

Technical Report No. 66

STATE OF THE ART FOR CHLORIDE MANAGEMENT

Appendix X

**CALCULATIONS FOR CHLORIDE REMOVAL
AT WWTPS COSTS**

Reviewed costs from three sources:

AECOM, Chloride Compliance Study for NSWTP, June 2015.

Minnesota Pollution Control Agency, "Alternatives for addressing chloride in wastewater effluent", December 2018.

Minnesota Pollution Control Agency, "Analyzing Alternatives for Sulfate Treatment in Municipal Wastewater", May 2018.

General notes for WWTP Cl removal cost assessment:

Chloride Compliance Study Nine Springs WWTP costs include RO and EDR

Alternatives for Addressing Chloride in Wastewater Effluent costs are for RO with brine reduction

Analyzing Alternatives for Sulfate Treatment in Municipal Wastewater costs are for RO with brine reduction

Costs are in per MGD rather than per capita to account for industrial and commercial wastewater flows.

SUMMARY OF COSTS¹ FROM ALL THREE STUDIES

CAPITAL COSTS	Low Est.	High Est.	Year of	CCI ratio	CCI index
			report		
Chloride Compliance Study Nine Springs WWTP	\$500,000,000	\$600,000,000	2015	1.288	2023 16941.328
Alternatives for Addressing Chloride in Wastewater Effluent	\$711,900,000	\$711,900,000	2018	1.172	2022 16171.313
Analyzing Alternatives for Sulfate Treatment in Municipal Wastewater	\$311,605,000	\$495,645,000	2018	1.172	2021 15505.022
O&M COSTS					2020 15008.745
Chloride Compliance Study Nine Springs WWTP	\$48,205,000	\$48,205,000	2015	1.288	2019 14743.849
Alternatives for Addressing Chloride in Wastewater Effluent	\$62,950,000	\$62,950,000	2018	1.172	2018 14452.613
Analyzing Alternatives for Sulfate Treatment in Municipal Wastewater	\$12,751,500	\$24,331,500	2018	1.172	2017 13896.979
					2016 13532.117
					2015 13156.768

¹ Costs based on 50 MGD for capital costs and 15 MGD for O&M costs to be consistent across the three studies (see note below for rationale). For studies with high and low costs being the same, a single cost was presented rather than a range.

COST IN 2023 DOLLARS

	Capital Costs - Total ¹		Capital Costs - Per MGD	
	Low Est.	High Est.	Low Est.	High Est.
Chloride Compliance Study Nine Springs WWTP	\$644,000,000	\$773,000,000	\$13,000,000	\$15,000,000
Alternatives for Addressing Chloride in Wastewater Effluent	\$834,000,000	\$834,000,000	\$17,000,000	\$17,000,000
Analyzing Alternatives for Sulfate Treatment in Municipal Wastewater	\$365,000,000	\$581,000,000	\$7,000,000	\$12,000,000
	O&M Costs - Total		O&M Costs - Per MGD ¹	
	Low Est.	High Est.	Low Est.	High Est.
Chloride Compliance Study Nine Springs WWTP	\$62,000,000	\$62,000,000	\$4,000,000	\$4,000,000
Alternatives for Addressing Chloride in Wastewater Effluent	\$74,000,000	\$74,000,000	\$5,000,000	\$5,000,000
Analyzing Alternatives for Sulfate Treatment in Municipal Wastewater	\$15,000,000	\$29,000,000	\$1,000,000	\$2,000,000

¹ Costs based on 50 MGD for capital costs and 15 MGD for O&M costs to be consistent across the three studies (see note below for rationale). For studies with high and low costs being the same, a single cost was presented rather than a range.

Chloride Compliance Study Nine Springs WWTP

CAPITAL COSTS (includes brine minimization; varies based on RO vs EDR and other factors; year 2015 dollars)

	Cost for 50 MGD	Cost per MGD
Low estimate (w/ brine minimization)	\$500,000,000	\$10,000,000
High estimate (w/ brine minimization)	\$600,000,000	\$12,000,000

Note: * 2.6 MGD is the current conditions average flow
 * 7.3 MGD is the future conditions average flow
 * 15 MGD is the design capacity
 * 50 MGD is the total softened water capacity for source water softening alternatives, so WWTP costs for 50 MGD allow for comparison between WWTP treatment alternatives and source softening alternatives. At 50 MGD, the chloride removal system would produce 5 MGD of brine

OPERATION AND MAINTENANCE COSTS (year 2015 dollars)

Alternative	Cost for 15 MGD	Cost per MGD
RO w/ evaporator and crystallizer	\$48,205,000	\$3,214,000
EDR w/ evaporator and crystallizer	\$25,395,000	\$1,693,000

Note: The volume for treatment would vary seasonally. The O&M costs vary with flow, and the full design capacity of the treatment system would not be required to be operated at all times. As such, 15 MGD was the largest volume assessed for O&M.

Alternatives for Addressing Chloride in Wastewater Effluent (MPCA)

Note: since the costs in this report are based on population size, we can use the Nine Springs population served to be able to compare to the costs in the Nine Springs report. This would mean 50 MGD for capital costs and 15 MGD for O&M costs as per the Nine Springs study

Nine Springs population served: 407,000

Costs are only for RO treatment (with evaporation and crystallization)

Since costs only go up to a population of 50,000 in the report but are linear, we extrapolated out to 407,000

CAPITAL COST (year 2018 costs) equation² is approximately $y=1,700*x+20,000,000$, where x is population and y is capital cost so, at a population of $x=407,000$, the capital cost would be \$711,900,000

ANNUAL O&M COSTS (year 2018 costs) equation is approximately $y=150x+1,900,000$, where x is population and y is annual O&M costs so, at a population of $x=407,000$, the annual O&M cost would be \$62,950,000

² The costs in the report were presented in graphical form as cost curves. The equations listed above for capital costs and annual O&M costs were approximated from the "most likely cost" curves in the report.

Analyzing Alternatives for Sulfate Treatment in Municipal Wastewater (MPCA)

Costs are for RO treatment and brine reduction system (year 2018 dollars)

	Cost for 10 MGD (lower est.) ^{3,4} (higher est.)		Cost per MGD (lower est.) (higher est.)		Cost for 50 MGD (cap) or 15 MGD (O&M) (lower est.) (higher est.)	
	Capital costs	\$62,321,000	\$99,129,000	\$6,232,100	\$9,912,900	\$311,605,000
O&M	\$8,501,000	\$16,221,000	\$850,100	\$1,622,100	\$12,751,500	\$24,331,500

Note: ³ Lower and higher estimates are based on different brine treatment technologies.

⁴ With there being three different brine treatment alternatives, the lowest capital cost alternative does not correspond with the lowest O&M alternative.

brine minimization alt	SUMMARY OF CAPITAL COSTS AND O&M COSTS			O&M for RO system	O&M for brine treatment	O&M total
	cap cost for RO system	cap cost for brine treatment	total cap cost			
(1)	\$33,821,000	\$34,000,000	\$67,821,000	\$1,623,000	\$14,033,000	\$15,656,000
(2)	\$33,821,000	\$28,500,000	\$62,321,000	\$1,623,000	\$14,598,000	\$16,221,000
(3)	\$33,821,000	\$65,308,000	\$99,129,000	\$1,623,000	\$6,878,000	\$8,501,000