Evaluation of the technical, economic, and social impacts associated with updating major wastewater treatment infrastructure to address aquatic life uses and values for the Delaware Estuary

DRBC Water Quality Advisory Committee

West Trenton, NJ

Dec 3, 2020

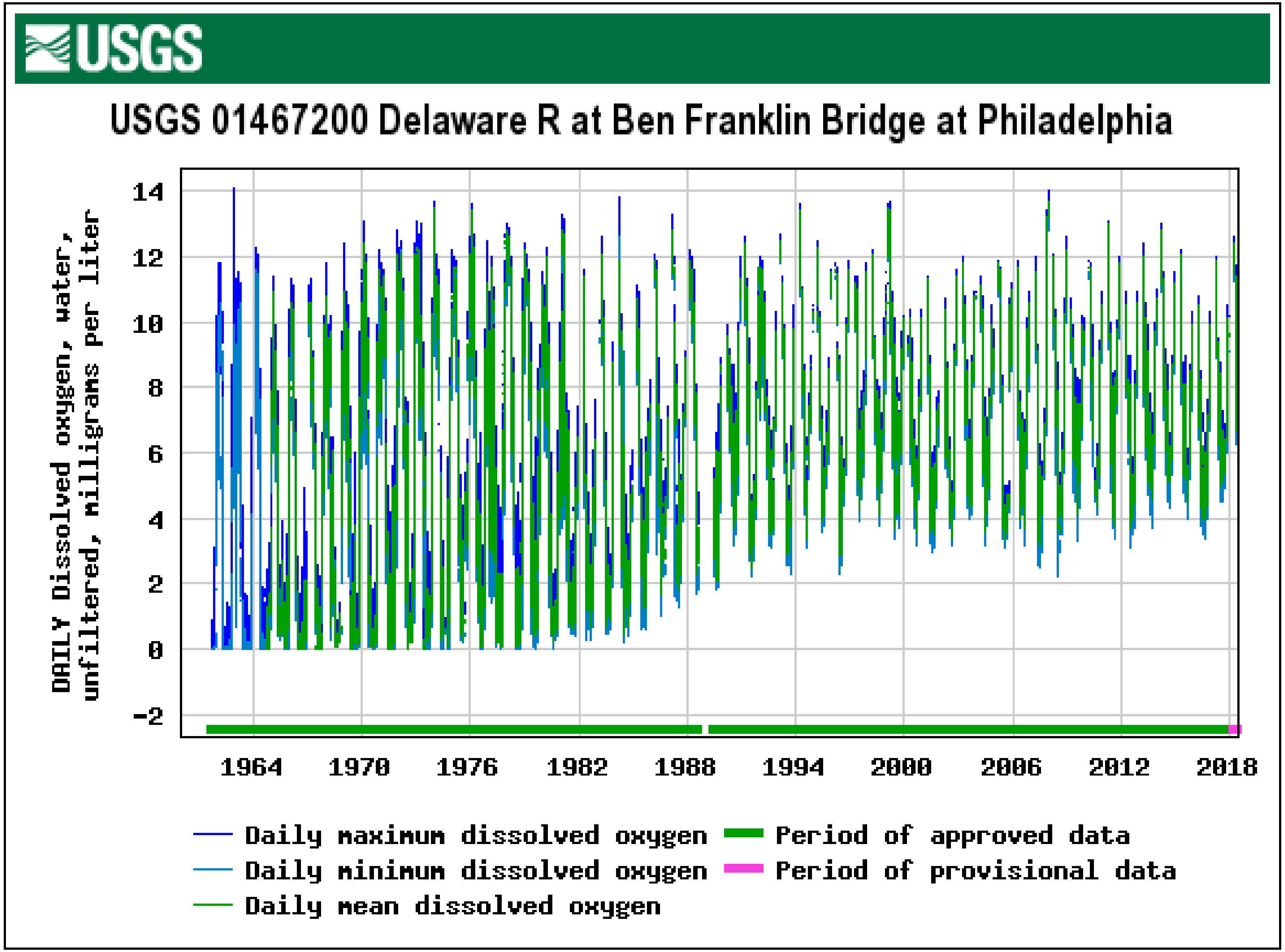
Gerald McAdams Kauffman, Director

University of Delaware

Water Resources Center

Biden School of Public Policy & Administration

Newark, Del.



What are the costs and benefits of achieving improved water quality in the Delaware Estuary?

Schedule

Commence Project	Dec 2020
1. Form Advisory Subcommittee	Dec 2020
2. Define Costs	Jan 2021
3. Estimate Benefits	Feb 2021
4. Submit Draft Report	Mar 2021

Scope

- Estimate costs and benefits from increased levels of wastewater treatment (ammonia and nitrogen) to improve dissolved oxygen in the Delaware Estuary.
- Present DO between Wilmington and Philadelphia is 3.5 mg/L (24-hour mean) with 6 mg/L seasonal mean criteria during spring and fall.
- Economic analysis conducted at DO increasing in increments of 0.5 mg/l from present standard of 3.5 mg/l to 100% saturation of DO at 30 deg C of 7.5 mg/l.
- Costs derived from ammonia treatment levels of 10 mg/L, 5 mg/L, 1.5 mg/L and TN treatment of 4 mg/L as per Kleinfelder report.
- Dischargers/stakeholders provide input on costs/upgrades, rates/rate structure for benefits universe (service area, municipalities in study area, etc.).
- Costs and benefits derived for population residing in the service areas of the 12 wastewater dischargers (or population within Delaware Estuary watershed?).

