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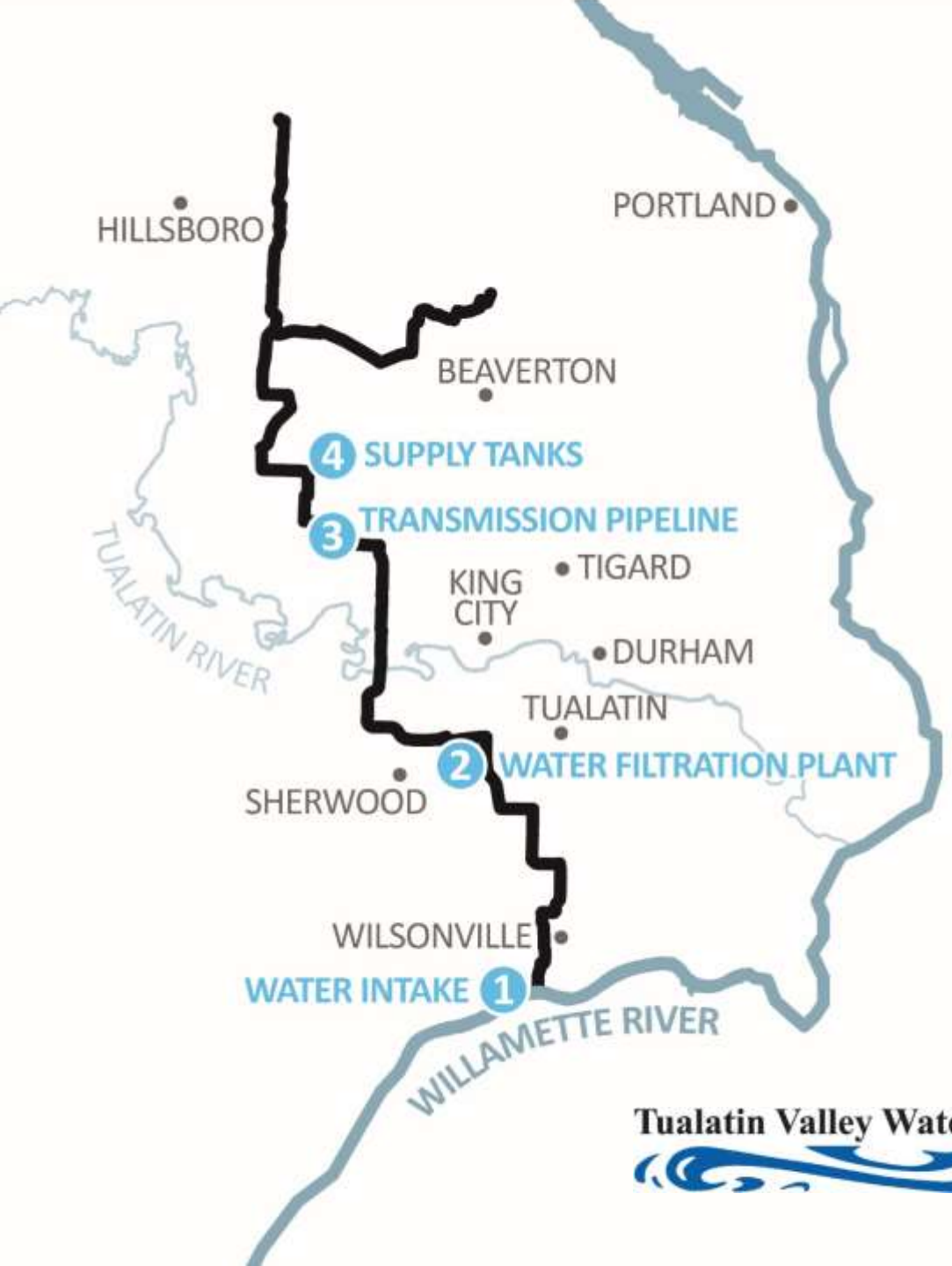
2018 TACOMA PNWS-AWWA

Optimizing WWSP's Trenchless Pipeline Crossing of the Tualatin River

April 27, 2018

Outline

- Introduction & Program Overview
- River crossing overview
- Geotechnical overview
- Tualatin River crossing details
- Tunnel method and shaft considerations
- Alternatives evaluations
- Conclusions



Water Supply Program

- Modified water intake
- New water filtration plant
- Water reservoirs
- 30+ miles of large diameter pipeline
- Tualatin Valley Water District: 60% City of Hillsboro: 40%
- Scheduled completion: 2026

Tualatin Valley Water District

Hillsboro OREGON

Project location

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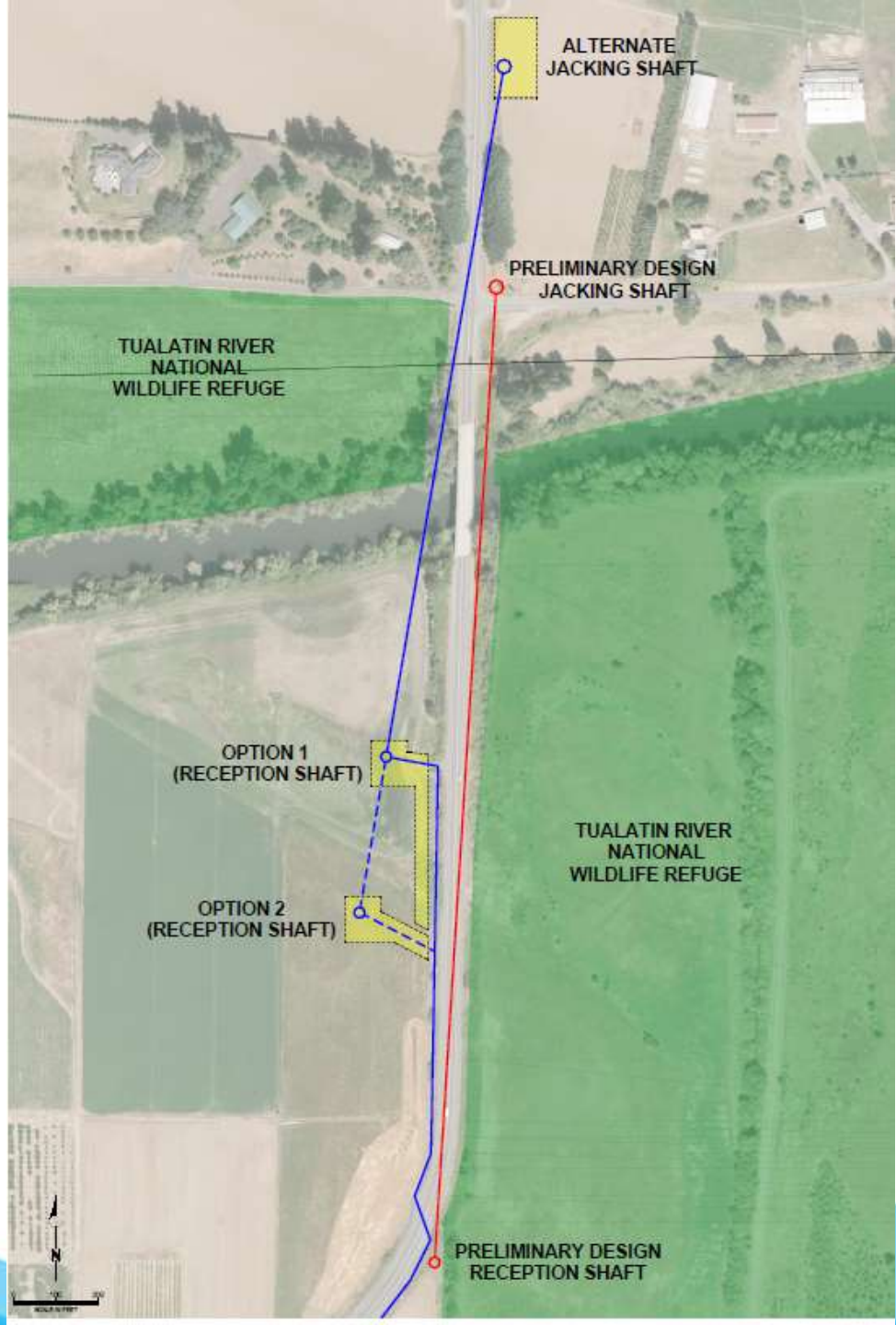
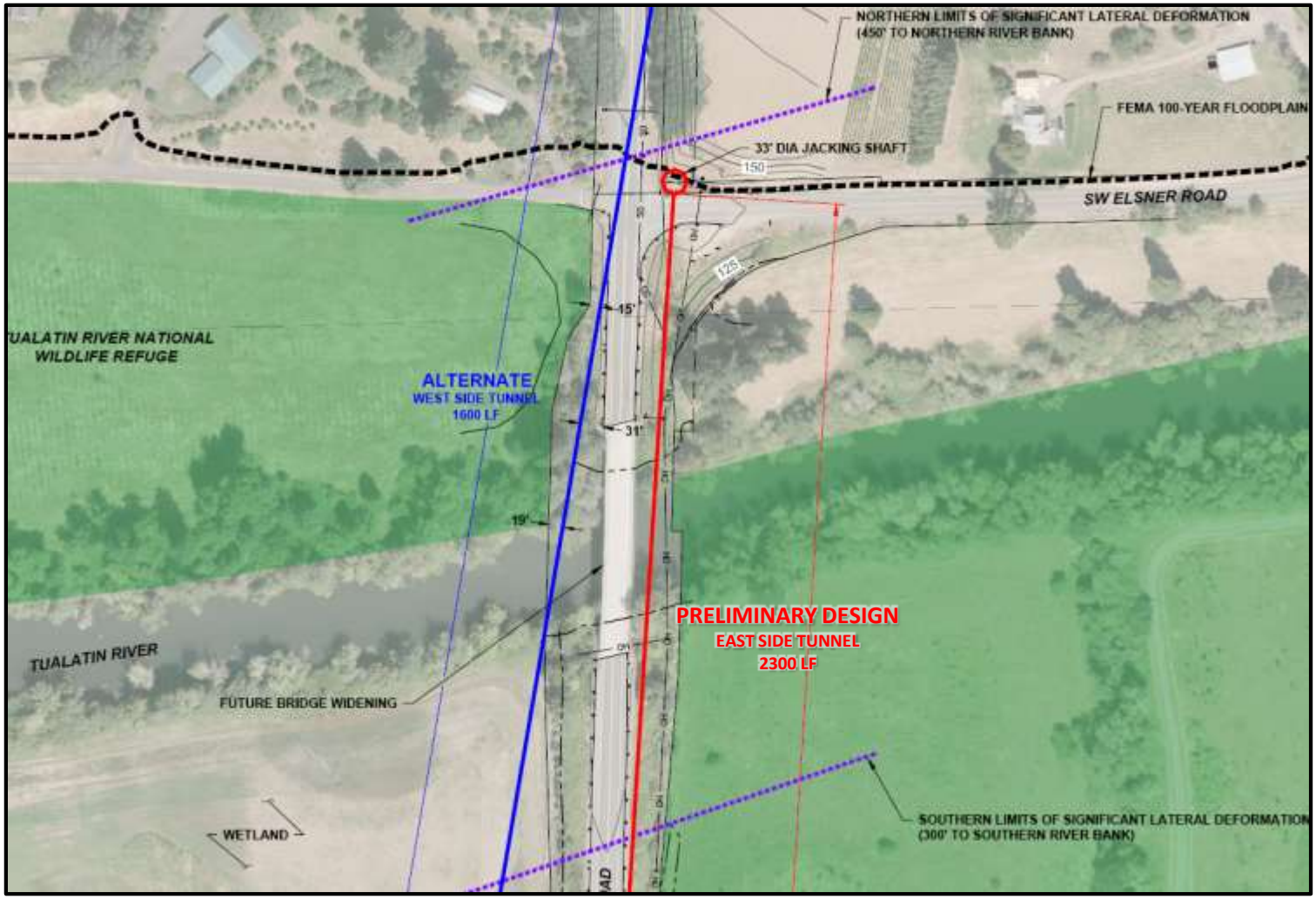
River crossing overview

