APPENDIX R
COST ESTIMATES

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APPENDIX R

COST ESTIMATES

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Introduction

The evaluation of water management strategies requires the development of cost estimates. The strategy evaluations contained in this regional plan represent preliminary overviews and should not be considered as detailed feasibility analyses. Due to the forward looking nature of these types of planning efforts, the cost estimates in this plan do not necessarily represent what actual costs may be to design, build, or operate water supply systems. Project specific analyses should be developed at the time a project is undertaken to establish a more accurate estimate.

Costs for pipelines, pump stations and water treatment facilities are based on standard unit costs that include contractors' mobilization, overhead and profit. The unit costs do not include engineering, contingency, financial and legal services, costs for land and rights-of-way, permits, environmental and archeological studies, or mitigation, all of which are added separately. Previous cost estimates were used when available.

The cost estimates include two components:

- Initial capital costs, including engineering and construction costs, and
- Average annual costs, including annual operation and maintenance costs, water purchase costs, and debt service.

Table R-1 is an example of the preferred format for capital costs.

Costs for Conveyance Systems

Conveyance systems include pipelines, pump stations, intake and outlet structures for delivering raw or treated water from one location to another.

Table R-1
Example of Preferred Cost Estimate Format

Construction Costs					
Well Field Facilities	**Size**	**Quantity**	**Unit**	**Unit Price**	**Cost**
Water Wells		12	LS	$50,000	$600,000
Transmission to Pump Station	10 in.	120,000	LF	$28	$3,360,000
					$3,960,000
Engineering and Contingencies (30%)					$1,188,000
Subtotal for Well Field Facilities					**$5,148,000**
Transmission Facilities	**Size**	**Quantity**	**Unit**	**Unit Price**	**Cost**
Pipeline	30 in.	368,860	LF	$74	$27,296,000
Right of way easements (ROW)		368,860	LF	$1	$369,000
Storage Tank at High Point	4 MG	1	LS	$746,000	$746,000
					$28,411,000
Engineering and Contingencies (30%)					$8,523,000
Subtotal for Pipeline					**$36,934,000**
	Size	**Quantity**	**Unit**	**Unit Price**	**Cost**
Pump Station at Well Field	1100 HP	1	LS	$2,510,000	$2,510,000
Storage Tank at Well Field	4 MG	1	LS	$746,000	$746,000
Booster Station	1100 HP	1	LS	$2,510,000	$2,510,000
Storage Tank at Booster Station	4 MG	1	LS	$746,000	$746,000
					$6,512,000
Engineering and Contingencies (35%)					$2,279,200

Table R-1, Continued					
Subtotal for Pump Stations					**$8,791,200**
Environmental and Archeological Studies		**Quantity**	**Unit**	**Unit Price**	**Cost**
		368,860	LF	$0.60	$221,000
Construction Total					**$50,873,200**
Interest During Construction					$3,978,000
Total Cost					**$54,851,200**
Annual Costs					
Debt Service					$3,984,880
Electricity					$1,645,000
Operation and Maintenance					$487,000
Total Annual Costs					**$6,116,880**
Unit Costs					
Per Acre-Foot					**$910**
Per 1000 gallons					**$2.79**

Determination of Pipe Size

1. First, lay out the route of the pipeline on a topographic map. Considerations in selecting a route include:

   - The shortest route is usually the best route. Draw a line between the source and the point of use and follow that line as closely as possible.
   - Avoid urban areas if possible.
   - Follow highways, rail lines, power lines or other existing easements whenever possible. Avoid petroleum product pipelines because of interference from cathodic protection.
   - Avoid conflicts where possible. Conflicts include highway and rail line crossings, major rivers and reservoirs, and large oil fields.
   - Avoid high points above the hydraulic grade line if possible.

2. Develop a profile of the route. A detailed profile is not required, but it is important to include high and low points.

3. Select a design capacity based upon the amount of water needed. If the pipeline is to be used to supply a treatment plant, the design capacity should be based upon the peak-day delivery rate. Assume a 2.0 peaking factor unless other information is available. If the pipeline is used to deliver water to terminal storage the design capacity should be from 1.25 to 1.5 times the average annual demand. If the water were used to supplement another source, the design capacity would be between 1.5 to 2.0 times the annual average demands.

