How the Changing Dynamics of the Conowingo and Other Susquehanna River Dams Affect the Bay Restoration Effort

Key Points from the Lower Susquehanna River Watershed Assessment

METROPOLITAN WASHINGTON
Council of Governments

COG Staff Technical Brief
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Note on Sources: The facts and figures in this briefing paper were compiled by COG staff from the October 2014 draft Lower Susquehanna River Watershed Assessment report and related documents, from the USGS Scientific Investigations Report 2012–5185 and from various Chesapeake Bay Program Modeling Workgroup presentations.

Key Point

New understanding of the changing dynamics of sediment and associated nutrient flows through the dams of the lower Susquehanna River will prompt several major decisions by the federal government, the state of Maryland and the Bay Program. These include a decision on whether or not to relicense the operation of the dam and to require any actions to address its water quality impacts. The Chesapeake Bay Program may have to revise the load allocations under the Chesapeake Bay TMDL to account for the dam's negative impact on water quality.

The Conowingo decision has become caught up in a broader debate about local governments' role in achieving load reductions. Although it is not clear that the COG region has a stake in the relicensing decision, it does have a stake in the Bay Program decision.

The rest of the briefing paper is divided into the following sections"

Background

The Susquehanna River watershed covers more than 27000 square-miles of areas between New York, Pennsylvania, and Maryland. It is the largest watershed in the Chesapeake Bay. Based on U.S. Geological Survey monitoring data from 1985 to 2013, which estimates the loads from the nine fall-line monitoring stations on the Bay's major tributaries, the Susquehanna River contributes about 60 percent of the fresh water, 67 percent of the nitrogen, 46 percent of the phosphorus and 47 percent of the sediment entering the Bay.

In the last century three hydroelectric dams were built on the lower Susquehanna River to generate renewable energy. These dams are Safe Harbor and Holtwood in Pennsylvania, and Conowingo dam in Maryland. The dam at Conowingo is the largest in terms of storage capacity, at 300,000 acre-feet.

Dam	Reservoir Name	Construction Date	Dam Height (feet)	Capacity (acre- feet)	Trapping Capacity Status
Safe Harbor, PA	Lake Clarke	1931	75	150,000	Dynamic equilibrium reached in the 1950s
Holtwood, PA	Lake Aldred	1910	55	60,000	Dynamic equilibrium reached in the 1920s
Conowingo, MD	Conowingo Reservoir	1928	94	300,000	Dynamic equilibrium reached in the 2000's, very limited capacity remaining

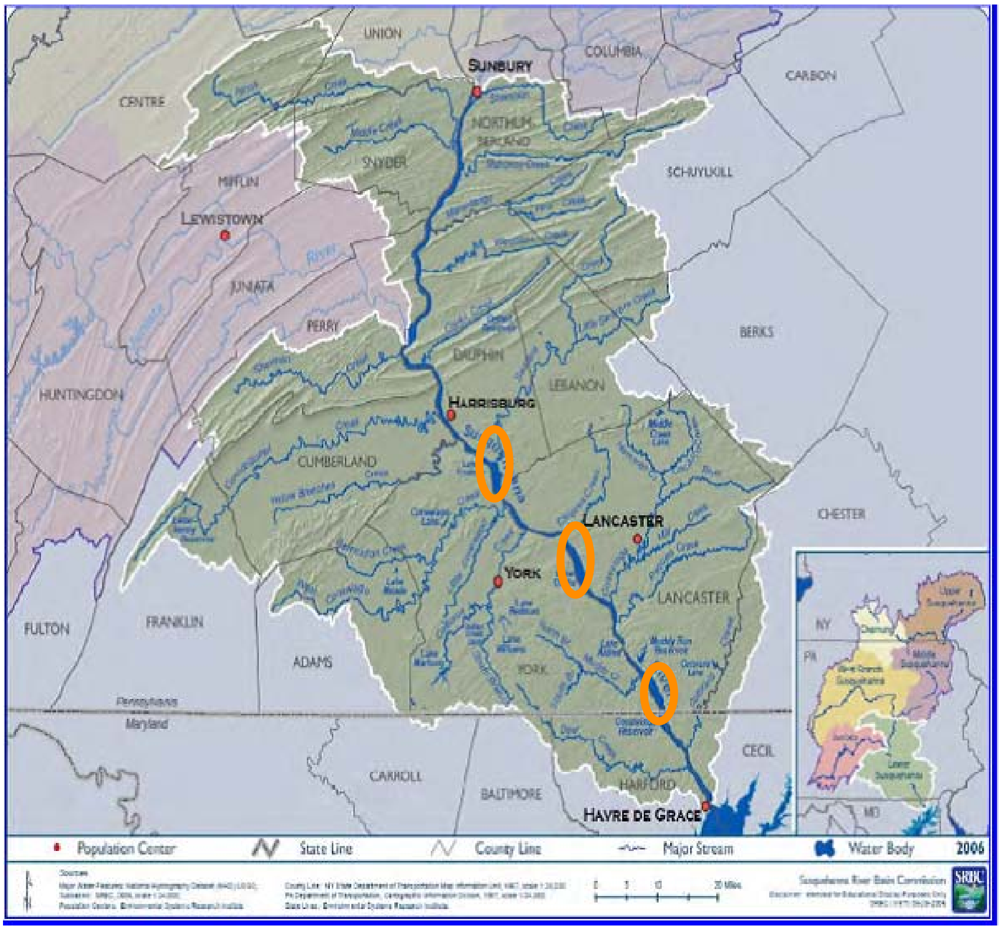
As the dams have gradually filled with sediment, they have reached a state that has been termed "dynamic equilibrium." As the lowermost dam in the system, the one at Conowingo is the last one to reach dynamic equilibrium and thus has become the primary focus of management concerns about the dams.

