TECHNICAL MEMORANDUM

MWH

Bend Oregon Collection System Master Plan
Preserving Bend's Water Environment

TM 3-6 – Cost Criteria

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INTRODUCTION

Project costs for capital projects identified in the Master Plan need to be specific to the City of Bend (City). This is due to many factors such as:

- Contractor availability
- Contractor expertise
- Unique geotechnical conditions
- Demand for pipe
- Materials cost
- Construction and development climate

The project costs that were developed for each project in the Master Plan are based on costs unique to construction in the City. All costs were developed in 2006 dollars based on an ENR Index of 8449. This Technical Memorandum (TM) summarizes the bases of all costs developed for projects identified in the Master Plan.

BASIS OF COSTS

Estimates of the capital and operations and maintenance costs associated with the preferred collection system and treatment alternatives were prepared and used during the evaluation process. All cost estimates prepared as a part of the planning effort are order-of-magnitude estimates as defined by the American Association of Cost Engineers (AACE). An order of magnitude estimate is one that is made without detailed engineering data, and uses techniques such as cost curves and scaling factors from similar projects. The overall expected level of accuracy of the cost estimates presented is +30 percent to -20 percent. This is consistent with the guidelines established by the AACE for planning level studies.

The project costs presented in this plan include estimated construction dollars, contingencies, permitting, legal, administration and engineering fees. Construction costs are based on the preliminary concepts and layouts of the collection system components developed in the master planning process. The estimated construction costs prepared at the planning level are intended to represent average bidding conditions for projects that are similar in nature. With this in mind, it is understood that variations in the bidding environment at the time of project implementation will likely affect actual construction costs. Although estimated costs have been adjusted to account for known conditions at this time, they are reflective of planning level efforts and will not be as accurate as costs developed during final design. For these reasons, construction costs will be lower or higher than estimated in this plan.

LOCAL CONTRACTOR INFORMATION

It is very important to obtain construction costs from local contractors to ensure that local factors and conditions are properly applied to the construction cost estimates. MWH provided the City with a template to gather construction costs from their local contractors. MWH received only one cost estimate. This information was used as the basis for the pipeline installation and rock excavation costs used in developing the cost estimates in the Master Plan. The completed cost

template is provided in ***Attachment B***. As mentioned earlier, the cost estimate accuracy is +30 percent to -20 percent.

COST DEVELOPMENT

The methodology for developing the costs for constructing new gravity sewers, upgrading the capacity of existing gravity sewers, constructing new force mains and for new pump stations and pump station capacity upgrades were developed. This methodology sums the cost for materials, installation, engineering and administration and to develop the project cost. In addition, a project contingency is applied to each project to cover the cost of unknowns that will be determined during detailed design of each alternative. The cost basis and methodology for each type of project is summarized in the following sections.

New Gravity Sewers

New gravity sewers will be constructed as part of each interceptor and in the currently undeveloped areas. The costs to construct the gravity sewers include the costs for pipe, manholes, installation and restoration of the surface of the excavated area back to its natural state. The basis for each of these cost elements is summarized in the following sections.

Pipe Material

The pipe material that was assumed for new gravity sewers was dependent on the size of the line. The pipe materials that were used in estimating costs are PVC and reinforced concrete pipe, depending on the required diameter.

Figure 1 – PVC Pipe

PVC pipe was used for all gravity sewers less than 15-inches in diameter. PVC pipe is made of polyvinyl chloride and is assembled in lengths up to 14-feet. The specification for the type of pipe that the cost estimate is based is SDR35 ASTM D-3034. A photo of this type of pipe is shown in ***Figure 1***. A manufactures brochure describing this type of pipe is provided in ***Attachment C***.

Reinforced concrete pipe (RCP) was assumed for all sewers 18-inches in diameter and over. The specifications for the type of pipe that the cost estimate is based are ASTM C76 Cl3. A photo of this type of pipe is shown in ***Figure 2***. A manufactures brochure describing this type of pipe is provided in ***Attachment D***.

Figure 2 – Reinforced Concrete Pipe

The reason that PVC pipe is used for the smaller diameter lines and RCP is used for the larger lines is

principally the required strength of the pipe. PVC pipe has a tendency to deflect, which requires additional bedding to compensate for the deflection. RCP pipe is very rigid and does not require the same attention to the bedding materials. In contrast, PVC pipe is very corrosion resistant and is easier to install because it comes in longer lengths and is much lighter and therefore easier to handle. For these reasons, the choice of pipe material by size was made. The unit pipe cost per lineal foot for each diameter as provided by a local Bend supplier is summarized in ***Table 1***.

