Siting, Characterization, and Preliminary Design

for Groundwater Recharge and Watershed Augmentation

for

Kitsap County and the Suquamish Tribe, Kingston, WA

Presented by

Jon Turk, PG, LHG

Suquamish Tribe

Brown AND Caldwell

KITSAP COUNTY 1857 WASHINGTON

Aspect CONSULTING

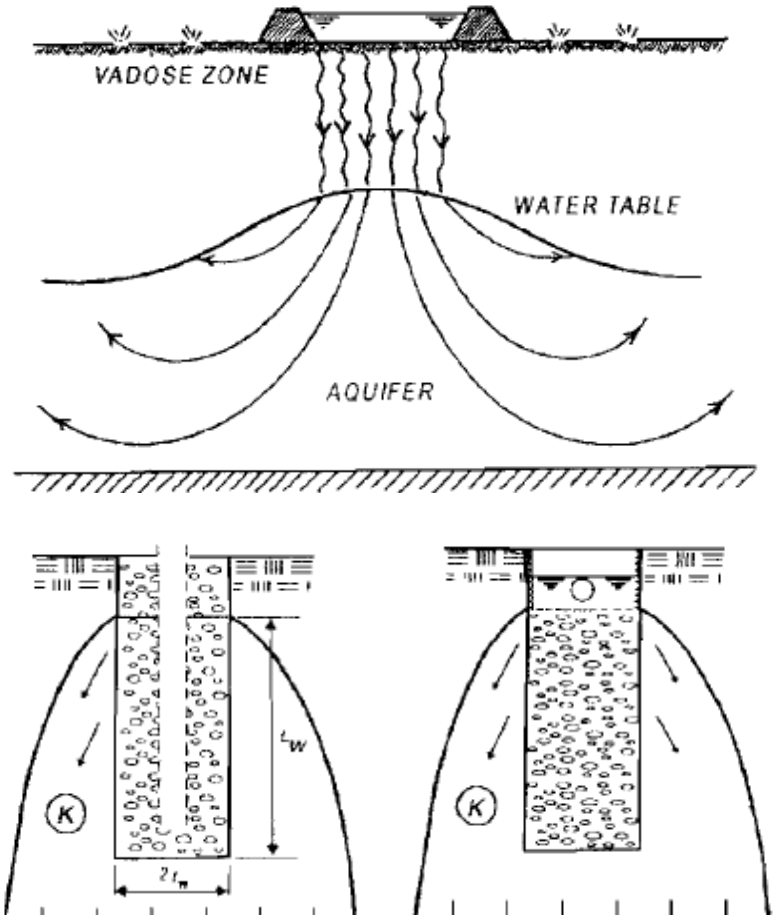
earth + water

Core Concepts

- **Reclaimed water is a resource**
  - Treatment cost versus end use water quality needs.
  - WAC 172-219 (reclaimed water rules), RCW 90.46, and the Purple Book (Ecology publication #15-10-024 revised February 2019).
- **Integrated natural resource planning**
  - Balancing the needs of humans, fish, and the environment.
  - Multiple stakeholder benefits.
  - Highest and best use of available sources of supply.
- **Reclaimed water groundwater recharge**
  - Augments natural aquifer recharge.
  - Multiple barrier approach (treatment, infiltration, transport).
  - Helps with legal and physical water availability.

Groundwater Recharge

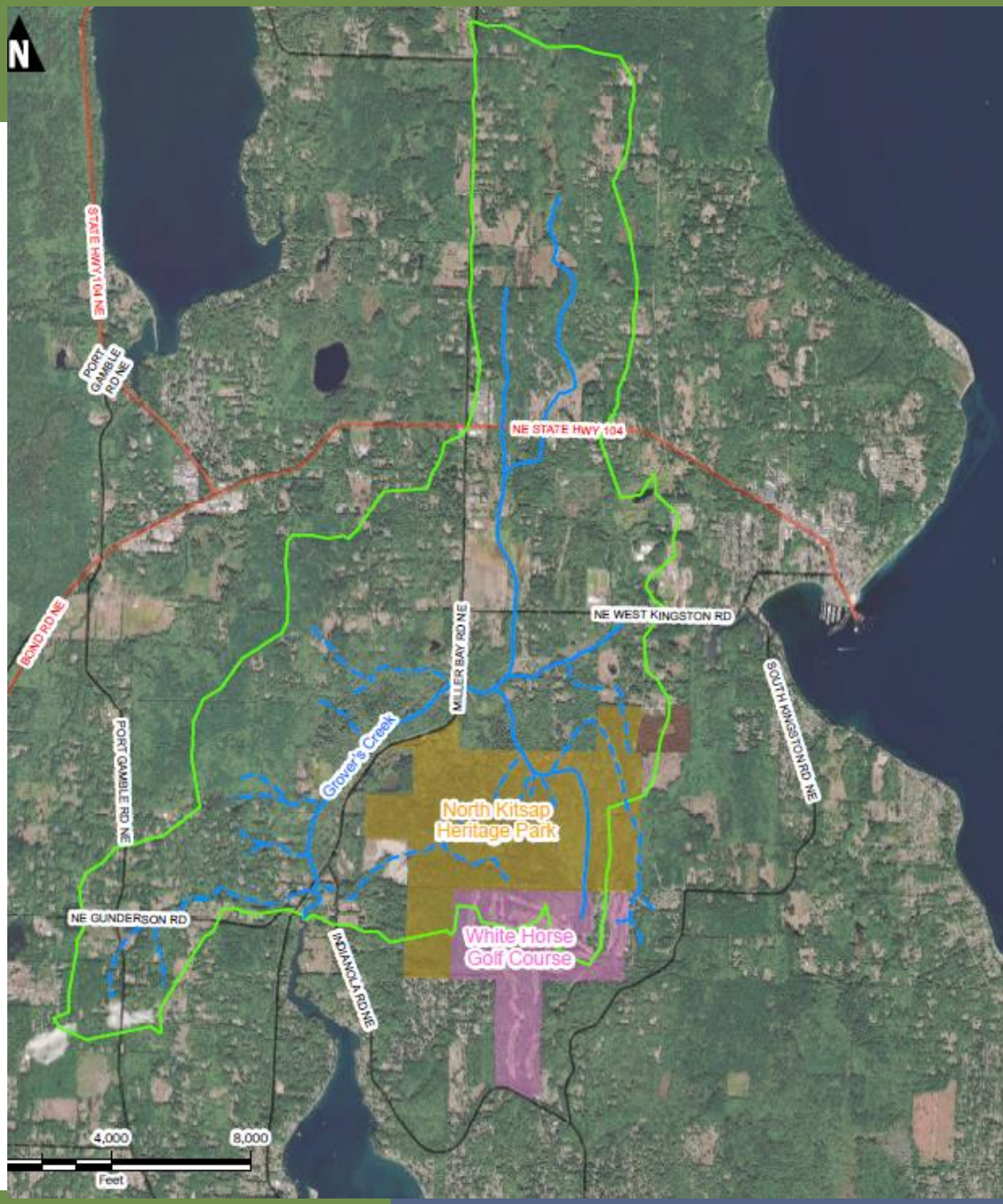
- **Discharge to the land surface at greater than agronomic rates**
  - Rapid infiltration basins
  - Spreading ponds (slow infiltration)
- **Discharge within the vadose zone, infiltration galleries**
- **Direct injection**



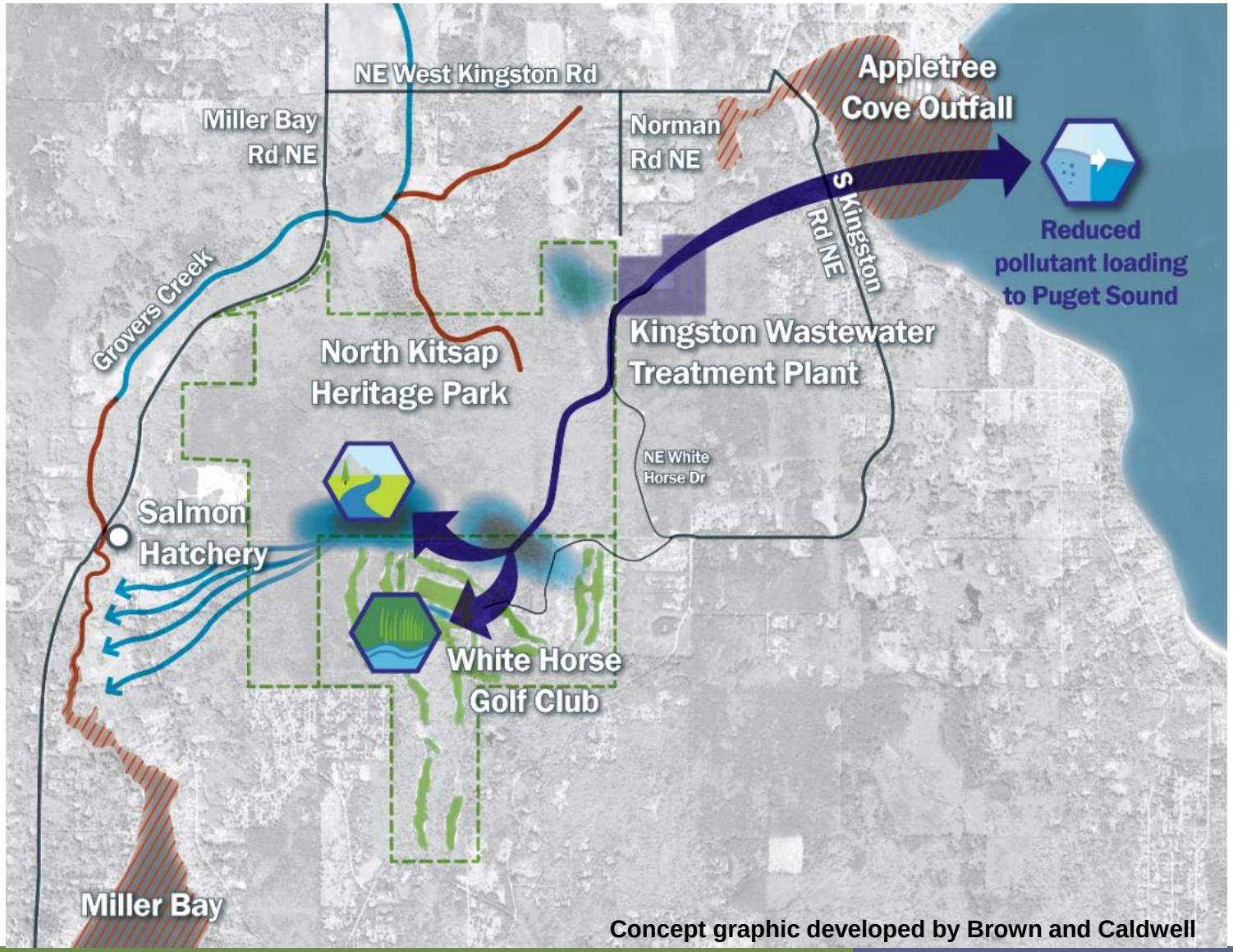
Recharge basin and injection and dry well discharge schematics. From Bouwer 2002.

