

APPENDIX A
Survey of Construction Costs for
Wastewater Treatment Facilities

APPENDIX A
SURVEY OF CONSTRUCTION COSTS FOR WASTEWATER TREATMENT FACILITIES

FACILITY	#	TOWN	DESIGN	CONSTRUCTION COST		UNIT COST,	SOURCES AND NOTES
			FLOW, gpd	PRIOR YEAR	2009	\$/gpd	
				<i>Variable ENR</i>	<i>ENR, 2009</i>		
Anonymous (residential)	1	E. Bridgewater	15,000	970,000 7,864	1,061,000 8,600	70.7	Wright-Pierce preconstr. estimate
Camp Jewell	2	Western Conn.	19,000	1,010,000 7,308	1,189,000 8,600	62.6	Wright-Pierce includes upgrade
Anonymous (school)	3	So. New England	17,500	648,000 7,763	718,000 8,600	41.0	Aquapoint
Cotuit Stop n Shop	4	Barnstable	22,000	760,000 6,538	1,000,000 8,600	45.5	VHB
Mass. Correct. Fac.	5	Plymouth	31,000	2,300,000 8,250	2,398,000 8,600	77.4	Horsley-Witten
Harvard Ridge	6	Boxborough	34,000	1,250,000 6,635	1,620,000 8,600	47.6	EarthTech
Anonymous (residential)	7	Cohasset	38,000	1,280,000 7,856	1,401,000 8,600	36.9	RH White
Berkshire School	8	W. Mass.	40,000	1,000,000 6,538	1,315,000 8,600	32.9	Zenon
Camp Beckett	9	W. Mass.	40,000	1,500,000 7,900	1,633,000 8,600	40.8	CDM
Bolton Municipal	10	Bolton	40,000	1,800,000 7,940	1,950,000 8,600	48.8	Tata & Howard
Anonymous (residential)	11	Weston	40,000	2,100,000 7,900	2,286,000 8,600	57.2	RH White
Shops at Derby Street	12	Hingham	54,000	2,500,000 6,600	3,258,000 8,600	60.3	Martinage Eng. Assoc.
New Silver Beach	13	Falmouth	60,000	4,000,000 8,000	4,300,000 8,600	71.7	Town of Falmouth
Anonymous (residential)	14	No. Reading	63,000	2,400,000 7,700	2,681,000 8,600	42.6	RH White
Anonymous (residential)	15	Acton	96,000	2,879,000 7,888	3,139,000 8,600	32.7	Developer
West Island	16	Fairhaven	100,000	2,300,000 5,825	3,396,000 8,600	34.0	Town of Fairhaven

FACILITY	#	TOWN	DESIGN	CONSTRUCTION COST		UNIT COST,	SOURCES AND NOTES
			FLOW, gpd	PRIOR YEAR	2009	\$/gpd	
Tisbury Municip.	17	Tisbury	104,000	5,170,000 <i>6,500</i>	6,840,000 <i>8,600</i>	65.8	Town of Tisbury
Pine Hills	18	Plymouth	150,000	4,800,000 <i>6,222</i>	6,635,000 <i>8,600</i>	44.2	Wright-Pierce Phase 1 only
Oak Bluffs Municip.	19	Oak Bluffs	320,000	6,800,000 <i>6,222</i>	9,399,000 <i>8,600</i>	29.4	Wright-Pierce
Provincetown Mun.	20	Provincetown	500,000	7,420,000 <i>6,400</i>	9,971,000 <i>8,600</i>	19.9	Town of Provincetown Phase 1 only
Edgartown Mun.	21	Edgartown	750,000	12,200,000 <i>6,500</i>	16,142,000 <i>8,600</i>	21.5	Town of Edgartown
Jaffrey Municip.	22	Jaffrey, NH	1,250,000	11,000,000 <i>7,850</i>	12,051,000 <i>8,600</i>	9.6	Wright-Pierce
Falmouth Municip.	23	Falmouth	2,200,000	12,500,000 <i>7,000</i>	15,357,000 <i>8,600</i>	7.0	Town of Falmouth
Chatham Municip.	24	Chatham	2,300,000	36,000,000 <i>8,600</i>	36,000,000 <i>8,600</i>	15.7	Town of Chatham some existing facil.

