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Technical Memorandum

King County Tabula: Task 1—Revise/Update Existing Wastewater Capital Construction Cost Estimates

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This memorandum pertains to the King County Wastewater Treatment Division's Work Order #3 for revisions and updates to its Tabula cost estimating program, and specifically discusses Task 1: revise/update existing wastewater capital construction cost estimates.

This memo is a submittal of findings and recommendations for updating unit costs within the Tabula program. After King County has reviewed these recommendations, a meeting will be held to discuss them and determine whether to accept them. Accepted changes will then be made to the Tabula program by Brown and Caldwell.

Even after the changes have been made to Tabula, this program will remain a parametric estimating tool. The estimates produced by Tabula will be Class 5 or Class 4 estimates as defined by the Association for the Advancement of Cost Engineering (AACE)[1]. Therefore, appropriate contingencies must be applied to the resulting estimates from the Tabula program in order to develop adequate planning level budgets.

In addition to contingencies for unknown project scope definition attention should be given in the upcoming months and years to the recent effects of the turbulent economy on the construction industry.

This memo explains the process of updating the unit costs contained in King County's Tabula estimating program. The unit costs contained within this program were established by HDR in December 1999 and were revised in 2005 by CH2M HILL, and they have not been updated since then. King County has

[1] AACE defines a Class 5 estimate as an estimate preformed at the 0–2 percent level of design and has an expected accuracy of <+50 percent to <-30 percent. This class of estimate is used primary for screening or feasibility studies. A Class 4 estimate is an estimate developed at the 1 percent to 15 percent level of design and has an expected accuracy range of +50 percent to -30 percent. This class of estimate is used primarily for conceptual of feasibility studies. Both Class 4 and 5 estimates are also known as Order of Magnitude estimates.

contracted Brown and Caldwell to examine the unit costs contained within the program and compare them with current construction costs and, where necessary, recommend new costs to reflect the existing construction market.

In general, several sources of information were used to develop these new cost units: bid tabulations from the Washington State Department of Transportation (WSDOT), Sacramento County Water Association (SCWA), and other various agencies; vendor material quotes; contractor information; King County prevailing wage rates to develop labor costs when necessary; and *RS Means 2008 Heavy Construction* information adjusted for King County wage rates. When the data were not available, a standard multiplier of 1.1314 (4.2 percent per year for 3 years) was applied to escalate the cost values from 2005 dollars to 2008 dollars.

Once the data were validated, a standard curve fitting software application was used to develop the equations for each of the components. For the 2008 upgrade, we used an online curve fitting application called ZunZun.com. We verified the resulting equations and results.

Section 1: Pipeline Cost Information

The "Fixed Input Parameters" were compared against a variety of cost sources. Trench shoring was compared against recent SCWA bid tabs and several recent jobs, and then adjusted for King County labor. Special shoring can pertain to a variety of shoring alternatives which result in varying pricing, depending on the system employed. In this study we compared costs to the Contra Costa Canal Replacement and means were adjusted for King County labor. Earthwork costs were developed by comparing *RS Means* costs using King County labor rates, WSDOT bid tabs, SCWA bid tabs, and vendor costs for imported backfill material costs.

Asphalt concrete pavement (ACP) paving costs were collected from WSDOT bid tabs and other projects that have recently been bid. For patching, the cost is based on a 6" thickness which is the indicated depth on the trench geometry profile in the Tabula report. Pavement removal and saw cutting are also included in the pavement patching costs. Costs for overlays outside of the trench patching area costs are based on a 2" overlay depth, which is a typical depth seen in construction projects. The cost for grinding and pavement re-striping is included in the overlay costs.

Tabula uses the *Engineering News Record* Construction Cost Index (ENR CCI) for the means to adjust historical costs to current costs. Brown and Caldwell confirmed the use of this index because it is based on the Northwest regional construction economy and it is widely used for this purpose in the construction industry. October 2008 (8815 ENR CCI) was selected as the current dollar index. Table 1.1 (below) lists the 2005–2008 ENR CCI values used in this revision of the program.

Table 1.1. ENR CCI Values Added to Tabula

Year	ENR CCI Value	Based On
2005	8458.00	Annual Average
2006	8641.00	Annual Average
2007	8618.00	Annual Average
2008	8815.00	October 2008 ENR Value

Table 1.2 (below) shows a summary of the "Fixed Input Costs" currently used in the Tabula program expressed in September 2005 dollars (ENR CCI = 8390) and the recommended 2008 unit costs based on our cost comparisons. See Appendix A for cost information details.

Table 1.2. Fixed Input Parameters				
Items	Units	Current Tabula Unit Cost (Sept. 2005 Dollars)	Escalated Tabula Unit Cost (Sept. 2008 Dollars)	Recommended Unit Cost (Sept. 2008 Dollars)
Mob/Demob	LS	10%	10%	6%
Trench Safety (Box)	SF	$0.50	$0.53	$0.53
Special Shoring	SF	$12	$13	$17
Excavation	CY	$12	$13	$13
Imported Backfill	CY	$32	$34	$34
Place Backfill	CY	$8	$8	$6
Spoil Load & Haul	CY	$12	$13	$16
Asphalt Paving (Trench)	SY	$55	$58	$86
Asphalt Paving (Beyond Trench)	SY	$25	$26	$28

Tabula currently uses three types of pipes for costing purposes: Class V reinforced concrete pipe (RCP) for gravity sewer, Class 53 Tyton Joint ductile iron pipe for force mains, and restrained joint ductile iron pipe for force mains with high head applications. Cost quotes for the various pipe materials were obtained from local area vendors. Pipe installation production rates and crew sizes were taken from *RS Means*. King County labor rates were used to calculate installation costs for the various pipe sizes. See Appendix B for cost information details.

Table 1.3. Pipe Material and Installation Costs												
	Current Tabula Costs (Sept. 2005 Dollars)				Escalated Tabula Costs (Sept. 2008 Dollars)				Recommended Costs (Oct. 2008 Dollars)			
Pipe Dia (in.)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)
8	18	24	8	18	19	25	8	19	30	33	N/A	22
10	24	31	10	20	25	33	11	21	46	45	N/A	23
12	30	38	16	24	32	40	17	25	48	56	17	25
14	38	50	N/A	24	40	53	N/A	25	61	71	N/A	26
15	N/A	N/A	17	24	N/A	N/A	18	25	N/A	N/A	20	27
16	45	59	N/A	26	47	62	N/A	27	75	77	N/A	27
18	52	68	22	27	55	71	23	28	82	97	24	29
20	58	78	N/A	29	61	82	N/A	30	91	114	N/A	30
21	N/A	N/A	24	30	N/A	N/A	25	32	N/A	N/A	31	31
24	73	98	32	36	77	103	34	38	114	131	36	33
27	N/A	N/A	49	51	N/A	N/A	51	54	N/A	N/A	46	36
30	105	139	60	53	110	146	63	56	159	202	51	38

Table 1.3. Pipe Material and Installation Costs												
	Current Tabula Costs (Sept. 2005 Dollars)				Escalated Tabula Costs (Sept. 2008 Dollars)				Recommended Costs (Oct. 2008 Dollars)			
Pipe Dia (in.)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)
36	145	191	73	65	152	201	77	68	215	279	77	45
42	196	250	95	70	206	263	100	74	300	382	86	52
48	260	310	121	79	273	326	127	83	396	455	123	60
54	340	410	151	97	357	431	159	102	503	578	168	70
60	400	470	210	105	420	494	221	110	610	701	220	81
72	N/A	N/A	270	126	N/A	N/A	284	132	N/A	N/A	346	109
78	N/A	N/A	320	140	N/A	N/A	336	147	N/A	N/A	414	126
84	N/A	N/A	380	158	N/A	N/A	399	166	N/A	N/A	490	146
96	N/A	N/A	490	210	N/A	N/A	515	221	N/A	N/A	658	197
108	N/A	N/A	610	315	N/A	N/A	641	331	N/A	N/A	853	265
120	N/A	N/A	740	420	N/A	N/A	777	441	N/A	N/A	1,072	357
144	N/A	N/A	1,300	505	N/A	N/A	1,365	530	N/A	N/A	1,587	646

Manhole material costs were established by obtaining a vendor quote for the manhole sections. Manhole depths were calculated based on 12 feet of cover for the pipe. Different sized manholes are used depending on the pipe size. The largest pipe diameter indicated in each manhole range was used to calculate the final invert depth. For manholes with greater than 12 feet of cover an additional cost to add sections to the manhole was developed. These costs are in additional vertical linear feet of depth (VLF). Installation costs were developed using the crews based on local wage rates. These calculated rates were then compared to local bid tabs, unit costs, and *RS Means* costs for similar sized manholes. See Appendix C for cost information details.