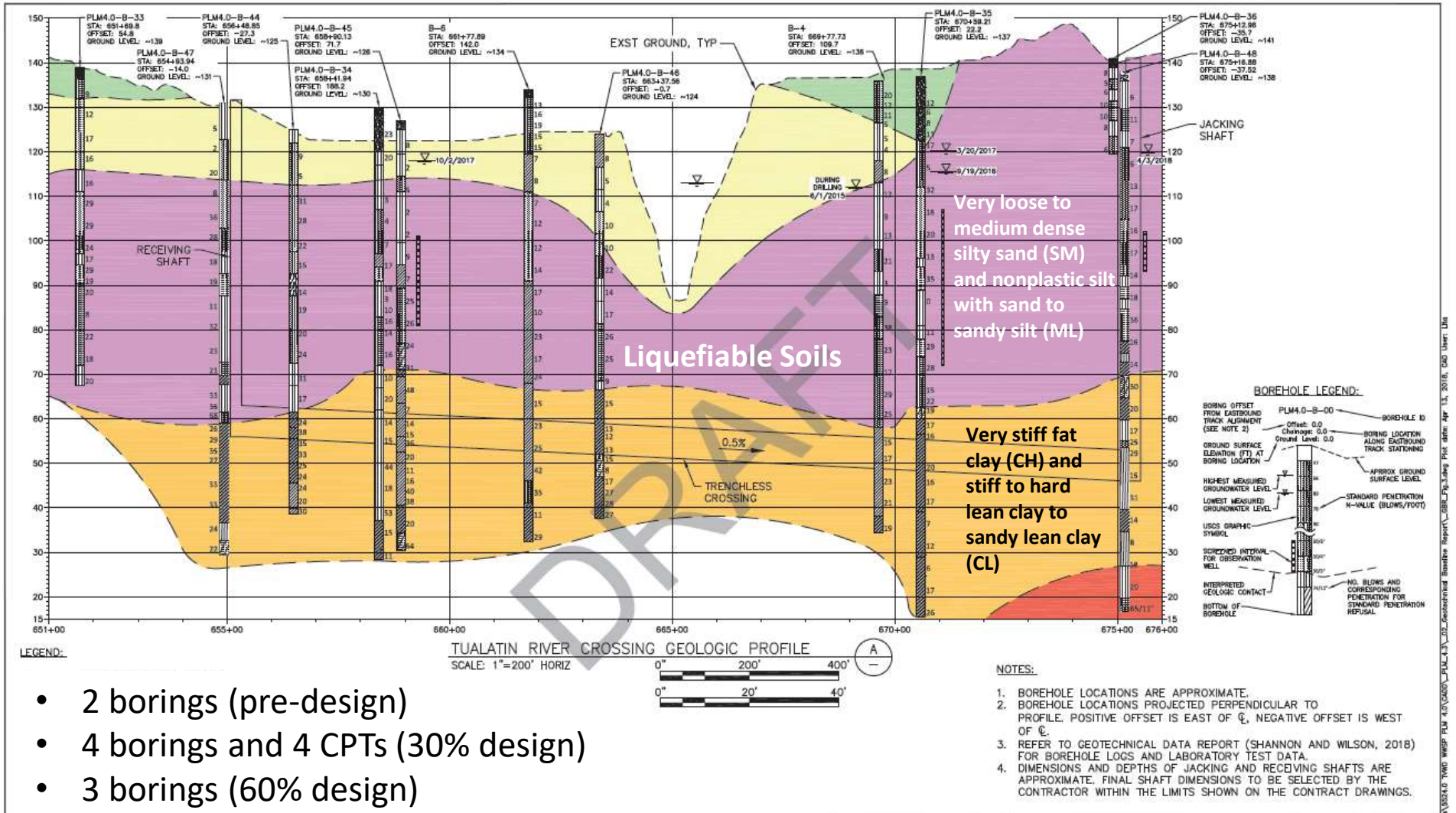
Table 1. Tualatin River Crossing "Quick Facts"		
	East-side (red)	Alternate (blue)
Length	2,300 LF	1,600 LF (+350 LF for southern shaft)
Tunneling Method	Microtunnel	Microtunnel
Construction Duration	10.5-12 months	8-10 months (9.5-11 months)
Permitting	Adjacent to TRNWR	Wetlands Private property Less adjacent to TRNWR
Resiliency	Northern shaft located within zone of significant lateral deformation	High confidence
Risks	Higher risk (longer tunnel)	Lower risk (shorter tunnel)



Crossing constraints

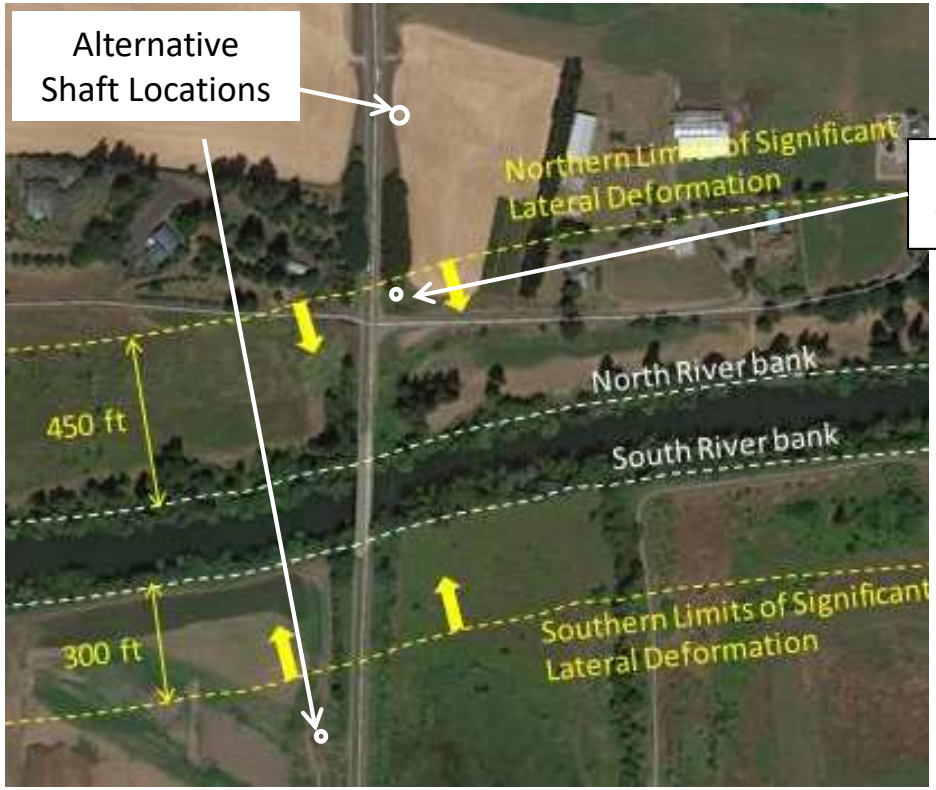


Geologic profile

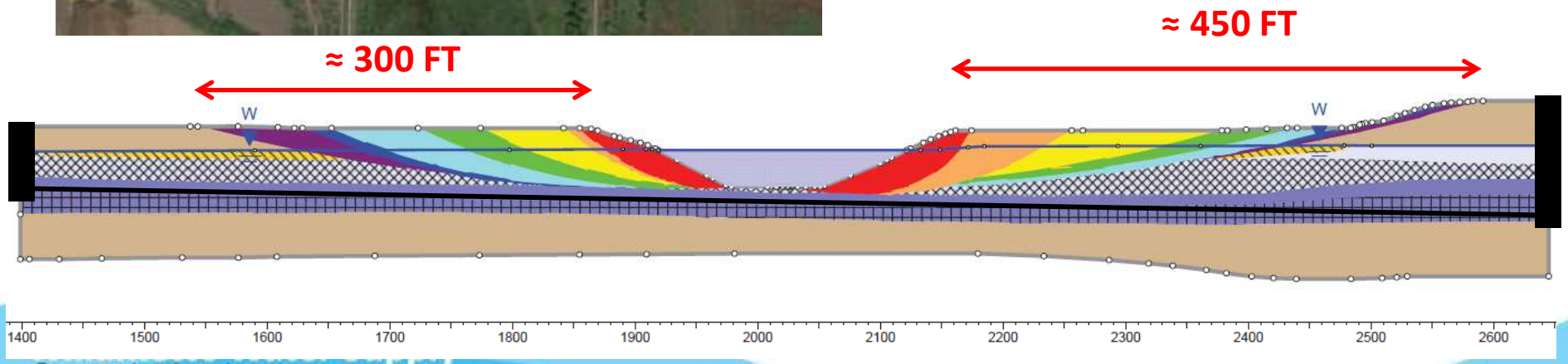


- 2 borings (pre-design)
- 4 borings and 4 CPTs (30% design)
- 3 borings (60% design)
- 1 boring (90% design)

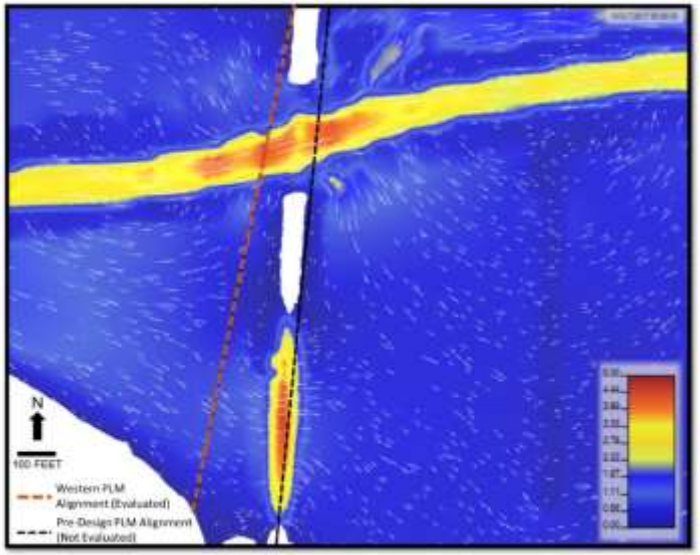
Seismic resiliency

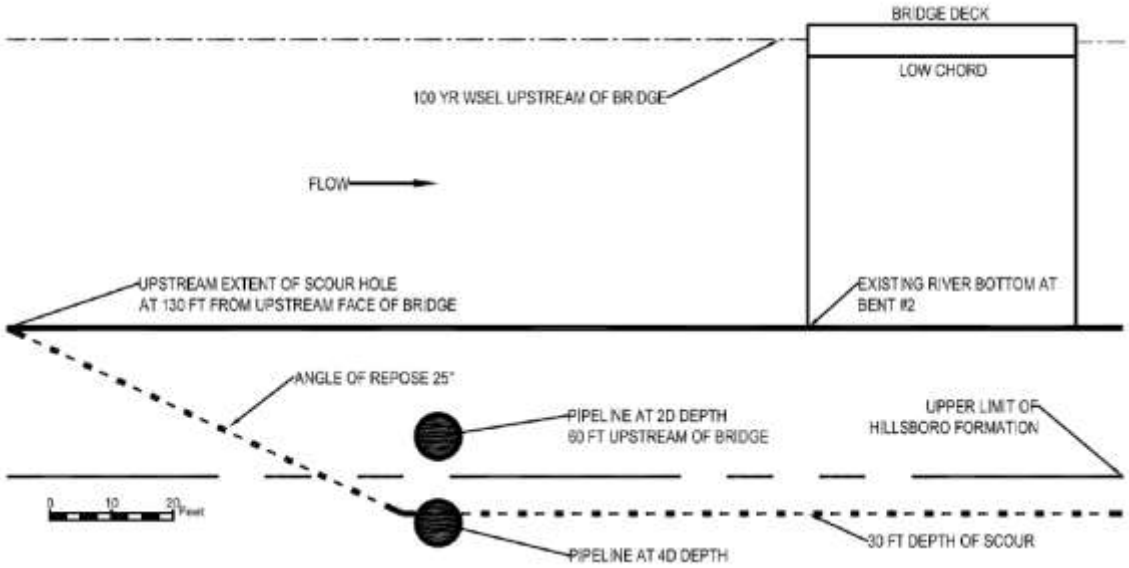


Material Name	Color	Range of Lateral Spread Displacements (inches)
Flow Failure		/
ky=0.02g		> 60
ky=0.03g		24 to 60
ky=0.04g		12 to 24
ky=0.05g		6 to 12
ky=0.06g		3 to 6
ky=0.07g		1 to 3