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APPENDIX B
Survey of O&M Costs for
Wastewater Treatment Facilities

APPENDIX B
SURVEY OF O&M COSTS FOR WASTEWATER TREATMENT FACILITIES

FACILITY	#	TOWN	FLOWS, gpd		O&M COST, \$/yr	UNIT COST, \$/yr/gpd	SOURCES AND NOTES
			DESIGN	ANNUAL AVG			
Patriot Square	1	Dennis	17,000	6,000	85,000	14.2	Coastal Engineering
Camp Jewell	2	Western Conn.	19,000	6,700	84,000	12.5	Owner
Comm. of Jesus	3	Orleans	21,700	6,500	87,900	13.5	Owner
Skaket Corner	4	Orleans	22,000	6,000	85,200	14.2	Coastal Engineering
Martha's Vineyard Airport	5	Edgartown	37,000	9,000	156,500	17.4	Dukes County
Anonymous (residential)	6	Cohasset	38,000	21,000	174,000	8.3	Weston & Sampson projected future
Horace Mann School	7	Barnstable	42,000	10,000	103,000	10.3	Town of Barnstable
Mashpee Commons	8	Mashpee	80,000	19,000	222,000	11.7	Owner
West Island	9	Fairhaven	100,000	16,300	165,000	10.1	Town of Fairhaven
Tisbury Municipal	10	Tisbury	104,000	36,000	360,000	10.0	Town of Tisbury
Pine Hills	11	Plymouth	300,000	125,000	623,000	5.0	Veolia
Oak Bluffs Municipal	12	Oak Bluffs	320,000	89,000	603,000	6.8	Town of Oak Bluffs
Provincetown Mun.	13	Provincetown	575,000	150,000	780,000	5.2	Town of Provincetown
Edgartown Municipal	14	Edgartown	750,000	170,000	850,000	5.0	Town of Edgartown
Spencer Municipal	15	Spencer	1,080,000	780,000	1,820,000	2.3	Town of Spencer
Falmouth Municipal	16	Falmouth	1,200,000	400,000	1,137,000	2.8	Town of Falmouth
Jaffrey Municipal	17	Jaffrey, NH	1,250,000	500,000	832,000	1.7	Town of Jaffrey
Wareham Municipal	18	Wareham	1,560,000	1,067,000	2,980,600	2.8	Town of Wareham
Chatham Municipal	19	Chatham	2,300,000	1,300,000	1,900,000	1.5	Town fo Chatham projected future
Plymouth Municipal	20	Plymouth	3,000,000	1,650,000	1,996,000	1.2	Veolia
Hyannis Municipal	21	Barnstable	4,200,000	1,800,000	2,265,000	1.3	Town of Barnstable

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APPENDIX C
Example Calculations and Assumptions
for Sensitivity Analyses

BARNSTABLE COUNTY WASTEWATER COST TASK FORCE

Sample Calculations

Base Case for 100,000-gpd Satellite and 1.5-mgd Centralized Systems

	Satellite: 100,000 gpd	Centralized: 1.5 mgd
Wastewater Flow		
Number of homes/properties	284	3,375
Number of bedrooms/home	3.2	
Number of bedrooms	909	
Title 5 flow, gpd	99,990	
Short-term peak flow, gpd		1,500,000
Annual average flow		
Percent of Title 5	45	45
Actual, gpd	45,000	675,000
Capital Costs		
Collection		
Sewer length per connection	100	100
Cost per property	20,000	20,000
Number of properties	284	3,375
Construction cost	5,681,000	67,500,000
Transport to treatment		
Distance, 1000 ft	0.40	5.00
Cost per foot	200	250
Construction cost	80,000	1,250,000
Treatment		
Cost per unit flow	34	16
Flow, gpd	100,000	1,500,000
Construction cost	3,400,000	24,000,000
Transport to disposal		
Distance, 1000 ft	0.35	3.00
Cost per foot	200	250
Construction cost	70,000	750,000
Disposal		
Construction cost	520,000	5,250,000
Total construction cost		
Cost	9,751,000	98,750,000