Agenda

- **Kingston Project background**
- **Siting/Characterization**
  - Site testing
  - Groundwater Modeling
- **Preliminary design process**
- **Next steps**



Kingston Project Concepts

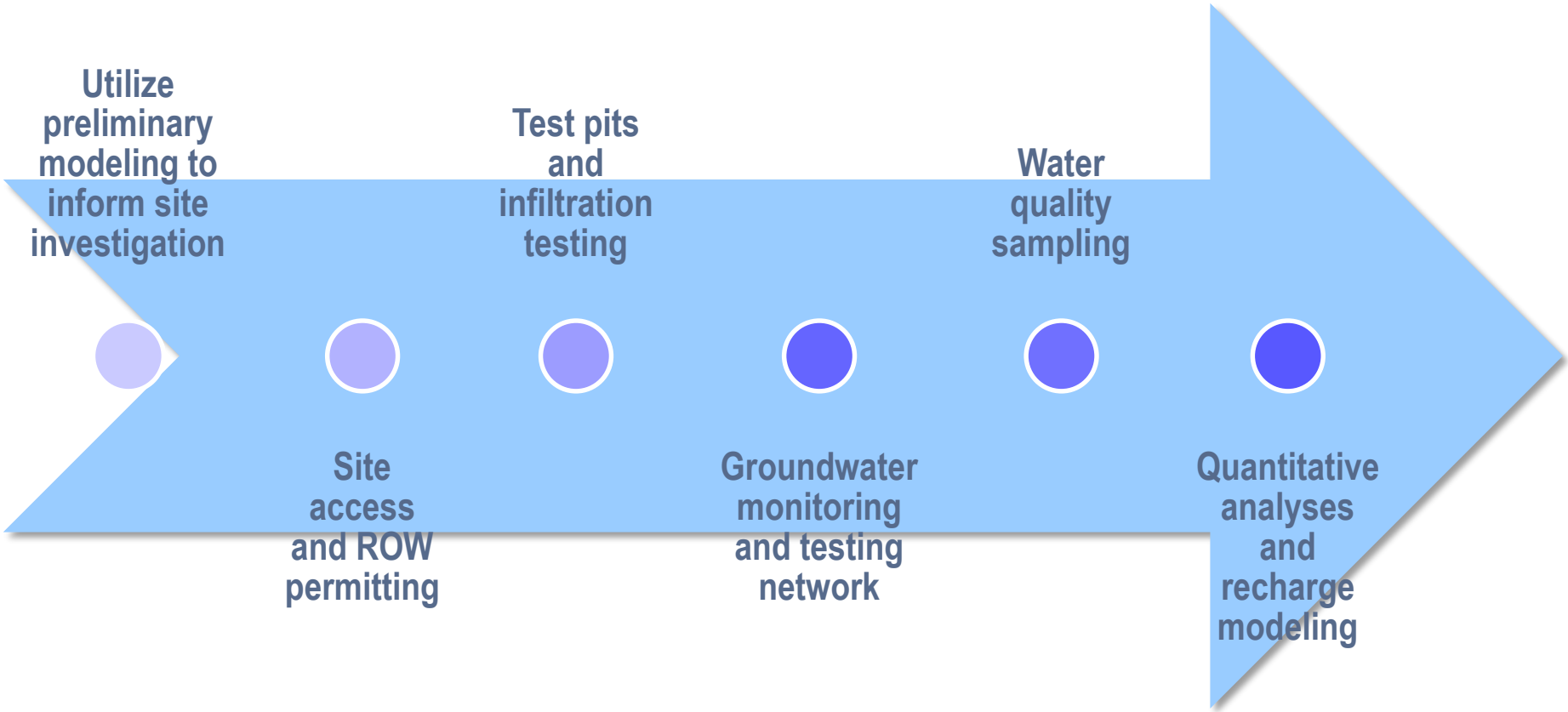


Concept graphic developed by Brown and Caldwell

Regulatory Framework

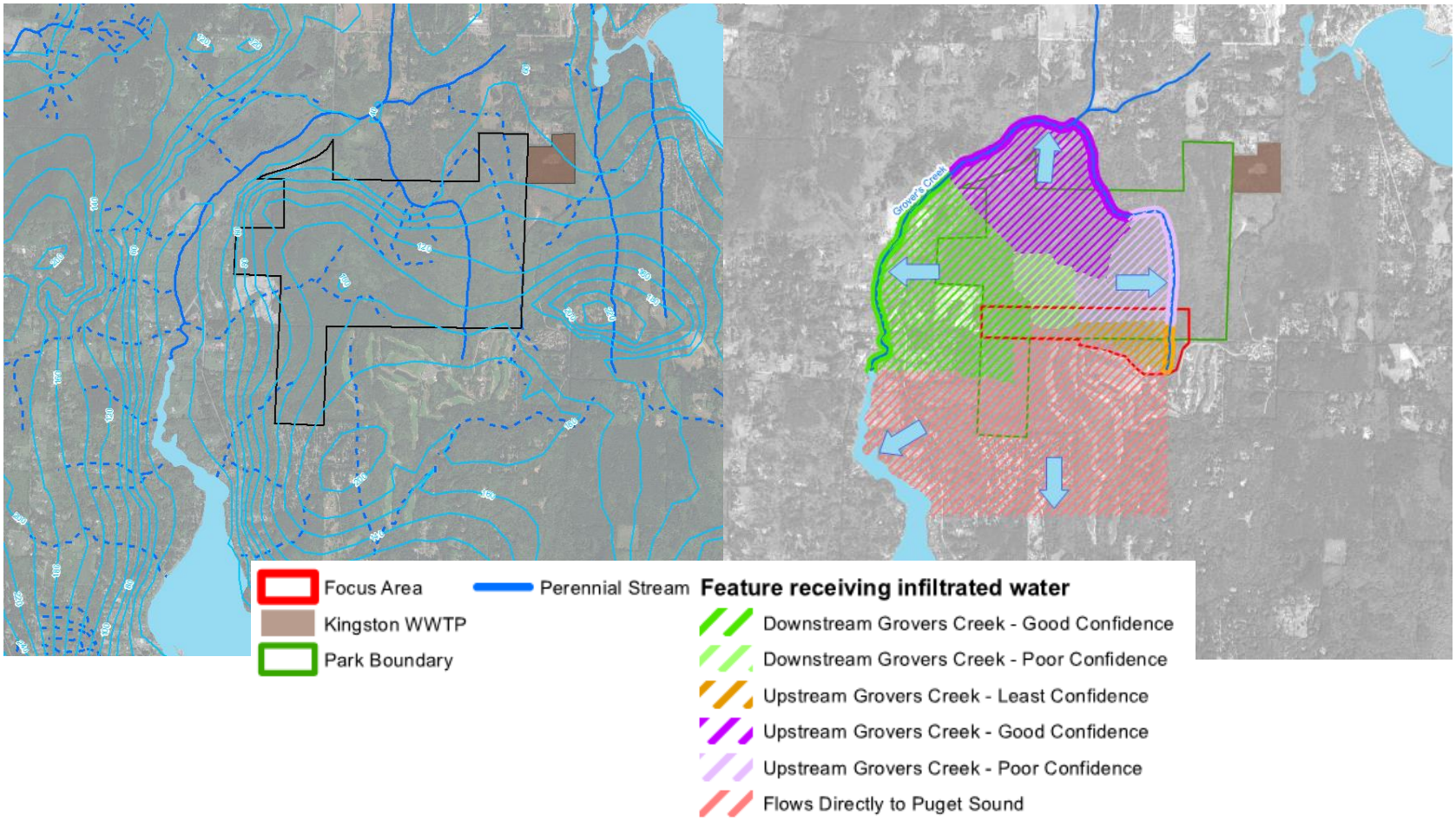
- **Meet both performance standards (WAC 173-219-330) and use-based requirements (WAC 173-219-390 Table 3) for reclaimed water quality.**
- **Primary beneficial use is irrigation of White Horse Golf Course (WAC 173-219-390 Table 3, Beneficial Use #2).**
  - Regulatory point of compliance at the end of the treatment system for golf course irrigation.
- **Secondary beneficial of indirect aquifer recharge (WAC 173-219-390 Table 3, Beneficial Use #21) from an engineered infiltration basin.**
  - Indirect aquifer recharge has the potential to support increased base flows within the Grover's Creek Watershed.
  - Regulatory point of compliance within a groundwater monitoring well network for indirect aquifer recharge.
  - Indirect aquifer recharge requires that State groundwater and surface water standards (173-200 and 173-218 WAC) are met at a groundwater monitoring point of compliance.