Table 1.4. Manhole Sizes and Costs							
Manhole Diameter (in.)	Pipe Diameter Range (in.)	Current Tabula Base Cost ($/each) (Sept. 2005 Dollars)	Current Added VLF Cost ($/VLF) (Sept. 2005 Dollars)	Escalated Tabula Base Cost ($/each) (Sept. 2008 Dollars)	Escalated Added VLFCost ($/VLF) (Sept. 2008 Dollars)	Recommended Base Cost ($/each) (Oct. 2008 Dollars)	Recommended Added VLF Cost ($/VLF) (Oct. 2008 Dollars)
48	<21	$4,000	$290	$4,200	$305	$8,329	$299
54	24–27	$5,000	$430	$5,250	$452	$7,386	$385
72	30–42	$9,500	$900	$9,975	$945	$9,717	$538
84	48	$14,000	$1,300	$14,700	$1,365	$12,550	$672
96	54–60	$18,000	$1,500	$18,900	$1,575	$15,382	$805

Table 1.4. Manhole Sizes and Costs							
Manhole Diameter (in.)	Pipe Diameter Range (in.)	Current Tabula Base Cost ($/each) (Sept. 2005 Dollars)	Current Added VLF Cost ($/VLF) (Sept. 2005 Dollars)	Escalated Tabula Base Cost ($/each) (Sept. 2008 Dollars)	Escalated Added VLFCost ($/VLF) (Sept. 2008 Dollars)	Recommended Base Cost ($/each) (Oct. 2008 Dollars)	Recommended Added VLF Cost ($/VLF) (Oct. 2008 Dollars)
108	72	$22,000	$1,900	$23,100	$1,995	$17,702	$1,076
120	78	$29,000	$2,200	$30,450	$2,310	$20,022	$1,346
144	84–144	$36,000	$2,600	$37,800	$2,730	$41,718	$1,967

Right-of-way costs were updated according to annual reports provided by the King County Assessor's office. These costs included urban and suburban residential costs, and commercial and industrial properties in King County from 2005 to 2008. Using this information, a percent increase in property values from 2005 was established and that percentage was applied to the 2005 Tabula costs. A recommended land value cost was established. See Appendix D for cost information details.

Table 1.5. Right--of--Way Acquisition and& Easements						
Area	Current Tabula Property Acquisition Cost ($/SF) (Dec. 2005 Dollars)	Current Tabula Permanent Easement Cost ($/SF) (Dec. 2005 Dollars)	Escalated Tabula Property Acquisition Cost ($/SF) (Sept. 2008 Dollars)	Escalated Tabula Permanent Easement Cost ($/SF) (Sept. 2008 Dollars)	Recommended Property Acquisition Cost ($/SF) (Sept. 2008 Dollars)	Recommended Permanent Easement Cost ($/SF) (Sept. 2008 Dollars)
Residential-Urban	$58	$17	$61	$18	$78	$23
Residential-Suburban	$36		$38		$48	
Residential-Rural	$24		$25		$31	
Industrial	$23	$7	$24	$7	$31	$9
Commercial	$37	$11	$39	$12	$49	$15

Dewatering costs for trench sump and wellpoint dewatering were calculated by prorating values from existing values in Tabula and comparing these numbers to VSB treatment bid tabs and means adjusted for King County labor. See Appendix E for cost information details.

Table 1.6. Easement Adjustment Factors	
City	Land Cost Adj. Factor
King County Average	1.00
Seattle	0.79
Algona	0.36
Auburn	0.43
Beaux Arts	1.61

Table 1.6. Easement Adjustment Factors	
City	Land Cost Adj. Factor
Bellevue	1.01
Black Diamond	0.59
Bothell	0.66
Burien	0.56
Carnation	0.49
Clyde Hill	2.33
Covington	0.46
Des Moines	0.49
Duvall	0.60
Enumclaw	0.41
Federal Way	0.49
Hunts Point	6.55
Issaquah	0.88
Kenmore	0.68
Kent	0.49
Kirkland	0.93
Lake Forest Park	0.73
Maple Valley	0.51
Medina	3.66
Mercer Island	1.82
Milton	0.44
Newcastle	0.95
Normandy Park	0.88
North Bend	0.60
Pacific	0.40
Redmond	0.77
Renton	0.55
Sammamish	0.96
SeaTac	0.43
Shoreline	0.61
Skykomish	0.21
Snoqualmie	0.76
Tukwila	0.44
Woodinville	0.75
Yarrow Point	3.05
Unincorporated Area	0.65

An additional factor has been implemented into the Tabula easement calculations. Using the King County average land cost as the basis, the areas listed above are all assigned values as a percentage of the King County average. This allows a more refined estimate of easement costs.

Table 1.7. Dewatering Costs						
Pipe Diameter (in.)	Current Tabula Trench Sump Dewatering ($/LF) (Sept. 2005 Dollars)	Current Tabula Wellpoint Dewatering ($/LF) (Sept. 2005 Dollars)	Escalated Tabula Trench Sump Dewatering ($/LF) (Sept. 2008 Dollars)	Escalated Tabula Wellpoint Dewatering ($/LF) (Sept. 2008 Dollars)	Recommended Trench Sump Dewatering ($/LF) (Sept. 2008 Dollars)	Recommended Wellpoint Dewatering ($/LF) (Sept. 2008 Dollars)
8–12	$20	$60	$21	$63	$24	$80
14–21	$20	$65	$21	$68	$24	$87
24–30	$20	$75	$21	$79	$24	$100
36–48	$30	$80	$32	$84	$35	$107
54–66	$30	$95	$32	$100	$35	$127
72–84	$45	$110	$47	$116	$53	$147
90–96	$55	$125	$58	$131	$65	$167
108–144	$75	$150	$79	$158	$88	$200

Traffic control costs in Tabula are calculated as either average or heavy. These costs are based on different ranges of pipe sizes. All traffic control costs were calculated using King County hourly wage rates for flaggers. Average traffic control costs were based on one non-uniformed police officer, one flagger during the entire construction period, and two flaggers for heavy traffic areas. To find the linear foot cost for flagging, a production rate for pipe placement and surface restoration was established. This production rate was set at half the pipe production rate for pipes under 66" diameter and at two thirds the pipe production rate for pipes over 66" diameter in order to account for earthwork and surface restoration costs such as paving. See Appendix E for cost information details.

Table 1.8. Traffic Costs Recommendation						
Pipe Diameter (in.)	Current Tabula Average Traffic Control Cost ($/LF) (Sept. 2005 Dollars)	Current Tabula Heavy Traffic Control Cost ($/LF) (Sept. 2005 Dollars)	Escalated Tabula Average Traffic Control Cost ($/LF) (Sept. 2008 Dollars)	Escalated Tabula Heavy Traffic Control Cost ($/LF) (Sept. 2008 Dollars)	Recommended Average Traffic Control cost ($/LF) (Sept. 2008 Dollars)	Recommended Heavy Traffic Control cost ($/LF) (Sept. 2008 Dollars)
8–21	$8	$16	$8	$17	$8	$16
24–42	$12	$24	$13	$25	$12	$24
48–66	$18	$36	$19	$38	$18	$36
72–84	$25	$50	$26	$53	$25	$50
96–144	$50	$100	$53	$105	$50	$100

Utility conflict is broken into no conflicts, average conflicts, and complex conflicts depending on the location of the pipeline. These costs cover utility protections and, where necessary, utility replacement. See Appendix E for cost information details.

Table 1.9. Utility Conflict Costs Recommendation						
Pipe Diameter (in.)	Current Tabula Average Conflict Cost ($/LF) (Sept. 2005 Dollars)	Current Tabula Complex Conflict Cost ($/LF) (Sept. 2005 Dollars)	Escalated Tabula Average Conflict Cost ($/LF) (Sept. 2008 Dollars)	Escalated Tabula Complex Conflict Cost ($/LF) (Sept. 2008 Dollars)	Recommended Average Conflict Cost ($/LF) (Oct. 2008 Dollars)	Recommended Complex Conflict Cost ($/LF) (Oct. 2008 Dollars)
8–12	$25	$45	$26	$47	$3	$32
14–18	$35	$70	$37	$74	$3	$42
20–30	$45	$90	$47	$95	$5	$58
36–42	$55	$115	$58	$121	$11	$120
48–54	$70	$140	$74	$147	$16	$166
60	$90	$185	$95	$194	$25	$265
72–78	$115	$230	$121	$242	$34	$360
84–96	$140	$275	$147	$289	$77	$773
108–144	$170	$345	$179	$362	$119	$1,191

Section 2: Trenchless Technology

Trenchless technology choices in Tabula consist of microtunnels, bore and jacks, and horizontal directional drilling (HDD). For the fixed input parameters the costs were compared to WSDOT bid tabs, *RS Means*, and SCWA costs. For right-of-way costs use the cost recommended in the pipeline costs section. See Appendix F for cost information details.