Much of that focus has been driven by a 2012 request from the Exelon Corporation, which owns the dam at Conowingo, for federal relicensing. As part of that process, Maryland must certify that the operation of the dam meets water quality standards. In concert with other partners, the state undertook a number of studies of the changing dynamics at the dam. The most significant of these is the Lower Susquehanna River Watershed Assessment (LSRWA), which issued a Phase I draft report in October 2014. Currently, the relicensing process is on hold, as Exelon and Maryland pursue further studies of the dams' impact on water quality in the Chesapeake Bay.

LSRWA findings:

- Deposition and scouring rates are different than previously understood.
- Under TMDL attainment levels of load reduction, not addressing the changing dynamics of the dam would result in not meeting water quality standards in 3 of the Bay's 92 tidal water segments.
- The non-attainment would result from the nutrients associated with the increase in sediment fluxes over the dam, not directly from the sediments themselves.
- The vast majority of the nutrients and sediment flowing over the dam come from upstream sources, not scouring.
- Dredging or other types of dam operational adjustments cannot offset the impact of increased scouring at realistic levels of investment.
- Upstream source control is more effective than dredging

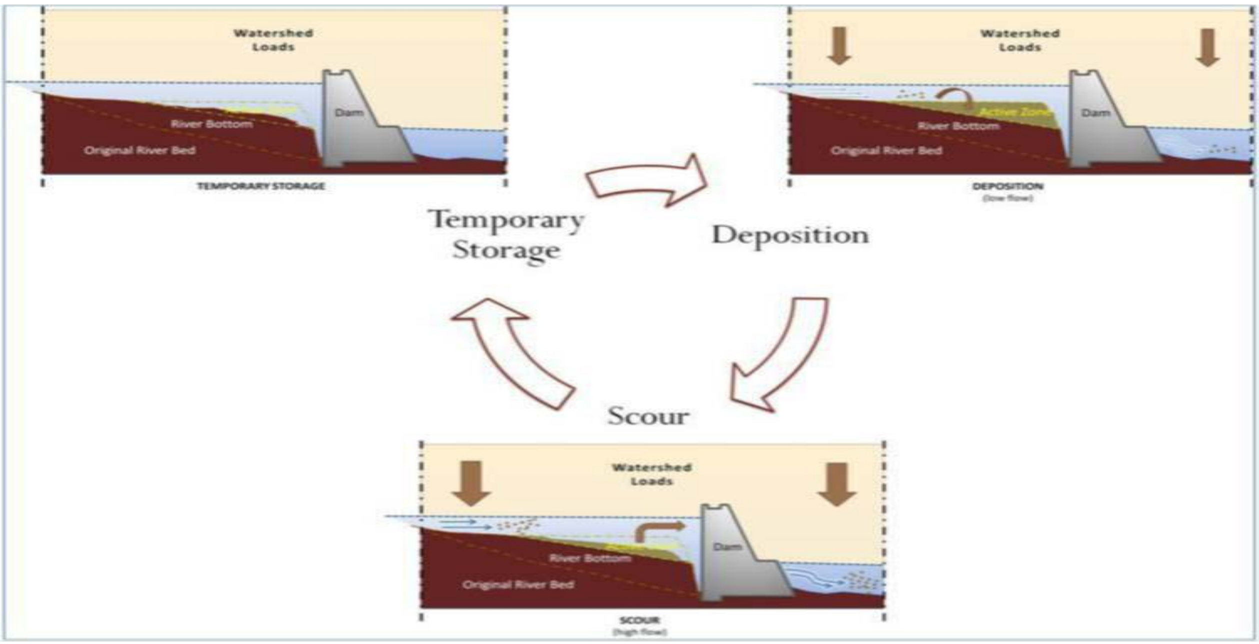
Figure 1. The LSRWA study area is particularly focused on the lower part of the Susquehanna River watershed and the system of three hydroelectric dams on that portion of the river.