Siting and Characterization



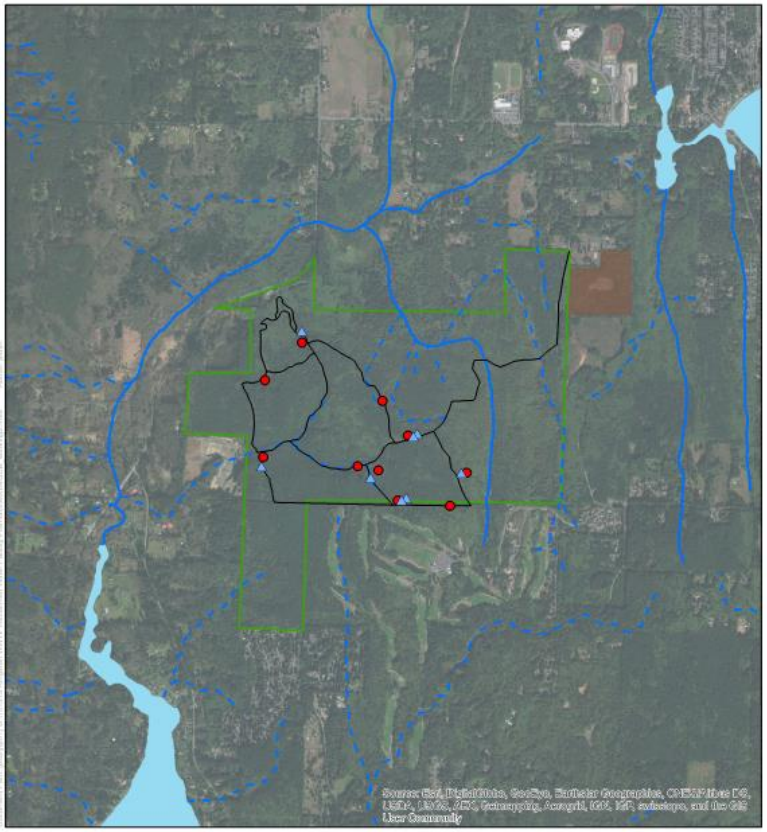
Infiltration Alternative
Preliminary Groundwater Modeling

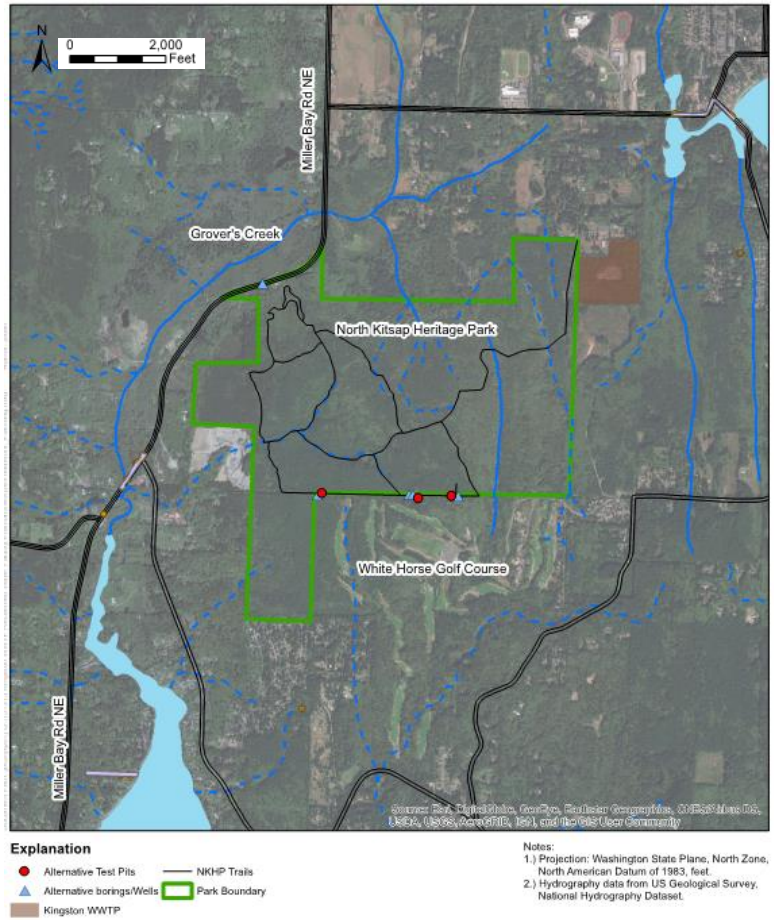
Simulated Groundwater Levels → Generalized Groundwater Flows



Infiltration Alternative
Modified Fieldwork Approach

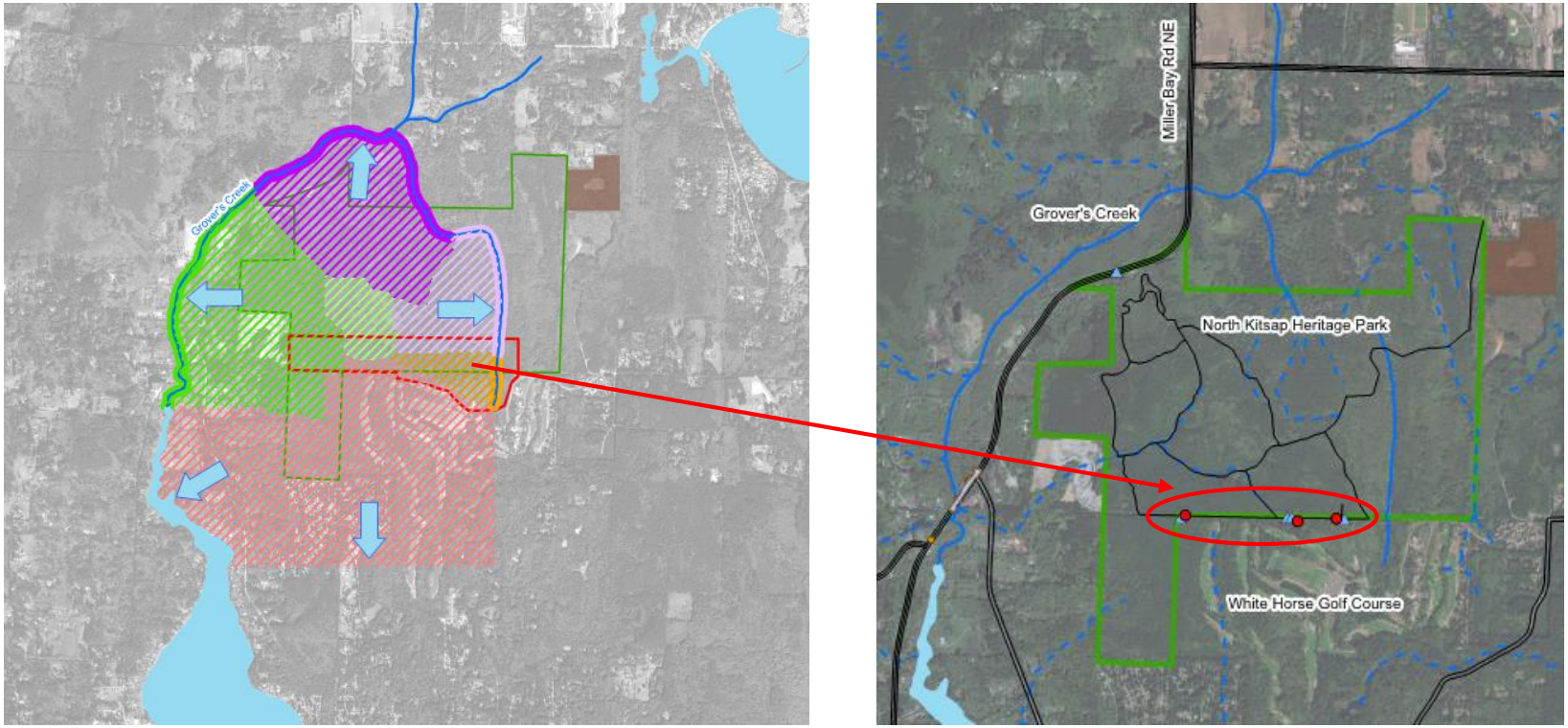
Original Field Assessment Plan → Revised Field Assessment Plan





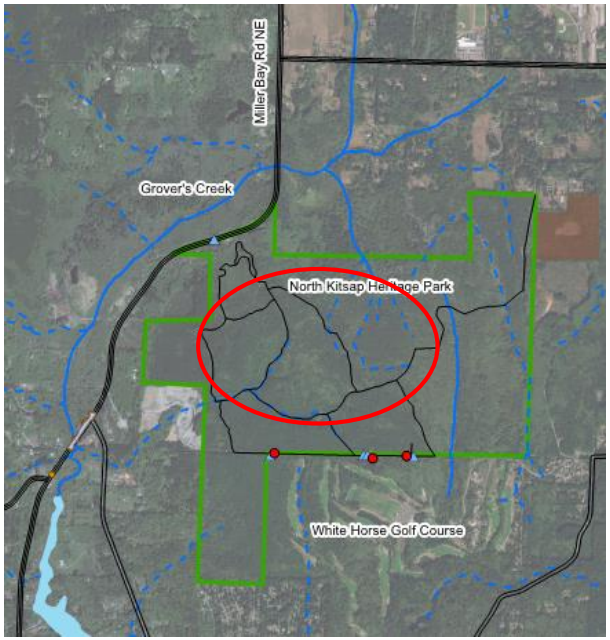
Modified Fieldwork Approach

Preliminary modeling results emphasize need to focus on area with uncertainty in groundwater flow path direction

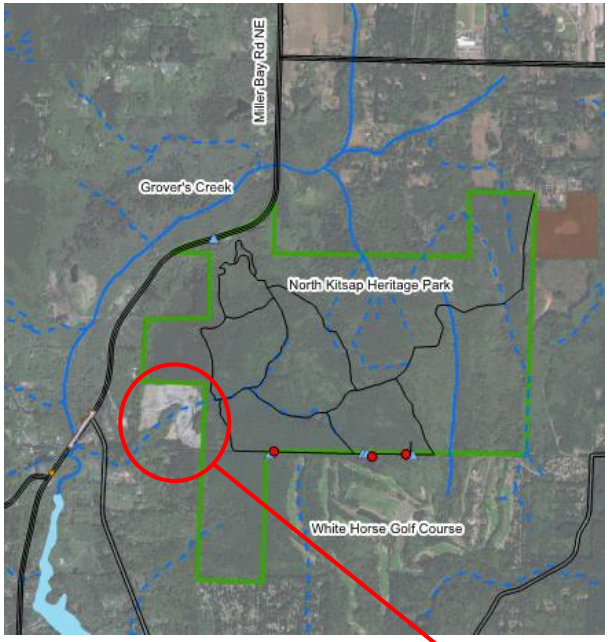


Infiltration Alternative
Modified Fieldwork Approach – Within NKHP

NKHP to be traversed on foot, using small-diameter hand-driven soil probes or augers to assess soils to depths of 5 feet.