Table 1.10. Trenchless Technology Fixed Input Parameters				
Items	Units	Current Tabula Unit Cost (Sept. 2005 Dollars)	Escalated Tabula Unit Cost (Sept. 2008 Dollars)	Recommended Unit Cost (Oct. 2008 Dollars)
Shaft Excavation	CY	$25	$26	$25
Shaft Backfill	CY	$25	$26	$4
Shaft Waste Haul	CY	$25	$26	$33
Combined Excavation & Backfill Cost	CY	$25	$26	$25
Asphalt Paving (Trench)	SY	$50	$53	$74
Existing Utilities (Average)	SF	$6	$6	$6
Existing Utilities (Complex)	SF	$10	$11	$13
Hydroseed	SY	$5	$5	$3

Microtunneling costs were discussed with a local microtunneling contractor. The contractor recommendations were then compared to bid tab information, the existing tabula microtunneling information escalated to August 2008. Based on these comparisons a recommended microtunneling cost was established. These recommended costs are shown in Table 1.11 below. See Appendix F for cost information details.

For situations where a casing pipe is needed, the user selects the carrier pipe diameter size. Tabula then increases the microtunnel size based on Table 1.11 to an appropriately sized casing pipe diameter. The casing diameter determines the microtunnel costs used by Tabula. The casing material costs are included in the microtunneling costs, so there is no need to add any additional cost for the casing material. Instead this was changed so that the program now adds in the additional cost of a carrier pipe to the microtunnel, bore and jack, or HDD costs when using a cased carrier pipe.

The casing carrier pipe costs for microtunnels and bore and jacks are shown in Table 1.12. For HDD the casing carrier pipe costs are shown in Table 1.18.

Table 1.11. Microtunnel Costs

Micro-tunnel ID (in.)	Current Tabula MTBM Fixed Cost ($/LF) (Sept. 2005 Dollars)	Current Tabula Microtunnel Cost ($/in. dia./lf) (Sept. 2005 Dollars)	Escalated Tabula MTBM Fixed Cost ($/LF) (Sept. 2008 Dollars)	Escalated Tabula Microtunnel Cost ($/in. dia./lf) (Sept. 2008 Dollars)	Recommended MTBM Fixed Cost ($/LF) (Oct. 2008 Dollars)	Recommended Microtunnel Cost ($/in. dia./lf) (Oct. 2008 Dollars)
12	$120,000	$40	$126,000	$42	$132,115	$51
15	$130,000	$37	$136,500	$39	$165,144	$43
18	$160,000	$35	$168,000	$37	$198,173	$37
21	$190,000	$32	$199,500	$34	$231,201	$33
24	$210,000	$31	$220,500	$33	$264,230	$31
30	$270,000	$30	$283,500	$32	$330,288	$27
36	$330,000	$29	$346,500	$30	$396,345	$26
42	$400,000	$28	$420,000	$29	$462,403	$25
48	$470,000	$27	$493,500	$28	$528,460	$25
54	$540,000	$27	$567,000	$28	$594,518	$25
60	$600,000	$26	$630,000	$27	$660,575	$26
66	$670,000	$25	$703,500	$26	$726,633	$26
72	$740,000	$25	$777,000	$26	$792,690	$27
84	$800,000	$24	$840,000	$25	$924,805	$29

Table 1.12. Microtunnel and Bore and Jacking Casing Pipe Diameter Based on Carrier Pipe Diameter

Carrier Pipe Size (in.)	Casing Pipe Size (in.)
12	24
15	30
18	30
21	36
24	36
30	42
36	48
42	54
48	60
54	72

Table 1.12. Microtunnel and Bore and Jacking Casing Pipe Diameter Based on Carrier Pipe Diameter	
Carrier Pipe Size (in.)	Casing Pipe Size (in.)
60	72
66	84
72	84
84	96
90	108
96	108
108	120
120	144

Table 1.13. Microtunnel and Bore & Jack Casing Carrier Pipe Material Cost				
Carrier Pipe Size (in.)	Casing Pipe Size (in.)	Current Tabula Casing Pipe Material Cost ($/lf) (Sept. 2005 Dollars)	Escalated Tabula Casing Pipe Material Cost ($/lf) (Sept. 2008 Dollars)	Recommended Casing Carrier Pipe Cost ($/lf) (Oct. 2008 Dollars)
12	24	$50	$53	$62
15	30	$65	$68	$76
18	30	$70	$74	$90
21	36	$90	$95	$103
24	36	$95	$100	$116
30	42	$120	$126	$165
36	48	$145	$152	$223
42	54	$220	$231	$286
48	60	$255	$268	$349
54	72	$285	$299	$443
60	72	$320	$336	$542
66	84	$520	$546	$421
72	84	$570	$599	$455
84	96	$665	$698	$636
90	108	$715	$751	$745
96	108	$760	$798	$855
108	120	$860	$903	$1,118
120	144	$1,270	$1,334	$1,429

The assumption for dewatering made in Tabula is that the shoring system will be watertight thus dewatering will be limited to minor seepage. See Appendix F for cost information details.

Table 1.14. Trenchless Technology Dewatering Costs						
Number of Shafts	Current Tabula Standard Dewatering (Total $) (Sept. 2005 Dollars)	Current Tabula Significant Dewatering (Total $) (Sept. 2005 Dollars)	Escalated Tabula Standard Dewatering (Total $) (Sept. 2008 Dollars)	Escalated Tabula Significant Dewatering (Total $) (Sept. 2008 Dollars)	Recommended Standard Dewatering (Total $) (Oct. 2008 Dollars)	Recommended Significant Dewatering (Total $) (Oct. 2008 Dollars)
2	$50,000	$70,000	$52,500	$73,500	$44,235	$55,293
3	$55,000	$80,000	$57,750	$84,000	$66,146	$82,683
4	$60,000	$105,000	$63,000	$110,250	$98,344	$122,931
5	$70,000	$120,000	$73,500	$126,000	$136,907	$171,134
5+	$90,000	$140,000	$94,500	$147,000	$154,352	$192,940

Traffic control for Trenchless technology is calculated on a per-shaft cost. For purposes of calculating the traffic control the costs are based on two flaggers working over a 2-month period from the opening to closing up of the shafts. This was arrived at on the basis that the shafts are 1,000 ft apart and the microtunneling production rate is 35 ft/day. Then 2 weeks are added in for shaft construction and backfill. Finally 1 additional week is added in for surface/pavement restoration and other miscellaneous sitework. This adds up to 45 days of traffic control labor, or 2 months. In addition, a lump sum for barriers, signs, and re-striping are added to the labor cost. See Appendix F for cost information details.

Table 1.15. Trenchless Technology Traffic Control Costs			
	Current Tabula Traffic Control Cost ($/Shaft) (Sept. 2005 Dollars)	Escalated Tabula Traffic Control Cost ($/Shaft) (Sept. 2008 Dollars)	Recommended Traffic Control Cost ($/Shaft) (Oct. 2008 Dollars)
Standard Traffic	$15,000	$15,750	$15,300
Heavy Traffic	$25,000	$26,250	$27,600

Bore and jack costs were then compared to recent bore and jack bid tab information. Because bore and jacking should take place above the water table, Tabula uses a minimal fixed value dewatering cost. See Appendix F for more cost information details.

Table 1.16. Bore and Jack Costs			
Bore & Jack Casing ID (in.)	Current Tabula Bore & Jack Cost ($/in. dia./lf) (Sept. 2005 Dollars)	Escalated Tabula Bore & Jack Cost ($/in. dia./lf) (Sept. 2008 Dollars)	Recommended Bore & Jack Cost ($/in. dia./lf) (Oct. 2008 Dollars)
12	$20	$21	$23
15	$18	$19	$23
18	$17	$18	$23
21	$17	$18	$23
24	$17	$18	$23
30	$18	$19	$24

Table 1.16. Bore and Jack Costs			
Bore & Jack Casing ID (in.)	Current Tabula Bore & Jack Cost ($/in. dia./lf) (Sept. 2005 Dollars)	Escalated Tabula Bore & Jack Cost ($/in. dia./lf) (Sept. 2008 Dollars)	Recommended Bore & Jack Cost ($/in. dia./lf) (Oct. 2008 Dollars)
36	$20	$21	$24
42	$22	$23	$24
48	$22	$23	$25
54	$22	$23	$25
60	$23	$24	$25
66	$23	$24	$26
72	$27	$28	$26
84	$28	$29	$27
90	$28	$29	$28
96	$29	$30	$28
108	$29	$30	$29
120	$30	$32	$31

Horizontal directional drilling costs were compared with similar projects on trenchless technology. See Appendix F for cost information details.