Dynamic Equilibrium

Dynamic equilibrium indicates a balance between sediment inflow and outflow over a long period of time and it is based on the frequency and timing of scouring events. During high flow from storm events, the sediment and associated nutrients behind the dam are scoured and deposited downstream; that leaves storage capacity behind the dam where new sediment and nutrient settle in as shown in the graph.

Figure 2. A schematic depiction of dynamic equilibrium



As a result of this dynamic equilibrium, more sediment and its associated nutrient loads from upstream watershed areas are now being deposited in the upper Bay than was previously the case.

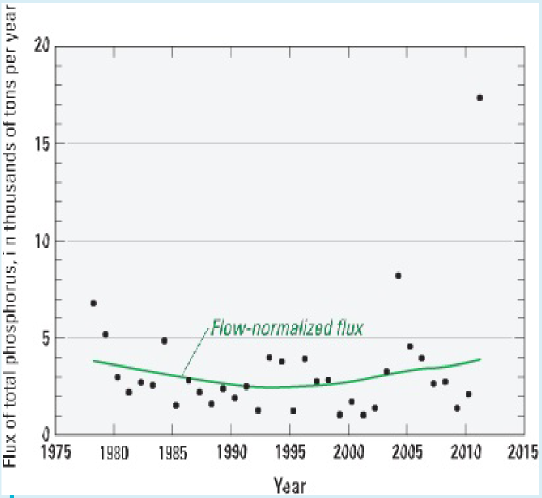
TECHNICAL FINDINGS

Effects on Loads

According to recent USGS study total nitrogen (TN) and total phosphorous (TP) concentrations are steadily declining at low and moderate flow rates. However, at very high flows or storm events (above about 150,000 cfs) both constituents are subject to event-driven increases. This increase in concentration of TN and TP at higher flows is almost certainly a result of the decrease in the Conowingo dam reservoir’s storage capacity.

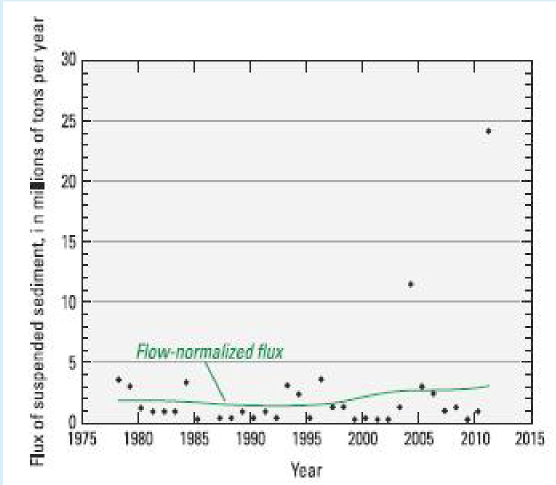
Dynamic equilibrium is also thought to be the cause of significantly increasing load trends for TP and suspended sediment at Conowingo since the mid-1990s, as calculated by USGS using WRTDS, its flow-adjusted method for estimating loads.