Satellite: 100,000 gpd	Centralized: 1.5 mgd
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Construction contingencies, legal, engineering, permitting, etc.			
Percentage of construction		40	40
Cost	3,900,000		39,500,000
Land			
Treatment area, acres	1.10		8
Disposal area, acres	2.65		24
Total area	3.75		32
Cost per acre	250,000		200,000
Cost	935,000		6,400,000
Total capital cost	14,586,000		144,650,000
Capital costs summary	14,586,000		144,650,000
O&M Costs			
Annual average flow, gpd	45,000		675,000
Unit cost, \$/yr per gpd	8.6		2.5
O&M cost, \$/yr	387,000		1,687,500
O&M Cost summary	387,000		1,687,500
Present Worth			
Period, yr	20		
Interest rate, %	5		
PW Factor	12.46		
Capital cost	14,586,000		144,650,000
O&M cost	387,000		1,687,500
PW of O&M	5,047,000		21,030,000
Total present worth	19,633,000		165,680,000
Equivalent Annual Cost, \$/yr			
Amortized capital cost	1,170,000		11,607,000
O&M cost	387,000		1,688,000
Total EAC	1,557,000		13,295,000

Satellite: 100,000 gpd	Centralized: 1.5 mgd
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Nitrogen removal (compared with Title 5)

Title 5 effluent N conc., mg/l	26.25	26.25
Satellite effluent N conc., mg/l	7	5
Conc removed, mg/l	19.25	21.25
Load removed, lb/yr		
In-watershed disposal	2,637	43,600
Out-of-watershed disposal	3,596	53,900

Cost of N removal--in-watershed disposal

EAC, \$/lb	590	305
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Cost of N removal--out-of--watershed disposal

EAC, \$/lb	433	247
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Costs per property

Capital	51,300	42,900
O&M	1,360	500
EAC	5,480	3,940

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ASSUMPTIONS INCLUDED IN SENSITIVITY ANALYSES

Individual Denitrifying Systems

Base Case--see Table 1

- A. Additional site restoration--capital costs increased by \$4,000 to reflect possible greater disruption of decks, patios and landscaping at currently developed properties, and/or for pumping.
- B. Municipal procurement--capital costs increased by 20% to reflect public bidding requirements and prevailing wages.
- C. Municipal oversight of operation--O&M costs increased by \$150 per year to account for possible town staff overseeing the contract operations of these systems.
- D. Reuse of existing on-site system components--one half of properties would incur reduced capital cost by reusing septic tank and leaching field. New construction would be limited to denitrifying system for one half of properties.
- E. Reduced effluent sampling--BOD and TSS tests eliminated from suite of effluent testing.
- F. Improved effluent quality--effluent nitrogen concentration reduced by 3 mg/l (to 16 mg/l for "current practice", and to 10 mg/l for "enhanced current practice" and "TMDL compliance").
- G. Further improved effluent quality--effluent nitrogen concentration reduced to 5 mg/l for all scenarios.

Cluster Systems

Base Case--see Table 1

- A. Seasonal nature of service area--annual average flow (and therefore annual nitrogen load reduction) decreased by 10% to approximate a neighborhood with one-third seasonal homes.
- B. Reduced land costs--land for treatment and disposal assumed to be available at no cost to project.
- C. More densely-developed service area--construction costs for collection reduced by 20% to reflect serving a neighborhood with smaller lots.
- D. Reduced treatment costs--construction costs for treatment system reduced by 20% to anticipate possible future technology breakthroughs.
- E. Reduced operator oversight--use of remote sensing of treatment system performance to reduce operator time by 20%.
- F. Discharge outside sensitive watersheds--effluent disposal site located in watershed with adequate assimilative capacity.
- G. Improved effluent quality--effluent nitrogen concentration reduced by 2 mg/l (to 13 mg/l for "current practice", and to 6 mg/l for "TMDL compliance").
- H. Further improved effluent quality-- effluent nitrogen concentration reduced to 5 mg/l for all scenarios.