Table 1.17. Horizontal Directional Drilling Costs			
HDD ID (in.)	Current Tabula HDD Cost ($/lf) (Sept. 2005 Dollars)	Escalated Tabula HDD Cost ($/lf) (Sept. 2008 Dollars)	Recommended HDD Cost ($/lf) (Oct. 2008 Dollars)
6	$60	$63	$63
12	$180	$189	$189
15	$270	$284	$284
18	$380	$399	$399
21	$470	$494	$494
24	$530	$557	$557
30	$630	$662	$662
36	$750	$788	$788
42	$890	$935	$935
48	$1,010	$1,061	$1,061

Table 1.18. Horizontal Directional Drilling Casing Pipe Diameter based on Carrier Pipe Diameter	
Carrier Pipe Size (in.)	Casing Pipe Size
6	12
12	15
15	18
18	21
21	24
24	30
30	36
36	42
42	48
48	NA

Table 1.19. Horizontal Directional Drilling Casing Pipe Material Cost				
Carrier Pipe Size (in.)	Casing Pipe Size	Current Tabula Casing Pipe Material Cost ($/lf)	Escalated Tabula Casing Pipe Material Cost ($/lf)	Recommended Casing Carrier Pipe Cost ($/LF)
6	12	$18	$21	$19
12	15	$26	$31	$31
15	18	$30	$35	$40
18	21	$43	$51	$47
21	24	$43	$51	$58
24	30	$80	$94	$91
30	36	$108	$127	$109
36	42	$140	$165	$127
42	48	$200	$235	$146
48	N/A	N/A	N/A	N/A

Section 3: Tunnels

Tunneling costs were discussed with a tunneling contractor to compare the Tabula cost information with current market conditions. These tunneling costs were then compared to bid tabs from recent tunneling jobs.

Table 1.20. Tunneling Costs						
Tunnel Inside Dia. (ft)	Current Tabula TBM Fixed Cost (Sept. 2005 Dollars)	Current Tabula Tunnel Cost ($/lf) (Sept. 2005 Dollars)	Escalated Tabula TBM Fixed Cost (Sept. 2008 Dollars)	Escalated Tabula Tunnel Cost ($/lf) (Sept. 2008 Dollars)	Recommended TBM Fixed Cost (Oct. 2008 Dollars)	Recommended Tunnel Cost ($/lf) (Oct. 2008 Dollars)
8	$2,000,000	$2,200	$2,100,000	$2,310	$3,988,133	$2,381
9	$2,500,000	$2,200	$2,625,000	$2,310	$4,435,517	$2,399
10	$2,750,000	$2,200	$2,887,500	$2,310	$4,820,195	$2,445
11	$3,000,000	$2,200	$3,150,000	$2,310	$5,146,721	$2,531
12	$3,500,000	$2,400	$3,675,000	$2,520	$5,419,652	$2,630
13	$3,750,000	$2,600	$3,937,500	$2,730	$5,643,545	$2,750
14	$4,000,000	$2,700	$4,200,000	$2,835	$5,822,957	$2,890
15	$4,500,000	$2,900	$4,725,000	$3,045	$5,962,444	$3,037
16	$5,000,000	$3,200	$5,250,000	$3,360	$6,066,561	$3,192
18	$5,500,000	$3,400	$5,775,000	$3,570	$6,186,916	$3,525

Table 1.21. Tunneling Dewatering Costs						
Tunnel Length (ft)	Current Tabula Standard Dewatering Cost (Total $) (Sept. 2005 Dollars)	Current Tabula Significant Dewatering Cost (Total $) (Sept. 2005 Dollars)	Escalated Tabula Standard Dewatering Cost (Total $) (Sept. 2008 Dollars)	Escalated Tabula Significant Dewatering Cost (Total $) (Sept. 2008 Dollars)	Recommended Standard Dewatering Cost (Total $) (Oct. 2008 Dollars)	Recommended Significant Dewatering Cost (Total $) (Oct. 2008 Dollars)
<1,000	$40,000	$60,000	$42,000	$63,000	$42,000	$63,000
1,000–5,000	$45,000	$70,000	$47,250	$73,500	$47,250	$468,347
5,000–10,000	$50,000	$90,000	$52,500	$94,500	$52,500	$1,346,087
>10,000	$60,000	$100,000	$63,000	$105,000	$63,000	$2,169,971

Section 4: Pump Stations

Pump station cost curves in Tabula were based on several pump stations constructed between 1991 and 2007. The construction costs for the pump stations have been escalated using the Seattle ENR CCI index to bring them to October 2008 dollars.

Appendix H shows the cost curves and data used to obtain the new recommended pump station cost formula. These costs are construction costs only and do not included allied costs. As a check the new cost curves were then compared to the existing Tabula cost curves adjusted to August 2005 dollars. This was done by escalating the cost component in the existing curve using the Seattle ENR CCI index. This escalated curve output was then compared to the output of the existing curve with the value escalated to October 2008 dollars. Both curves were within 2 percent of each other so this method was considered valid for escalating the existing curve costs. Appendix H shows the comparison of output of the new recommended curves verse the escalated values of the existing curves.

To facilitate larger pump stations, the configured range of sizes for pump stations has been expanded. The expanded range extends from 0.5 to 300 mgd. All testing included capacities that covered the entire range.

Below is a summary of the current and recommend cost formulas for the pump stations.

Current Site/Civil Cost:

Site/Civil Cost ($) = $57,000 x Capacity (mgd) $^{0.90}$

Recommended Site/Civil Cost:

Site/Civil Cost ($) = 0.93 x $83,438.49 x Capacity (mgd)$^{0.90}$

Current Electrical/Instrumentation Cost:

Electrical/Instrumentation Cost ($) = $12,000 x Pump Power (HP) $^{0.70}$

Recommended Electrical/Instrumentation Cost:

Electrical/Instrumentation Cost ($) = 0.93 x $15099.30 x Pump Power (HP) $^{0.70}$

Current Architectural/Structural Cost:

Architectural/Structural Cost ($/mgd) =

$40.29 x Capacity (mgd)^2 - $3,597 x Capacity (mgd) + $206,344

Recommended Architectural/Structural Cost:

Architectural/Structural Cost ($/mgd) =

0.93 x ($450582.20 – $220058.40 x Capacity (mgd) + $10238.40 x Capacity (mgd)^2 - $187.67 x Capacity (mgd)^3)/(1.0 – $0.67 x Capacity (mgd) + $0.0286 x Capacity (mgd)^2 – 0.00078 x Capacity (mgd)^3)

Current Architectural/Structural Adjustment Cost:

Arch/Struct Adjust Cost ($/mgd) =

$0.24 x ((Excavation depth (ft)-30)/30+0.01 x (TDH (ft)-120)/120) x 10^6

Recommended Architectural/Structural Adjustment Cost:

Arch/Struct Adjust Cost ($/mgd) =

$0.272 x ((Excavation depth (ft)-30)/30+0.01 x (TDH (ft)-120)/120) x 10^6

Current Base Mechanical Cost:

Base Mechanical Cost ($/mgd) = $261,700 x Capacity (mgd)$^{-0.289}$

Recommended Base Mechanical Cost:

Base Mechanical Cost ($/mgd) = 0.93 x ($196,087.40 x 0.85 x (Capacity (mgd) + 5.687 x 10^{-8})$^{-0.289}$)

Current Mechanical Adjustment Cost:

Mechanical Adjustment Cost ($/mgd) =

$0.06 x ((TDH (ft) - 120)/120) x 10^6 for TDH < 300

1.2 x Base Mechanical Cost ($/mgd) for TDH >= 300

Recommended Mechanical Adjustment Cost:

Mechanical Adjustment Cost ($/mgd) =

$0.0679 x ((TDH (ft) - 120)/120) x 10^6 for TDH < 300

1.2 x Base Mechanical Cost ($/mgd) for TDH >= 300

Currently pump stations with high mgd capacities and a low total dynamic head (TDH) can end up with a negative overall mechanical cost. This allows for some decrease in the mechanical cost for pump stations with a low TDH without overly reducing the base mechanical cost. If the mechanical cost adjustment is more than 30% of the base mechanical cost, the mechanical cost adjustment is capped at 30% of the base cost.

After finalizing the pump station cost calculations, the values were typically 7% higher than the predicted costs. We subsequently added a scaling factor to the Site/Civil, Electrical/Instrumentation, Architectural/Structural, and Base Mechanical Costs. This adjusted the average overall value to within one percent of the historical values provided by our estimating group.

Section 5: Storage Facilities

The Storage Facility cost curve in Tabula was originally developed by comparing the costs of a number of storage facilities built in the late 1990s. For the 2005 update, these costs were escalated using the ENR CCI index to bring them to 2005 dollars and then adjusted to the Seattle area using the *RS Means* regional adjustment factors. For 2008, we reviewed the model and escalated the values generated by the model to 2008 dollars. We then added cost data for two additional storage facilities in other areas of the country and adjusted them to local labor and material costs. By comparing these data to the model results, we recalibrated the model and developed the following recommended cost adjustments.