Table 1
City of Bend Collection System Master Plan
Gravity Sewer Estimated Unit Construction Costs

No.	Description	Pipe Material ($/ft)	Installation ($/ft)	Surface Restoration			Total		
				Local ($/ft)	Arterial ($/ft)	Dirt/Gravel ($/ft)	Local St. ($/ft)	Arterial St. ($/ft)	Dirt/Gravel ($/ft)
8-inch Diameter									
1	0' - 10' deep	5.65	67.00	7.35	16.71	3.89	80.00	89.36	76.54
2	10' - 15' deep	5.65	85.00	7.35	16.71	3.89	98.00	107.36	94.54
3	15' - 20' deep	5.65	110.00	7.35	16.71	3.89	123.00	132.36	119.54
10-inch Diameter									
4	0' - 10' deep	8.85	70.00	7.35	16.71	3.89	86.20	95.56	82.74
5	10' - 15' deep	8.85	88.00	7.35	16.71	3.89	104.20	113.56	100.74
6	15' - 20' deep	8.85	113.00	7.35	16.71	3.89	129.20	138.56	125.74
12-inch Diameter									
7	0' - 10' deep	12.75	72.00	7.35	16.71	3.89	92.10	101.46	88.64
8	10' - 15' deep	12.75	90.00	7.35	16.71	3.89	110.10	119.46	106.64
9	15' - 20' deep	12.75	115.00	7.35	16.71	3.89	135.10	144.46	131.64
15-inch Diameter									
10	0' - 10' deep	18.80	77.00	7.88	17.90	4.17	103.68	113.70	99.97
11	10' - 15' deep	18.80	95.00	7.88	17.90	4.17	121.68	131.70	117.97
12	15' - 20' deep	18.80	120.00	7.88	17.90	4.17	146.68	156.70	142.97

Table 1 (cont)
City of Bend Collection System Master Plan
Gravity Sewer Estimated Unit Construction Costs

No.	Description	Pipe Material ($/ft)	Installation ($/ft)	Surface Restoration			Total		
				Local ($/ft)	Arterial ($/ft)	Dirt/Gravel ($/ft)	Local St. ($/ft)	Arterial St. ($/ft)	Dirt/Gravel ($/ft)
18-inch Diameter									
13	0' - 10' deep	17.00	87.00	8.40	19.09	4.44	112.40	123.09	108.44
14	10' - 15' deep	17.00	105.00	8.40	19.09	4.44	130.40	141.09	126.44
15	15' - 20' deep	17.00	130.00	8.40	19.09	4.44	155.40	166.09	151.44
16	20' - 25' deep	17.00	145.00	8.40	19.09	4.44	170.40	181.09	166.44
17	25' - 30' deep	17.00	160.00	8.40	19.09	4.44	185.40	196.09	181.44
21-inch Diameter									
18	0' - 10' deep	18.50	97.00	9.45	21.48	5.00	124.95	136.98	120.50
19	10' - 15' deep	18.50	115.00	9.45	21.48	5.00	142.95	154.98	138.50
20	15' - 20' deep	18.50	140.00	9.45	21.48	5.00	167.95	179.98	163.50
21	20' - 25' deep	18.50	155.00	9.45	21.48	5.00	182.95	194.98	178.50
22	25' - 30' deep	18.50	170.00	9.45	21.48	5.00	197.95	209.98	193.50
24-inch Diameter									
23	0' - 10' deep	22.00	107.00	9.45	21.48	5.00	138.45	150.48	134.00
24	10' - 15' deep	22.00	125.00	9.45	21.48	5.00	156.45	168.48	152.00
25	15' - 20' deep	22.00	150.00	9.45	21.48	5.00	181.45	193.48	177.00
26	20' - 25' deep	22.00	165.00	9.45	21.48	5.00	196.45	208.48	192.00
27	25' - 30' deep	22.00	180.00	9.45	21.48	5.00	211.45	223.48	207.00

Table 1 (cont)
City of Bend Collection System Master Plan
Gravity Sewer Estimated Unit Construction Costs

No.	Description	Pipe Material ($/ft)	Installation ($/ft)	Surface Restoration			Total		
				Local ($/ft)	Arterial ($/ft)	Dirt/Gravel ($/ft)	Local St. ($/ft)	Arterial St. ($/ft)	Dirt/Gravel ($/ft)
27-inch Diameter									
28	0' - 10' deep	35.00	135.00	11.00	25.00	6.00	181.00	195.00	176.00
29	10' - 15' deep	35.00	150.00	11.00	25.00	6.00	196.00	210.00	191.00
30	15' - 20' deep	35.00	180.00	11.00	25.00	6.00	226.00	240.00	221.00
31	20' - 25' deep	35.00	215.00	11.00	25.00	6.00	261.00	275.00	256.00
32	25' - 30' deep	35.00	250.00	11.00	25.00	6.00	296.00	310.00	291.00
30-inch Diameter									
33	0' - 10' deep	40.00	160.00	12.60	28.64	6.67	212.60	228.64	206.67
34	10' - 15' deep	40.00	175.00	12.60	28.64	6.67	227.60	243.64	221.67
35	15' - 20' deep	40.00	205.00	12.60	28.64	6.67	257.60	273.64	251.67
36	20' - 25' deep	40.00	215.00	12.60	28.64	6.67	267.60	283.64	261.67
37	25' - 30' deep	40.00	230.00	12.60	28.64	6.67	282.60	298.64	276.67
36-inch Diameter									
38	0' - 10' deep	46.00	190.00	14.18	32.22	7.50	250.18	268.22	243.50
39	10' - 15' deep	46.00	205.00	14.18	32.22	7.50	265.18	283.22	258.50
40	15' - 20' deep	46.00	235.00	14.18	32.22	7.50	295.18	313.22	288.50
41	20' - 25' deep	46.00	245.00	14.18	32.22	7.50	305.18	323.22	298.50
42	25' - 30' deep	46.00	265.00	14.18	32.22	7.50	325.18	343.22	318.50