Figure 3:
USGS flow weighted load trend for TP at Conowingo



Total P trend: up 55% from 1996-2011

Figure 4.
USGS flow weighted load trend for suspended sediment at Conowingo



Suspended sediment trend, up 97% from 1996-2011

Data from Hirsch, R.M., 2012, "Flux of Nitrogen, Phosphorus, and Suspended Sediment from the Susquehanna River Basin to the Chesapeake Bay during Tropical Storm Lee, September 2011, as an Indicator of the Effects of Reservoir Sedimentation on Water Quality," U.S. Geological Survey Scientific Investigations Report 2012–5185

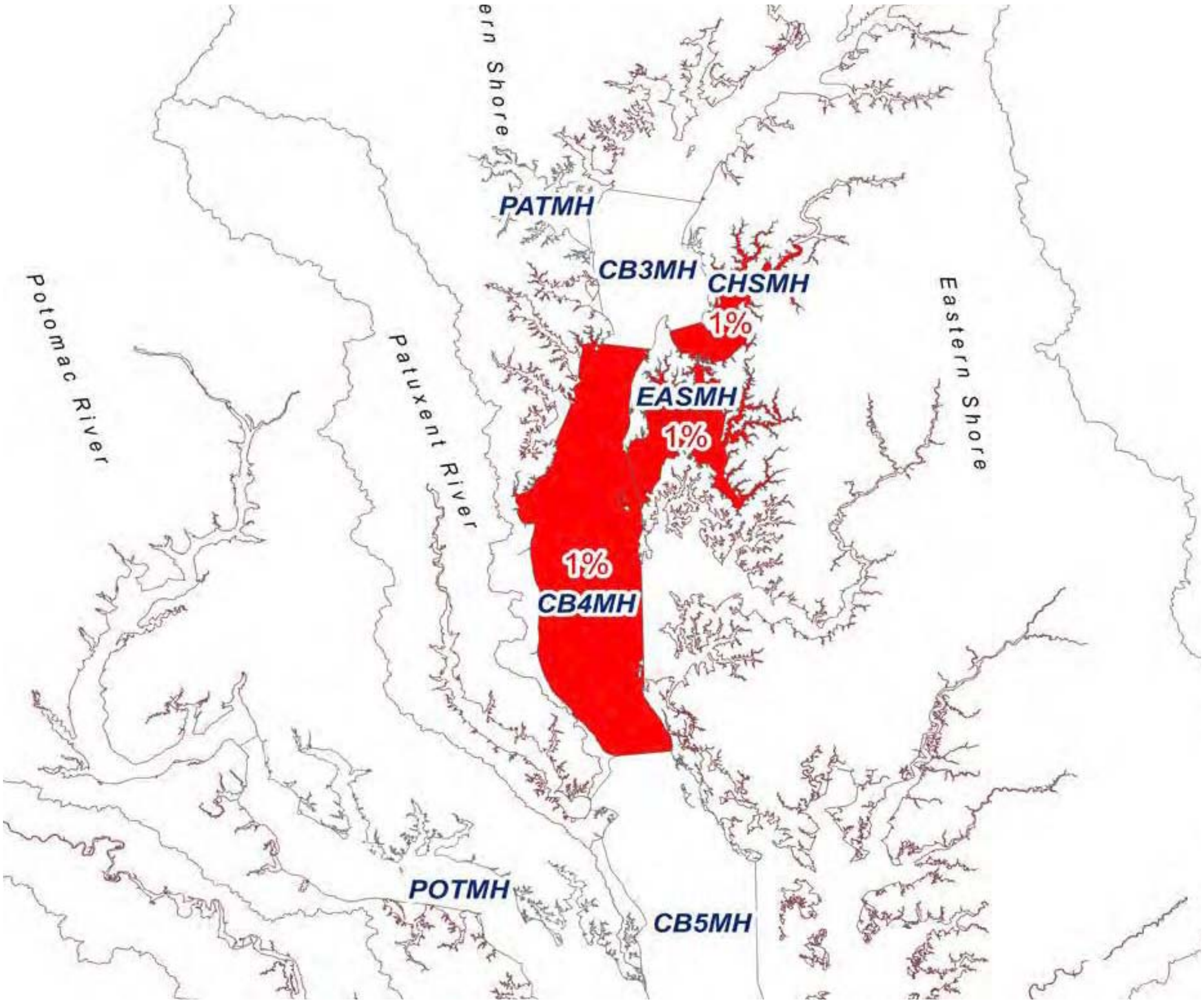
USGS has estimated an actual decreasing load trend for total nitrogen during this period as a small increasing trend for the particulate nitrogen associated with sediment is more than offset by continued declines in NO3 –nitrogen.