Scour analysis

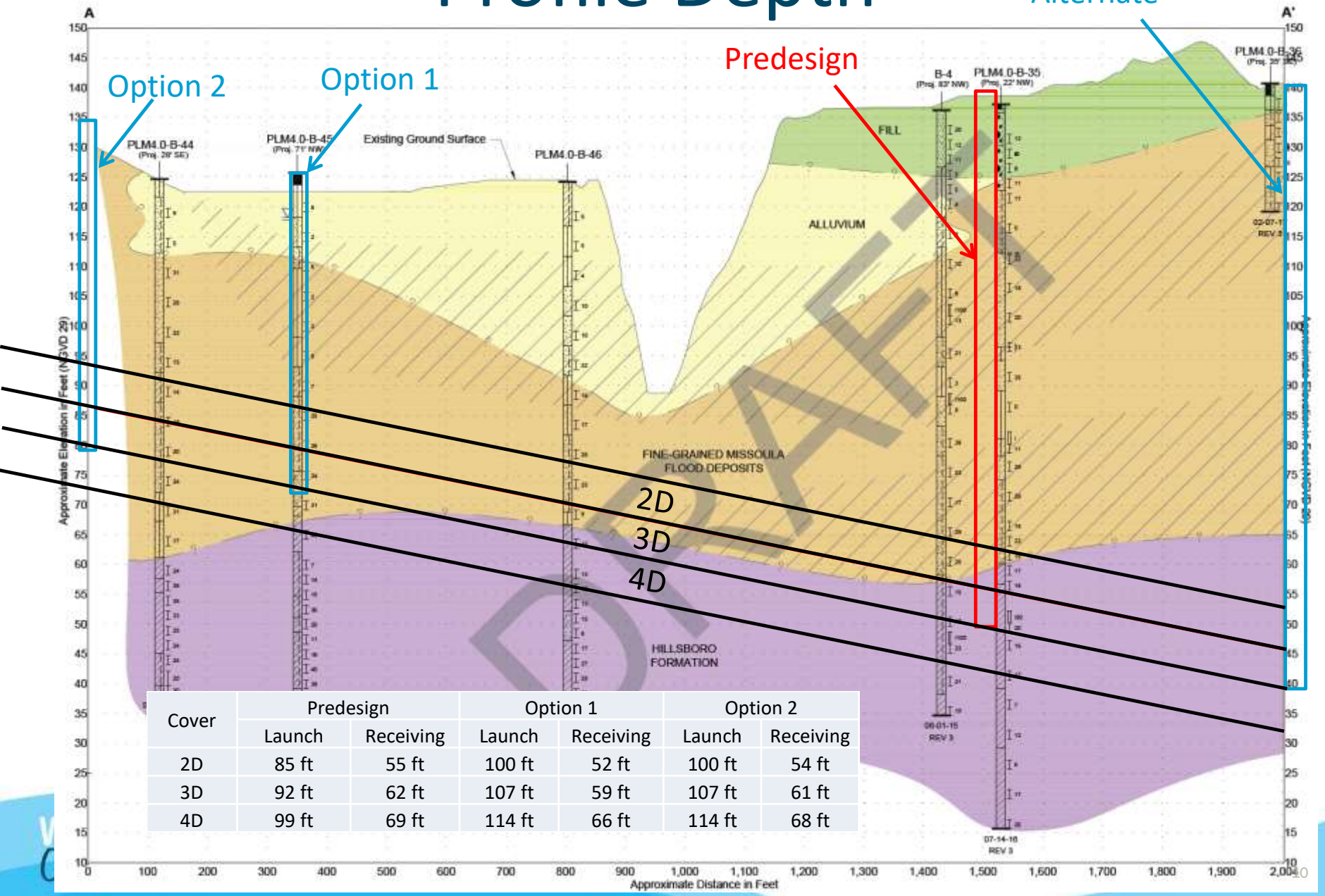




Scour Assessment of the Proposed WWSP Pipeline Main Crossing (TVWD WWSP PLM 4.0) of Tualatin River, near Sherwood, Oregon. Cardno, March 23, 2018

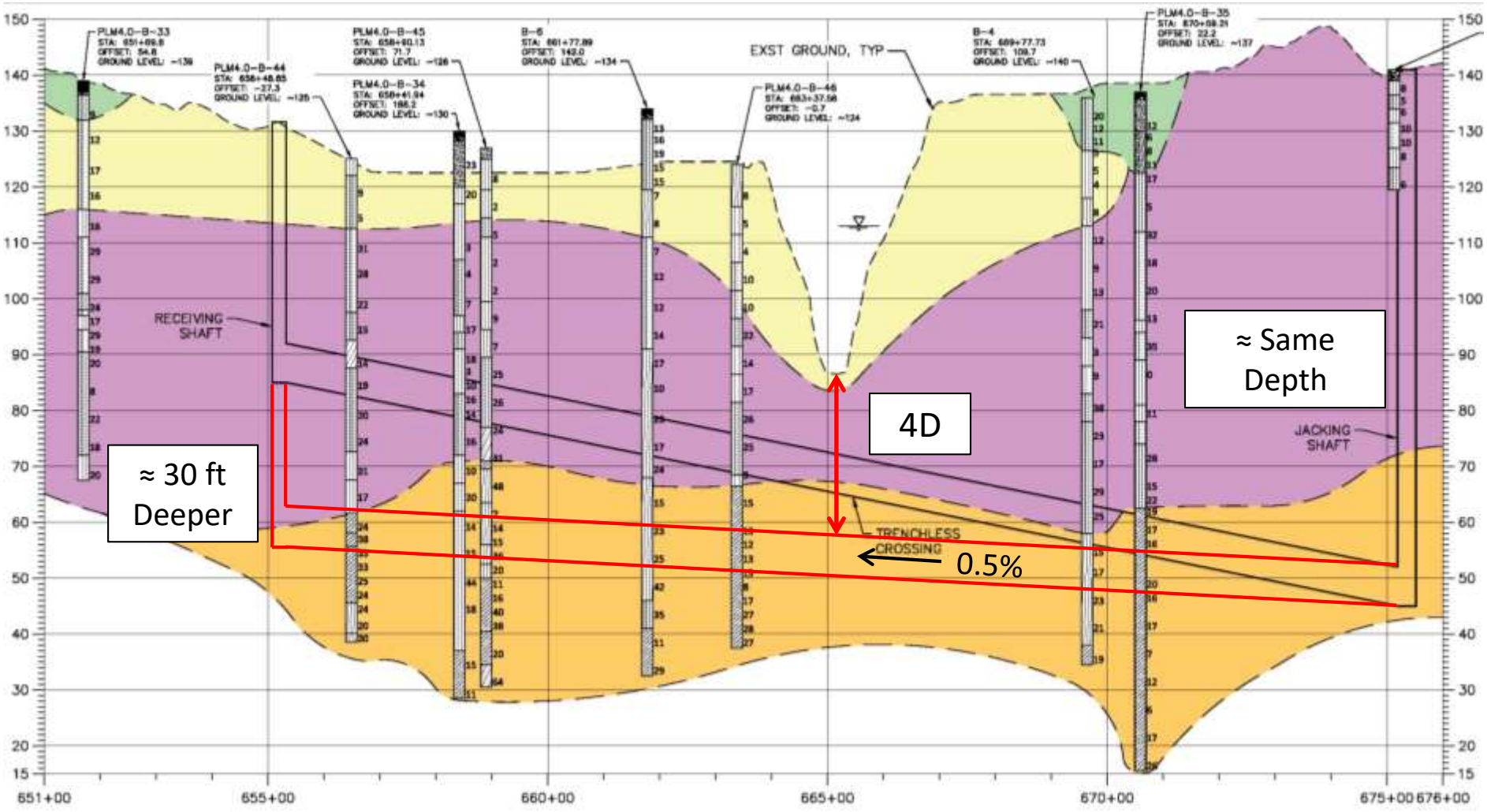
- 28 feet (4 times pipe diameter)
- Place pipe in the Hillsboro Formation
  - lower erodibility than the overlying Missoula Flood deposits

Profile Depth



Cover	Predesign		Option 1		Option 2	
	Launch	Receiving	Launch	Receiving	Launch	Receiving
2D	85 ft	55 ft	100 ft	52 ft	100 ft	54 ft
3D	92 ft	62 ft	107 ft	59 ft	107 ft	61 ft
4D	99 ft	69 ft	114 ft	66 ft	114 ft	68 ft

Selected profile

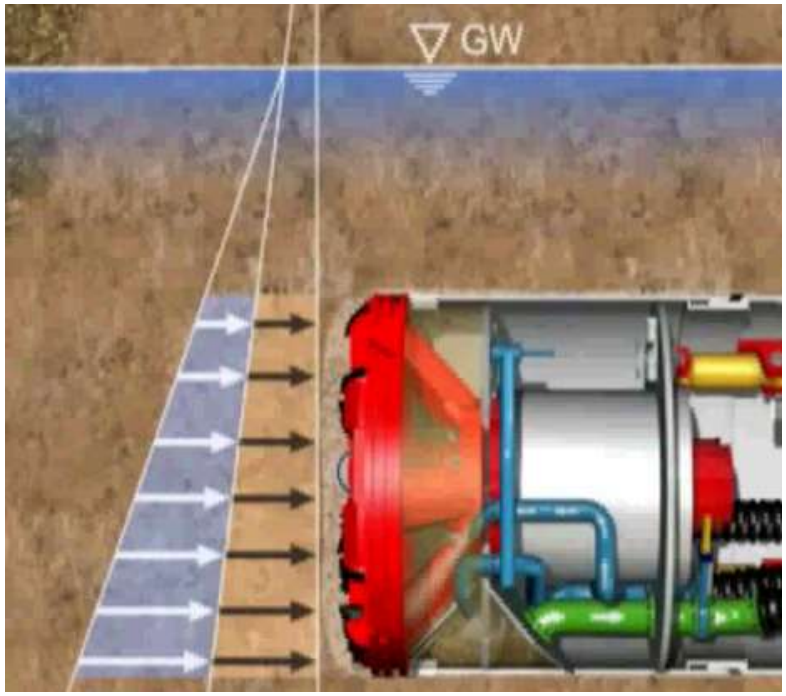


Ground behavior

- **Firm** – Advance heading several feet without support. Includes hard clays and cemented sands and gravel.
- **Raveling** – Following excavation material tends to flake off or ravel. Includes slightly cohesive sands, silts and fine gravels.
- **Running** – Cohesionless, dry soils run from unsupported face to AOR. Includes clean loose sands and gravels.
- **Flowing** – Seepage at the face in raveling or running ground can create flowing conditions. Includes silt, sand or gravel below the water table.
- **Squeezing** – Soils advance into the tunnel in plastic flow. Function of soil strength vs. overburden. Soft to stiff clays.
- **Swelling** – Where ground absorbs water and swells into opening. Includes highly over-consolidated clays.