Table 1 (cont)
City of Bend Collection System Master Plan
Gravity Sewer Estimated Unit Construction Costs

No.	Description	Pipe Material ($/ft)	Installation ($/ft)	Surface Restoration			Total		
				Local ($/ft)	Arterial ($/ft)	Dirt/Gravel ($/ft)	Local St. ($/ft)	Arterial St. ($/ft)	Dirt/Gravel ($/ft)
42-inch Diameter									
43	0' - 10' deep	57.00	220.00	15.75	35.80	8.33	292.75	312.80	285.33
44	10' - 15' deep	57.00	235.00	15.75	35.80	8.33	307.75	327.80	300.33
45	15' - 20' deep	57.00	265.00	15.75	35.80	8.33	337.75	357.80	330.33
46	20' - 25' deep	57.00	275.00	15.75	35.80	8.33	347.75	367.80	340.33
47	25' - 30' deep	57.00	300.00	15.75	35.80	8.33	372.75	392.80	365.33
48-inch Diameter									
48	0' - 10' deep	72.00	250.00	15.75	35.80	8.33	337.75	357.80	330.33
49	10' - 15' deep	72.00	265.00	15.75	35.80	8.33	352.75	372.80	345.33
50	15' - 20' deep	72.00	300.00	15.75	35.80	8.33	387.75	407.80	380.33
51	20' - 25' deep	72.00	325.00	15.75	35.80	8.33	412.75	432.80	405.33
52	25' - 30' deep	72.00	350.00	15.75	35.80	8.33	437.75	457.80	430.33

Installation Cost

The installation cost includes the costs for excavation, pipe bedding, pipe placement, backfill and compaction. As the depth of excavation and the trench width increase for deeper and larger pipes, the costs increase. Therefore, a specific cost has been identified for each pipe diameter for each pipe depth. These costs are based on the information provide to the City by a local contractor. The unit installation costs on a lineal foot basis are summarized in ***Table 1***.

Surface Restoration

The contractor is required to restore the surface where the construction occurred to complete the project. Three surface types were identified to provide costs to. These are dirt/gravel, local streets and arterials. The dirt/gravel restoration quantity will be used for gravel roads or cross country construction. Local streets are neighborhood streets that are not required to carry heavy truck traffic. On the local streets, a 3-inch layer of asphalt is assumed. Arterials are the main roads that will be used for sewer rights-of-ways. An 8-inch layer of asphalt is assumed for these streets.

As with the installation costs, the surface restoration costs will increase with the size of pipe due to the larger trench that will need to be excavated. Therefore, a unit surface restoration cost has been used for each pipe diameter and surface type. The unit surface restoration costs on a lineal foot basis are summarized in ***Table 1***.

Manholes

Manholes are assumed to be located at a maximum spacing of 400-feet and at every change in the direction of sewer. The manhole costs include the cost for the base, frame, standard cover and installation. The manhole material costs that were used are shown in **Table 2**. The manhole installation costs that were provided to the City by a local contractor are shown in **Table 3**.

Table 2
Manhole Material Costs ($)

Manhole Component	Manhole Diameter		
	48"	60"	72"
Base	285	550	600
Riser/ft	70	200	200
Cone	210	550	600
Frame & Cover	245	245	245

Table 3
Manhole Installation Costs ($)

Depth	Manhole Diameter		
	48"	60"	72"
0 to 10'	1,440	3,345	3,445
10 to 15'	1,790	4,345	4,445
15 to 20'	2,140	5,345	5,445
20 to 25'	2,490	6,345	6,445
25 to 30'	2,840	7,345	7,445

The manhole material cost and installation costs were then determined for each manhole diameter and depth combination. No restoration cost was included as this cost is included as a

separate cost by lineal foot (LF) of line. The total estimated costs for each manhole based on size and depth is summarized in ***Table 4***.