Stakeholder Advisory Subcommittee

1. Form a discharger/stakeholder subcommittee of the DRBC Water Quality Advisory Committee to provide guidance to the UDWRC cost benefit analysis.

Conventional Activated Sludge

- City of Wilmington
- Delaware County Regional Water Authority Western Regional Treatment Plant (DELCORA)
- Gloucester County Utilities Authority (GCUA)
- Philadelphia Water Department Southeast WPCP (PWD SEWPCP)
- PWD Northeast WPCP (PWD NEWPCP)
- Lower Bucks County Joint Municipal Authority (LBCJMA)

Pure Oxygen Activated Sludge

- PWD Southwest WPCP (PWD SWWPCP)
- Delaware #1 WPCP / Camden County Municipal Utilities Authority (CCMUA)
- Morrisville Borough Municipal Authority (MMA)

Fixed Film

- Trenton Sewer Utility
- Willingboro MUA Water Pollution Control Plant (Willingboro MUA)
- Hamilton Township Water Pollution Control Facility (Hamilton Township)

2. Define Costs

Utilize load reduction costs (Kleinfelder) at 12 WWTPs in Delaware Estuary for improved DO.

2.1. Ammonia and N reduction: Estimate capital and O&M costs for WWTPs per Kleinfelder. Compute ammonia reduction costs ($/yr) for WWTP improvement options at 10, 5, and 1.5 mg/l and 4 mg/l TN. Define marginal abatement cost curves (doesn't limit DRBC's decision on CE).

2.2. Rate Analysis: Tabulate existing wastewater rates for 12 wastewater utilities. Estimate future wastewater rates to pay for ammonia reduction program from use attainability analysis ("UAA") as per EPA Economic Guidance for Water Quality Standards and AWWA, NACWA and WEF white paper "Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector", April 2019. Water, wastewater, and stormwater rates bundled together in a "One-Water" approach to capture affordability at household and community level. Rate analysis utilize EPA existing RI based on median income affordability with Household Burden Indicator (HBI). Stakeholders will be consulted during rate analysis process.

2.3. Finance: Examine Federal / state / nonprofit finance programs to fund load reductions. Examine ability-to-pay estimated rates for selected sensitive groups, areas, and customers.

3. Quantify Benefits

What are the economic benefits of improved water quality due to ammonia waste load reductions in the Delaware River? This task will estimate benefits of improved water quality for recreation, boating, fishing, wildlife-viewing, property value, and other uses. Marginal benefits (MB) or change in benefits as WQ incrementally improves from current (DO 3.5 mg/l) to future condition(s).

3.1 Recreation: Benefits are estimated for improved water quality to go from current conditions to higher uses in the Delaware River. Annual recreation benefits to achieve boating and fishing water quality are conducted by selecting per person values from travel cost studies and multiplying by the U.S. Census (2010 adult population (>18 yr old) for the agreed upon study area (i.e. the basin and/or service areas). The value of recreation will be estimated due to improved water quality using the unit day value method by multiplying the number of visitor days by the unit value ($/day) of a recreation day. Recreation benefits of improved water quality are measured by the increase in the number of activity days by participants at the river.

3.2. Use values: Economic benefits of improved water quality are estimated for boating, fishing, bird watching, waterfowl hunting, and beach going by determining the number of visitors who participated in recreational activities in the Delaware River. Define for (1) boating, fishing, bird/wildlife watching recreation from net factor income, productivity, and travel cost methods, (2) commercial fishing using market price method from NMFS, (3) water supply, municipal/industrial, (may have limited benefits) using market price and productivity methods from decreased treatment costs, (4) viewing/aesthetics from willingness to pay and contingent valuation methods, and (5) increased property value using hedonic pricing methods for river-side parcels.

3.3. Benefits Transfer: If primary valuation data collected from studies in the Delaware Basin were not available, then benefits transfer techniques are employed to translate data from other watersheds. Due to uncertainty in the selection of parameters and transferring data to the Delaware River, lower and upper bound benefits are defined based on the population in the basin who benefit, assuming a range in the percent change in benefit due to improved water quality, and selecting low and high range unit values (WTP in $/person). Benefits from the original base year were converted to 2010 dollars based on the average annual change (2.6% rounded to 3%) in the Consumer Price Index (CPI) in the Northeast Region from 1991-2010 as reported by the Bureau of Labor Statistics.

3.4. **Nonuse values:** From stated preference and contingent valuation surveys, determine willingness to pay by the public and customers (rate payers) in the service areas for improved water quality for existing/future generations. Carson and Mitchell (1993) surveyed the public on willingness to pay to achieve Clean Water Act goals based on a water quality ladder (Table 1 and Figure 2). Nonuse values are defined as willingness to pay (WTP) to improve water quality and include existence values from the satisfaction that a water resource exists and is protected but may never be visited and bequest values from satisfaction that the river is preserved for future generations.