Tunnel construction method

- Microtunneling methods
  - Regionally proven
  - Most ground types
  - Below water table
  - Continuous face support
  - Steerable
  - Remotely operated
  - Long distances

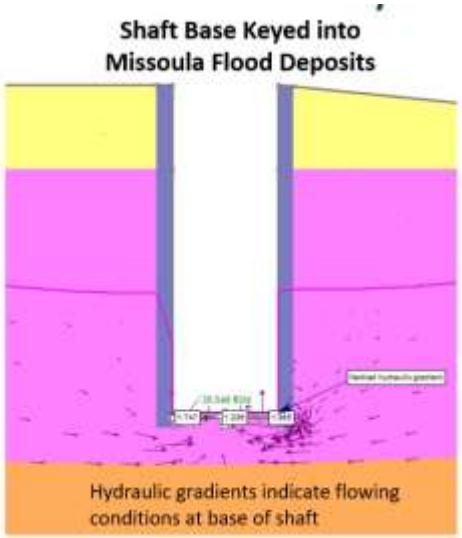


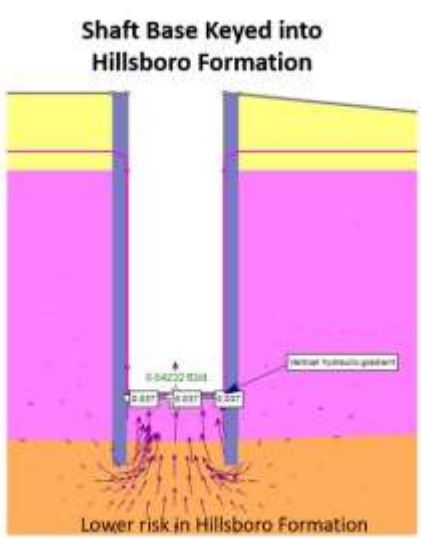
Project	Pipe Size	Drive Lengths (feet)	Project Highlights
Portsmouth Force Main	81-inch ID Steel	1,900	Record for the longest U.S. drive using a jacked steel casing
Balch Consolidation Conduit	84-inch ID RCP	1595, 1,670	Longest microtunneling drive in gravel. ACEC Grand Project Award 2011
ESCSO	84-inch ID RCP	3,055	Longest microtunneling drive in North America
Tanner Creek	72-inch ID RCP	1,000	First use of slurry microtunneling in Portland

Microtunneling systems

1. Microtunneling machine
2. Propulsion system
3. Spoil removal system
4. Guidance and control system
5. Pipe lubrication system

Shaft stability



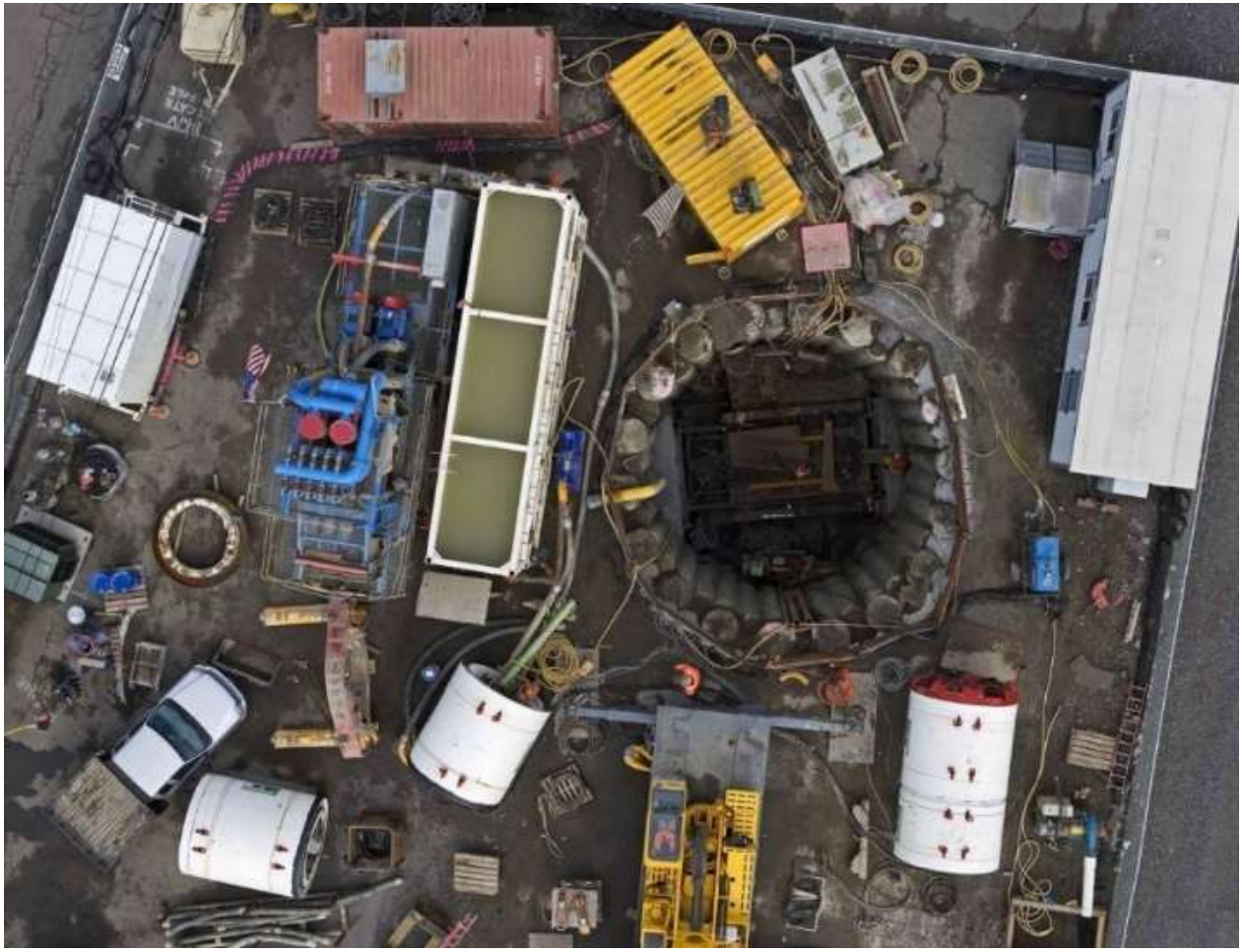


Shaft design considerations

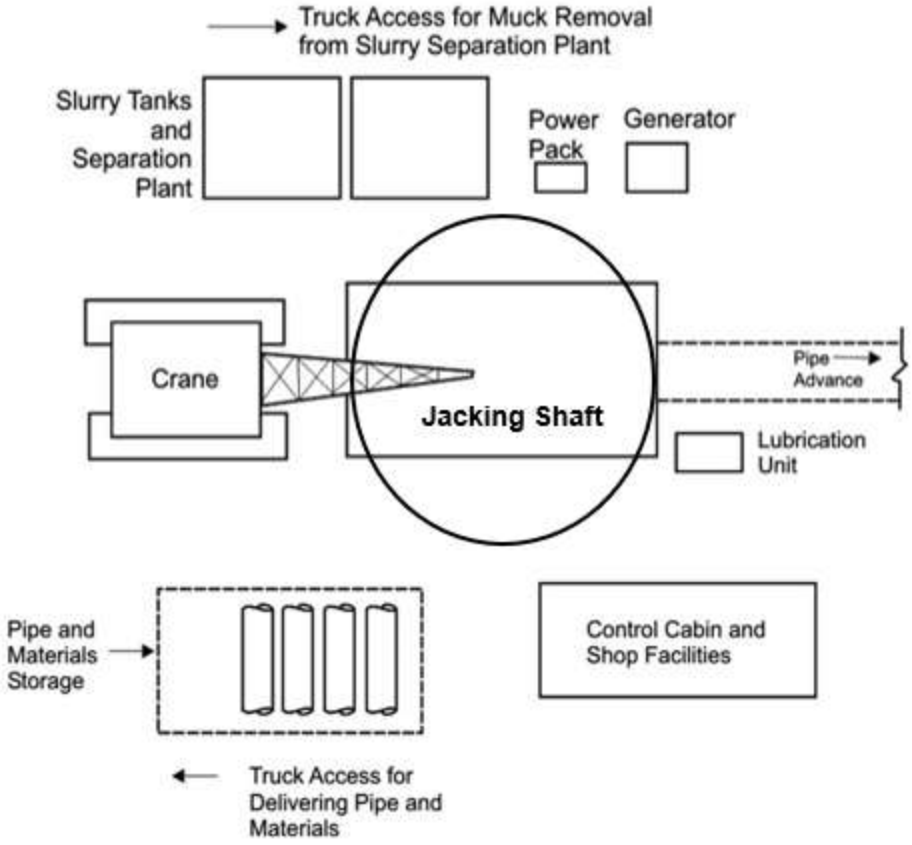
Water tight

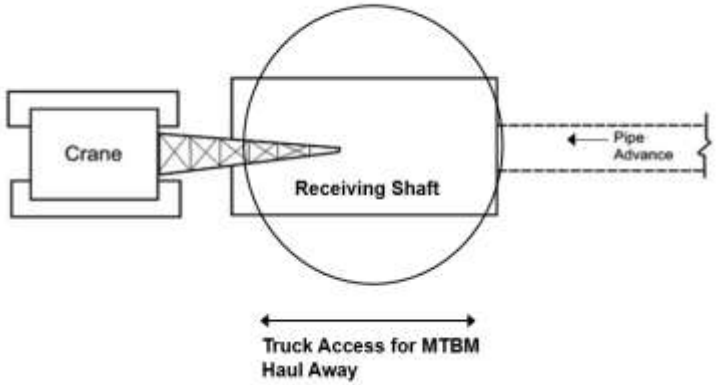
Shaft site staging

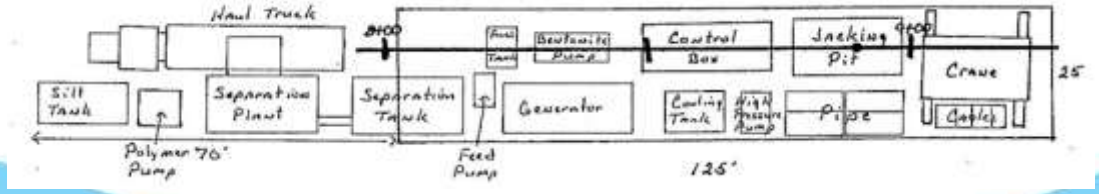
- Slurry tanks and separation plant
- Crane
- Control cabin
- Generator
- Power pack
- Pipe storage
- Truck access