Table 4
City of Bend Collection System Master Plan
Manhole Construction Costs
($ per Manhole)

Manholes	Materials	Installation	Restoration	Total
48-inch Manhole				
0' - 10' deep	1,440	2,200	0	3,640
10' - 15' deep	1,790	3,200	0	4,990
15' - 20' deep	2,140	4,600	0	6,740
20' - 25' deep	2,490	5,600	0	8,090
25' - 30' deep	2,840	6,600	0	9,440
60-inch Manhole				
0' - 10' deep	3,345	5,000	0	8,345
10' - 15' deep	4,345	6,500	0	10,845
15' - 20' deep	5,345	8,000	0	13,345
20' - 25' deep	6,345	9,500	0	15,845
25' - 30' deep	7,345	11,000	0	18,345
72-inch Manhole				
0' - 10' deep	3,445	10,000	0	13,445
10' - 15' deep	4,445	12,500	0	16,945
15' - 20' deep	5,445	15,000	0	20,445
20' - 25' deep	6,445	18,000	0	24,445
25' - 30' deep	7,445	21,000	0	28,445

Canal Crossings

The irrigation canal system runs throughout the City and must be crossed many times. It is assumed that the canal crossing can be done during the winter season when the canals are not in operation. This will minimize the construction cost as the construction can be done using open cut construction instead of boring under the canal. Cutting through the canal will require additional restoration to reconstruct the canal where the excavation was made. A cost of $250 per LF was assumed for each canal crossing. The length of each canal crossing was assumed to be 200-feet.

Railroad and Highway Undercrossings

Construction can be done on major streets with proper traffic control. This will present disruptions to the areas local to the construction. It was assumed that open cuts could not be made at crossings of Highway 97 and Highway 20. It was assumed that the pipelines would be bored under these major highways so that the traffic would not be disrupted. A cost of $1,000 per LF was assumed for each highway crossing. The length of each highway crossing was assumed to be 250-feet.

Erosion Control

Erosion control is required by the State of Oregon on all projects. This cost may be minimized in the Bend area due to the low rainfall and lack of drainage areas. The cost of erosion control was still added to each project at a cost of $4.00 per LF of constructed sewer.

Siphon Structures

Two siphon structures are required on the Plant Interceptor, one on each side of the canal. It has been assumed in this work that a new structure will be constructed next to each existing structure and tied in to provide the flexibility for using any combination of the siphons. A lump sum cost of $150,000 was estimated for the construction of each siphon box.

Traffic Control

Traffic control will be required for all construction projects. The cost and level of effort for traffic control is based on the time required to do construct the project. The cost for traffic control was based on two flaggers at $35 per hour for the estimated number of days that it would take to construct the project. The estimated number of days was based on a production rate based on the size of the line and the complexity of the construction. The cost for traffic control has been separately itemized for each project.

Easements

Most of the new sewers will be constructed on public rights-of-way. In these situations, there is no requirement for easements. There are some areas that easements will be required for the new interceptors. In these situations, an easement unit cost of $10.00 per LF was assumed. This value was determined by using a cost for easements of 5-percent of the property value and a property value of $500,000 per acre.

Gravity Sewer Capacity Upgrades

The Master Plan has identified a number of gravity sewers that are currently beyond their design capacity and many that will reach their capacity as the City continues to grow. The capacity of these sewers will need to be increased by replacing the existing sewer with one of a larger diameter to provide the required capacity. A number of assumptions were made to develop a cost estimate for upgrading the capacity of existing sewers through replacement with a larger line. These include:

- Each pipeline will be enlarged to a designated pipe diameter as determined by system modeling for build-out flow
- All lines are located in paved public streets - arterials
- Replacements will be done by cut-and-cover methods
- All replacements will require traffic control
- Existing backfill will not be reused
- Lines < 15" will be PVC, lines 18" and larger will be RCP
- Current flows will be handled by bypass pumping for all lines

- Service reconnection assumed 2 connections per 100 ft of sewer line

The materials and installation costs were assumed to be the same for replacement and capacity upgrades of existing sewers as those for new sewers. Therefore, the costs for materials and installation of capacity upgrades are also provided in ***Table 1***. In addition to those costs, there will be a cost for bypass pumping and reconnection of sewer laterals. The basis for these costs is defined in the following sections.

Bypass Pumping

The sewers with capacity deficiencies will need to continue to pass flow while they are being upsized. It has been assumed that each capacity upgrade will be done on the same alignment as the existing sewer. This will require the pumping of flow from the upstream to the downstream manholes while construction is being done on each line segment. This bypass pumping must be done in a manner that will provide no spillage of wastewater during the operation.

The project team obtained the costs of pumps, hoses and diesel generators for use in the Bend area. These costs were then factored into an average production rate for the upsizing of these sewers. This resulted in an average cost of $11.60 per foot for bypass pumping. This cost was applied to each sewer capacity upgrade project as a lump sum cost.

