Estimating Avoided Drinking Water Treatment Costs from Improved Source Water Quality

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Avoided Drinking Water Treatment Costs

- Understanding determinants of drinking water treatment costs can help support decisions related to technology selection, production, and treatment process.
- $Treatment\ Costs = f\,(Output, Input\ Prices, Source\ Water\ Quality\,)$
- When cost functions include source water quality (SWQ), economists can calculate avoided-cost benefits from improved SWQ. E.g., if turbidity decreases by x%, drinking water treatment costs will decrease by $y.
- Avoided drinking water treatment costs
  - can help determine whether source water protection (SWP) would be a cost-effective component of producing potable water (Heberling et al., 2015; Price et al., 2018)
  - **can inform federal and state regulations about the benefits of improved water quality**
  - are a key knowledge gap for both regulation and source water protection decisions

Meta-Analysis

The effects of source water quality on drinking water treatment costs: A review and synthesis of empirical literature (Price and Heberling, 2018)

- Study overview
  - Identified 24 studies (75 elasticity estimates)
  - Studies used diverse measures of SWQ, definitions of cost, and statistical methods
  - Overall, changes in SWQ have statistically significant but modest affects on costs
  - Estimated changes are smaller in studies that incorporated key control variables

Meta-Analysis Results

Water Quality Measure	Number of Estimates	Number of Estimates w/ key controls	Mean Elasticity[1,2,3] (95% Confidence Interval)
Turbidity	12	5	0.12 (0.10 – 0.14)
TOC	5	2	-
Nitrogen/Nitrate	2	1	0.06 (0.04 – 0.08)
Sediment load	3	1	0.05 (0.03 – 0.07)
Phosphorus load	2	1	0.02 (0.01 – 0.03)
Pesticide load	2	0	-
Forestland	7	2	-0.58 (-0.68 – -0.48)

[1] Statistically significant at $p<0.1$ using one-tailed t-test.
[2] Based on studies that incorporated control variables consistent with economic theory in their models.
[3] Calculated from a small number of observations; caution should be taken when applying these values to other contexts.

Avoided Drinking Water Treatment Costs: Steam Electric Power Generating Effluent Guidelines (2024)

Final Rule published on May 9, 2024, and effective July 8, 2024.
See: https://www.epa.gov/eg/steam-electric-power-generating-effluent-guidelines-2024-final-rule.

- Effluent Limitation Guidelines (ELGs) apply to steam electric power plants.
- Power plants that burn coal to produce electricity use large volumes of water.
- When this water is returned to waterbodies it can include:
  - Toxic and bioaccumulative pollutants such as selenium, mercury, arsenic, and nickel;
  - Halogen compounds such as bromide, chloride, and iodide;
  - Nutrients such as nitrogen and phosphorus; and total dissolved solids.

Steam Electric ELGs

- Three policy options* identified that cover all four types of regulated waste streams:
  - Flue Gas Desulfurization (FGD) Wastewater, Bottom Ash Transport Water (BATW), Combustion Residual Leachate (CRL), and legacy wastewater.
- Regulatory Options: Each successive option from Option A to Option C would achieve a greater reduction in wastewater pollutant discharges.
- Categories of benefits included: Human health effects (IQ, cardiovascular), ecological and recreation, market/productivity, and air-quality effects
  - Market/productivity benefits category: Estimate the avoided drinking water treatment costs

Source: https://www.epa.gov/eg/steam-electric-power-generating-effluent-guidelines

*All three options include the same technology basis for FGD wastewater (zero-discharge systems) and BATW (dry-handling or closed-loop systems) while incrementally increasing controls on CRL and legacy wastewater and removing certain subcategories as one moves from Option A to Option C.

Data and Methodology

1. Identify water systems with surface water intakes downstream of steam electric power plant discharges.
2. Estimate total nitrogen (TN) and total suspended solids (TSS) baseline levels and reductions in source water using SPARROW modelling.
3. Convert TSS levels and reductions to turbidity levels and reductions following US EPA (2009b).
4. Compute the percent change in TN and turbidity for each regulatory option and all regulatory periods.
5. Estimate drinking water treatment costs at affected water systems using the median cost by system size according to responses to the 2006 Community Water System Survey (US EPA, 2009a).
6. Estimate the percent change in drinking water treatment costs associated with reductions in TN and turbidity levels using the elasticities in Price and Heberling (2018).

Source: https://www.epa.gov/eg/steam-electric-power-generating-effluent-guidelines

Treatment Cost Elasticity Approach

- Avoided drinking water treatment costs, $\Delta Cost_{itp}$, for drinking water system *i*, period *t*, and each water quality parameter *p*:

$$\Delta Cost_{itp} = \eta_p * \frac{\Delta Concentration_{itp}}{Concentration_{itp}} * Cost_{it}$$

- Where η_p represents the elasticity between source water concentrations of water quality parameter *p* and drinking water treatment costs ($Cost_{it}$).
  - For TN, EPA uses elasticity values 0.05 to 0.06 that represent average elasticity values presented in Price and Heberling (2018).
  - For TSS, EPA uses turbidity elasticity estimates of 0.10 to 0.12 from the same study to represent low and high estimates.