4. Prepare Report:

Prepare report detailing cost/benefit analysis of improved water quality in Delaware Estuary.

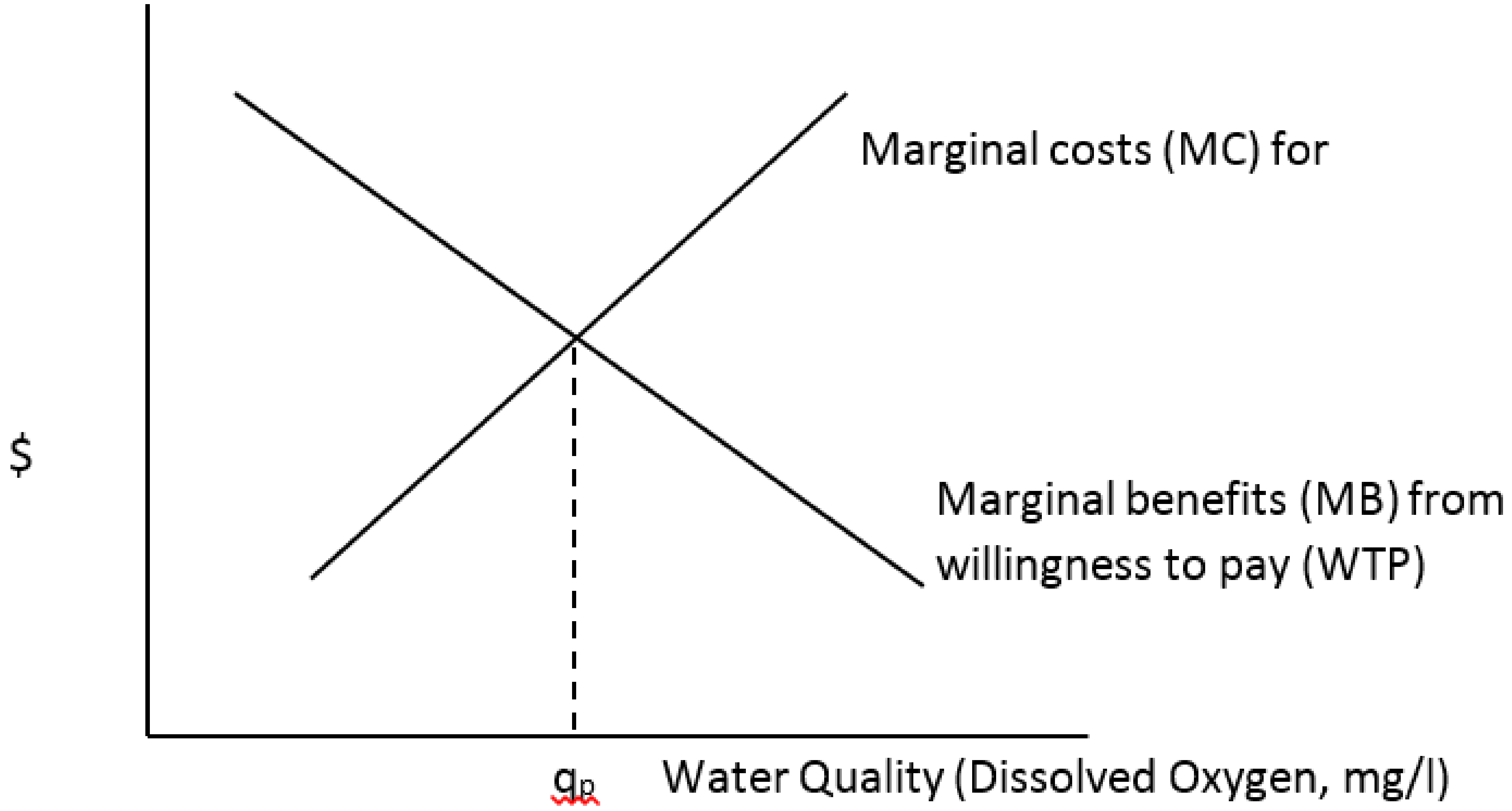


Figure 1. Optimal water quality

Table 4. Benefits of Improved Water Quality in the Delaware River

Category	**Activity**
Use	
Recreation	Viewing, Boating, Fishing
	Boating
	Fishing
	Shad fishing
	Bird/Wildlife Watching
	Waterfowl Hunting
	Swimming
	Beach Going
Commercial	Fishing
	Agriculture
	Navigation
Indirect Use	Property Value
Water Supply	Municipal Water Supply
	Industrial Water Supply
Nonuse	
Existence/Bequest	WTP Boatable to Fishable WQ
Total	

Table 4. Water Quality Ladder
(Carson and Mitchell 1993 from Resources for the Future)

Water Quality	Grade	Use	Dissolved Oxygen
10			
9		Potable (Safe for drinking)	
8			
7	A	Swimmable (Safe for swimming)	5 mg/l
6			
5	B	Fishable (Game fish like bass can live in it)	4 mg/l
4			
3	C	Boatable (OK for boating)	3 mg/l
2			
1			
0		Worst possible water quality	1 mg/l