Reconnection

The replacement of sewers will require the termination of lateral connections and reconnecting each lateral following the placement of the larger pipe. An estimated cost of $1000 was assumed for handling each sewer lateral during construction. The number of sewer laterals was assumed to be two per 100-feet of sewer. This assumption was based on that assumption that the average lot was 100-feet wide. This cost was applied to each sewer capacity upgrade project as a lump sum cost.

Pressure Sewer

Pressure sewers are required for pump station force mains. The Master Plan includes the need to replace existing force mains that are undersized and for constructing new force mains for new pump stations. The cost for the installation of force mains was done using the same installation costs that was used for 0 to 10-foot deep gravity sewers. PVC pipe was assumed to be the material of choice for all pressure sewers.

Pipe Material

The PVC pipe that the force mains (pressure sewers) were estimated around was based on the ASTM specification D2241. This pipe is designed for sanitary sewer service. The pressure rating of the pipe and the surge requirements need to be considered during design and the specific pipe with the proper pressure rating needs to be specified. The costs for PVC

pressure pipe were obtained from a pipe supplier located in the City. The pipe costs used to estimate force main costs are summarized in ***Table 5.***

Table 5
Force Main Costs

PVC
6" - $6.00/ft
8" - $7.87/ft
10" – 12.34/ft
12" – 17.72/ft
15" – 26.33/ft
18" – 41.78/ft

Engineering, Administration & Legal

Engineering, administration and legal costs are those costs required to design, permit, and provide construction management and administration of the project. These costs have been broken down into two categories, engineering and administration.

The engineering costs include design, surveying and construction management for the project. Engineering will cost more on a more complex project requiring canal crossings, highway crossing, utility confirmation and special planning for traffic control. The typical engineering cost for a planning effort such as this is 25% of the construction cost. This factor was applied to this project for all new construction.

The engineering for smaller upgrade and replacement projects will be less due to better knowledge of the construction conditions and utilities, if proper record drawings are available. On these projects, the line grade has been established requiring less design. For sewer capacity upgrade projects, an engineering cost of 15% of the construction cost was used.

The administration and legal costs are those associated with the City providing oversight of the contract. These costs were estimated at 10% of the construction cost.

Contingency

At the planning level of an engineering project, a contingency must be applied to cover the cost of uncertainties in the estimate. These uncertainties include unknown details of the project not covered in the unit costs, changes in site conditions and variability in the bidding climate. For the estimated costs developed in this Master Plan, a contingency of 30% has been applied on the sum of the estimated construction and engineering costs.

Pump Stations

The methodology for estimating the cost of new pump stations and pump station upgrades was done using a similar methodology. A pump station cost estimating worksheet is shown in ***Table 6***.

The first step in developing the pump station cost estimate is to determine the major mechanical components for the pump station. A preliminary sizing of these components was done and a cost estimate of the purchase price for the equipment item was obtained from the manufacturer. The costs for new and replacement pumps were based on Flygt pumps. A 30% mechanical installation factor was then added to the total equipment cost.

The second step is to determine the cost of any structure. This item will consist of wet wells, dry wells and buildings. The major structural elements are itemized by component and a unit

Table 6
New Pump Station Cost Estimates
Drake Pump Station

No.	Cost Category	Quantity	Unit Cost	Total Cost	Comments
	Equipment				
1	Pumps to 450-gpm	2	$ 11,490	$ 22,980	Flygt NP3153.091-463, 20hp, 4" Volute
2	Standby Generator Set	1	$ 30,000	$ 30,000	Estimate
3	Odor Control System	1	$ 20,000	$ 20,000	Estimate
4				$ -	
	Equipment Subtotal			$ 72,980	
	Mechanical				
	Mechanical Installation	30%		$ 21,894	Percent of Material Cost
	Mechanical Subtotal			$ 94,874	
	Structures				
1	60" x 15' Manhole	1.0	$ 3,765	$ 3,765	Quote from Hanson Pipe & Products
2	Pump Station slab, yd3	0.9	$ 450	$ 405	10" thickness
3	Manhole Cover	1.0	$ 1,000	$ 1000	
	Structures Subtotal			$ 5,070	
	Yard Piping				
1					
	Yard Piping Subtotal			$ -	
	Other Appurtances				
1	Excavation, yd3	11	$ 15.00	$ 165	Contractor Provided Cost
2					
	Other Appurtances Subtotal			$ 165	
	Accumulated Subtotal			**$ 100,109**	
	Specialties				
	Demolition	-		$ 30,000	Estimate
	Site Work	2%		$ 2,002	Percent of Accumulated Subtotal
	General Conditions	5%		$ 5,005	Percent of Accumulated Subtotal
	Finishes	1.5%		$ 1,502	Percent of Accumulated Subtotal
	Electrical/I&C	16%		$ 16,017	Percent of Accumulated Subtotal
	Mechanical	9%		$ 9,010	Percent of Accumulated Subtotal
	Contract Management				
	Accumulated Subtotal			$ 163,646	
	Mobilization, Legal, Adm	5%		$ 8,182	Percent of Accumulated Subtotal
	Accumulated Subtotal			$ 171,828	
	Contingency	30%		$ 51,548	Percent of Accumulated Subtotal
	Accumulated Subtotal			$ 223,376	
	Engr/Legal/Admin	25%		$ 55,844	Percent of Accumulated Subtotal
	Accumulated Subtotal			$ 279,220	
	Construction Difficulty Factor	30%		$ 83,766	Percent of Accumulated Subtotal
	Total Estimated Project Cost			$ 362,986	