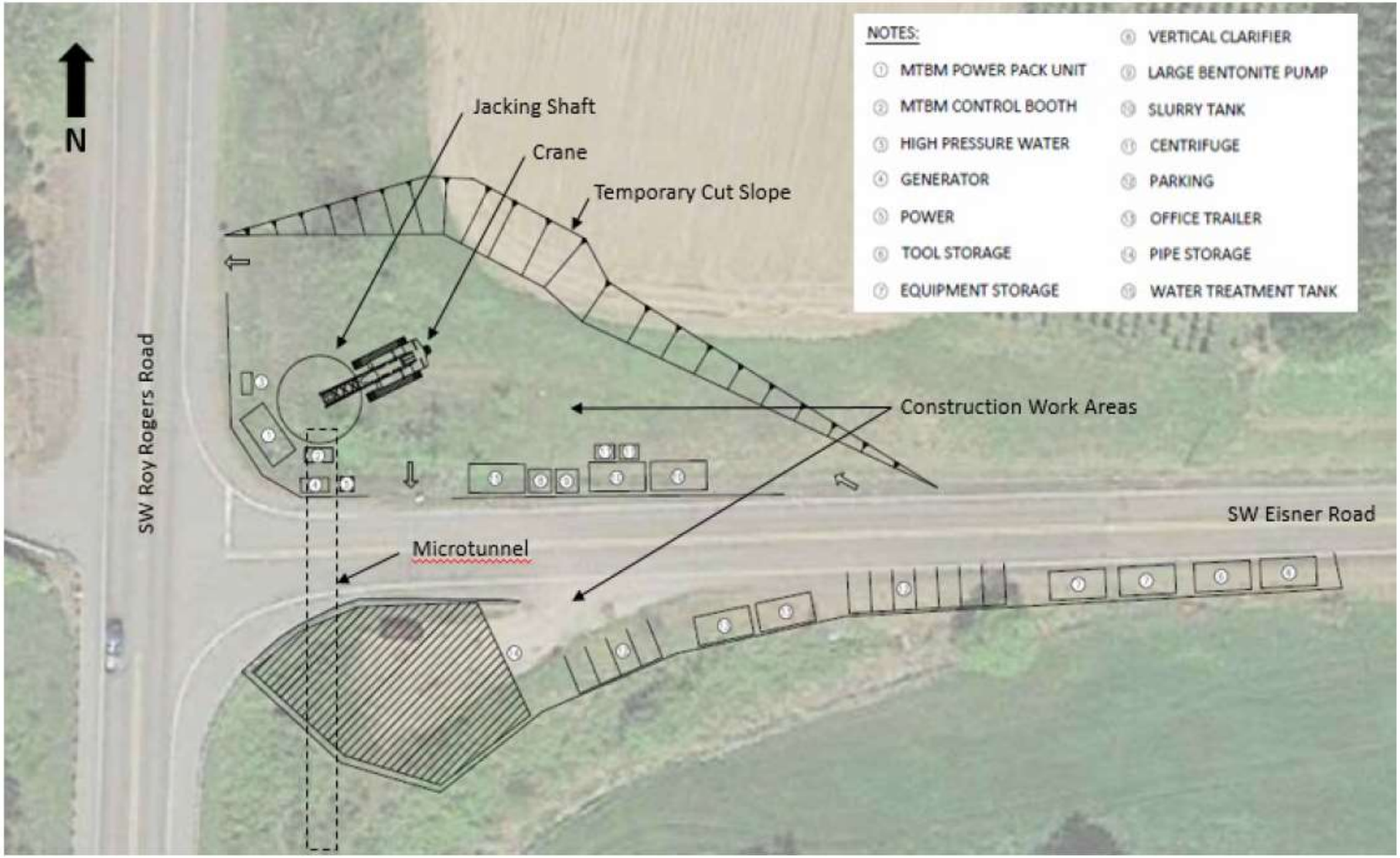
General shaft site layout



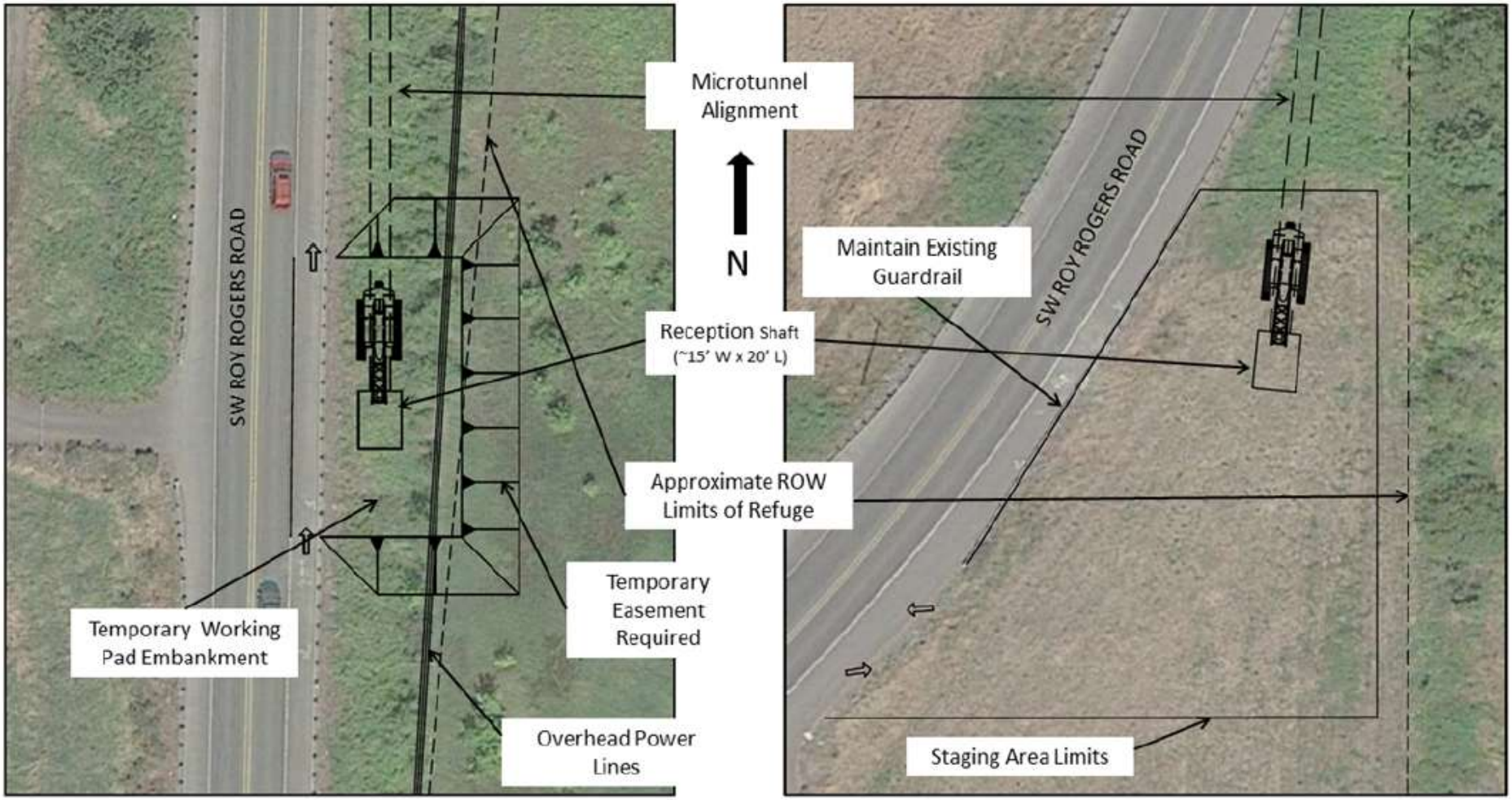




East-side jacking shaft



East-side receiving shaft



Possible intermediate receiving shaft adjacent to Refuge

Full-drive receiving shaft adjacent to Refuge (2,300 LF)

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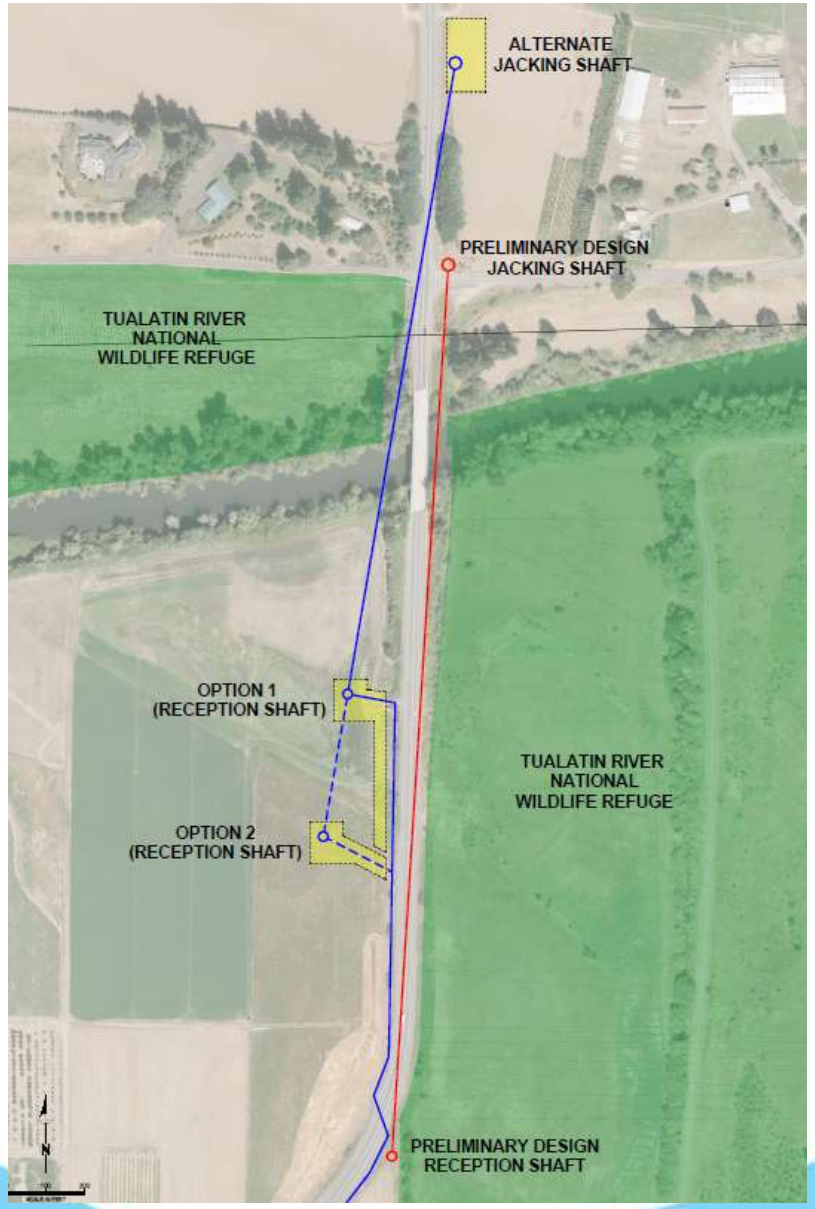
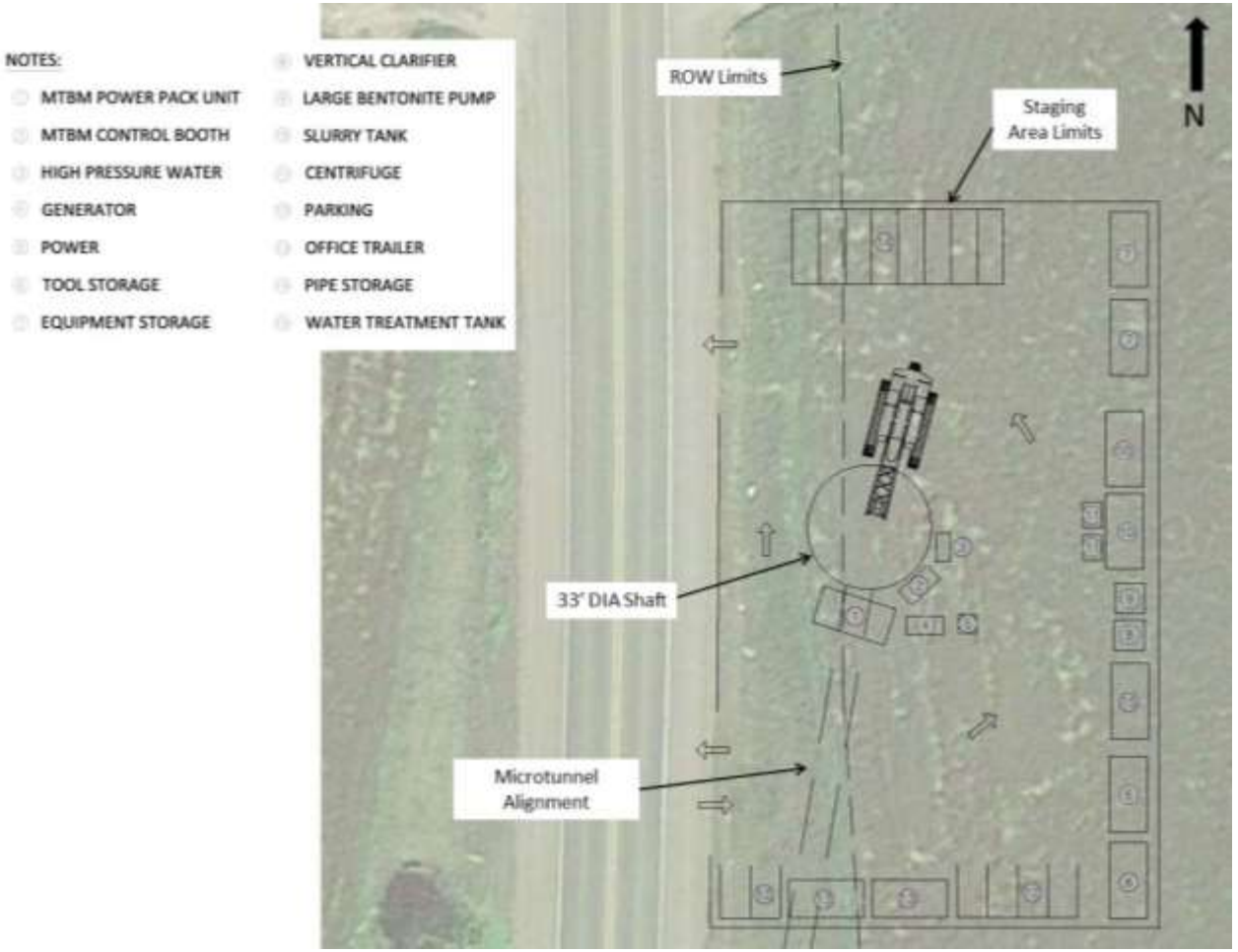
Alternate alignment (west side)