4. Graph a hydraulic grade line using the Hazen-Williams equation at the design flow and a C factor of 120. Select the pipe size using the following criteria:
   - The velocity in the pipe at maximum flow should be between 4 and 6 ft/sec.
   - The head loss in the pipe should be between 1.5 and 2.5 feet/1000 feet.
   - Pipe sizes should be limited to standard diameters (i.e. the ones in the tables). However, if the pipeline is very long alternative diameters may be considered because the pipe supplier will be willing to manufacture non-standard sizes if the pipe is ordered in sufficient quantity.

5. In most cases assume that pump stations should add a maximum of 461 feet of head (200 PSI) to the HGL. Station losses of 10 feet should be assumed at each pump station. Booster pump stations should be added whenever the HGL is below 46 feet (20 PSI). If possible locate booster pump stations at topographic high points and near sources of power. Costs of pump stations are based upon number of pumps and the HP of each pump. The number of pumps is based upon the expected range of pumping. In general assume one additional pump as a backup. The amount of head required at a pump station may be converted into horsepower using the following formula:

$$HP = 0.17536 * Q_{mgd} * H_{ft} / \text{Efficiency}$$

Developing Costs for Conveyance Projects

1. Conveyance project capital and operational costs should include the items listed in Table R-2.

2. The costs of installed pipe and ROW width may be found in Table R-3. Costs are for 150-class pipe installed in rural areas. The cost with appurtenances includes items such as valves and fittings as well as a normal amount of boring under roadways. Increase costs if an unusual number of conflicts such as major highway or numerous railroad crossings are encountered. Add 20% for pipelines in urban areas. Costs might be even higher for small pipes in cities. Add 5% to 10% for shorter lengths. Additional costs should be added for obstacles such as rock excavation or forested areas. Cost should be reduced for easy pipeline conditions, such as soft soil in flat country.

Table R-2
Cost Items for Conveyance Projects

Capital Costs	
Pipelines	**Pump Stations**
Installed pipe, including appurtenances	Pumps, building and appurtenances
ROW	Storage tanks
Conflicts	Intake structures
Outlet structures	
Other Initial Costs	
Engineering	Environmental and archeological studies
Contingencies	Interest during construction
Construction Management	Mitigation
Operation and Maintenance Costs	
General O&M	Estimated annual power costs
Debt service	

Table R-3
Costs for Pipe and ROW Width

Diameter (Inches)	Base Installed Cost ($/Foot)	Cost with Appurtenances ($/Foot)	Assumed ROW Width (Feet)	Assumed Temporary Easement Width (Feet)
8	22	24	20	60
10	26	28	20	60
12	29	32	20	60
14	33	37	20	60
16	37	41	20	60
18	41	45	20	60
20	44	48	20	60
24	51	56	20	60
30	67	74	20	60
36	83	91	20	60
42	100	110	30	70
48	115	127	30	70
54	132	145	30	70
60	167	184	30	70
66	192	211	30	70
72	217	239	30	70
78	243	267	40	80
84	273	300	40	80
90	301	331	40	80
96	347	382	40	80
102	394	433	40	80
108	435	479	40	80
114	483	531	40	80
120	524	576	40	80

Notes: a. Costs based on class 150 pipe for long, rural pipelines.
b. Appurtenances assumed to be 10% of installed pipe costs.
c. For urban pipelines, add 20% to base costs and 35% to cost with appurtenances for pipes 40" or larger. Add more for smaller pipelines.
d. Adjust costs for obstacles (rock, forested areas) and easy conditions (soft soil in flat country).

3. The unit costs with appurtenances include an expected amount of conflicts such as highway and railroad crossings.

4. Pipeline easements are additional and consist of a permanent easement and a construction easement. Table R-3 gives the assumed ROW width for various sizes of pipe. It should be assumed that a permanent right-of-way is purchased for most projects.
5. Outlet structure cost is assumed to be $100,000 for most sizes of pipe.

Pump Stations

1. Table R-4 presents the costs for individual pump stations. Each pump station includes a metal building with slab, pumps, miscellaneous valving and piping, electrical and instrumentation, a motor control center and land acquisitions including an access road.
2. It is assumed that a booster pump station will require ground storage tanks. The cost of ground storage includes slab, delivery of tank, and painting or coating of the tank. The tanks should be sized hold 8 hours of pumping at peak rates. Table R-5 presents assumed costs per storage volume.
3. Costs for intake structures are estimated on a case-by-case basis.