cost for the type of structure is applied. The estimated cost for all of the structural components is then added together for the total estimated structural cost.

The third step is to determine the cost of yard piping. This item consists of lines between tankage, valves and other associated equipment. The estimated cost for all of the yard piping is then added together for the total estimated yard piping cost.

The fourth step is to determine the cost of any other appurtances or specialty items. In the example in Table 5, the cost for excavation is included in this category. This category can include special mitigation requirements, flow meters, fencing and other such items. The estimated cost for all of the other appurtances is added together for the total estimated other appurtances cost.

The fifth step is to total the estimated costs of equipment, mechanical installation, structural and other appurtances. This total becomes the accumulated total. This accumulated total is used as the value to determine the cost of specialties. The specialties consist of the following project components:

- Demolition – The cost to demolish existing facilities. This cost includes the labor and expenses for demolition. An estimate of the demolition cost was included based on the size of the estimated size of the project and the potential salvage value of the facilities being removed from services.
- Site Work – The cost to develop the site. This includes site preparation, stormwater management facilities, etc. A percentage of 2% of the accumulated cost was applied to the project for site work.
- General Conditions – This is the cost for the contractor to perform those items identified in the general conditions of the contract. This will include: manufacturers O&M manuals, warranties, project scheduling and management. A percentage of 5% of the accumulated cost was applied to the project for general conditions.
- Finishes – This is the cost for painting and protective coatings of concrete and exposed metals. A percentage of 1.5% of the accumulated cost was applied to the project for finishes.
- Electrical/I&C – This is the cost for providing electrical, instrumentation and control (I&C) for the project. This will include the cost for motor control centers, SCADA, communications and wiring of the electrical components. A percentage of 9% of the accumulated cost was applied to the project for electrical and I&C.
- Mechanical – This mechanical cost is the cost for heating, ventilation and air conditioning components for the project. A percentage of 9% of the accumulated cost was applied to the project for mechanical systems.

The sum of the specialties is then added to the accumulated total to arrive at the total cost of construction. This value is then multiplied by a specific percentage for each of the contract management components of the project and then totaled. These include:

- Contractor Mobilization, Legal & Administration – This consists of the contractor's costs for project mobilization and contract administration. A percentage of 5% of the

accumulated subtotal is applied to this component. The estimated project cost is then subtotaled to include this cost.

- Contingency – In this cost estimate, the project contingency is added to the project at a rate of 30% of the project accumulated subtotal. The estimated project cost is then subtotaled to include this cost.
- Engineering/Legal/Administration – This project component includes the cost of engineering, legal and project administration for the owner. A percentage of 25% was applied to the project for this component. The estimated project cost is then subtotaled to include this cost.
- Construction Difficulty Factor – Many projects will have a higher cost due to the difficulty of construction. This difficulty factor can be based on providing temporary services, maintaining systems in operation during construction and confined construction activities. Each of these variables will make construction more difficult and will require coordinated scheduling of the project construction. This will result in a longer construction period, resulting in additional project costs. The construction difficulty factor provides the estimated additional cost that is a result of these project variables. A construction difficulty factor can range from 0% for a Greenfield project to 40% for a very confined project that requires a large amount of construction sequencing. In the example of the Drake Pump Station replacement project shown in ***Table 6***, a Construction Difficulty Factor of 30% was added to the project. The estimated project cost is then totaled to get the cost of the project.

The project cost is the cost used in the budget and/or Capital Improvement Plan (CIP) by the City. The project cost has been developed in 2006 dollars. Therefore, this cost needs to be increased by inflation in future years beyond 2006.

Project Cost

The project cost is the sum of each of the cost elements plus the cost of engineering and administration and contingencies. A worksheet was used to develop the costs for each of the projects in the Master Plan. An example of the worksheet is shown in ***Table 7*** for the project cost estimate for the North Interceptor.

The project cost is developed by dividing the project into components based on gravity sewer size. In addition, the additional components are included such as pump stations, canal crossings, highway crossings, erosion control and traffic control. The appropriate unit costs are applied to each component and summed. This sum is the estimated construction cost.