It was determined that the formulas for calculating the dewatering, odor control, and pump stations looked reasonable for this level of estimate and just needed to be adjusted for escalation to October 2008 dollars. Without an in-depth study, more accurate costs for these items are not achievable.

Because there was no "Required Easement" entry box for this model, we did not add the easement adjustment factor. Within the model, there is an easement component based on the land acquisition value. This component can be added during the next revision of the program.

Storage Facility Cost Curve Actually Used in the Tabula Program:

Storage Facility ($/gallon) = $15.02 x Storage (Mgal)$^{-0.621}$

Recommended Storage Facility Cost Curve:

Storage Facility ($/gallon) = $16.99 x Storage (Mgal)$^{-0.621}$

Current Surface Restoration Costs:

Hydroseeding ($) = $5 x (Surface Area (sq ft) / 9)

Pavement ($) = $40 x (Surface Area (sq ft) / 9)

Recommended Surface Restoration Costs:

Hydroseeding ($) = $6 x (Surface Area (sq ft) / 9)

Pavement ($) = $43 x (Surface Area (sq ft) / 9)

Current Dewatering Costs:

Standard ($) = $880 x (Storage (Mgal))^2 + $43,000 x (Storage (Mgal)) + $400,000

Significant ($) = $1,175 x (Storage (Mgal))^2 + $80,500 x (Storage (Mgal)) + $765,000

Recommended Dewatering Costs:

Standard ($) = $990 x (Storage (Mgal))^2 + $48,600 x (Storage (Mgal)) + $452,000

Significant ($) = $1,320 x (Storage (Mgal))^2 + $91,000 x (Storage (Mgal)) + $865,000

Current Odor Control Cost:

Odor Control Cost ($) = $150,000 x Capacity (Mgal) + $12,000

Recommended Odor Control Cost:

Odor Control Cost ($) = $160,000 x Capacity (Mgal) + $13,400

Current Effluent Pump Station Cost:

Effluent Pump Station ($) = $1.35 x (22,000 x Capacity (Mgal)$^{0.85}$ + 120,000)

Recommended Effluent Pump Station Cost:

Effluent Pump Station ($) = $1.52 x (22,000 x Capacity (Mgal)$^{0.85}$ + 120,000)

APPENDIX A

Fixed Cost Parameters

Appendix A. Fixed Input Parameters

Items	Units	Current Tabula Unit Cost (Sept. 2005 Dollars)	Escalated Tabula Unit Cost (Sept. 2008 Dollars)	Recommended Unit Cost (Sept. 2008 Dollars)	Comment	Source for Recommendation
Mob/Demob	LS	10%	10%	6%		Multiple Estimates
Trench Safety (Box)	SF	$0.50	$0.53	$0.53		SCWA; adjusted for King Co Labor
Special Shoring	SF	$12	$13	$17	Price varies widely depending upon system employed	Contra Costa Canal Replacement & Means adjusted for King Co. Labor
Excavation	CY	$12	$13	$13		SCWA; adjusted for King Co Labor
Imported Backfill	CY	$32	$34	$34		Means adjusted for King Co Labor
Place Backfill	CY	$8	$8	$6		SCWA; adjusted for King Co Labor
Spoil Load & Haul	CY	$12	$13	$16		SCWA; adjusted for King Co Labor
Asphalt Paving (Trench)	SY	$55	$58	$86		Means adjusted for King Co Labor; WSDOT
Asphalt Paving (Beyond Trench	SY	$25	$26	$28	$42 for small, irregular areas; $12.82 for long, full width lane overlay.	Means adjusted for King Co Labor; WSDOT

9/2005 ENR CCI = 8390
10/2008 ENR CCI = 8815

No additional comments for this section.

APPENDIX B

Pipe Material and Installation Costs

Appendix B Table 1. Pipe Material and Installation Costs

	Current Tabula Costs (Sept. 2005 Dollars)				Escalated Tabula Costs (Sept. 2008 Dollars)				Recommended Costs (Oct. 2008 Dollars)			
Pipe Diameter (in.)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)
8	$18	$24	$8	$18	$19	$25	$8	$19	$30	$33	N/A	$22
10	$24	$31	$10	$20	$25	$33	$11	$21	$46	$45	N/A	$23
12	$30	$38	$16	$24	$32	$40	$17	$25	$48	$56	$17	$25
14	$38	$50	NA	$24	$40	$53	NA	$25	$61	$71	N/A	$26
15	NA	NA	$17	$24	NA	NA	$18	$25	NA	NA	$20	$27
16	$45	$59	NA	$26	$47	$62	NA	$27	$75	$77	N/A	$27
18	$52	$68	$22	$27	$55	$71	$23	$28	$82	$97	$24	$29
20	$58	$78	NA	$29	$61	$82	NA	$30	$91	$114	N/A	$30
21	NA	NA	$24	$30	NA	NA	$25	$32	NA	NA	$31	$31
24	$73	$98	$32	$36	$77	$103	$34	$38	$114	$131	$36	$33
27	NA	NA	$49	$51	NA	NA	$51	$54	NA	NA	$46	$36
30	$105	$139	$60	$53	$110	$146	$63	$56	$159	$202	$51	$38
36	$145	$191	$73	$65	$152	$201	$77	$68	$215	$279	$77	$45
42	$196	$250	$95	$70	$206	$263	$100	$74	$300	$382	$86	$52
48	$260	$310	$121	$79	$273	$326	$127	$83	$396	$455	$123	$60
54	$340	$410	$151	$97	$357	$431	$159	$102	$503	$578	$168	$70
60	$400	$470	$210	$105	$420	$494	$221	$110	$610	$701	$220	$81
72	NA	NA	$270	$126	NA	NA	$284	$132	NA	NA	$346	$109
78	NA	NA	$320	$140	NA	NA	$336	$147	NA	NA	$414	$126
84	NA	NA	$380	$158	NA	NA	$399	$166	NA	NA	$490	$146
96	NA	NA	$490	$210	NA	NA	$515	$221	NA	NA	$658	$197
108	NA	NA	$610	$315	NA	NA	$641	$331	NA	NA	$853	$265
120	NA	NA	$740	$420	NA	NA	$777	$441	NA	NA	$1,072	$357
144	NA	NA	$1,300	$505	NA	NA	$1,365	$530	NA	NA	$1,587	$646

53 P/O	53 RJ	Class V	Install Entry	
15.26	18.42	18.72	$24	SCWA adj. labor; DI per ACIPCO; conc. per Hansen
20.26	25.93	30.02	$35	SCWA adj. labor; DI per ACIPCO; conc. per Hansen
29.47	43.82	58.96	$57	SCWA adj. labor; DI per ACIPCO; conc. per Hansen
38.68	66.91	90.86	$83	SCWA adj. labor; DI per ACIPCO; conc. per Hansen

APPENDIX C

Manhole Costs

No additional comments for this section.

APPENDIX D

Right-of-Way Acquisition & Easements

Right-of-Way Acquisition was escalated from 2005 values, compared to known values, and adjusted to more closely reflect 2008 values.

An additional factor was introduced to allow adjustment of easement costs based on apparent land values for each municipality. Refer to Memorandum 4 for more details on the derivation the additional easement costs.

APPENDIX E

Dewatering, Traffic Control, and Utility Conflicts

Dewatering Costs and Assumptions

Pipe Diameter (in.)	Current Tabula Trench Sump Dewatering ($/LF) (Sept. 2005 Dollars)	Current Tabula Wellpoint Dewatering ($/LF) (Sept. 2005 Dollars)	Escalated Tabula Trench Sump Dewatering ($/LF) (Sept. 2005 Dollars	Escalated Tabula Wellpoint Dewatering ($/LF) (Sept. 2008 Dollars)	Recommended Trench Sump Dewatering ($/LF) (Sept. 2008 Dollars)	Recommended Wellpoint Dewatering ($/LF) (Sept. 2008 Dollars)	
8–12	$20	$60	$21	$63	$24	$80	Prorated
14–21	$20	$65	$21	$68	$24	$87	Prorated
24–30	$20	$75	$21	$79	$24	$100	Prorated
36–48	$30	$80	$32	$84	$35	$107	Prorated
54–60	$30	$95	$32	$100	$35	$127	Prorated
72–84	$45	$110	$47	$116	$53	$147	VSB treatment & *RS Means* adjusted for King Co Labor. PRORATION BASIS
96	$55	$125	$58	$131	$65	$167	Prorated
108–144	$75	$150	$79	$158	$88	$200	Prorated