Other Initial Costs

1. Following SB1 guidelines, it will be assumed that engineering, contingency, construction management, financial and legal costs will be 30% of construction cost for pipelines and 35% of construction costs for pump stations.
2. It will be assumed that environmental and archeological studies will be $0.57 per linear foot of pipeline for large transmission projects and $0.28 for smaller transmission projects that follow existing easements. The minimum cost for environmental and archeological studies is $25,000.

Operation and Maintenance Costs

According to SB1 guidelines operation and maintenance is assumed to be 1.0% of the construction cost of pipelines and 2.5% of the construction costs of pump stations.

Table R-4
Pump Station Costs

Horsepower	Costs
100	$ 620,000
200	$ 930,000
300	$ 1,200,000
400	$ 1,500,000
500	$ 1,700,000
600	$ 1,800,000
700	$ 1,900,000
800	$ 2,100,000
900	$ 2,200,000
1,000	$ 2,400,000
2,000	$ 3,500,000
3,000	$ 4,200,000
4,000	$ 5,100,000
5,000	$ 5,800,000
6,000	$ 6,600,000
7,000	$ 7,200,000
8,000	$ 7,800,000
9,000	$ 8,500,000
10,000	$ 9,000,000
20,000	$14,000,000
30,000	$17,000,000

Table R-5
Ground Storage Tank Costs

Size (Million Gallons)	With Roof	Without Roof
0.10	$ 75,000	
0.25	$ 100,000	
0.50	$ 156,000	
1.00	$ 275,000	$ 220,000
1.50	$ 354,000	$ 278,000
2.00	$ 432,000	$ 335,000
2.50	$ 510,000	$ 385,000
3.00	$ 589,000	$ 435,000
3.50	$ 668,000	$ 485,000
4.00	$ 746,000	$ 535,000
5.00	$ 895,000	$ 630,000
6.00	$ 1,043,000	$ 724,000

Water Treatment Plants

Costs for treatment plants are given in terms of construction costs for building new plants or expansion of existing plants. Costs are presented for conventional plants. Engineering and contingency fees are 35% of the capital cost.

Conventional Water Treatment Plants

Conventional water treatment plants are plants that use standard flocculation, sand-filtration and chlorine or ozone disinfection or similar processes to produce potable water.

Capital Costs

Table R-6 presents approximate capital costs for construction of a new water treatment plant and expansion of an existing treatment plant. The cost includes the treatment facilities, piping, clearwell storage and administrative and other buildings. The cost does not include acquisition of property, high service pump stations, or treatment studies.

Table R-6
Conventional Water Treatment Plant Costs

Plant Capacity (mgd)	New Conventional Plants	Conventional Plant Expansions
1	$ 4,000,000	$ 2,000,000
3	$ 7,300,000	$ 5,100,000
7	$ 11,500,000	$ 8,500,000
10	$ 14,000,000	$ 10,000,000
15	$ 17,500,000	$ 12,500,000
20	$ 21,000,000	$ 15,500,000
30	$ 28,000,000	$ 21,000,000
40	$ 35,000,000	$ 26,500,000
50	$ 42,000,000	$ 31,500,000
60	$ 48,750,000	$ 36,500,000
70	$ 55,500,000	$ 41,500,000
80	$ 62,000,000	$ 46,750,000
90	$ 68,000,000	$ 52,000,000
100	$ 74,750,000	$ 57,500,000

Operation and Maintenance Costs

The operation and maintenance of a conventional water treatment plant is $0.35 per 1,000 gallons for small systems (less than 6 mgd) and $0.25 per 1,000 gallons for large systems (greater than 6 mgd). These costs include chemicals, labor and electricity.

Reservoir Sites

1. Site-specific cost estimates are made for reservoir sites. The elements required for reservoir sites are included in Table R-7.

