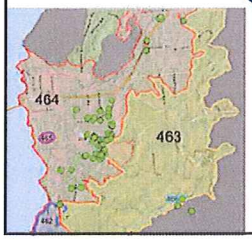


Solution: 12 transects perpendicular to shore

METHODS

ISSUE: Confined aquifer

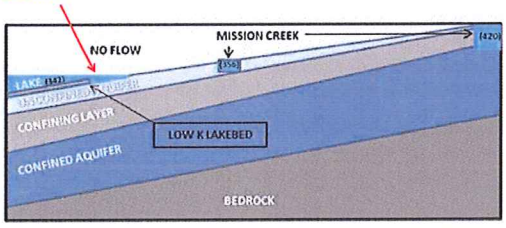




Solution: Preliminary Cross Section Modelling

METHODS

Nearshore



Vary the K value (~how permeable the material is) over typical ranges
24 + 18 Scenarios

RESULTS 14

Outline | Background | Methods | **Results** | Discussion | Conclusions | Next Steps

OVER FLOW CALCULATION = 0.37 x 10^6 m^3/yr

INTER-ANNUAL VARIABILITY

YEAR 1 = 0.41 x 10^6 m^3/yr

YEAR 2 = 0.29 x 10^6 m^3/yr

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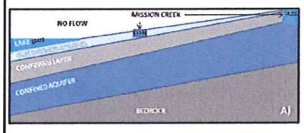
Patterns observed in MODFLOW scenario results:

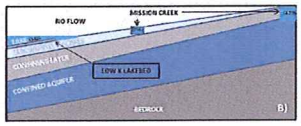
NO LAKEBED LAYER



↓ $K_{confined}$ = ↑ $discharge_{NEARSHORE}$

26 – 100% of flow captured in the nearshore area (mean of 72%)

LAKEBED LAYER



↓ $K_{confining}$ = ↓ $discharge_{NEARSHORE}$

↓ $K_{lakebed}$ = ↑ $discharge_{NEARSHORE}$

56 – 100% of flow captured in the nearshore area (mean of 87%)

RESULTS 15

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OVER FLOW CALCULATION = 0.37 x 10^6 m^3/yr

INTER-ANNUAL VARIABILITY

YEAR 1 = 0.41 x 10^6 m^3/yr

YEAR 2 = 0.29 x 10^6 m^3/yr

	Flux at Long-Term Stations		
	Knox ($m^3/m^2/s$)	Maude-Roxby ($m^3/m^2/s$)	Lakeshore ($m^3/m^2/s$)
Sept - Oct 2011	1.65E-07	3.20E-07	3.58E-07
Sept - Oct 2012	1.43E-07	1.55E-07	1.04E-07
Percentage of 2011 fluxes observed in 2012	87%	48%	29%
July - Aug 2012	2.60E-07	2.67E-07	1.53E-07
July - Aug 2013	4.06E-08	2.07E-08	2.34E-07
Percentage of 2012 fluxes observed in 2013	16%	8%	153%

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RESULTS COMPARISON

Study	Method	GW Discharge to Ok Lake (m^3/yr)	Comment
OBWB Phase II Supply & Demand Project	Calculated groundwater flow through aquifers	32 x 10^6	Separation of flow to lake and flow to creeks?
OBWB Phase II Supply & Demand Project	Estimated from groundwater component of a regional hydrology model	4 x 10^6	
Smerdon/Allen (2009)	Groundwater Model	183 x 10^6	Used older conceptual model of groundwater flow.
This Study	Measurements along shoreline	0.4 x 10^6	

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UPGRADIENT CONTROLS

	STUDY YEAR ONE	STUDY YEAR TWO	CHANGE
Precipitation?	300 mm	331 mm	10% ↑
Recharge from Mission Creek?			Not Estimated
Groundwater levels? (aquifer 464 during summer)	373.68 masl	373.34 masl	- 0.34 m
Pumping? (One water purveyor)	2.8 x 10^6 m^3	3.2 x 10^6 m^3	14% ↑

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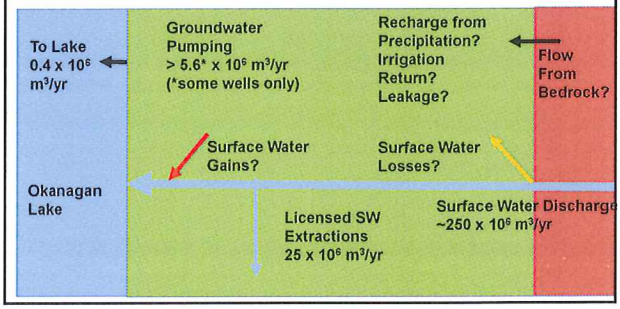

CONCLUSIONS

1. Directly measured groundwater discharge from the Kelowna aquifers to Okanagan Lake
   - GW discharge estimate = 0.37×10^6 m^3/year
2. Investigate the potential implications of the observed groundwater discharge volume and patterns
   - GW discharge < OBWB Phase 2 Study GW study estimates
   - Inter-annual variation in observed flux rates (up to 84% in some locations) may be tied to GW extraction
   - GW discharge estimate < 7% of the volume being extracted from upgradient aquifers

CONCLUSIONS

RESEARCH VALUE:

- Supports local or regional model calibration including the OBWB's Supply and Demand Model
- Provides groundwater flow information required for future groundwater contaminants research
- Demonstrates the use of seepage meters to support water balance estimates

NEXT STEPS

1. Further work to characterize the hydrogeological environment within the Kelowna area;
2. Investigate GW/SW interactions along major fluvial systems (including pumping);
3. Further quantification of other water budget parameters;
4. Completion of a coupled groundwater/surface water model

THANK YOU SPONSORS, PARTNERS and tireless RESEARCH ASSISTANTS

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RA's: Jordan Wu, Bob Cao, Craig Baptie, Jordan White, Maryssa Soroke

and THANK YOU FOR LISTENING. ANY QUESTIONS?