Satellite Systems

Base Case--see Table 1

- A. Increasing the transport distances--both the distance from the collection area to the treatment plant site and the distance between the treatment and disposal sites are increased by a factor of 3.0.
- B. Discharging within a water supply zone II--construction costs for treatment are increased by 35% to address the requirements of the groundwater discharge permitting program, and O&M costs are increased by 40%. The effluent nitrogen concentration is reduced to 5 mg/l.
- C. Reduced land costs--land for treatment and disposal assumed to be available at no cost to project.
- D. Discharge outside sensitive watersheds--effluent disposal site is located in watershed with adequate assimilative capacity.
- E. Improved effluent quality--effluent nitrogen concentration reduced by 2 mg/l.
- F. Further improved effluent quality-- effluent nitrogen concentration reduced to 5 mg/l for all scenarios.
- G. Reduced treatment costs--construction costs for treatment system reduced by 20% to anticipate possible future technology breakthroughs.

Centralized Systems

Base Case--see Table 1

- A. Increasing the transport distances--both the distance from the collection area to the treatment plant site and the distance between the treatment and disposal sites are increased by a factor of 3.0.
- B. Discharging within a water supply zone II--construction costs for treatment are increased by 35% to address the requirements of the groundwater discharge permitting program, and O&M costs are increased by 40%. The effluent nitrogen concentration is reduced to 5 mg/l.
- C. Reduced land costs--land for treatment and disposal assumed to be available at no cost to project.
- D. Discharge outside sensitive watersheds--effluent disposal site is located in watershed with adequate assimilative capacity.
- E. Improved effluent quality--effluent nitrogen concentration reduced to 3 mg/l for all scenarios.
- F. Regionalization--construction and O&M costs for treatment system reduced by 10% to account for economies of scale in a regional system.

APPENDIX D
Sources of Data and Summary of
Adjustments and Assumptions
for Example Projects

APPENDIX D
SOURCES OF DATA
AND
SUMMARY OF ADJUSTMENTS AND ASSUMPTIONS
FOR
EXAMPLE PROJECTS

BRACKETT LANDING, EASTHAM

Sources

McShane Construction and SeptiTech

Adjustments and Assumptions--"Current Practice" Scenario

Capital cost. McShane Construction quoted a cost of \$530,000 for the wastewater facilities that were completed in early 2006. To this figure was added 10% for engineering, legal and permitting, and \$300,000 for land (estimated 1.2 acres at \$250,000 per acre). This project was not subject to public procurement requirements.

Operation and Maintenance Costs. McShane quoted \$12,000 for the operator and for testing. Added to this figure were: \$2,600 for electricity, \$5,400 for sludge disposal, \$3,500 for administrative costs including engineering and insurance, and \$2,000 for equipment repair and replacement.

Flow. Current annual average flows are approximately 1,600 gpd, reflecting less than full development of the project. This analysis is based on an estimated flow at project completion of 3,300 gpd, approximately 40% of the design flow, consistent with other example projects.

Nitrogen Load. Load is based on 3.5 mg/l average effluent quality (as reported by Barnstable County) and in-watershed disposal.

Adjustments and Assumptions--"For TMDL Compliance" Scenario

Operation and Maintenance Costs. Based on DEP input on the level of oversight and testing associated with this scenario (see text), upward adjustments were made to the "current practice" costs to a revised total of \$64,500. Labor costs were increased to \$41,600 to reflect 10-hour-per-week oversight at \$80 per hour. Testing costs were increased to \$6,900 for monthly testing of influent and effluent and quarterly testing of monitoring wells. An allowance of \$1,000 was added for chemicals (alkalinity). Also added were \$1,000 for additional engineering, and \$500 for additional equipment repair and replacement.