Infiltration Alternative
Recon of the Arness Sand Pit



- Pit walls provide outcrop exposure of glacial outwash sequence, same hydrogeologic unit targeted for on-site infiltration.
- Outcrop shows >85 feet of glacial outwash.
- Pit base at ~200 feet elevation
- Pit wall max elevation of ~300 feet
- No glacial till observed at Arness Pit

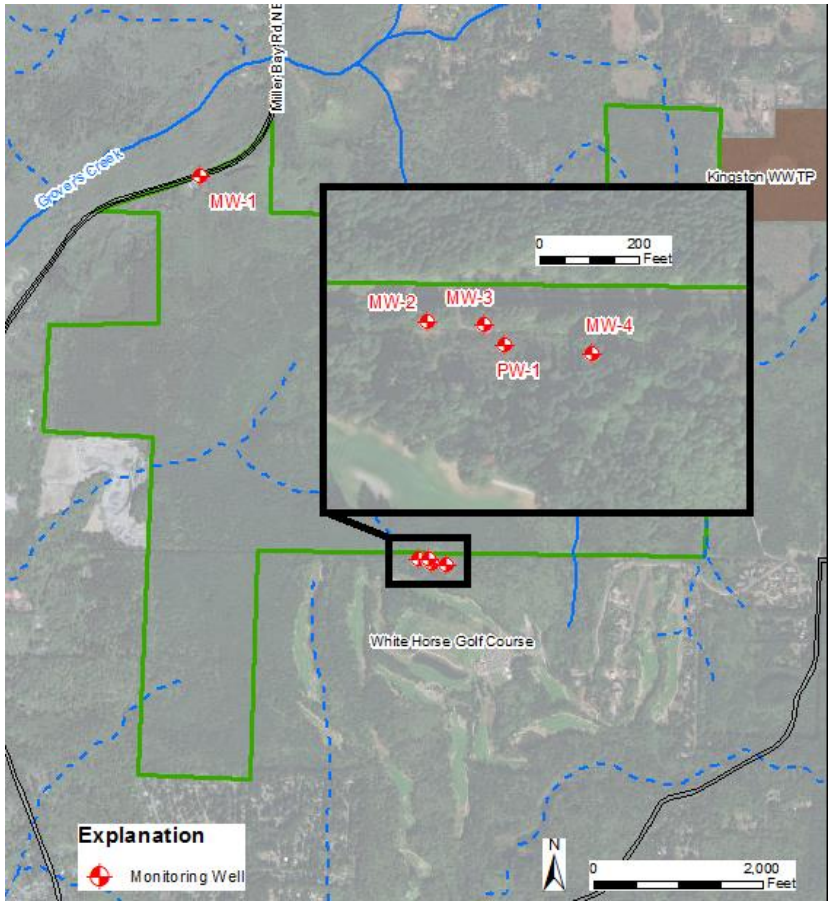
Test Pits and Infiltration Testing

- **Three pits and infiltration tests.**
- **Test pit logs show similar soils profiles generalized as well-graded sand and gravel.**
- **Infiltration testing at three locations**
  - Constant head and falling head tests.
  - Flow rates and duration limited by the use of 2,000 gallon water truck.

Infiltration Alternative
Deep Drilling and Monitoring Network Installation

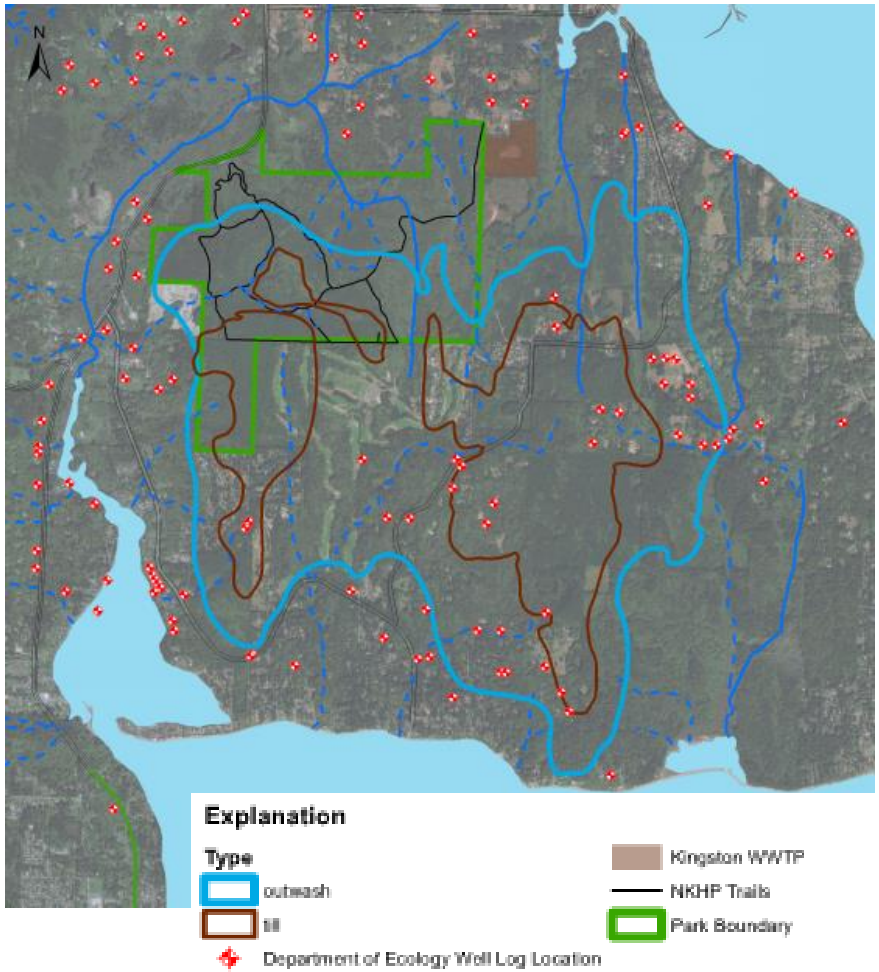
Summary of Hydrogeologic Site Characterization Wells

Well ID	Ground Elevation [1]	Screen top elevation	Screen bottom elevation	Aquifer Unit
MW-1	62	12	2	Sea Level Aquifer
MW-2	270	230	210	Surficial Aquifer
MW-3	280	240	220	Surficial Aquifer
MW-4	275	225	205	Surficial Aquifer
PW	270	230	210	Surficial Aquifer



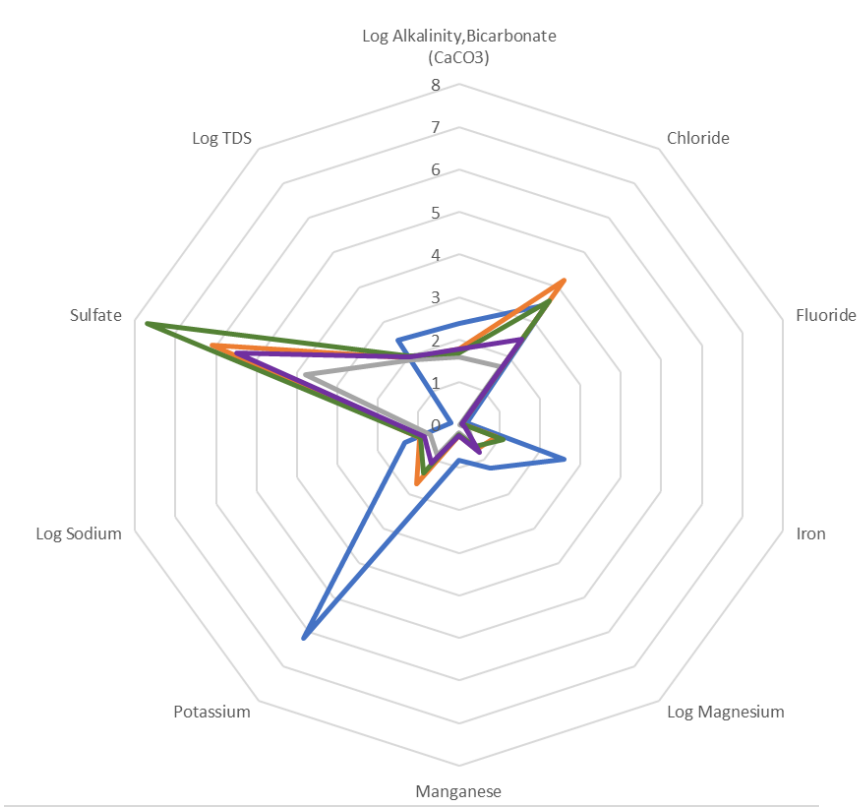
Sonic Drilling Method Produces Continuous Core Logs

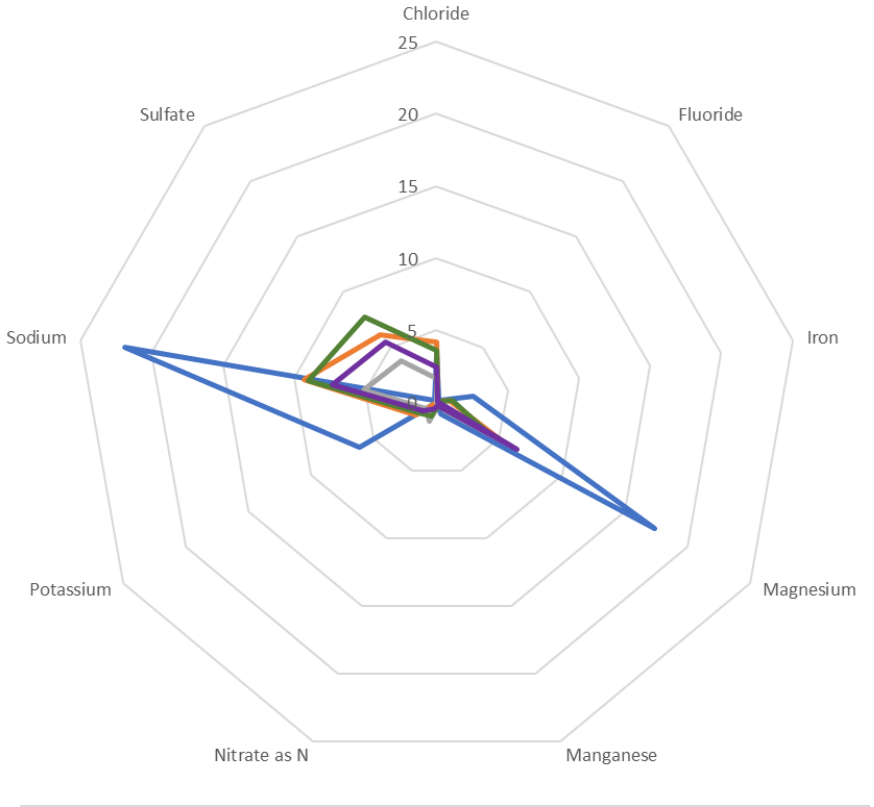
Update Geologic Mapping



- **Historical surficial geologic maps show conflicting information, some show broad regional glacial till at surface, some show outwash. Need to refine historical data.**
- **Local outwash deposits are generally mantled by glacial till at elevations >300 feet.**
- **Outwash generally overlies glacial lake sediments or till at elevations between 150 – 200 feet.**
- **Outwash deposits thicken to the west – up to 100 feet thick near Arness pit, and thin eastward to less than 10 feet near Kingston Rd. Historical data suggest outwash was deposited by northwesterly water flows.**
- **Bottom of outwash unit generally dips to the west as the sequence thickens.**