Table 1. Benefits of improved water quality

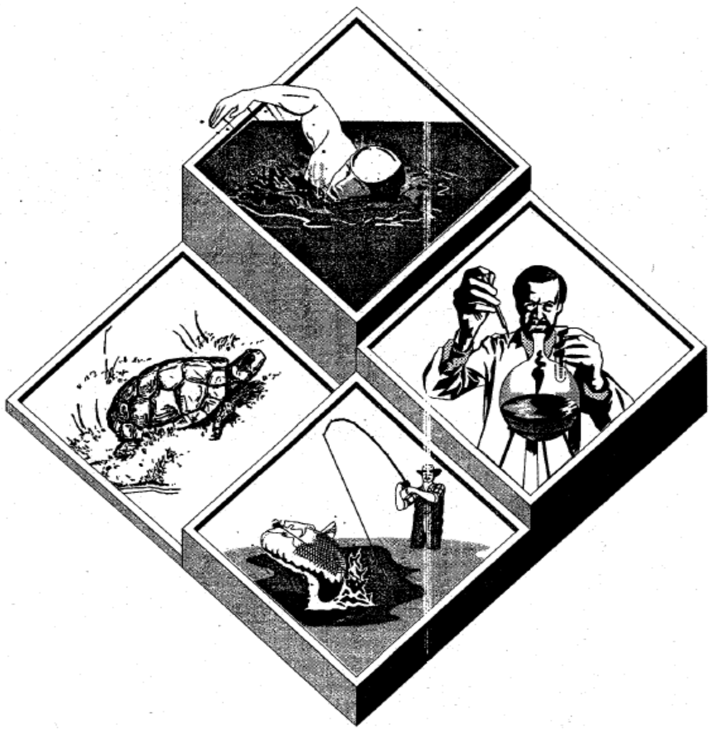
Benefit	Category	Examples	Method
Use	Recreation	Increased boating, fishing, swimming expenditures	Travel Cost
	Aesthetic/Viewing	Commuting, hiking, picnicking, photography	Travel Cost
	Fishing	Commercial	Market Price
	Water Supply	Lowered municipal/industrial water treatment costs	Avoided Cost
	Property Value	Increased river-side property value	Hedonic Price
	Ecosystem	Boating, fishing, bird watching, waterfowl Hunting	Travel Cost
	Navigation	Reduced dredging costs	Avoided Cost
Nonuse	Existence	Relatives, friends, American public	Contingent Valuation
	Bequest	Family, future generations	Contingent Valuation

United States Environmental Protection Agency
Office of Water (4303)
EPA-823-B-95-002
March 1995

EPA

Interim Economic Guidance for Water Quality Standards

Workbook



"... to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

Section 101(a) of the Clean Water Act

Appendix M to the
Water Quality Standards Handbook - Second Edition

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Printed on paper that contains at least 50% recycled fiber

Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector

April 17, 2019

Prepared for

The American Water Works Association

National Association of Clean Water Agencies

Water Environment Federation

by

R. Raucher, PhD. and J. Clements Corona Environmental Consulting

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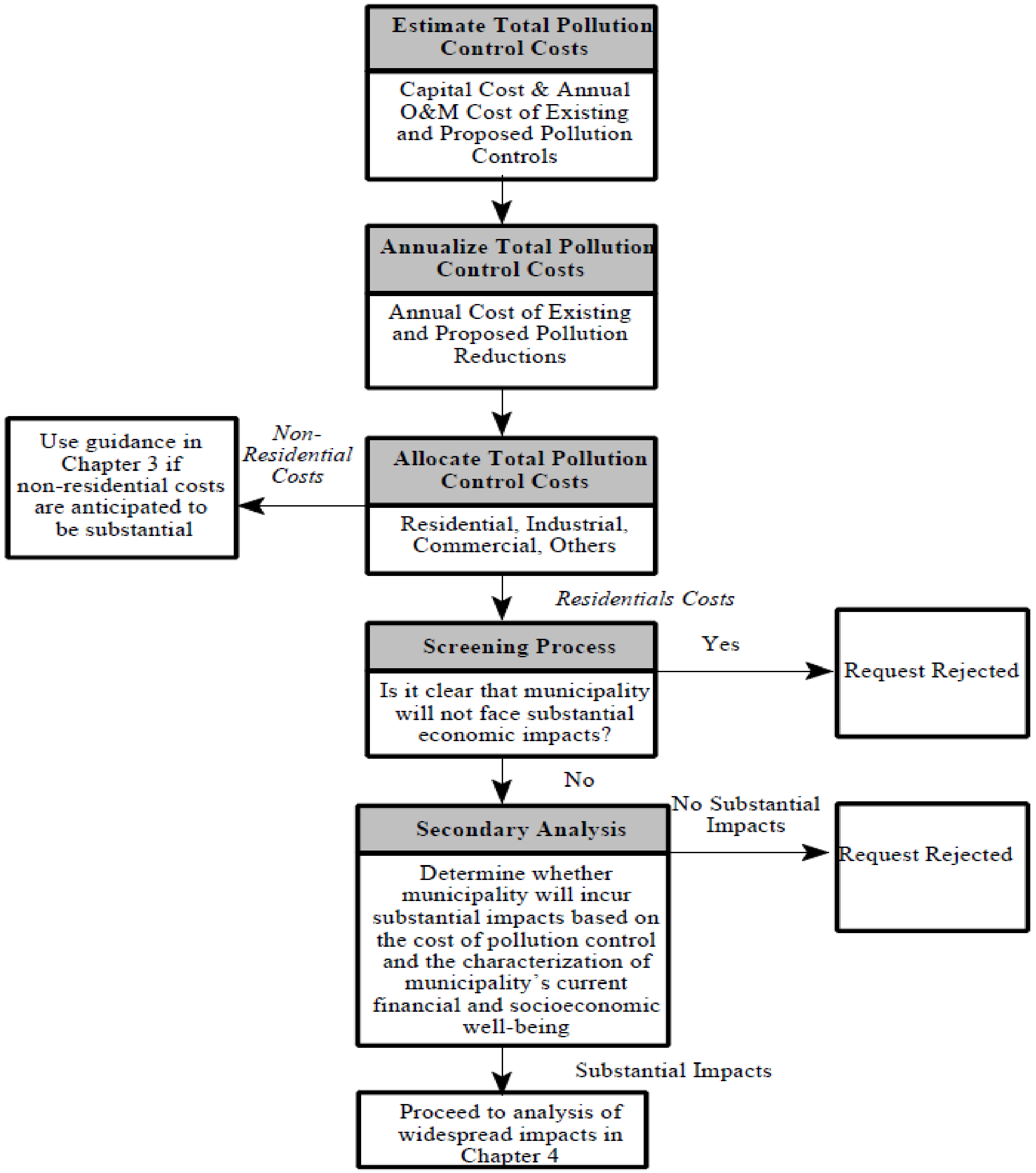