To obtain the estimated project cost, the engineering, administration and contingency costs must be added. The engineering and administration cost at 25% of the construction cost is calculated for each component. The contingency of 30% is then added to the sum of the construction and engineering/administration cost. The total estimated project cost is then calculated by calculating the sum of the estimated construction cost, engineering/administration cost and contingency.

Table 7
2006 Collection System Master Plan
North Interceptor Cost Estimate

Project Element	Diam	Total Length	Construction Cost					Allowances		Project Total
			Pipe Material	Installation	Manholes	Restoration	Easements	Engr/Admin	Contingency	
	(in)	(ft)	($)	($)	($)	($)	($)	($)	($)	($)
Plant Interceptor to Hwy 97	48	12,405	893,200	3,441,800	560,700	124,100	0	1,757,000	2,033,000	8,809,800
Juniper Ridge to Hwy 97	42	2,605	148,500	630,500	74,400	26,100	0	307,900	356,200	1,543,600
Hwy 97 to the Deschutes River	30	14,495	573,600	2,677,500	201,100	138,200	143,400	1,306,900	1,512,200	6,552,900
Deschutes River to Shevlin Park										
27" Segment	27	1,605	56,200	216,700	14,600	17,700	16,100	112,400	130,100	563,800
15" Segment	15	10,455	196,600	788,300	101,800	82,400	104,600	445,800	515,900	2,235,400
10" Segment	10	1,110	9,800	77,700	10,100	8,200	11,100	40,900	47,300	205,100
8" Segment	8	10,640	60,100	810,600	114,900	78,200	106,400	409,600	473,900	2,053,700
Deschutes River Force Main	15	1,610	42,400	115,900				55,400	64,100	277,800
North Interceptor Pump Station				1,226,400						1,226,400
Canal Crossings (3)		300		225,000				78,800	91,100	394,900
Traffic Control/Management		1 EA		50,000				17,500	20,300	87,800
Erosion Control		1 EA		212,640				74,500	86,100	373,200
Hwy 97 and Hwy 20 Bores		250		250,000				87,500	101,300	438,800
Railroad Undercrossing		150		150,000				52,500	60,800	263,300
										25,027,000

NOTES:
1. Construction Costs based on ENR-CCI of 8449
2. Allowances for engineering, administration and contingencies are 25%, 10% and 30% respectively
3. Assumed manhole spacing at an average of 400 ft.
4. Assumed North Trunk Junction to Hwy 97 restoration as native cover
5. Assumed Hwy 97 to Deschutes River restoration as half local street and half as native
6. Assumed 72" manholes for the 48" section, 60" manholes for the 42" and 48" manholes for the remainder.
7. Assumed no easement costs through Juniper Ridge
8. North Interceptor Pump Station - 4400-gpm, 6.3-mgd
9. Deschutes River crossing force main (1610+/- feet); Pipeline on bridge

PRESENT WORTH ANALYSIS

The present worth analysis is used to compare various project alternatives that occur independently over time. An example of the analysis used in the Master Plan was the evaluation of the continued operation of a pump station compared to the construction of a gravity sewer to remove the station from service. The present worth analysis determines the comparable amount of monies that are required today to pay for operation and maintenance (O&M) and capital projects over a designated period of time. In the analysis performed for this study, a present worth analysis for a 20-year and a 50-year period was done. The 20-year period is a good period for evaluating mechanical equipment. The 50-year period is a good period for the evaluation of long-life assets, such as a gravity sewer. The shorter life mechanical equipment is replaced at 20-year operating intervals in the 50-year analysis. The costs and methodology used in developing the present worth of the various project alternatives is summarized in the following sections.

O&M Costs

Operation and Maintenance (O&M) costs are based on the estimated manpower needs, resource requirements and equipment replacement and maintenance costs over the period of the analysis. O&M costs in this analysis were based on the current costs in the 2005–2006 operating budget. A copy of the 2005 – 2006 operating budget for the collection system and pump stations is provided in ***Attachment E***.

The costs for maintenance of the sewer lines were developed as a unit cost per 1,000 LF based on the budget. The City had 349,349 LF of force main and 1,565,913 LF of gravity sewer, totaling of 1,915,317 LF of sewer as of May 2005. During this time period, the City maintained 86 pump stations. The 2005-2006 operating budget for the O&M of the sewer lines and pump stations was $1,903,141. This budget is itemized in ***Table 8***.