Infiltration Alternative
Water Quality Analyses





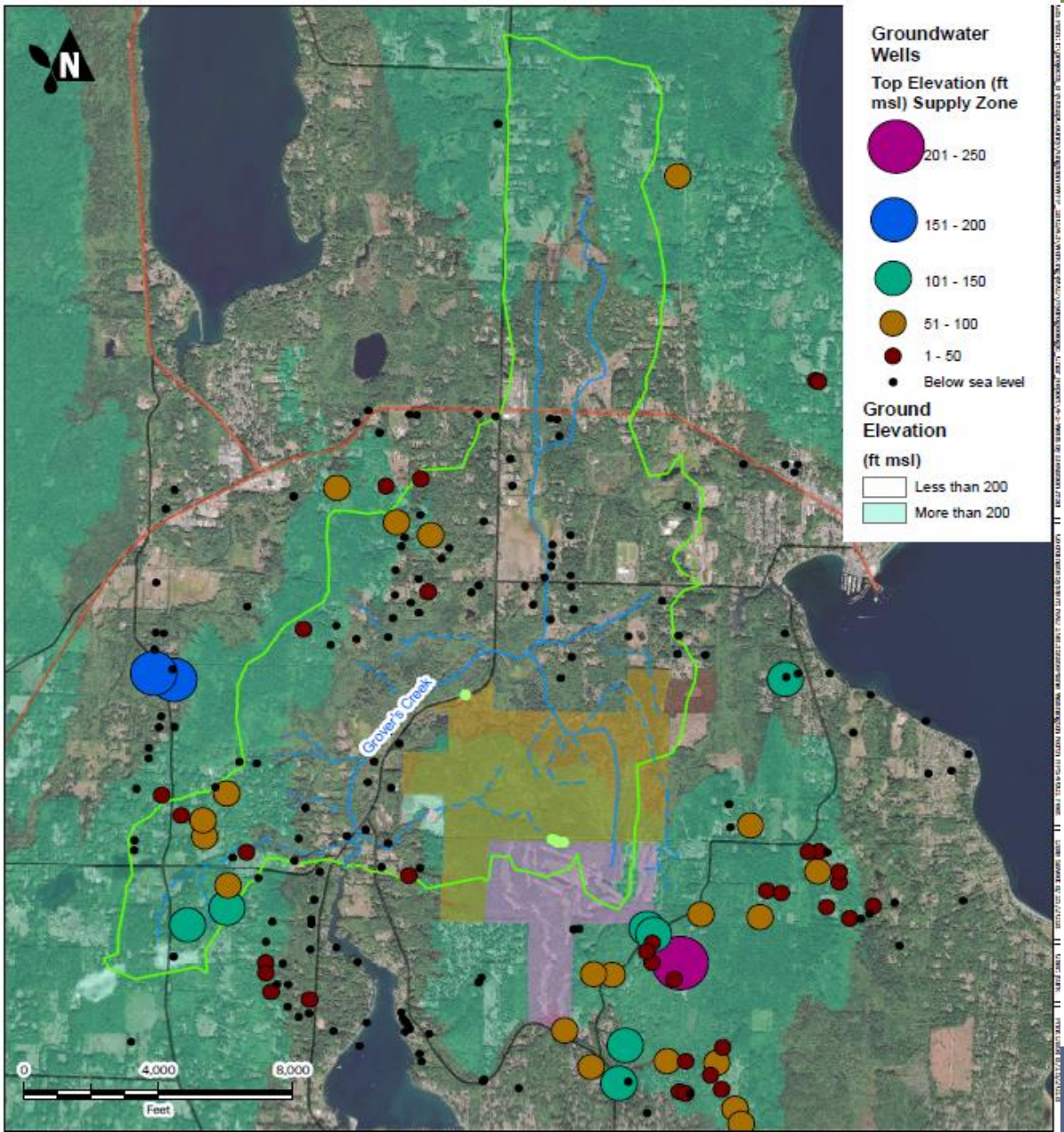
MW-1
MW-2
MW-3
MW-4
PW-1

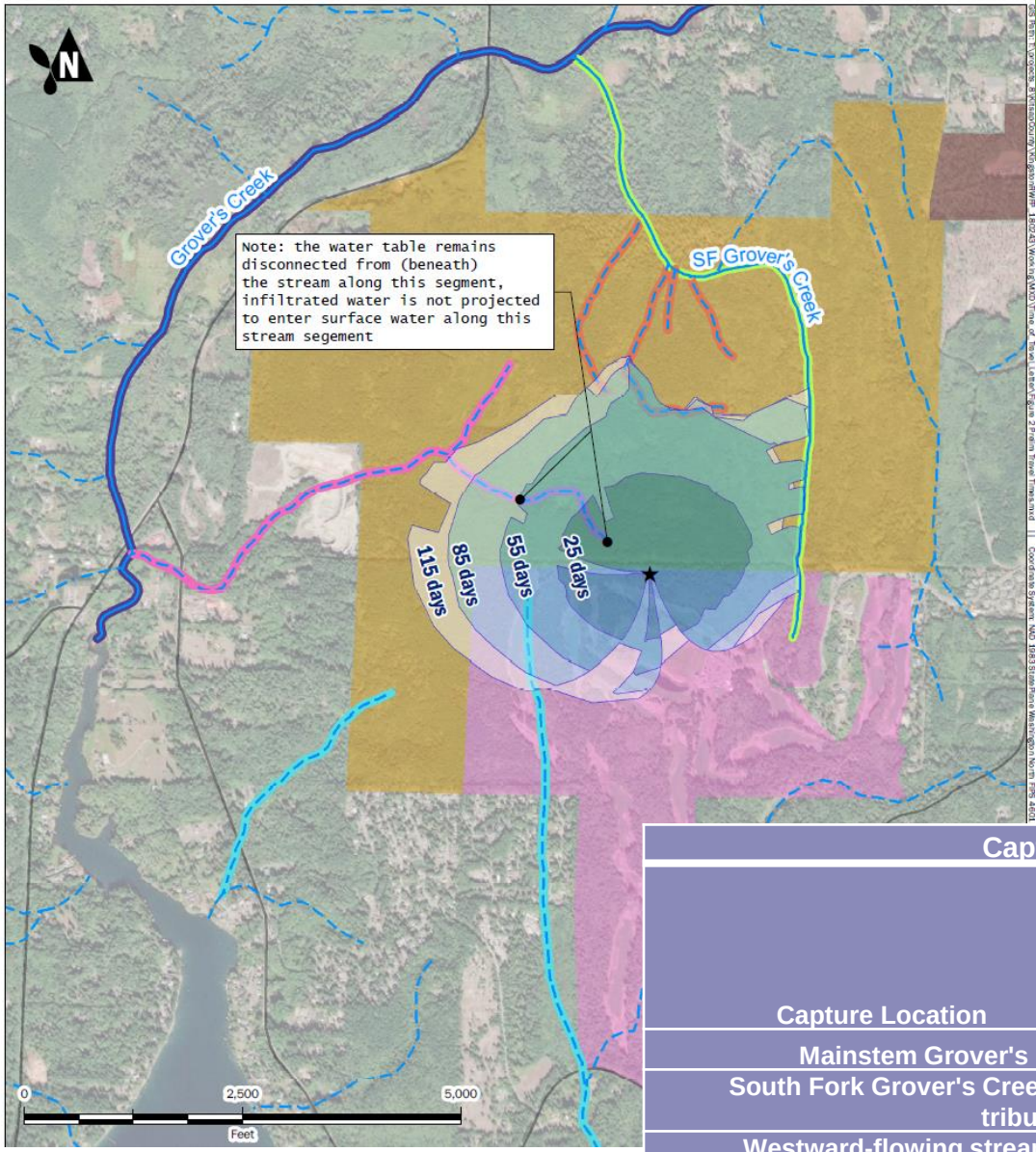
Develop Groundwater Model "Scenarios" to for infiltration alternative:

- **Current Conditions**
  - No infiltration
  - Existing irrigation pumping from KPUD
- **Winter Infiltration**
  - Reduced KPUD Pumping
  - Seasonal groundwater recharge
- **Year-Round Infiltration**
  - Reduced KPUD pumping
  - Year-round groundwater recharge

Infiltration Alternative

Assess Other Groundwater Uses





NAME

- Proposed Infiltration Site
- White Horse Golf Course
- North Kitsap Heritage Park

Streams

- Perennial
- Intermittent
- Distance to Stream (feet)

Zone

- Mainstem Grover's Creek
- South Fork Grover's Creek
- South Fork Grover's Creek Tributaries
- Southern Streams
- Westward-flowing stream

Capture Locations (Numerical Model)

Capture Location	Percent of Infiltrated Water Captured by Location		Length of Seepage Zones along Streams (ft)
	Constant Infiltration	Seasonal Infiltration	
Mainstem Grover's Creek	0%	0%	0
South Fork Grover's Creek and tributaries	64%	67%	4,539
Westward-flowing stream and tributaries	21%	19%	4,335
Southern Streams	5%	4%	1,307
Deeper Aquifers	10%	10%	NA