Estimate Total Pollution Control Costs
Capital Cost & Annual O&M Cost of Existing and Proposed Pollution Controls
Annualize Total Pollution Control Costs
Annual Cost of Existing and Proposed Pollution Reductions
Allocate Total Pollution Control Costs
Residential, Industrial, Commercial, Others
Non-Residential Costs
Use guidance in Chapter 3 if non-residential costs are anticipated to be substantial
Residentials Costs
Screening Process
Is it clear that municipality will not face substantial economic impacts?
Yes
Request Rejected
No
Secondary Analysis
Determine whether municipality will incur substantial impacts based on the cost of pollution control and the characterization of municipality's current financial and socioeconomic well-being
No Substantial Impacts
Request Rejected
Substantial Impacts
Proceed to analysis of widespread impacts in Chapter 4

Appendix A: Evaluation of Household Affordability Alternatives

Customer Affordability Methodology Evaluation Matrix

= Area of Relative Advantage

= Recommended Metric

A. Water Cost Burden Metrics

	Overall Framework Criteria	Criteria Weight	1 EPA Residential Indicator (Cost as % of MHI)	2 Cost as % Lowest Income Quintile	3 WARi® (Weighted average residential index)	4 AR20 (Basic cost for service as % of 20th % of Income)	5 Hours at Min Wage	Households Deliquent in Paying Bills %
1	Clearly defined terms.	Standard						
2	Customer affordability and financial capability.	Standard						
3	Valid, defensible measures from readily available, verifiable sources.	Higher						
4	Straightforward, direct, and transparent, with consistent yet flexible application.	Standard						
5	Applicable for comparisonsamong systems and across water services.	Standard						
6	Allows for flexible selection of metrics.	Standard						
7	Consider current and future cost of water, wastewater, and stormwater services.	Higher						
8	Consider all sources of revenue (user charge, tax-derived).	Standard						
9	Applicable to a broad range of EPA purposes but flexible in complexity.	Standard						

Table 1. Summarized dissolved oxygen requirements, temperatures, and salinities associated with lethal effects for sensitive stages of key oxygen sensitive species in the Delaware Estuary which are equal to or exceeding current DO standards (ANS).