Traffic Control Costs and Assumptions

Pipe Diameter (in.)	Current Tabula Average Traffic Control Cost ($/LF) (Sept. 2005 Dollars)	Current Tabula Heavy Traffic Control Cost ($/LF) (Sept. 2005 Dollars)	Escalated Tabula Average Traffic Control Cost ($/LF) (Sept. 2005 Dollars)	Escalated Tabula Heavy Traffic Control Cost ($/LF) (Sept. 2005 Dollars)	Recommended Average Traffic Control Cost ($/LF) (Sept. 2008 Dollars)	Recommended Heavy Traffic Control Cost ($/LF) (Sept. 2008 Dollars)
8–21	8	$16	$8	$17	$8	$16
24–42	12	$24	$13	$25	$12	$24
48–66	18	$36	$19	$38	$18	$36
72–84	25	$50	$26	$53	$25	$50
96–144	50	$100	$53	$105	$50	$100

Utility Conflict Cost Basis

Pipe Diameter (in.)	Basis for calc.	Basis for calc.	Range	Diameter	lf/day	Avg. eq. ft	Complex eq. ft	Avg. eq. %	Complex eq. %	Full Cost per lf	LF Cost Avg. 10,000 ft project	LF Cost Complex 10,000 ft project
8–12	2 hrs. for 24'	3 days for 50'	8–12	12	240	60	720	25.0%	300%	$108	3	32
14–18	2 hrs. for 24'	3 days for 50'	14–18	16	225	56	676	25.0%	300%	$139	3	42
20–30	2 hrs. for 24'	3 days for 50'	20–30	24	182	45	545	25.0%	300%	$194	5	58
36–42	3 hrs. for 24'	4 days for 50'	36–42	36	153	57	611	37.5%	400%	$300	11	120
48–54	3 hrs. for 24'	4 days for 50'	48–54	48	124	46	494	37.5%	400%	$416	16	166
60	3 hrs. for 24'	4 days for 50'	60	60	94	35	378	37.5%	400%	$662	25	265
72–78	3 hrs. for 24'	4 days for 50'	72–78	72	60	23	240	37.5%	400%	$900	34	360
84–96	4 hrs. for 24'	5 days for 50'	84–96	96	23	12	115	50.0%	500%	$1,546	77	773
108–144	4 hrs. for 24'	5 days for 50'	108–144	120	23	12	115	50.0%	500%	$2,382	119	1,191

APPENDIX F

Trenchless Technology Costs

Notes regarding Trenchless costing:

1) The carrier (product) pipe (cased carrier) is Restrained Joint Ductile ≤ 60″ diameter, and Class V concrete pipe > 60″ diameter.

2) Cased carrier refers to the standard two-pass tunnel, which has a separate casing and a carrier inside the casing.

3) The program makes allowances for optional calculation as a one-pass system wherein the casing and carrier pipe is one and the same, in which case the pipe could theoretically be called the casing or the carrier.

4) The casing pipe is medium gauge welded steel casing pipe.

5) Casing pipe is much heavier, and actually a different manufacturing process, pipe than the relatively thin-walled steel water line pipe.

6) The data in the tables accounts for a fixed cost of the TBM separately from the $/LF price of drilling; however there are considerable other fixed costs (e.g., rolling stock, liner machine transformers, scrubbers, etc.) that are currently accounted for in the $/LF price. We recommend including these costs in the TBM cost in a future revision.

7) The dewatering costs for large diameter tunnels are significantly more expensive than reflected in Tabula 2.0. These values have been increased for this revision.

8) Access shafts for deep tunnels vary widely. The costs shown in Tabula 2.0 are appropriate for relatively shallow access methods. We recommend separate fixed cost for "deep" tunnels which are usually round shafts ~50′ in diameter.

9) Existing shoring unit costs of $380/SF appears excessive. Shoring should be approximately $82/SF for 40′ deep access pits and $88/SF for deep tunnel shafts.

Trenchless Technology Basis for Fixed Input Parameters

Items	Comment	Source for Recommendation
Shaft Excavation	$33 for clamshell type operations; $17 for shallow pits reachable by surface backhoe	SCWA & Milwaukee Tunnel
Shaft Backfill		SCWA adjusted for King Co Labor
Shaft Waste Haul	$16 for clean dry mat'l; $50 for wet mat'l unsuitable for fill	Means adjusted for King Co Labor & local landfill rates
Combined Excavation & Backfill Cost		Above Items
Asphalt Paving (Trench)		Means adjusted for King Co labor
Existing Utilities (Average)		Productivity factor applied to Excavation
Existing Utilities (Complex)		Productivity factor applied to Excavation
Hydroseed		WSDOT

APPENDIX G

Tunneling Costs

Microtunnel Cost Basis

Microtunnel ID (in.)	ttc June 2002	ttc Oct. 2008	Means MTMB Mob	Means MTMB Mob Oct. 2008	Size	Casing/in.-dia.
12	44	51		$132,115		
15	37	43		$165,144		
18	32	37		$198,173		
21	28	33		$231,201		
24	26	31		$264,230	24	4.38
30	23	27		$330,288	30	4.32
36	22	26		$396,345	36	4.33
42	21	25		$462,403	42	4.20
48	21	25	$516,826	$528,460	48	4.23
54	22	25		$594,518	54	5.50
60	22	26		$660,575	60	5.58
66	23	26		$726,633		
72	23	27		$792,690	72	5.60
84	25	29		$924,805	84	8.29

For tunnel sizes < 24", MTBM is very rare and can cause considerable variation in the mobilization costs of the microtunnel.

Microtunnel Bore & Jack Casing Carrier Pipe Material Costs

Carrier Pipe Size (in.)	Casing Pipe Size (in.)	Casing	Casing CCI 2009	Carrier RJ	Carrier Conc.	Carrier Inst.	Avg. Carrier
12	24	**96**	**98**	$56	$17	$25	$62
15	30	**124**	**126**	NA	$20	$27	$76
18	30	**124**	**126**	$97	$24	$29	$90
21	36	**154**	**158**	NA	$31	$31	$103
24	36	**154**	**158**	$131	$36	$33	$116
30	42	**187**	**192**	$202	$51	$38	$165
36	48	**224**	**229**	$279	$77	$45	$223
42	54	**263**	**268**	$382	$86	$52	$286
48	60	**304**	**311**	$455	$123	$60	$349
54	72	**397**	**405**	$578	$168	$70	$443
60	72	**397**	**405**	$701	$220	$81	$542
66	84	**500**	**511**				$421
72	84	**500**	**511**	NA	$346	$109	$455
84	96	**615**	**628**	NA	$490	$146	$636
90	108	**741**	**757**				$745
96	108	**741**	**757**	NA	$658	$197	$855
108	120	**878**	**898**	NA	$853	$265	$1,118
120	144	**1,187**	**1213**	NA	$1,072	$357	$1,429