Infiltration Alternative

Table 1. Time to Surface Water Capture (Analytical Model)

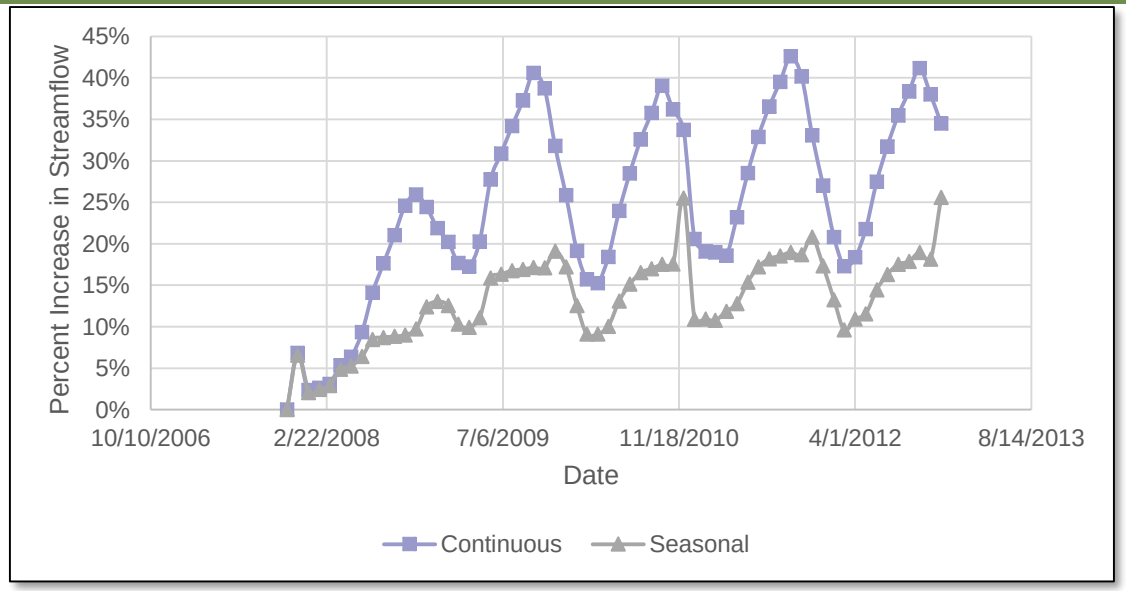
Capture Location	Distance to Stream (ft)	Estimated Groundwater Velocity (ft/d)			Estimated Time-of-Travel (d)		
		Min.	Avg.	Max.	Max.	Avg.	Min.
Mainstem Grover's Creek	6,171	1.00	2.35	5.25	6,171	2,626	1,175
South Fork Grover's Creek	1,694				1,694	721	323
South Fork Grover's Creek tributaries	1,836				1,836	781	350
Westward-flowing stream and tributaries	608				608	259	116
Southern Streams	1,408				1,408	599	268
Average[a]	1,387	NA	NA	NA	1,387	590	264

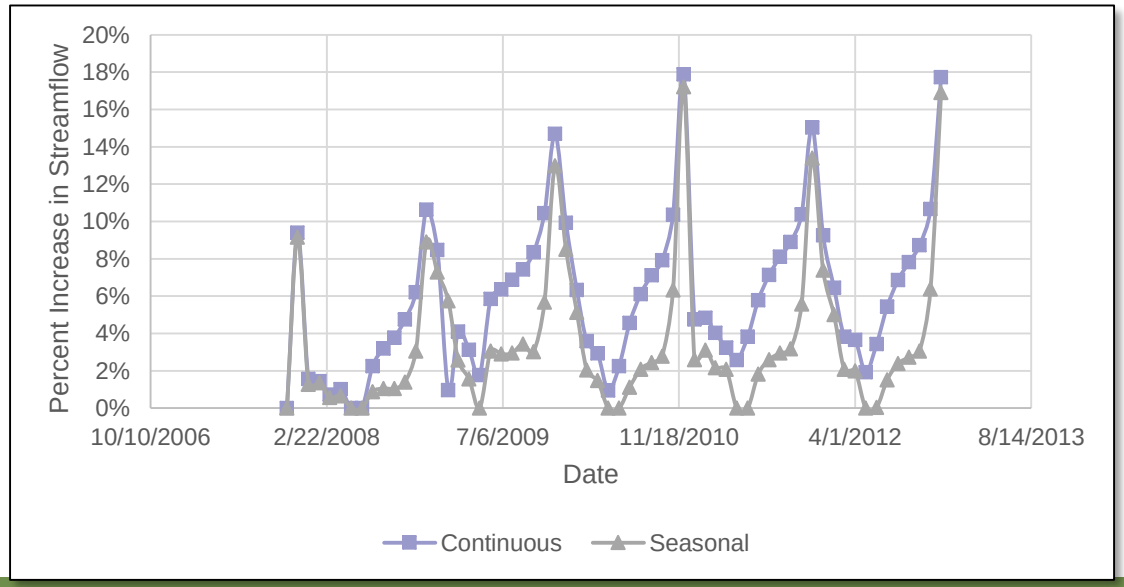
Table 2. Time to Surface Water Capture (Numerical Model)

Elapsed Time (days)[a]	Percent of Infiltration Captured by Surface Water	
	Constant Infiltration	Seasonal Infiltration
0	0%	0%
25	0%	0%
55	44%	41%
85	58%	59%
115	66%	63%
145	79%	74%
175	87%	85%
205	88%	89%
235	91%	90%
265	91%	90%
295	92%	90%
325	92%	91%
355	92%	91%

Infiltration Alternative

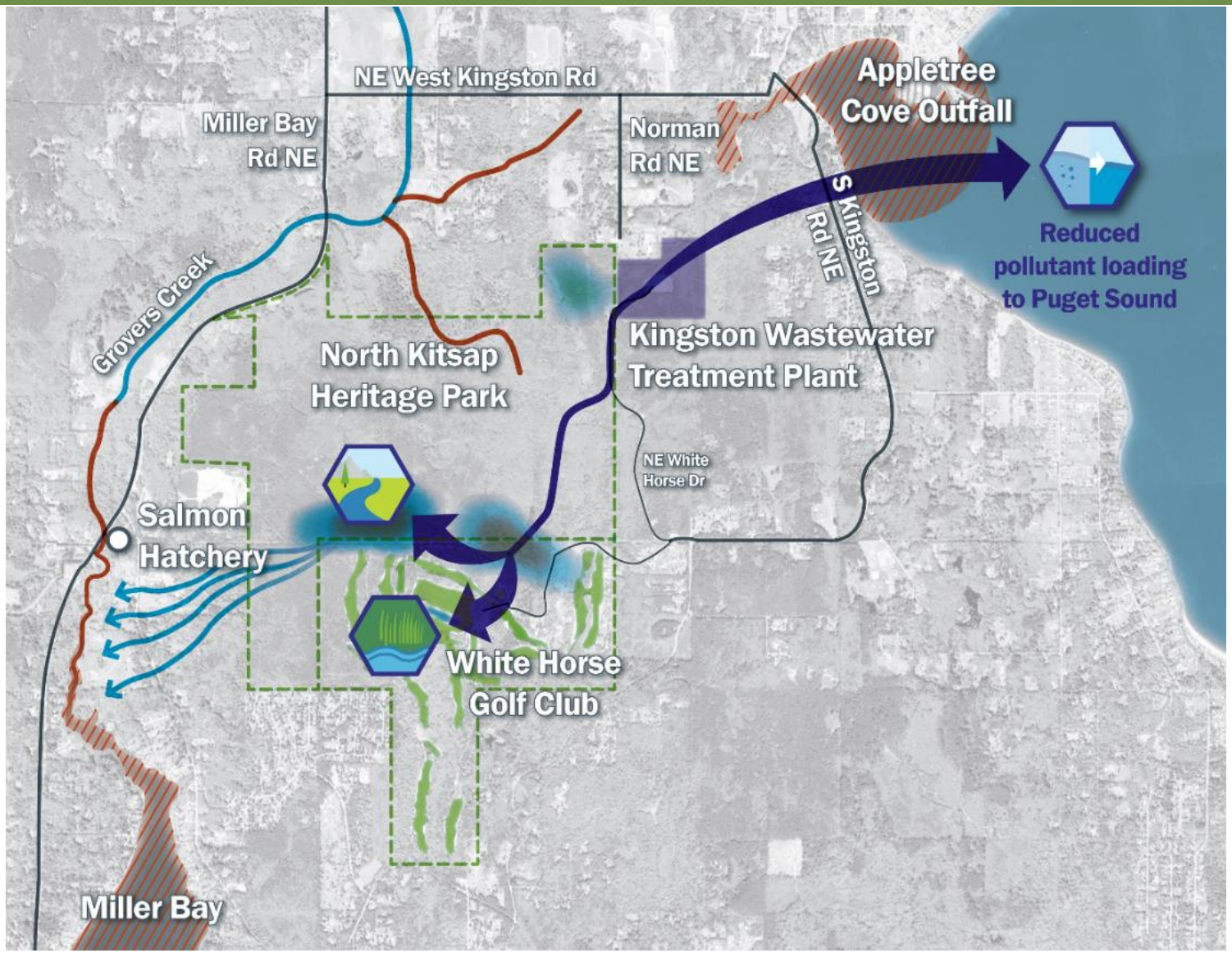
South Fork GC confluence with Mainstem





Mouth of GC at Appletree Cove

Basis of Design – 0.5 MGD Discharge



LOTT Clean Water Alliance, Hawks Prairie Recharge Facility, Thurston County, WA

earth + water

AACE Class 4 Cost Estimate

Estimate of Probable Construction Cost	
Description	Cost [a]
Class A Recycled Water Treatment	
Oxidation ditch 2 modifications	$534,000
New Secondary Effluent EQ tank	$479,000
New filter feed pump station	$264,000
New filtration system	$863,000
New recycled water building	$172,000
New disinfection system (UV)	$818,000
New reclaimed water pump station	1,464,000
Miscellaneous improvements	$653,000
Conveyance	
New pipeline	$1,757,000
EQ basin and irrigation at WHGC	$1,565,000
Infiltration basins and associated piping	$1,567,000
Construction and Project Costs	
Total construction cost (accuracy range)[b]	$10,136,000 ($7,095,000-$15,200,000)
Total Project cost [c]	$13,648,000
Annualized Costs[d]	$630,000
Estimated unit cost ($/MG)[e]	$6,700


Aspect
CONSULTING
Questions?
Jon Turk, PG, LHG
jturk@aspectconsulting.com
360.628.1675
www.aspectconsulting.com
2019 PNWS AWWA CONFERENCE
earth+water

Infiltration Alternative
Groundwater Modeling

Table 4. Hydrogeologic unit labels and terminology used in groundwater studies of the Kitsap Peninsula, west-central Washington.