Source: https://www.epa.gov/eg/steam-electric-power-generating-effluent-guidelines

Estimated Changes Water Quality

Average Percent Change in Source Water Concentrations of Total Nitrogen (TN) and Total Suspended Solids (TSS) Compared to Baseline

	Period 1 (2025-2029)		Period 2 (2030 -2049)	
Regulatory Option:	TSS	TN	TSS	TN
Option A	-0.0006	-0.008	-0.0012	-0.009
Option B (Final Rule)	-0.0006	-0.008	-0.0013	-0.009
Option C	-0.0009	-0.010	-0.0015	-0.009

Source: US EPA, 2024a.

Median Drinking Water Treatment Costs

Annual Expenditures by System Size

System Size (Population)	Surface Water		Affected Systems Count
	Median Treatment Cost	CWSS System Count	
<100	$20,890	18	11
101–500	$279,412	21	8
501–3,300	$436,572	24	27
3,301–10,000	$1,679,000	27	47
10,001–50,000	$3,108,194	36	80
50,001–100,000	$2,263,000	38	23
100,001–500,000	$11,101,192	104	27
>500,000	$90,992,030	39	10

Source: US Community Water System Survey (CWSS), 2006; US EPA, 2009a.

Notes: Surface-water systems include systems sourcing from groundwater under the influence of surface water. Dollars estimated to 2023$.

Annual Change in Treatment Costs

Estimated Average System-Level Annual Changes in Drinking Water Treatment Costs for **Total Nitrogen** under the Regulatory Options, Compared to Baseline

System Size (Population)	Low Estimate			High Estimate		
	Option A	Option B (Final Rule)	Option C	Option A	Option B (Final Rule)	Option C
<100	-5	-5	-8	-6	-6	-9
101–500	-57	-57	-93	-69	-69	-111
501–3,300	-353	-353	-387	-423	-423	-464
3,301–10,000	-481	-481	-482	-578	-578	-578
10,001–50,000	-1,527	-1,527	-1,692	-1,833	-1,833	-2,030
50,001–100,000	-230	-230	-430	-276	-276	-516
100,001–500,000	-914	-914	-1,338	-1,097	-1,097	-1,606
>500,000	-17,526	-17,526	-23,804	-21,031	-21,031	-28,565

Source: US EPA, 2024a.

Notes: The presented annual cost changes by system size not discounted or annualized and represent only changes to system treatment costs averaged over each year of the regulatory analysis period. Treatment costs include only ongoing operation and maintenance costs and exclude investments in irreversible capital equipment.

Annual Change in Treatment Costs

Estimated Average System-Level Annual Changes in Drinking Water Treatment Costs for **TSS** under the Regulatory Options, Compared to Baseline

System Size (Population)	Low Estimate			High Estimate		
	Option A	Option B (Final Rule)	Option C	Option A	Option B (Final Rule)	Option C
<100	-1	-1	-1	-1	-2	-2
101–500	-17	-21	-22	-20	-26	-27
501–3,300	-67	-81	-82	-80	-97	-99
3,301–10,000	-406	-415	-531	-487	-498	-638
10,001–50,000	-258	-291	-308	-309	-349	-370
50,001–100,000	-78	-90	-110	-94	-107	-133
100,001–500,000	-628	-697	-932	-754	-838	-1,119
>500,000	-3,291	-3,821	-5,312	-3,970	-4,610	-6,401

Source: US EPA, 2024a.

Notes: The presented annual cost changes by system size not discounted or annualized and represent only changes to system treatment costs averaged over each year of the regulatory analysis period. Treatment costs include only ongoing operation and maintenance costs and exclude investments in irreversible capital equipment.

Estimated Changes in Treatment Costs Compared to Total Benefits

Annualized Estimated Drinking Water Treatment Cost Savings under the Regulatory Options, Compared to Baseline (Million 2023$, Two Percent Discount Rate)

Regulatory Option:	TN		TSS		Combined		Total Benefits of the Rule (across all categories)
	Low Estimate	High Estimate	Low Estimate	High Estimate	Low Estimate	High Estimate	
Option A	$0.357	$0.429	$0.092	$0.111	$0.449	$0.539	$2,417
Option B (Final Rule)	$0.357	$0.429	$0.103	$0.124	$0.460	$0.552	$3,217
Option C	$0.460	$0.552	$0.133	$0.160	$0.592	$0.711	$3,919

Source: US EPA, 2024a.

Conclusions

- For its Clean Water Act programs, EPA is making a concerted effort to estimate additional benefits including ecosystem services (e.g., BenSPLASH and HAWQS).
- Steam Electric ELGs is an example of quantifying benefit category using treatment cost elasticity approach.
  - May provide rationale for researchers to develop additional treatment cost elasticities for use in future regulatory impact assessments.
- Some of the limitations:
  - Only quantifies changes in TSS and TN, not metals and halogens.
  - Uses 2006 CWSS for median costs, not average cost, because small sample sizes.
  - Treatment costs only vary by O&M costs, capital expenditures are assumed constant.
- For Proposed Meat and Poultry Processing ELGs (US EPA, 2023), EPA did not monetize changes in treatment costs. With framework, EPA is quantifying avoided treatment costs for the final rule.