Species Common Name	Stage	DO (mg/l)	Temp. (°C)	Salinity (‰)	Description	Reference
Shortnose Sturgeon	Juvenile	3.0	23	0-5	Significant decrease in percent survival.	Jenkins et al. 1993
Shortnose Sturgeon	Juvenile	2.2-3.1	22-30	2-4.5	LC50.	Campbell and Goodman 2004
Atlantic Sturgeon	Juvenile	6.3	20	1	Optimal for survival.	Niklitschek and Secor 2009a
Atlantic Sturgeon	Juvenile	4.3	12	1	Optimal for survival.	Niklitschek and Secor 2009a
Atlantic Sturgeon	Juvenile	4.3	26	-	Higher than this needed to protect survival (S. Atlantic DPS).	Federal Register 2017
American Shad	Juvenile	2.0-4.0	-	-	Surival possible with limited exposure.	Tagatz 1961
American Shad	Egg/Larval	2.5-2.9	-	-	LC50.	Stier and Crance 1985
American Shad	All	5.0	-	-	Required for spawning.	Stier and Crance 1985; Walburg and Nichols 1967
Blue Crab	Juvenile	4.1	20	10	LC50.	Stickle et al. 1989
Blue Crab	Juvenile	4.6	30	30	LC50.	Stickle et al. 1989
Blue Crab	Juvenile	5.0	24	22	28-day LC50.	Das and Stickle 1993
Blue Crab	Juvenile	5.2	30	20	LC50.	Stickle et al. 1989
Blue Crab	Juvenile	5.6	30	10	LC50.	Stickle et al. 1989
Blue Crab	Juvenile	6.0	20	30	LC50.	Stickle et al. 1989
Blue Crab	Juvenile	6.4	20	20	LC50.	Stickle et al. 1989
Atlantic Rock Crab	Larval	4.2-6.0	30	30	LC50.	Vargo and Sastry 1977
Atlantic Rock Crab	Larval	3.8	20	28-32	LC10.	Miller, Poucher, and Coiro 2002
Atlantic Rock Crab	Megalops	4.7	30	30	LC50.	Vargo and Sastry 1977
Scud (G. fasciatus)	Adult	4.3	20	-	24-hour LC50.	Sprague 1963
Scud (G. psuedolimnaeus)	Adult, Female	4.1	20	0*	Lowest DO resulting in significant mortality.	Hoback and Barnhart 1996
Channel Catfish	Egg/Larval	4.2	25	-	Decreased hatching success and survival.	Carlson, Siefert, and Herman 1974
Striped Bass	Egg	2.0-3.5	-	-	Complete absence.	Chittenden 1971
Striped Bass	Egg	4.0	-	-	Reduced survival.	Turner and Farley 1971
Striped Bass	Egg/Larval	5.0	18	-	Decreased hatching success and survival.	Turner and Farley 1971
Striped Bass	Juvenile	5.0	-	-	Threshold for high survival.	Krouse 1968 as in Bain and Bain 1982
Yellow Perch	Juvenile/Adult	4.3	26	-	Lowest DO for 100% survival.	Moore 1942
Yellow Perch	Juvenile/Adult	4.8	4	-	Lowest DO for 100% survival.	Moore 1942
Yellow Perch	Juvenile/Adult	5.1	19	-	Lowest DO for 100% survival.	Moore 1942

Where: "-" indicates absence of a temperature or salinity given in the reference; and * means test was done in "freshwater" and salinity is likely close to 0

Technical Memorandum - Draft
To: John R. Yagecic, P.E.
From: Timothy D. Bradley, P.E.
Date: May 22, 2020
cc: Namsoo Suk, Tom Amidon, Tushar Roy, Erin Dovel

Re: Nitrogen Reduction Cost Estimation Study Plant Specific Cost Estimates

1.0 INTRODUCTION

This draft Technical Memorandum presents the plant specific cost estimates and corresponding cost curves for achieving the three (3) agreed upon effluent levels for ammonia nitrogen (NH_3-N) reduction and the one (1) agreed upon effluent level for total nitrogen (TN) at the twelve (12) plants listed below by plant type that discharge to the lower Delaware River.

Conventional Activated Sludge

- City of Wilmington
- Delaware County Regional Water Authority Western Regional Treatment Plant (DELCORA)
- Gloucester County Utilities Authority (GCUA)
- Philadelphia Water Department Southeast WPCP (PWD SEWPCP)
- PWD Northeast WPCP (PWD NEWPCP)
- Lower Bucks County Joint Municipal Authority (LBCJMA)

Pure Oxygen Activated Sludge

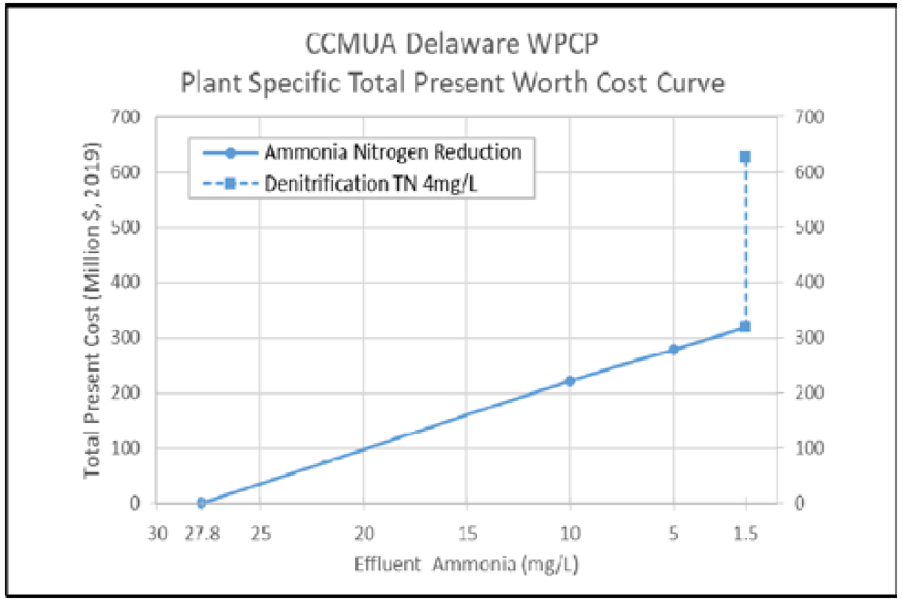
- PWD Southwest WPCP (PWD SWWPCP)
- Delaware #1 WPCP / Camden County Municipal Utilities Authority (CCMUA)
- Morrisville Borough Municipal Authority (MMA)