- Shafts located outside of limits of lateral spread
- Shorter drive length
- No staging or construction within refuge
- Avoids power lines
- Reduces traffic impacts



Alternate (west side) – jacking shaft



Evaluation criteria

- Social/community impacts
- Opportunities/benefits
- Environmental/permitting/land use
- System compatibility
- System resiliency
- Constructability
- O&M
- Cost

Real estate

East-side:

- Highest risk
- Microtunnel rescue shaft could require a temporary easement from the Tualatin River Wildlife Refuge (2-6 month process)

Alternate (west side):

- **Preferred alignment** (from real estate perspective)
- Least impact to future development (Option 1)
- Easement acquisition within the floodplain (Option 1)
- Impact to farmable land (Option 1 and 2)
- Easement acquisition outside of the floodplain (Option 2)

Environmental understanding

Table 2. Environmental Alignment Comparison		
Criteria	East-side	Alternate (west side)
Natural Resources	No important natural resources Rescue (if needed) within the Refuge	100-year floodplain (Option 1) Farmable Wetland (Option 1)
Cultural Resources	High sensitivity for resources; additional archaeological work required	Moderate level; additional archaeological work required
Land Use	Outside floodplain No SNRA issues EFU requires Type II, but County recommends Type III due to complexity	SNRA south of TR will require land use review EFU requires Type II, but County recommends Type III due to complexity
Hazardous Materials	No known issues	No known issues

EFU: Exclusive Farm Use
SNRA: Significant Natural Resource Area
TR: Tualatin River

Cost comparison

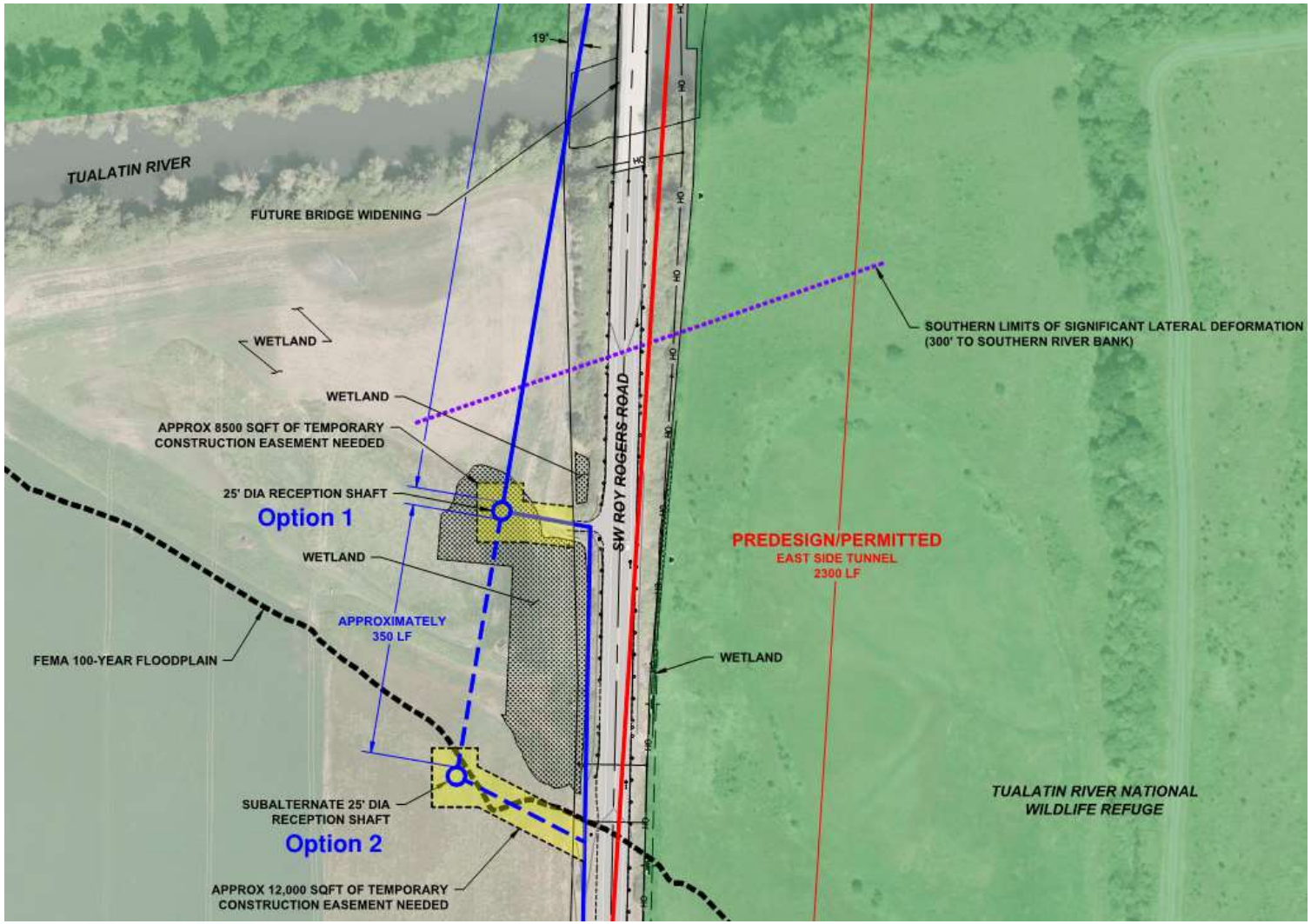
Table 3. Tualatin River Crossing Cost Evaluation		
Cost Item	East-side	Alternate (west side)
Microtunnel	$ 6.9 M	$ 4.8 - $ 5.9 M
Shafts	$ 2.6 M	$ 2.3 - $ 2.4 M
Open-cut*	$ 0.6 M	$ 1.6 – 1.1 M
TOTAL	**$ 10.1 M**	**$ 8.7 - $ 9.4 M**

*open-cut pricing included for all options in order to compare equivalent lengths

Alternative evaluation – east vs. west

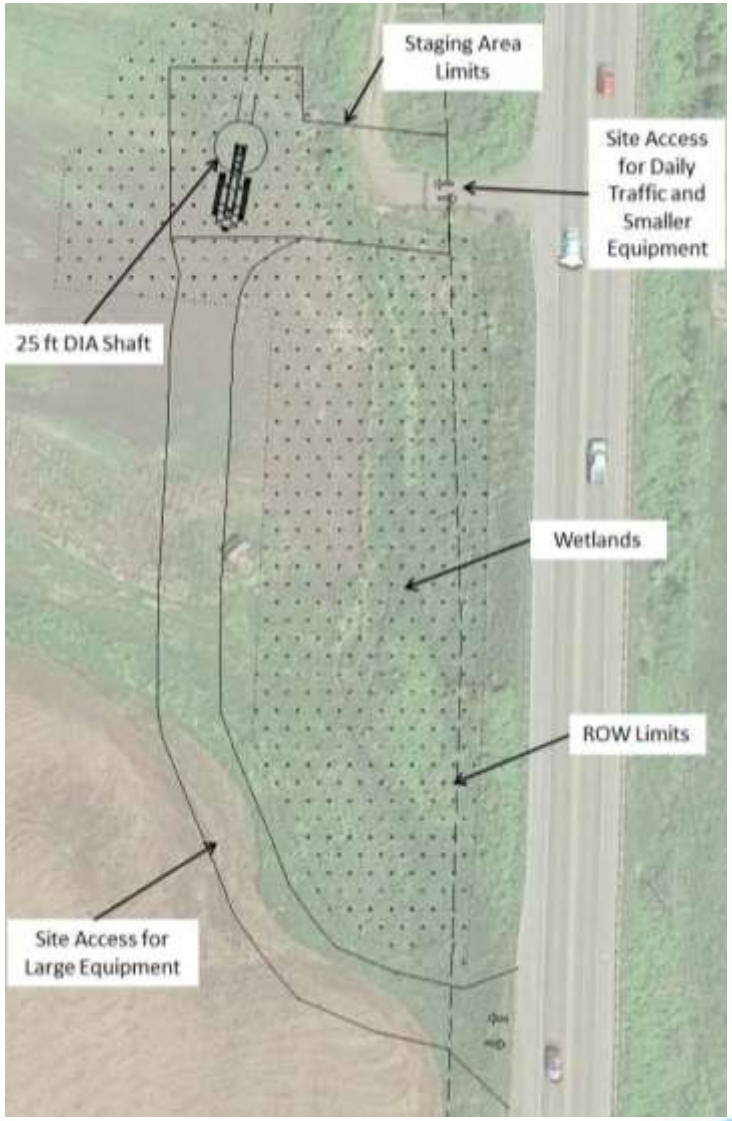
Table 4. Tualatin River Crossing Alternatives Evaluation				
Criteria	East-side (red)		Alternate (blue)	
Environmental / permitting	0	Adjacent to TRNWR Private property	–	Wetland Private property Much shorter length adjacent to TRNWR with lower risk
System resiliency	–	Northern shaft located within zone of significant lateral deformation	0	High confidence
Constructability	–	High risk (longer tunnel)	0	Moderate risk (shorter tunnel)
O&M	–	Jacking shaft within lateral deformation zone (access)	0	Shafts outside of lateral deformation zone (access)
Cost	N/A	$10.1 M	N/A	$8.7 M (Option 1) $9.4 M (Option 2)