[–, not defined]

Sceva, 1957 (Kitsap County)	Garling and others, 1965 (Kitsap Peninsula)	Dion and others, 1988 (Bainbridge Island)	Kitsap County Groundwater Advisory Committee and others, 1991 (Kitsap County)	Kato and Warren, Inc., and Robinson and Noble, Inc., 2000 (Bainbridge Island)	This study	Number of wells used to determine extent and thickness of unit
Alluvium	Alluvium	1	Qn1, alluvium and recessional deposits	Qvr, Shallow aquifer	Qvr, Vashon recessional aquifer	215
A, recessional outwash	Qvr, recessional outwash					
B, till	Qvt, till	2	Qg1, till	Qvt	Qvt, Vashon till confining unit	1,568
C, advance outwash	Qva, advance outwash	3	Qg1a, advance outwash/shallow aquifer	PA, perched aquifer system	Qva, Vashon advance aquifer	1,480
D, Puyallup sand	Qc, Colvos sand					
–	–	4	Qn2, 1st nonglacial deposits	C1, upper confining unit	QC1, Upper confining unit	1,368
			Qg2, 2nd glacial deposits	SPA, semi-perched aquifer system	QC1pi, Permeable interbeds	143
E, Kitsap Clay member	Qg/Qk, unnamed gravel/Kitsap formation		Qn3, 2nd nonglacial deposits	C2, lower confining unit	QC1, Upper confining unit	78
F, Orting gravel member	Qss, Salmon Springs (?) Drift	5	Qg3, 3rd glacial deposits/sea-level aquifer	SLA, sea level aquifer	QA1, Sea-level aquifer	1,109
–	Qpu, pre-Salmon Springs (?) deposits	6	Qn4, 3rd nonglacial deposits	C3, confining unit	QC2, Middle confining unit	387
		Pleistocene deposits (undifferentiated)	Qg4, 4th glacial deposits/deep aquifer; Qg4m marine glaciomarine deposits	GMA, glaciomarine aquifer system	QA2, Glacio-marine aquifer	289
G, Admiralty drift			Qn5, 4th nonglacial deposits	C4, confining unit	QC3, Lower confining unit	115
Pre-Orting deposits, undifferentiated			Qg5, 5th glacial deposits	FBA, Fletcher Bay Aquifer	QA3, Deep aquifer	69
			Qn6, ancient nonglacial deposits	C5, confining unit	QC4, Basal confining unit	29
Tertiary Blakeley Formation of Weaver, 1916	Tertiary Blakeley Formation of Weaver, 1916	Tertiary Blakeley Formation of Weaver, 1916	Tertiary Blakeley Formation of Weaver, 1916	Blakeley Harbor Formation of Fulmer, 1975	BR, Bedrock	46
				Blakeley Formation of Fulmer, 1975		

Infiltration Alternative
Preliminary Activities and Challenges

Activities

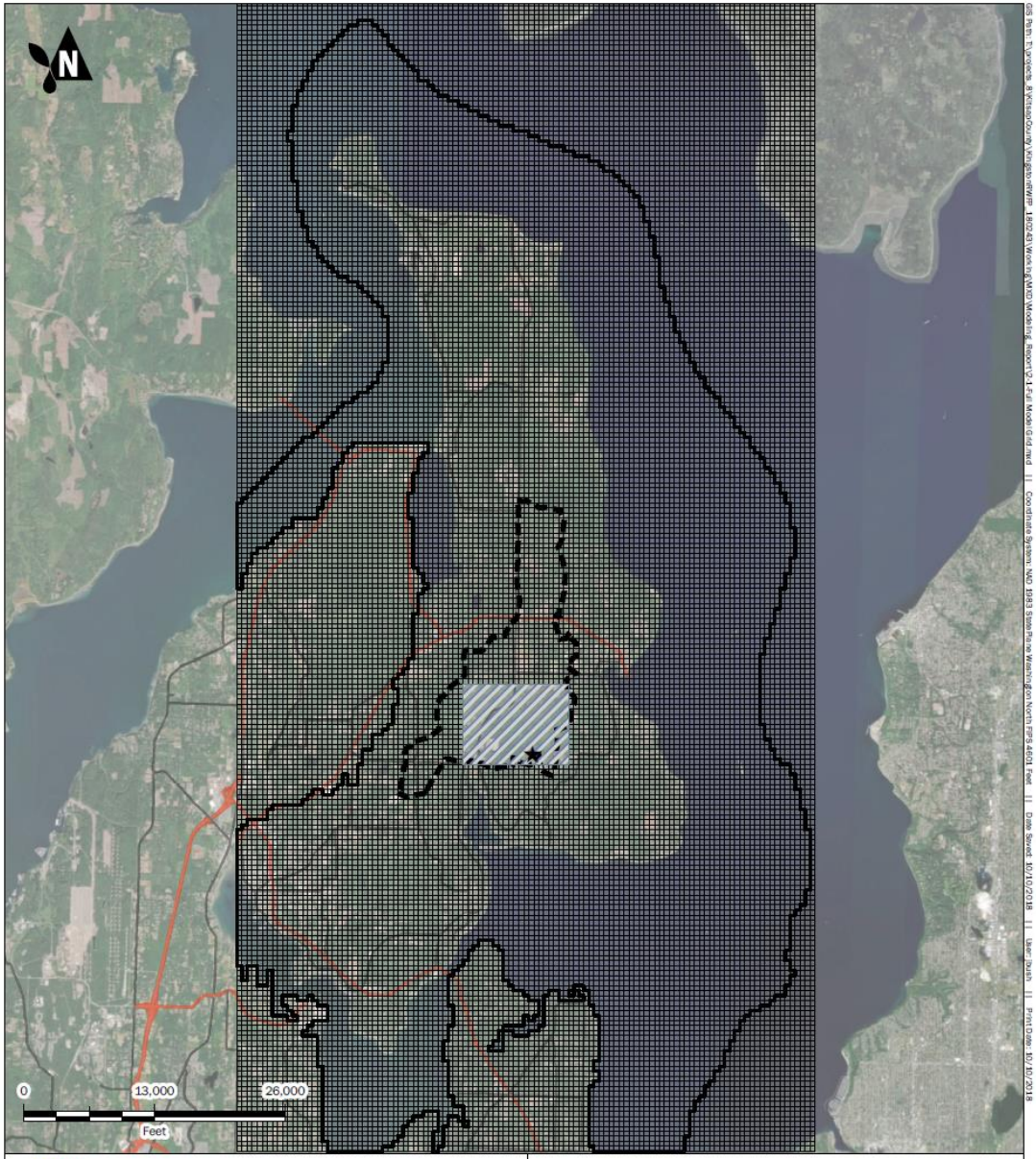
- Begin groundwater modeling early.
- Refine USGS regional model to project scale.
- Assess existing model errors, begin updates to aquifer layers and boundary conditions.
- Coordination of Access to NKHP, and Right of Way Permitting for fieldwork

Outcomes

- Preliminary model results used to inform fieldwork planning.
- Preliminary assessment of groundwater flow paths.
- Revise proposed fieldwork, no access to NKHP for motorized drilling/testing.