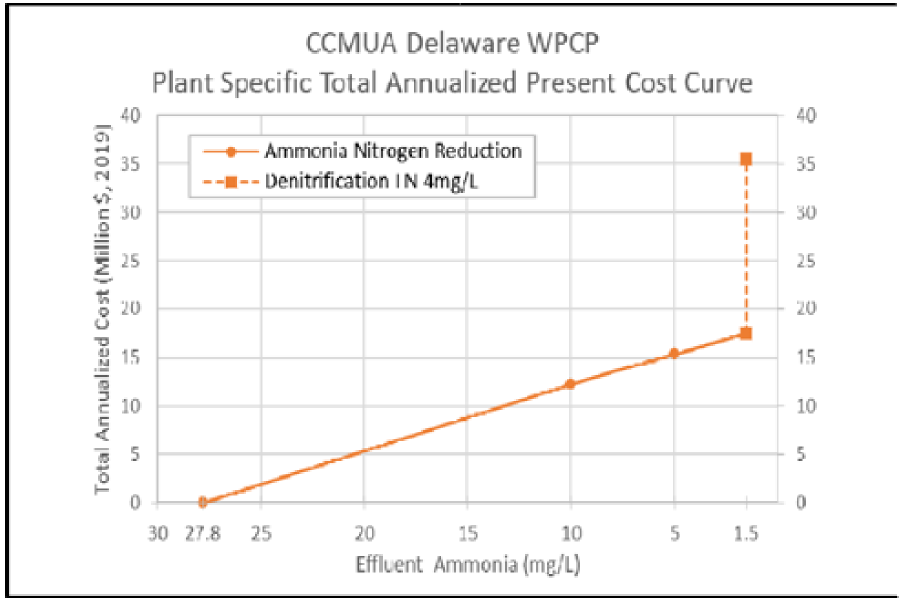
Fixed Film

- Trenton Sewer Utility
- Willingboro MUA Water Pollution Control Plant (Willingboro MUA)
- Hamilton Township Water Pollution Control Facility (Hamilton Township)

CCMUA Plant Specific Cost Estimates

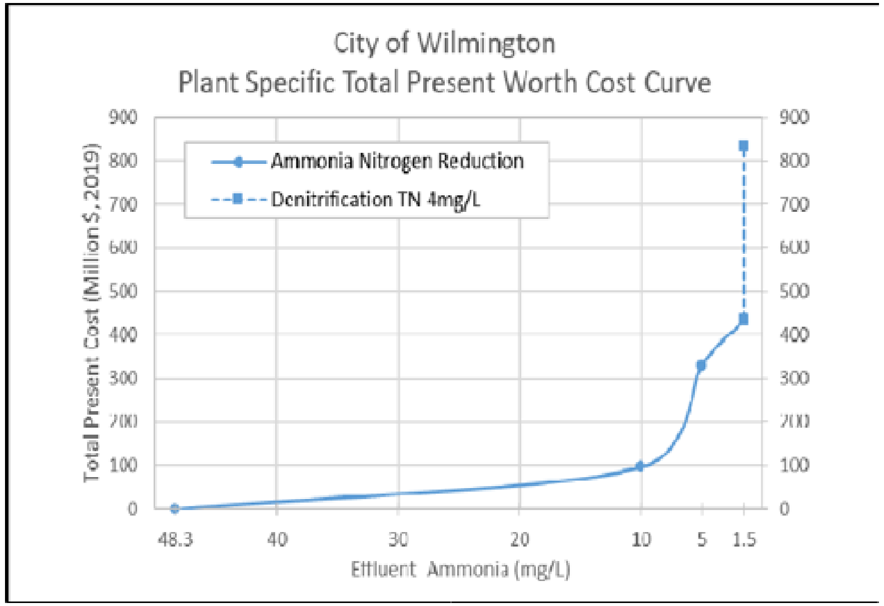
Effluent Level	Present Cost (Million $, 2019)			Annualized Present Cost (Million $/year, 2019)		
Scenario	Capital	O&M Present Worth	Total Present Worth Cost	Debt Service	Annual O&M	Total
NH_3-N - 10 mg/L	94	128	221	6	6	12
NH_3-N - 5 mg/L	114	164	278	7	8	15
NH_3-N - 1.5 mg/L	129	189	318	8	9	18
TN - 4 mg/L	310	316	626	20	15	35