Alternate (west side) – Option 1 vs. 2



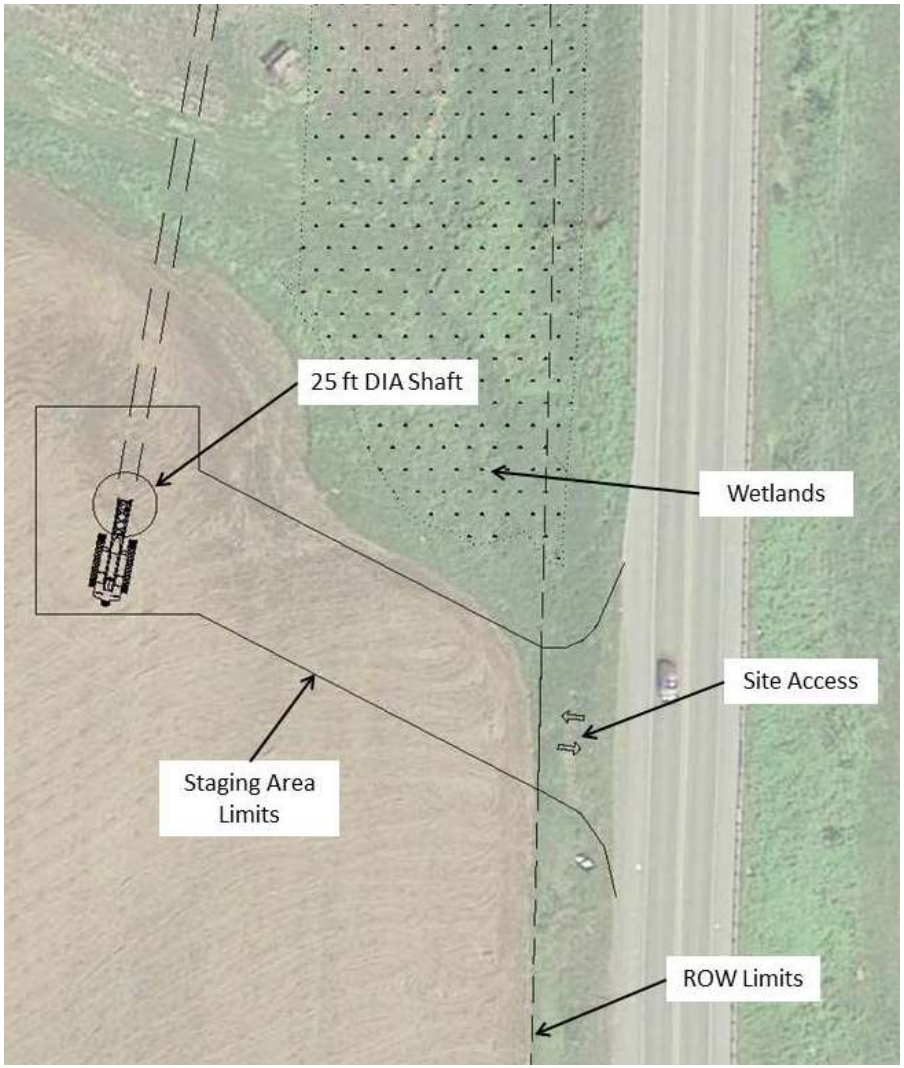
Receiving shaft (Option 1)

- Staging area and access located within wetlands
- Additional access required for large equipment due to steep slope of existing access
- Shaft within 100 year flood plain



Receiving shaft (Option 2)

- Avoids wetlands
- Shaft outside of 100 year flood plain
- Increased tunnel length



Real estate

Option 1:

- Preferred alignment (from real estate perspective)
- Least impact to future development
- Easement acquisition within the floodplain
- Impact to farmable land

Option 2:

- Easement acquisition outside the floodplain
- Greater impact to farmable land than Option 1
- Larger easement footprint likely required

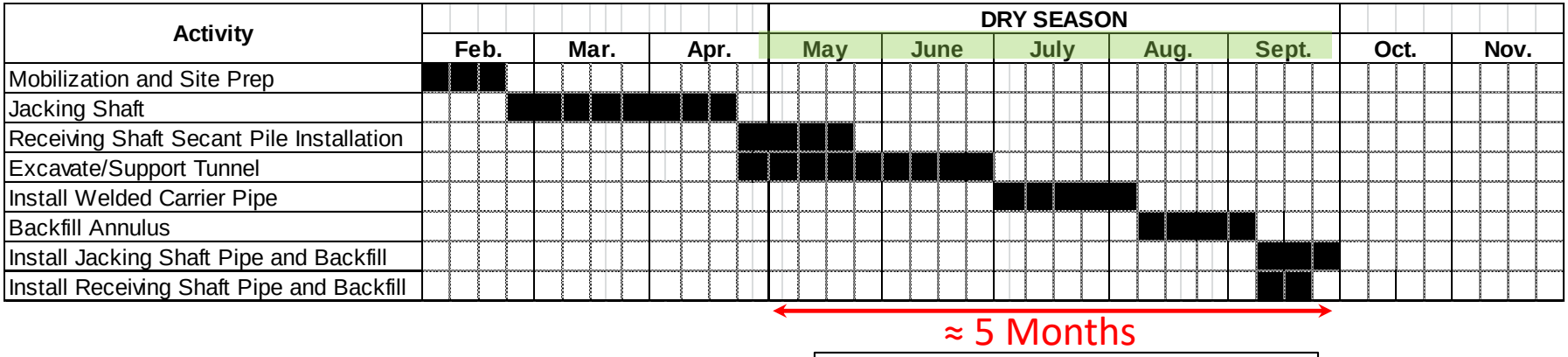
Environmental understanding

Table 6. Environmental Alignment Comparison		
Criteria	Alternate (Option 1)	Alternate (Option 2)
Natural Resources	Farmed wetland at reception shaft Within the 100-year floodplain Requires revisions to Enviro Permits	No important natural resources Outside 100-year floodplain
Cultural Resources	Moderate risk; additional archaeological work required	Moderate risk; additional archaeological work required
Land Use	SNRA south of TR will require land use review Floodplain construction requires permitting EFU requires Type II, but County recommends Type III due to complexity	SNRA south of TR will require land use review EFU requires Type II, but County recommends Type III due to complexity
Hazardous Materials	No known issues	No known issues

EFU: Exclusive Farm Use
SNRA: Significant Natural Resource Area
TR: Tualatin River

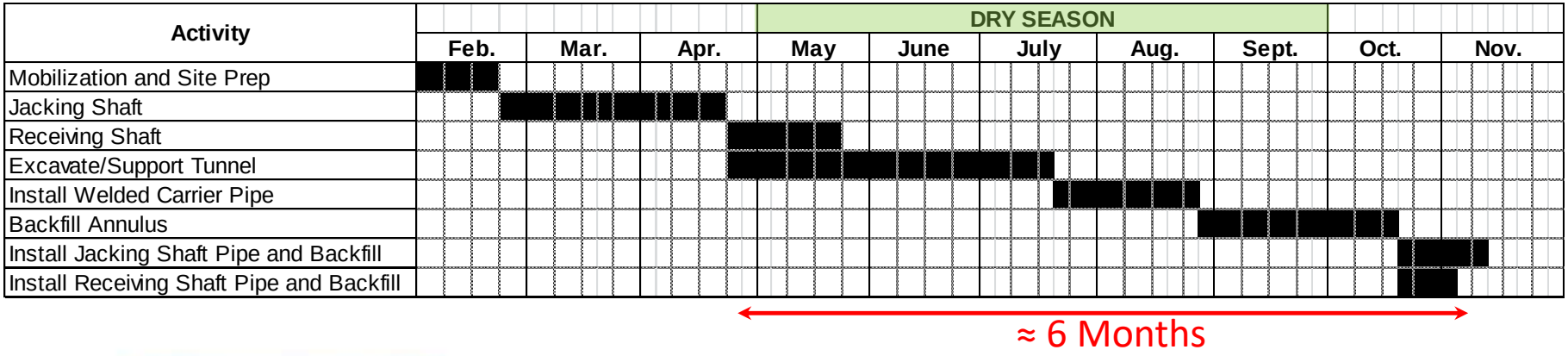
Schedule Comparison

Option 1



Receiving shaft work can be completed in the dry season

Option 2



Receiving shaft work cannot be completed in the dry season, however no real risk of flooding as tunnel would be complete