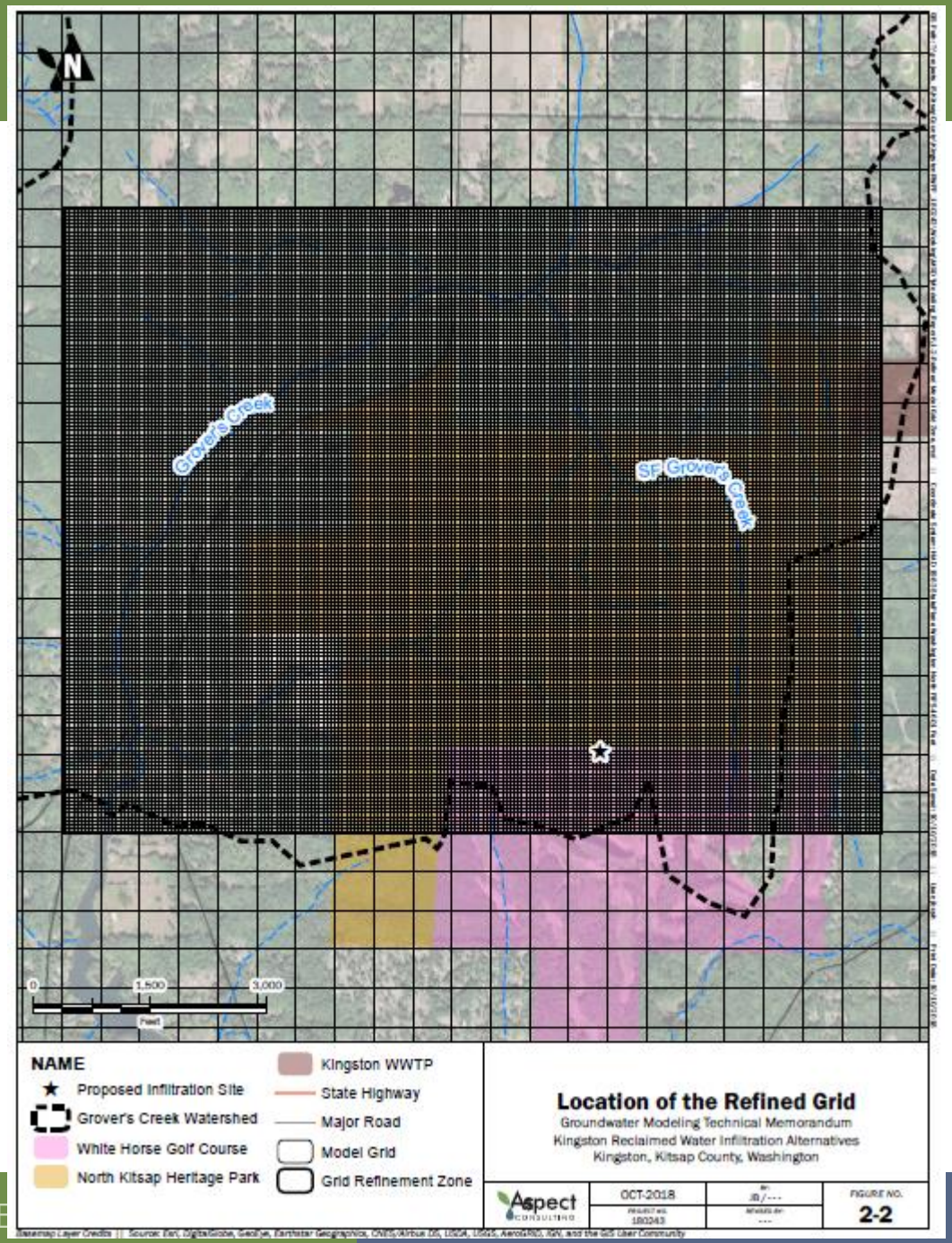
Infiltration Alternative

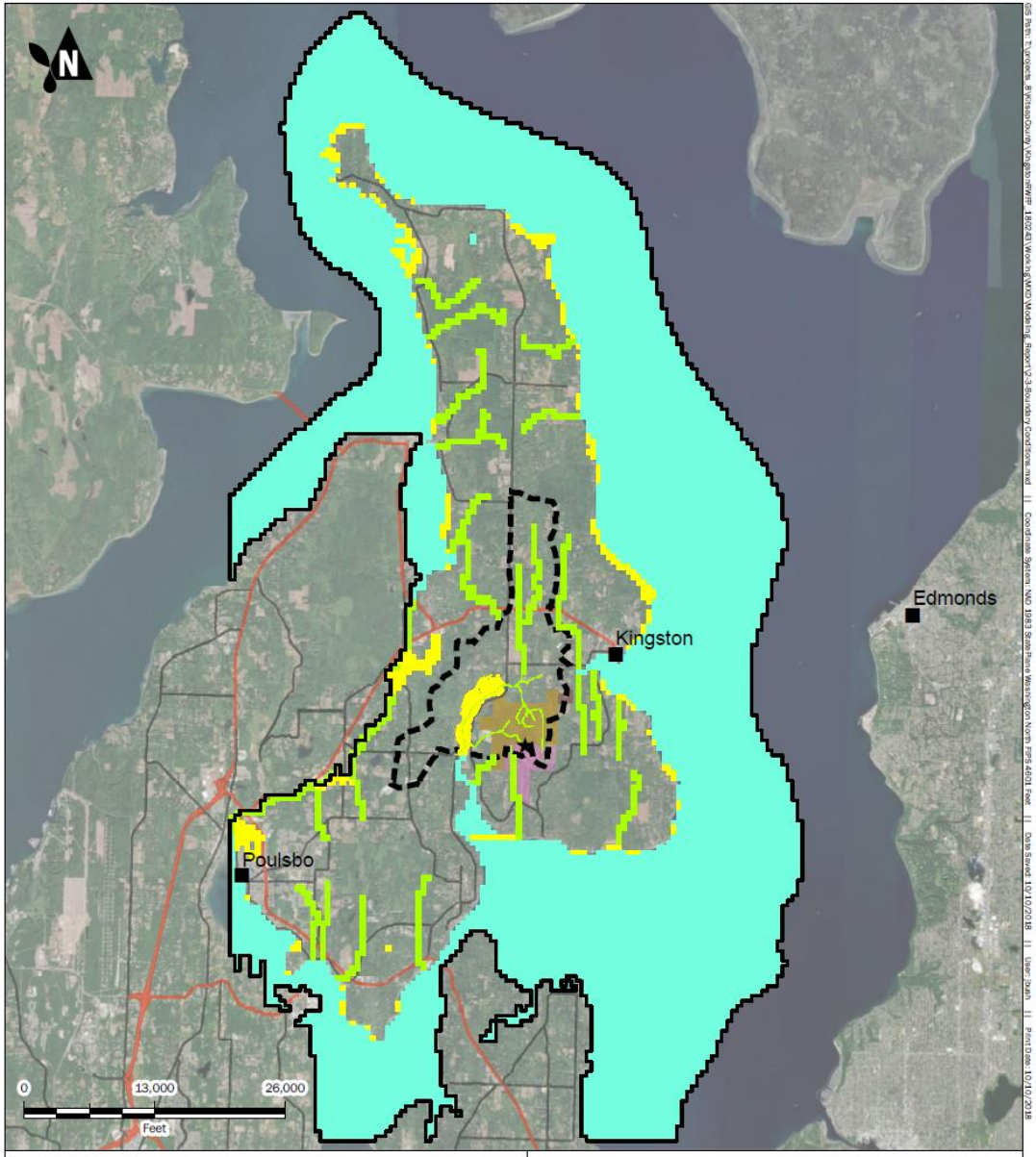
- **USGS model cropped to groundwater divide.**
- **USG grid nested within cropped regional model**



Infiltration Alternative

- **Updates to model properties within the USG grid only.**





NAME

- Proposed Infiltration Site
- Grover's Creek Watershed
- Active Model Area
- White Horse Golf Course
- North Kitsap Heritage Park
- State Highway
- Major Road

Boundary Conditions

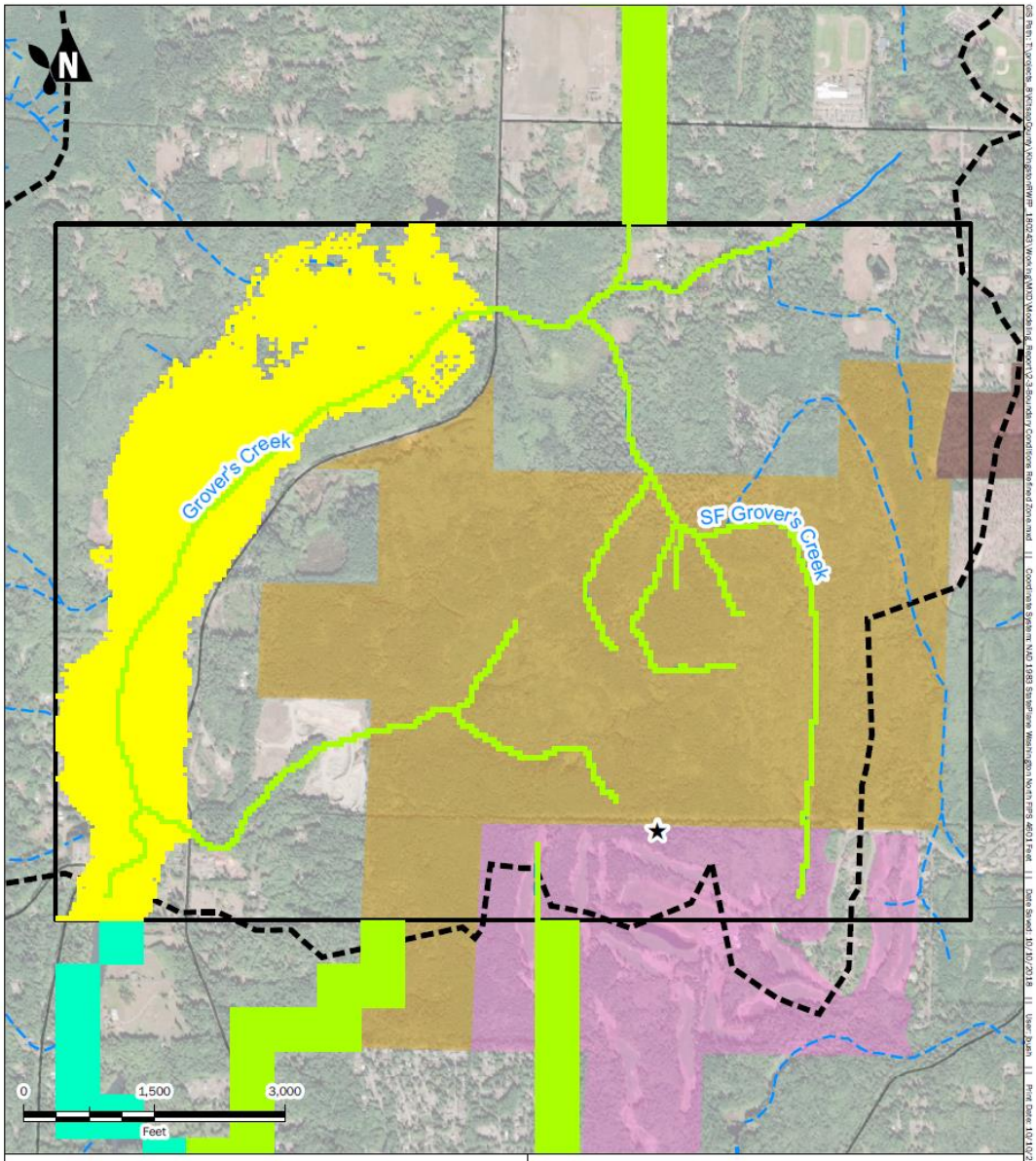
- Drain
- General Head
- Stream

Model Boundary Conditions

Groundwater Modeling Technical Memorandum
Kingston Reclaimed Water Infiltration Alternatives
Kingston, Kitsap County, Washington

Aspect Consulting	OCT-2018	BY: JB / ---	FIGURE NO. 2-3
	PROJECT NO. 180243	REVISED BY: ---	

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



NAME

- Proposed Infiltration Site
- Grover's Creek Watershed
- White Horse Golf Course
- North Kitsap Heritage Park
- Kingston WWTP
- State Highway
- Major Road
- Model Grid
- Grid Refinement Zone

Boundary Conditions in the Refined Zone

Groundwater Modeling Technical Memorandum
Kingston Reclaimed Water Infiltration Alternatives
Kingston, Kitsap County, Washington

Aspect Consulting	OCT-2018	BY: JB / ---	FIGURE NO. 2-4
	PROJECT NO. 180243	REVISED BY: ---	

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community