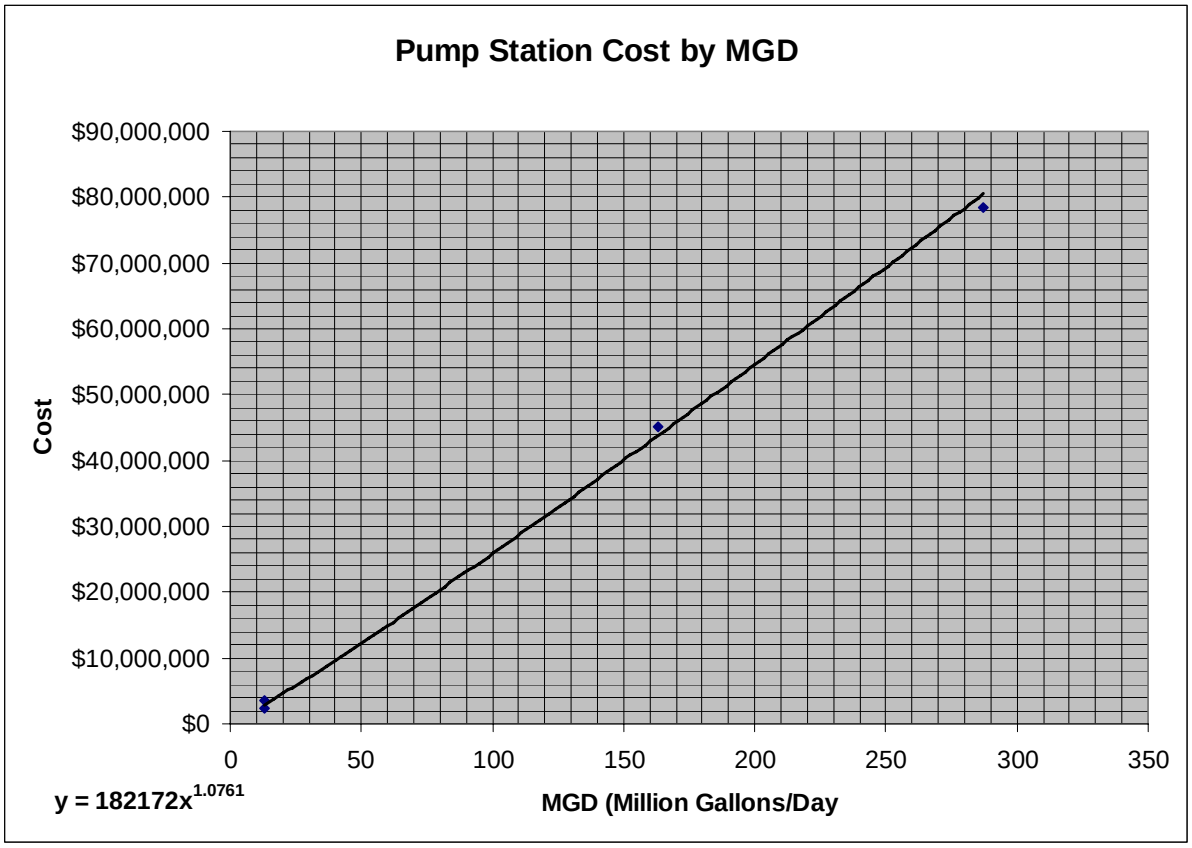
Estimate used Class V Concrete Only

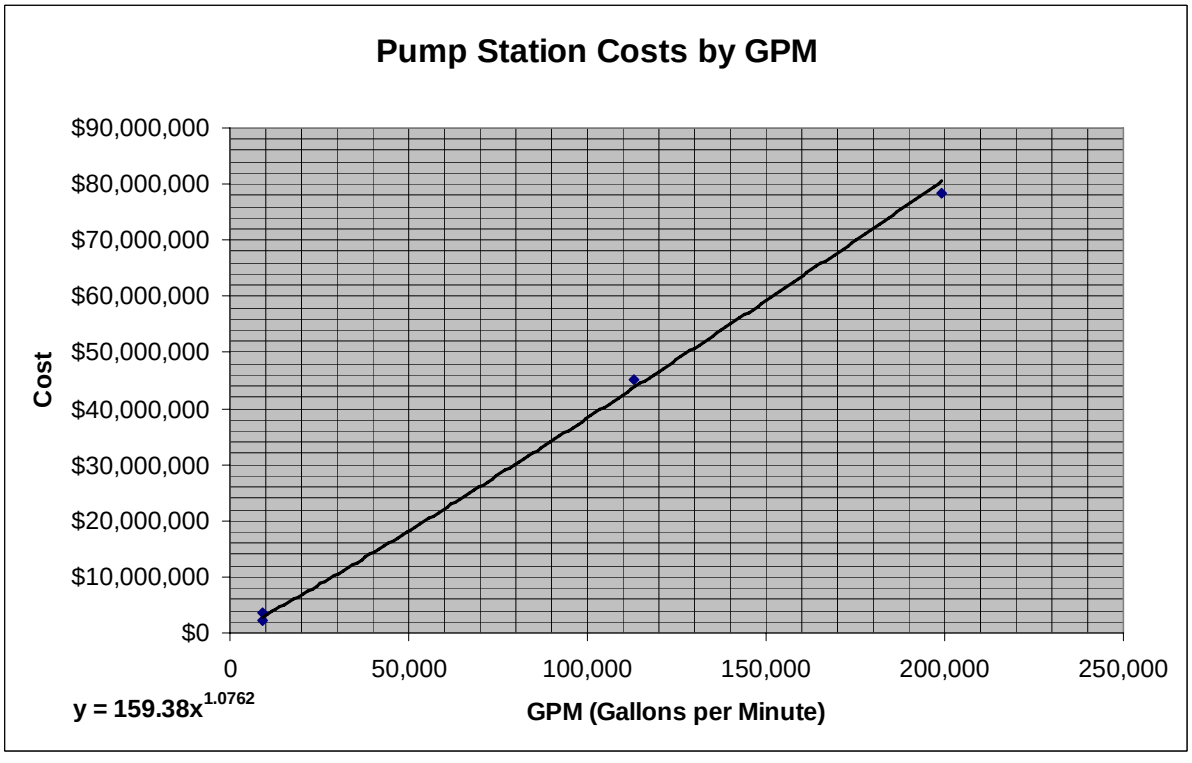
Basis for $/LF Calculations

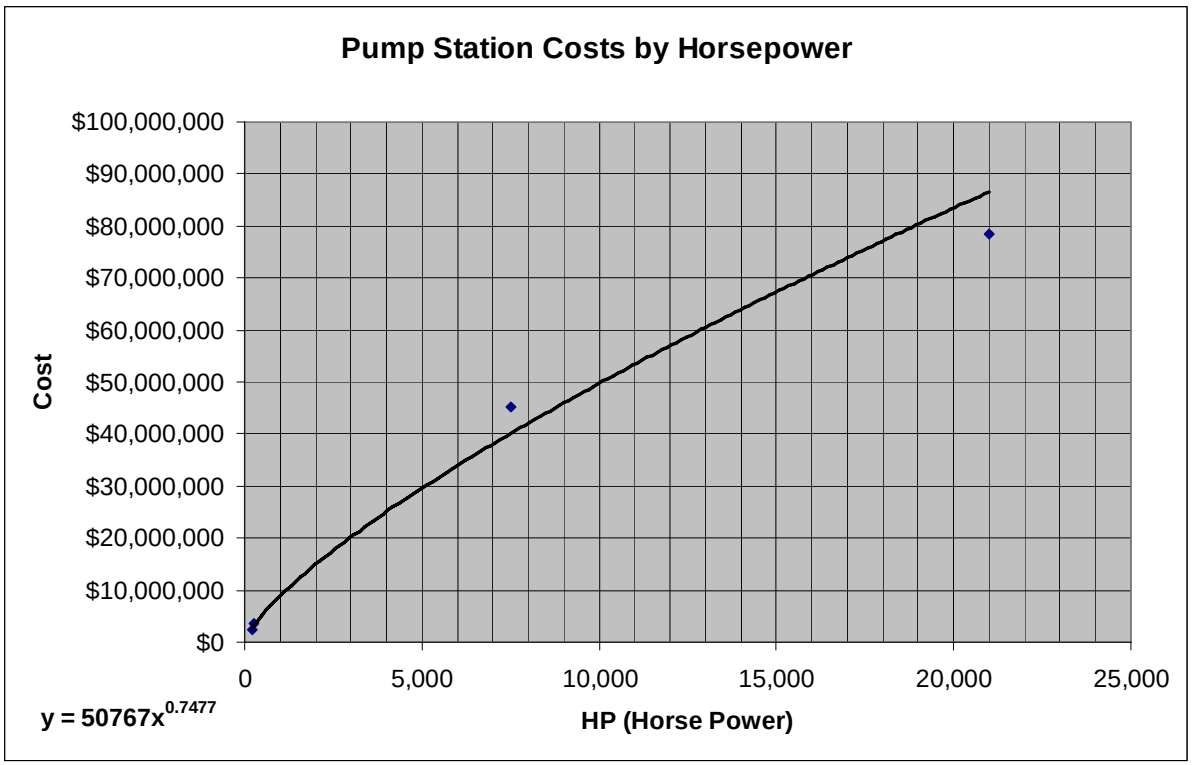
Tunnel Inside Dia (ft)	Milwaukee Washington Ave Tunnel	VSB	Brightwater	Milwaukee Northside	Tx Collider	Fermi
6		$2411				
8						$1914
9						
10						$2105
11						
12						$2425
13			$3938			
14						
15						
16						
18						
20	$5155			$3774		
21	$5417				$2248	
24	$4231					

APPENDIX H

Pump Station Costs & Curves


Pump Station Cost by MGD
$90,000,000
$80,000,000
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
Cost
0
50
100
150
200
250
300
350
MGD (Million Gallons/Day
y = 182172x1.0761


Pump Station Costs by GPM
$90,000,000
$80,000,000
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
Cost
0
50,000
100,000
150,000
200,000
250,000
GPM (Gallons per Minute)
y = 159.38x1.0762


Pump Station Costs by Horsepower
$100,000,000
$90,000,000
$80,000,000
$70,000,000
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
Cost
0
5,000
10,000
15,000
20,000
25,000
HP (Horse Power)
y = 50767x^0.7477

Pump Station Costs by MGD			Pump Station Costs by GPM	
Description	**Cost**		**Description**	**Cost**
Average	$41,697,942		Average	$43,713,017
25 MGD	$5,818,000		17,500 GPM	$587,200
50 MGD	$12,267,000		35,000 GPM	$12,381,000
75 MGD	$18,977,000		50,000 GPM	$18,175,000
100 MGD	$25,863,000		70,000 GPM	$26,105,000
125 MGD	$3,288,300		85,0000 GPM	$32,172,000
150 MGD	$40,011,000		100,000 GPM	$38,321,000
175 MGD	$47,230,000		120,000 GPM	$46,628,000
200 MGD	$54,528,000		140,000 GPM	$55,042,000
225 MGD	$61,896,000		160,000 GPM	$63,549,000
250 MGD	$69,327,000		175,000 GPM	$69,983,000
275 MGD	$76,815,000		190,000 GPM	$76,459,000
300 MGD	$84,355,000		210,000 GPM	$85,154,000

Note: Pump Station Costs using Olivenhain and San Vicente Pump Stations include the cost of surge facilities. These are construction costs only.