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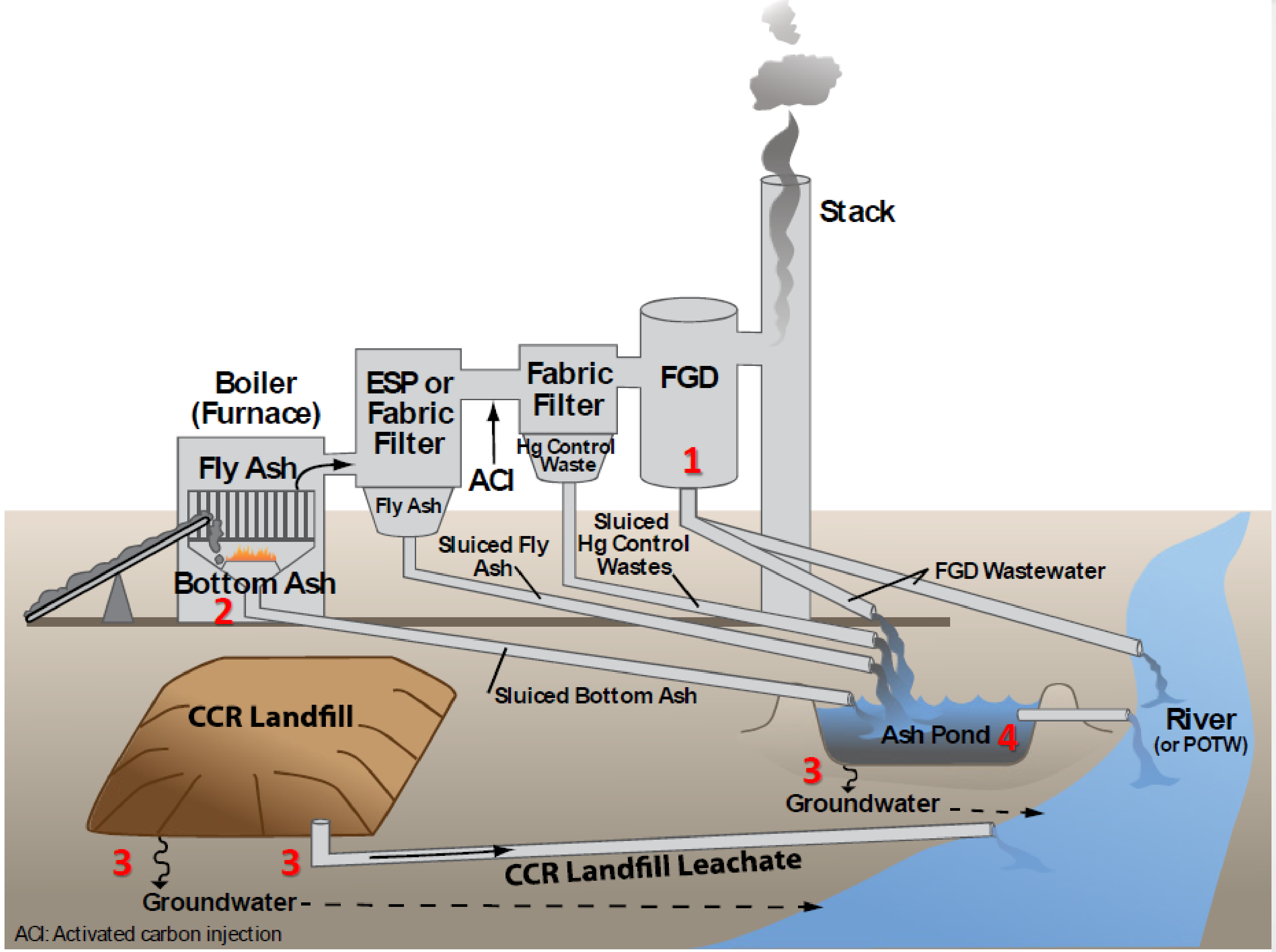
Study Examples

- Moore and McCarl (1987)
  - Off-site sediment costs on water treatment, daily data, one plant in OR
- Dearmont et al. (1998)
  - Cost of treatment due to poor water quality, chemical costs, monthly data, 12 plants in TX
- Forster and Murray (2007)
  - Costs of treatment with tillage and pesticide practices, annual data, 11 plants in OH
- Heberling et al. (2015)
  - Costs of treatment with changes in source water quality, production, and seasonal variables, daily data, one plant in OH
- Price and Heberling (2020)
  - Land use near surface water intakes and wellheads is employed as a proxy for source water quality, many plants across the US

Wastestreams Regulated in the 2024 Rule

1. Flue Gas Desulfurization (FGD) Wastewater
2. Bottom Ash Transport Water (BATW)
3. Combustion Residual Leachate (CRL) from ash/FGD ponds and landfills
4. Legacy Wastewaters



Source: US EPA, 2024b.