Table 8
City of Bend
2005-2006 Collection System O&M Budget

Object	Sewer Lines	Pump Stations
Labor Expense	$ 417,420	$ 402,521
Material and Services	$ 224,400	$ 152,500
Electricity	$ -	$ 86,300
Odor Control	$ -	$ 110,000
Capital	$ 200,000	$ 270,000
Vehicle & Communication Replacement	$ 20,000	$ 20,000
Total	**$ 861,820**	**$ 1,041,321**
Total Minus Electricity & Odor Control	$ 861,820	$ 845,021
Total Minus Elec, Odor Control & Capital	-	$ 710,021

Using this 2005-2006 budget for O&M of the sewer lines (assuming both gravity and pressure) the annual cost to maintain the 1,915,317 LF of sewer is $449.96 per 1000-LF. The same calculation was done to determine the average annual cost for operating and maintaining each

pump station. The cost for electricity and odor control were subtracted from the O&M cost prior to performing the calculation so the calculated average annual O&M cost per pump station ($8,256.06) does not include those costs. This was done because these costs are only for the current flows. As the system flows increase, the cost for electricity and odor control (chemicals) will increase proportionally. These cost increases are added into the operating cost on an annual basis in the present worth analysis.

Present Worth Development

Economic evaluations of the alternatives presented in this plan are based in part on comparison of their estimated present worth (PW). An alternative's PW is an estimate of the dollar value that would need to be invested in year zero, given an appropriate interest rate, in order to finance all capital and O&M costs that will be incurred over the planning period. Although all of the alternatives are assumed to have the same useful life over the planning period, they will each have different capital and O&M cost requirements. Determination of their PW is a way to compare them on an equivalent basis.

Given estimates of project capital costs and O&M costs, the associated NPW is calculated by the equation:

$$NPW = PW_c + PW_{O\&M}$$

Where: PW_c = present worth of capital costs
$PW_{O\&M}$ = present worth of O&M costs incurred over the 20 or 50-year planning period
NPW = Net Present Worth

A variety of cost components are required to develop the present worth of a specific project alternative. The components and the value used in this analysis are:

- PW Discount Rate - The discount rate (cost of money) used to bring annual O&M costs and future capital costs back to their net present worth value was 3% per year. This represents the assumed rate used to finance the alternatives minus the rate of inflation.
- Power Escalation Rate – The power escalation rate used in this analysis is 5% per year. A power escalation rate that is higher than the PW Discount Rate was used because the cost of power is projected to increase at a higher rate than inflation.
- O&M Escalation Rate – The O&M escalation rate is the rate of increase for operation and maintenance activities. This has increased at a greater rate than inflation over the past few years due to the higher than normal increases in medical programs and state retirement programs. A conservative rate of 3% per year was used in this analysis.
- Power Cost – A power cost of $0.065 per kW-hr was used in this analysis. This is slightly higher than the current rate, but is comparable to the current rate when demand charges, excess transmission charges and other miscellaneous charges are added to the power cost.
- Bioxide Cost – The chemical used for odor control is bioxide. This is a form of nitrate that provides oxygen to the wastewater, minimizing septicity. It was assumed that 50

gallons of bioxide would be used per million gallons of wastewater pumped at a cost of $1.25 per gallon.

- Service Area Growth Rate – A service area growth rate was incorporated into the analysis to provide an increase in flow rate. The growth rate was adjusted in each analysis to provide growth so that build-out of the service area would occur no later than 2035.
- Replacement Costs – The replacement costs are the costs to replace the pump station pumps. The replacement costs were obtained from Flygt pumps based on a comparable pump based on flow and TDH. The pumps were replaced every 20-years in the analysis beginning in 2025. For this analysis, all existing pumps were assumed in new condition and to last to 2025.
- Capital Costs – The capital costs were the estimated costs to construct a new gravity sewer that would allow for the pump station to be removed from service. This cost also included the cost to decommission and remove the existing pump station. It was assumed that the capital project would occur in 2015 in each analysis.

The present worth was then calculated for two scenarios. The first scenario was for continued operation of the pump station and the second was for removing the station from service. This analysis was done using an Excel worksheet. The analysis for each scenario was done for removal of the Boyd Acres Pump Station in the example provided in ***Attachment F***.

In the Boyd Acres Pump Station present value analysis, the continued operation of the pump station was compared with the removal of the station by constructing a 460-foot, 8-inch gravity sewer. This analysis determined that this project was cost-effective in a 20-year horizon. The present value of continued operation of the station was $203,617 and $497,487 for the 20-year and 50-year periods, respectively. The present value for replacement of the pump station with a gravity sewer was $180,872 and $187,081 for the 20-year and 50-year periods, respectively. This shows that the construction of the gravity sewer can save over $300,000 over a 50-year period.

Attachment A
Cost Estimate Template

Insert Cost Estimate Template

Attachment B
Bend Contractor Cost Estimate

Insert JRS Cost Estimate

Attachment C
PVC Pipe Information

Insert PVC Pipe Information

Attachment D
Reinforced Concrete Pipe Information

Insert RCP Pipe Information

Attachment E
City of Bend
Wastewater Division
Collection System & Pump Station
2005 – 2006 Operating Budget

Insert 2005 – 2006 Operating Budget

Attachment F
Boyd Acres Present Value Analysis Worksheets

Insert Boyd Acres PV Analysis