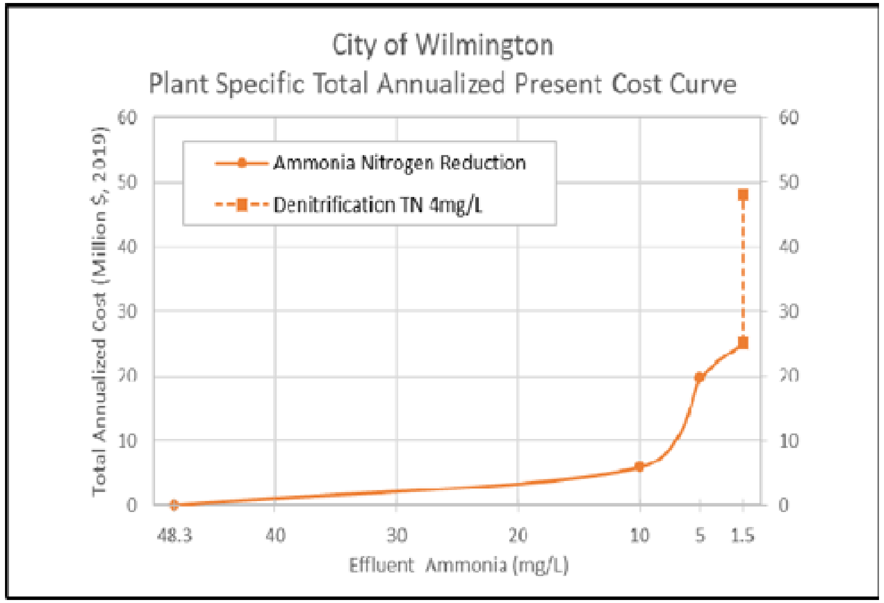




Wilmington Plant Specific Cost Estimates

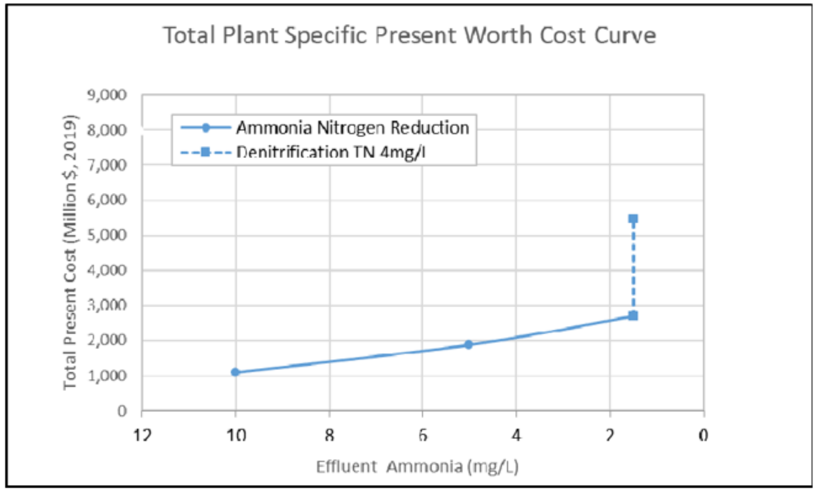
Effluent Level	Present Cost (Million $, 2019)			Annualized Present Cost (Million $/year, 2019)		
Scenario	Capital	O&M Present Worth	Total Present Worth Cost	Debt Service	Annual O&M	Total
NH_3-N - 10 mg/L	74	22	95	5	1	6
NH_3-N - 5 mg/L	221	108	330	14	5	20
NH_3-N - 1.5 mg/L	248	186	434	16	9	25
TN - 4 mg/L	474	360	834	31	17	48

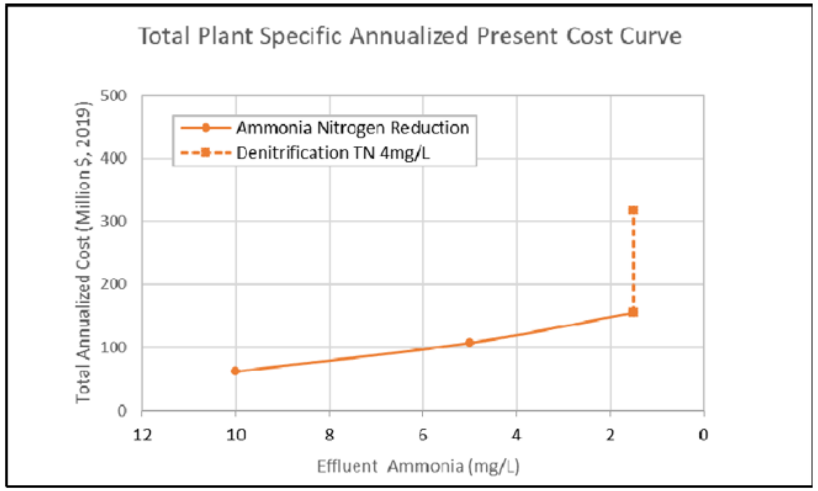




Overall Summary of Plant Specific Costs

Effluent Level	Present Cost (Million $, 2019)			Annualized Present Cost (Million $/year, 2019)		
Scenario	Capital	O&M Present Worth	Total Present Worth Cost	Debt Service	Annual O&M	Total
NH_3-N - 10 mg/L	559	530	1,090	36	26	62
NH_3-N - 5 mg/L	1,007	869	1,876	65	42	107
NH_3-N - 1.5 mg/L	1,541	1,142	2,683	100	55	155
TN - 4 mg/L	3,217	2,244	5,461	209	108	318





Questions?