Table R-7
Cost Elements for Reservoir Sites

Capital Costs	Studies and Permitting
Embankment	Environmental and archeological studies
Spillway	Permitting
Outlet works	Engineering and contingencies
Site work	
Land	
Administrative facilities	
Supplemental pumping facilities	
Terrestrial mitigation tracts	

2. According to TWDB guidance, engineering and contingencies are 35% of construction cost, annual O&M are 1.5% of construction costs, and mitigation cost is based upon the number of acres inundated times the cost of land.
3. Archeological and environmental studies are determined based upon site-specific information.

Water Wells

1. Costs for water wells are based on the relationship developed by LBG Guyton as shown in Table R-8.
2. Construction costs developed for municipal water providers included an additional $100,000 per well for connection to the existing distribution system.

Table R-8
Cost Elements for Water Wells

Well Diameter (inches)	Typical Production Range (gpm)	Estimated Cost a=production rate (gpm), b= well depth (feet) c=1 for PWS/Industrial or 0.55 for Irrigation
6	25-150	4000 + 68a + 60bc
8	150-300	5000 + 65a + 130bc
10	300-500	6000 + 63a + 170bc
12	500-800	8000 + 60a + 210bc
16	800-2000	8000 + 60a + 300bc

3. Engineering costs were estimated at 30% of the total construction costs. Mitigation and permitting were estimated at 1% of the total construction costs, with a minimum of $10,000 per well.

4. The construction and engineering costs were annualized based on a 30 year pay-off on capital with 6% interest. Operation and maintenance costs were estimated annually and added to the debt service. The maintenance costs for the pipelines and connections with distribution systems were estimated at 1%, and the pump station maintenance was estimated at 2.5%.

5. Chemical usage for water treatment was estimated to cost $0.10 per 1,000 gallons.

6. Pumping costs were developed on an annual basis using the average depth to water data from TWDB and the average amount pumped by the entity. The assumed cost per kilowatt hour is six cents.

Annual and Life-Cycle Costs

The parameters for annual costs specified in TWDB guidance are summarized in Table R-9. Present value calculations or adjustments for inflation are not required by TWDB. Unit costs are to be presented in dollars per acre-foot. It is also recommended that values be presented in dollars per 1,000 gallons because readers may be more familiar with those units.

Table R-9
Annual Cost Assumptions

Annual Cost Element	Value
Interest rate	6% per year simple interest
Length of debt service	30 years for most projects 35 year for state participation 40 years for reservoirs
Power costs	$0.6 per kWh, may be adjusted for local conditions
O&M costs	Pipelines – 1.0% of construction Pump Stations – 2.5% of construction Dams – 1.5% of construction Water wells – see text Water treatment – $0.25-$0.35 per 1,000 gallons
Water Purchase Costs	See Table R-10

Some management strategies require the purchase of raw water, treated water, or treated wastewater. Because the Region C plan includes many hundreds of potential water purchases, it was not practical to determine an individual water purchase cost for each purchase. Instead, assumed purchase costs were based on values within current ranges. It should be emphasized that these assumed purchase costs in no way represent or are intended to limit the price to be set in future water purchases. The actual price of water will be negotiated between the buyer and the seller, depending on the details of the particular transaction. Table R-10 shows the purchase costs assumed in this study.

Table R-10
Assumed Purchase Cost for Water

Type of water	Cost Range (per 1,000 gallons)	Assumed Purchase Cost	
		(per 1,000 gallons)	(per acre-foot)
Raw Water	0.25 to $1.00	$0.75	$245
Treated Water	0.75 to $3.50	$1.50	$490
Treated Wastewater	$0.15 to $1.00	$0.50	$163

Interest during construction is estimated assuming the total estimated project cost (excluding interest during construction) would be drawn down at a constant rate per month during the construction period. Interest during construction is the total of interest accrued at the end of the construction period using an 6 percent annual interest rate on total borrowed funds, less a 4 percent rate of return on investment of unspent funds. Factors for use in cost estimating are presented in Table R-10. These factors are multiplied by the cost to build the project, including engineering, contingencies, and environmental and ecological studies. The length of construction should be verified for individual projects.

Table R-11
Factors for Interest During Construction

Construction Period	Factor
6 months	0.021667
12 months	0.041667
18 months	0.057593
24 months	0.078194
36 month construction	0.118796

Cost Estimates for Projects

The following tables (R-12 through R-215) include cost estimates for the individual projects.