Cost comparison

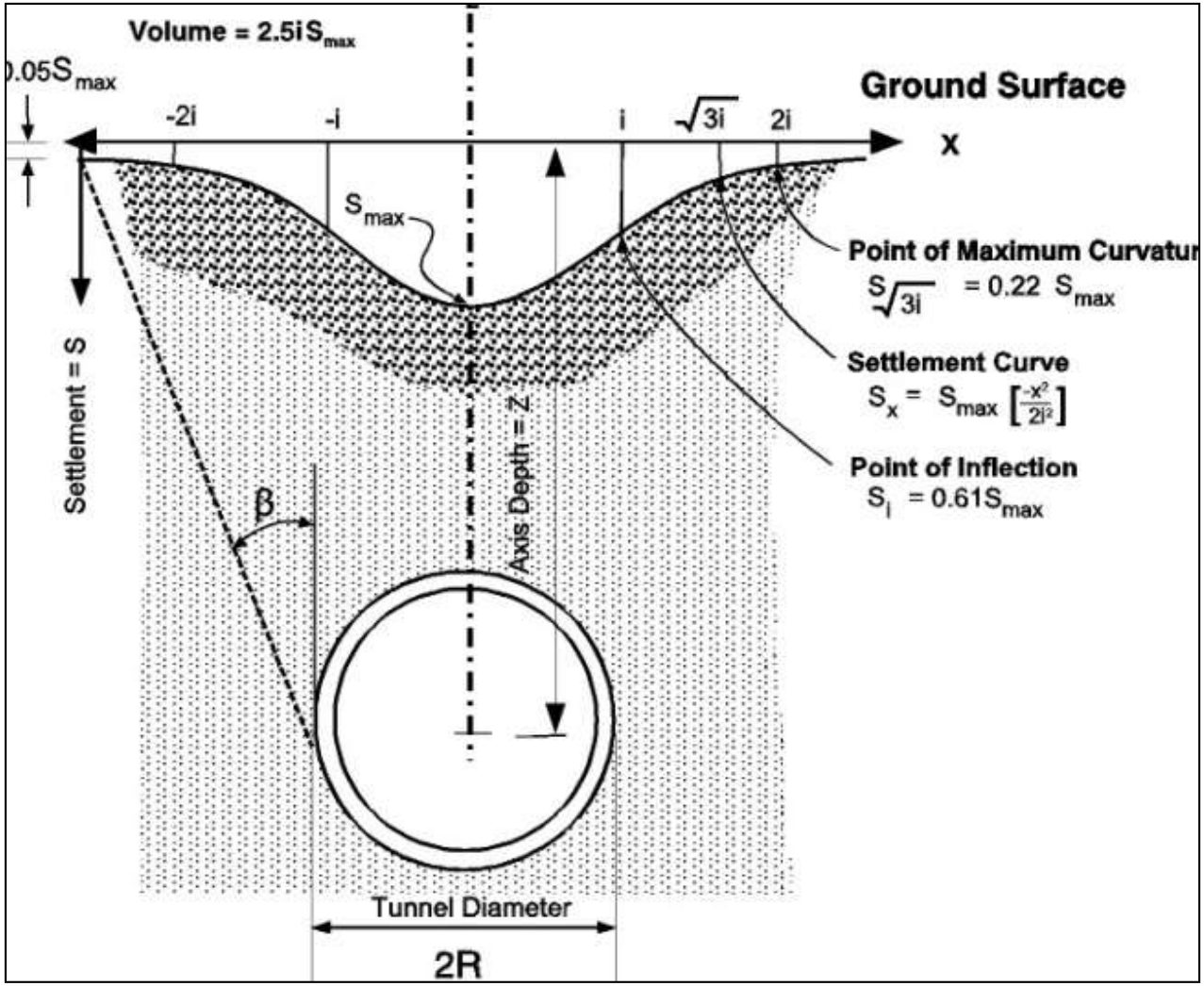
Table 7. Tualatin River Crossing Cost Evaluation		
Cost Item	Alternate (Option 1)	Alternate (Option 2)
Microtunnel	$ 4.8 M	$ 5.9 M
Shafts	$ 2.3 M	$ 2.4 M
Open-cut*	$ 1.6 M	$ 1.1 M
TOTAL	**$ 8.7 M**	**$ 9.4 M**

*open-cut pricing included for all options in order to compare equivalent lengths

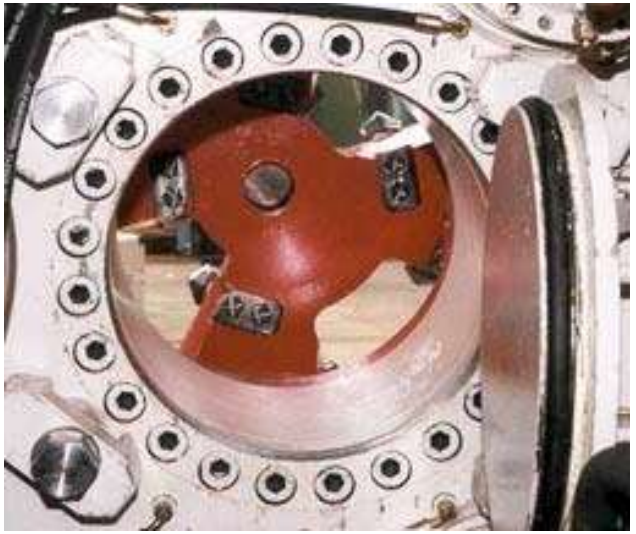
Risk

- Settlement
- Obstructions
- Jacking forces (length)
- Grade Control

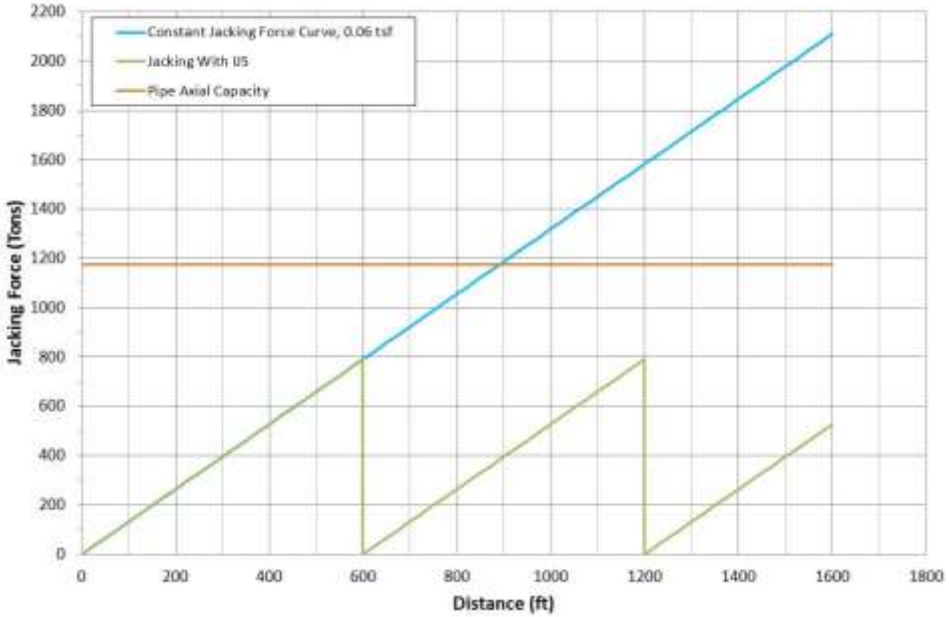
Settlement

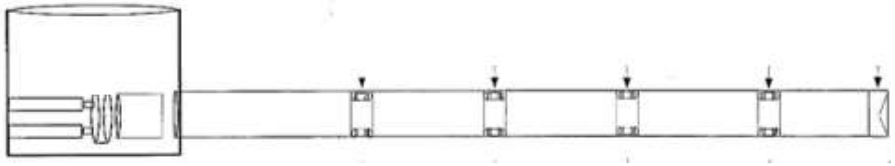

Volume = 2.5iS max
0.05S max
-2i
-i
i
√3i
2i
Ground Surface
X
S max
Point of Maximum Curvatur
S √3i = 0.22 S max
Settlement Curve
Sx = S max [-x²/2i²]
Point of Inflection
Si = 0.61S max
Settlement = S
β
Axis Depth = Z
Tunnel Diameter
2R

Obstructions

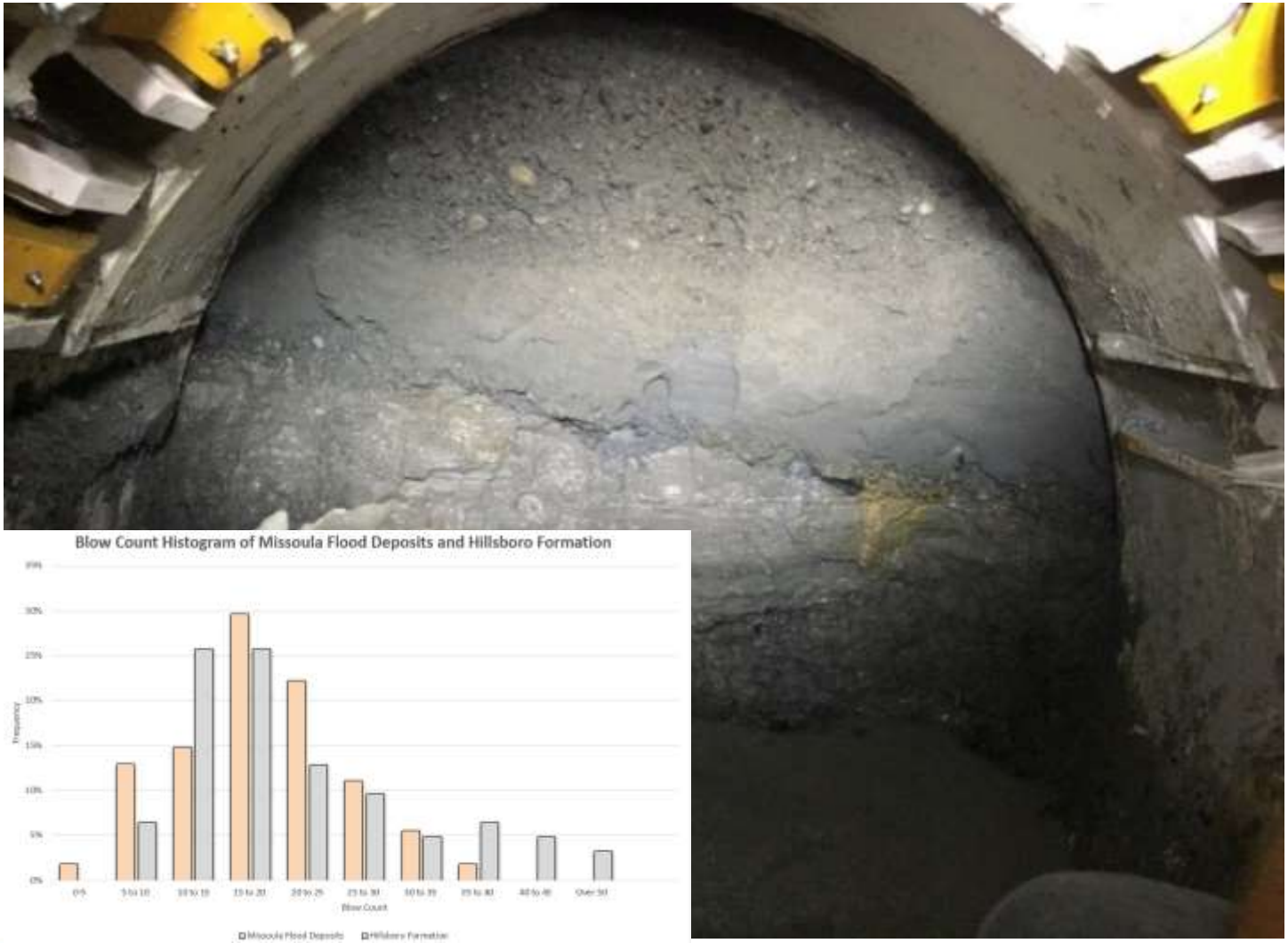


Jacking forces





Grade Control



Risk Comparison

Table 5. Alternate Tunnel Shaft Location Evaluation		
	Option 1	Option 2
Length	1,600 LF	1,975 LF
Obstructions	Lower risk	Higher risk
Jacking loads	Manageable drive length	Increased loads – more IJSs needed
Grade Control	Low risk	Longer drive has greater potential to get off line and grade

Alternative evaluation

Table 8. Tualatin River Crossing Alternatives Evaluation				
Criteria	Option 1		Option 2	
Environmental / permitting	–	Within the 100-year floodplain Farmed wetland Least impact to future develop' SNRA (Type II land use)	0	Outside the 100-year floodplain No important natural resources SNRA (Type II land use)
System resiliency	0	High confidence	0	High confidence
Constructability	0	Low risk (shorter tunnel) Risk of flooding (mitigated)	–	Moderate risk (longer tunnel)
O&M	–	Shafts outside of lateral deformation zone (access) Shaft in wetland	0	Shafts outside of lateral deformation zone (access)
Cost	N/A	$8.7 M	N/A	$9.4 M

SNRA: Significant Natural Resource Area

Selected alignment

Conclusions

- Incorporated constructability considerations and targeted technical analyses to inform alignment development and evaluate options.
- Selected a preferred alignment and documented rationale to support program right-of-way/easement acquisition and permitting.

Thank you!

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