CAMP JEWELL, COLEBROOK CONNECTICUT

Sources

Greater Hartford YMCA and Wright-Pierce

Adjustments and Assumptions

Capital cost. Costs are based on amounts paid to the construction contractor for Phase 1 and on the engineer's estimates for a proposed upgrading. To these figures was added

25% for engineering, legal and permitting expenses. No land costs or collection costs are included. This project was not subject to municipal procurement requirements.

Operation and Maintenance Costs. The YMCA's quoted costs were increased by \$3,000 for power and \$500 for engineering. Recent repair costs were assumed to represent once-in-three-year expenditures.

Nitrogen Load. Load is based on the expected 10 mg/l average effluent quality (after upgrading) and in-watershed disposal.

NEW SILVER BEACH, FALMOUTH

Sources

Falmouth Department of Public Works

Adjustments and Assumptions

Capital cost. Costs are based on amounts paid to contractors for construction of collection, treatment and disposal facilities. To these figure was added 25% for engineering, legal and permitting expenses. No land costs are included.

Flow. Connections are still being made to this system. This analysis is based on the expected flow of 25,000 gpd, approximately 40% of the design flow, consistent with other example projects.

Nitrogen Load. Since the plant is in the start-up phase, the load is based on an expected 10 mg/l average effluent quality and in-watershed disposal.

MASHPEE COMMONS, MASHPEE

Sources

Cornish LP

Adjustments and Assumptions

Capital cost. Costs include construction, engineering, permitting and legal expenses, and land. No collection costs are included. Municipal procurement requirements did not apply.

Nitrogen Load. Load is based on 5 mg/l average effluent quality and in-watershed disposal.

WEST ISLAND, FAIRHAVEN

Sources

Fairhaven Department of Public Works

Adjustments and Assumptions

Capital cost. Costs are based on amounts paid to contractors for the original construction plus 25% for engineering, legal, permitting and land acquisition expenses.

Operation and Maintenance Costs. The DPW's quoted costs were increased by \$30,000 for labor, \$15,000 for sludge handling and \$4,000 for administrative and engineering cost.

Nitrogen Load. Load is based on 7 mg/l average effluent quality and in-watershed disposal.

TISBURY MUNICIPAL FACILITIES

Sources

Tisbury Department of Public Works

Adjustments and Assumptions

Capital cost. Costs are based on actual amounts paid to contractors and engineers for the original construction. No land costs are included; treatment and disposal sites were Town-owned.

Nitrogen Load. Load is based on 5 mg/l average effluent quality and in-watershed disposal.

PROVINCETOWN MUNICIPAL FACILITIES

Sources

Provincetown Department of Public Works

Adjustments and Assumptions

Capital cost. Costs are based on amounts paid to contractors for the Phases 1 and 2 of construction plus 20% for engineering, legal, permitting, land acquisition and DBO procurement expenses.

Nitrogen Load. Load is based on out-of-watershed disposal.

PROPOSED ORLEANS MUNICIPAL FACILITIES

Sources

Orleans Comprehensive Wastewater Management Plan, April 2009

Adjustments and Assumptions

Capital cost. Costs are based on CWMP estimates and include construction, land, engineering, legal and contingencies. Costs for proposed supplemental cluster systems are not included. The proposed treatment and disposal sites are town-owned.

Operation and Maintenance Costs. Costs are based on CWMP estimates for all standard expenses, and exclude costs for treatment of out-of-town septage.

Nitrogen Load. Load is based on out-of-watershed disposal.

Regionalization. Cost advantages of regionalization are based on 2009 Wastewater Regionalization Study, assuming participation by Orleans, Eastham and Brewster.

CHATHAM MUNICIPAL FACILITIES

Sources

Chatham Department of Health and Environment and Stearns & Wheler

Adjustments and Assumptions

Capital cost. Costs are based on CWMP estimates for Phase 1 facilities updated for construction bids received in early 2010. Costs for proposed Phase 2 facilities are not included. Treatment and disposal site is town-owned.

Operation and Maintenance Costs. Costs are based on CWMP estimates for all standard expenses and exclude Phase 2 O&M costs.

Nitrogen Load. Load is based on out-of-watershed disposal.