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From: Abramson, Lee (Consultant)
Sent: Friday, January 23, 2009 11:16 AM
To: Struthers, James
Cc: Robison, Jim (Consultant); Jarnagan, Harry (Consultant); Nykamp, Monique (Consultant); Williamson, Alec
Subject: The South End of the Tunnel
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Jim:

I gave some additional thought to our discussions yesterday and offer the following:

1. Using a closed-face TBM to bore the first 600 feet of the tunnel will be exceedingly risky, difficult and expensive. Reasons for this include:

- Loose, wet sand with high amounts of lumber and wood pieces in the upper half of the bore and above
- Mixed face conditions with the above and glacial soils below
- Tiebacks remnant from previous building excavations and shoring
- Deep pile bridge foundations under the Railroad Way structure
- Shallow ground cover above the tunnel
- Dense utilities
- Seattle Area Ways
- Initiating tunneling (learning curve) in these conditions
- Curvature of alignment
- Potential adverse impacts on adjacent buildings
- Probable clogging of the TBM and support equipment
- Dangerous working conditions out ahead of the TBM cutting head
- Significant ground improvement (grouting, etc.) requirements
- Etc.

2. Initially, I see four alternative ways to tunnel this portion of the project including:

- **"Top-Down" cut and cover with decking over 1st Ave.** This would require excessive and difficult utility relocations in 1st Ave, disruptions to traffic, structural underpinning of adjacent buildings, ground improvement, etc. However, the cost of this type of construction could be somewhat less than bored tunnel and less risky.
- **Hand mining the first 600 feet.** This could be done with some combination of ground improvement and excavation support consisting of steel sets, spiling, lagging, breasting the face, etc. This part of the tunnel would need to be larger to accommodate installation of the TBM from within the starter tunnel. Hand mining might seem more difficult and expensive than boring but not really that much given the issues and significant difficulties anticipated above. This would be less risky than trying to bore through but might take a little longer schedule wise.
- **Tunnel jacking.** This involves prefabricating a concrete tunnel box in the access pit and then jacking it forward with a series of large hydraulic jacks. Typically, these boxes are about 300 feet long so two would be needed. A cutting shield is placed on the front of the first box. This would require additional ground improvement. The improved ground could be excavated with hydraulic spades or road headers. This type of

tunneling would probably take the longest to carry out.

- **Lower the vertical tunnel profile.** I'm inclined to think this would cost just as much as hand mining or jacking but would be very disruptive to the presently accepted designs and assumptions to the south. This would also increase the length of bored tunneling and the depth and volume of the access pit excavation.

3. In all of these scenarios, the TBM would be assembled, skidded and started further down the alignment and more room for full assembly of the TBM trailing gear would be provided.

I think **top-down** would be the way to go if you can tolerate the utility and traffic issues. If not, **hand mining** would be my first choice although it might have higher cost and schedule impacts.

I do not recommend boring the first 600 feet of the tunnel. That would be a very, very bad way to start the tunneling off.

This is just a first cut. Please let me know if you would like me to evaluate these or other options further.

Thanks.

Lee