Pump Horse Power Data

No.	Date	Client (Agency)	Project Name	Project Description	Pump Size (hp)	Construction Bid	Final Contract Cost (including CO)	Escalated Cost	Unit Cost $/hp	Bid Items/Activities	
1	1/29/91	Water Authority - Spec 428	Raw Water Pump Station & Mod. to 1st SD Aqua.	(2) 80 bhp Raw Water Pump Station	200	$ 1,242,949	$ 1,265,945	$ 1,973,672	$ 9868	Pump Station, modifications to Escondido 2, Crossover PL connection	Completed Construction Cost
2	6/22/99	Water Authority - Spec 451	Pipeline 2A Pump Station and FCF aka Valley Center PS	(2) 125 HP Pump Station	250	$ 2,269,000	$ 2,372,089	$ 3,207,444	$ 12830	Pump Station	Completed Construction Cost
3	7/1/02	Water Authority - Spec 503	Olivenhain Pump Station and Olivenhain 8 FCF	(3) 2500 HP Pump Station	7500	$ 22,925,000	$ 29,381,400	$ 30,449,708	$ 4060	Pump Station	Completed Construction Cost
4	10/31/06	Water Authority - Spec 534	San Vicente Pump Station	(3) 7000 HP Pump Station	21000	$ 65,237,000	$ 68,498,850	$ 68,498,850	$3262	Pump Station	Low Bid

Pump Station Flow (MGD) Data

Project Name	Project Description	Capacity (MGD)	Construction Bid	Final Contract Cost (including CO)	Escalated Final Cost	Unit Cost $/MGD	Bid Items/Activities	
Escondido Raw Water Pump Station & Mod. to 1st SD Aqua.	(2) 80 bhp Raw Water Pump Station	13	$ 1,242,949	$ 1,265,945	$ 1,973,672	$152,289	Pump Station, modifications to Escondido 2, Crossover PL connection	Completed Construction Cost
Pipeline 2A Pump Station and FCF aka Valley Center PS	(2) 125 HP Pump Station	13	$ 2,269,000	$ 2,372,089	$ 3,207,444	$ 248,133	Pump Station	Completed Construction Cost
Olivenhain Pump Station and Olivenhain 8 FCF	(3) 2500 HP Pump Station	163	$ 22,925,000	$ 29,381,400	$ 30,449,708	$ 184,192	Pump Station	Completed Construction Cost
San Vicente Pump Station	(3) 7000 HP Pump Station	287	$ 65,237,000	$ 68,498,850	$ 68,498,850	$ 238,701	Pump Station	Low Bid

Comparison Costs for Pump Station Equipment

Project Name	Project Description	Pump Size (hp)	Equipment Cost	Cost + CO (typ 0%)	Escalated Cost	Unit Cost $/hp	Bid Items/Activities	
Olivenhain Pump Station Equipment Pre-Procurement	Pumps, VFD's, motors	7500	$ 3,686,700	$ 3,686,700	$ 5,009,487	$ 668	Pumps, VFD's, motors	Completed Construction Cost
San Vicente Pump Station Equipment Pre-Procurement	Pumps, VFD's, motors	14000	$ 7,241,263	$ 7,325,123	$ 7,325,123	$ 523	Pumps, VFD's, motors	Completed Construction Cost
Raw Water Pump Station & Mod. to 1st SD Aqua.	(2) 80 bhp Raw Water Pump Station	200	$ 51,111	$ 51,111	$ 79,684	$ 398	Pump Station, modifications to Escondido 2, Crossover PL connection	Completed Construction Cost
Pipeline 2A Pump Station and FCF aka Valley Center PS	(2) 125 HP Pump Station	250	$ 100,668	$ 100,668	$ 136,119	$ 544	Pump Station	Completed Construction Cost

Combined Cost and Equipment Costs

Project Name	Project Description	Capacity (MGD)	Construction Bid	Final Contract Cost (including CO)	Escalation %	Escalated Cost	Unit Cost $/MGD	Bid Items/Activities	
Escondido Raw Water Pump Station & Mod. to 1st SD Aqua.	(2) 80 bhp Raw Water Pump Station	13	$ 1,294,060	$ 1,317,056	173.712%	$ 2,287,884	176,534	Pump Station, modifications to Escondido 2, Crossover PL connection	Completed Construction Cost
Pipeline 2A Pump Station and FCF aka Valley Center PS	(2) 125 HP Pump Station	13	$ 2,369,668	$ 2,472,757	145.640%	$ 3,601,323	278,604	Pump Station	Completed Construction Cost
Olivenhain Pump Station and Olivenhain 8 FCF	(3) 2500 HP Pump Station	163	$ 26,611,700	$ 33,068,100	136.740%	$ 45,217,319	274,862	Pump Station	Completed Construction Cost
San Vicente Pump Station	(3) 7000 HP Pump Station	287	$ 72,478,263	$ 75,823,973	103.303%	$ 78,328,439	272,955	Pump Station	Low Bid

Pump Station Costs Evaluation Results

		Tabula 3 2008 Cost Estimate			*Tabula 2 2008 Cost Estimate*		
MGD	Historical Cost Prediction	Cost Estimate	Variance from Predicted Costs	Variance Percentage	Cost Estimate	Variance from Predicted Costs	Variance Percentage
0.5	N/A	$ 490,000.00	$ 490,000.00		$ 329,000.00	$ 329,000.00	
1	$ 1,140,000.00	$ 1,030,000.00	$ (110,000.00)	-11%	$ 573,000.00	$ (567,000.00)	-99%
5	$ 2,210,000.00	$ 2,410,000.00	$ 200,000.00	8%	$ 2,100,000.00	$ (110,000.00)	-5%
10	$ 4,750,000.00	$ 4,430,000.00	$ (320,000.00)	-7%	$ 3,620,000.00	$(1,130,000.00)	-31%
15	$ 5,700,000.00	$ 5,890,000.00	$ 190,000.00	3%	$ 4,910,000.00	$ (790,000.00)	-16%
20	$ 6,390,000.00	$ 6,850,000.00	$ 460,000.00	7%	$ 6,080,000.00	$ (310,000.00)	-5%
25	$ 7,550,000.00	$ 7,540,000.00	$ (10,000.00)	0%	$ 7,180,000.00	$ (370,000.00)	-5%
30	$ 8,640,000.00	$ 8,250,000.00	$ (390,000.00)	-5%	$ 8,220,000.00	$ (420,000.00)	-5%
35	$ 9,710,000.00	$ 9,130,000.00	$ (580,000.00)	-6%	$ 8,720,000.00	$ (990,000.00)	-11%
40	$10,800,000.00	$10,200,000.00	$ (600,000.00)	-6%	$ 9,710,000.00	$(1,090,000.00)	-11%
45	$11,900,000.00	$11,400,000.00	$ (500,000.00)	-4%	$10,700,000.00	$(1,200,000.00)	-11%
50	$13,200,000.00	$12,800,000.00	$ (400,000.00)	-3%	$11,900,000.00	$(1,300,000.00)	-11%
60	$16,000,000.00	$15,600,000.00	$ (400,000.00)	-3%	$14,500,000.00	$(1,500,000.00)	-10%
70	$19,600,000.00	$18,500,000.00	$(1,100,000.00)	-6%	$17,800,000.00	$(1,800,000.00)	-10%
75	$21,850,000.00	$20,000,000.00	$(1,850,000.00)	-9%	$19,800,000.00	$(2,050,000.00)	-10%
80	$24,100,000.00	$21,400,000.00	$(2,700,000.00)	-13%	$22,000,000.00	$(2,100,000.00)	-10%
100	$25,863,000.00	$27,200,000.00	$ 1,337,000.00	5%	N/A		
125	$32,883,000.00	$34,300,000.00	$ 1,417,000.00	4%	N/A		
150	$40,011,000.00	$41,600,000.00	$ 1,589,000.00	4%	N/A		
175	$47,230,000.00	$48,900,000.00	$ 1,670,000.00	3%	N/A		
200	$54,528,000.00	$56,200,000.00	$ 1,672,000.00	3%	N/A		
225	$61,896,000.00	$63,400,000.00	$ 1,504,000.00	2%	N/A		
250	$69,327,000.00	$70,600,000.00	$ 1,273,000.00	2%	N/A		
275	$76,815,000.00	$77,700,000.00	$ 885,000.00	1%	N/A		
300	$84,355,000.00	$84,800,000.00	$ 445,000.00	1%	N/A		
			Average Variance Percentage :	-1%		Average Variance Percentage :	-17%

APPENDIX I

Storage Facility Costs & Curves

No additional notes on this subject.

All assumptions are in section 5 of this TM.