Impact on water quality

Generally, sediment settles within days and weeks due to its settling velocity. The coarser and heavier the sediment, the faster it settles into the bottom. Therefore, most of the sediment settles in the upper portion of the bay and, depending on when high-flow storm events occur, often misses the period of submerged aquatic vegetation (SAV) growth. On the other hand, the nutrients associated with the sediment scoured from the dam have greater impact on the ecosystem of the bay. Nutrient particles typically settle and then can be recycled into the water column in dissolved form, which stimulates algae production. Algal organic matters decay and consume dissolved oxygen (DO) that causes eutrophication and dead zones. In addition, algal growth hinders light attenuation and thus severely limits SAV growth.

A series of model Chesapeake Bay Program model runs performed for the LSRWA have estimated that the greater amounts of sediment and nutrients flowing over the dam as compared to the previous estimates of such loads, will increase non-attainment of the deep channel DO standard by about 1% in model segments CHSMH, EASMH, and CB4MH under the Chesapeake Bay TMDL water quality standards framework.

Figure 5:
Impact of dynamic equilibrium on attainment of water quality standards in the Chesapeake Bay

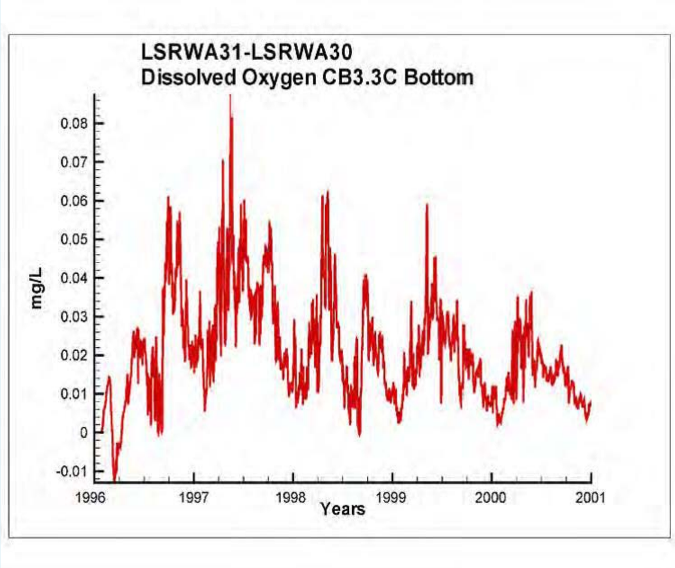


Source: LSRWA Report Appendix D (LWRSA scenario 21 – LSRWA scenario 3 computed change in deep channel DO for 1996-1998 hydrology period)

Why is dredging not recommended?

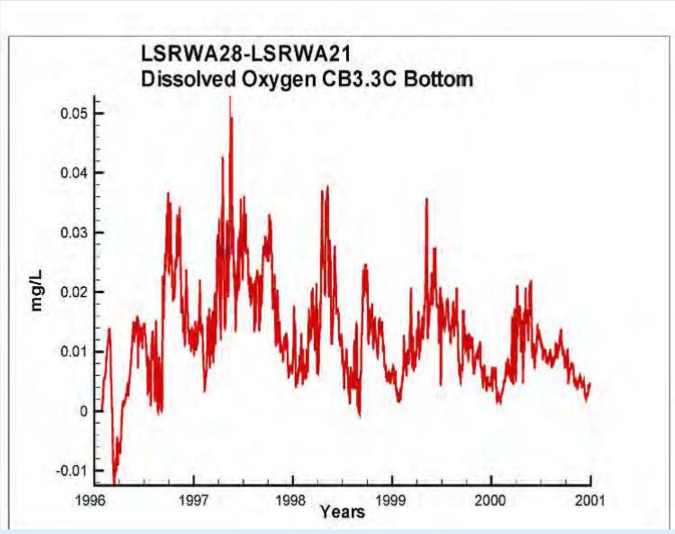
According to the LSRWA, dredging the dam reservoirs would be very costly and provide little benefit, since the sediment and associated nutrients flowing into the Bay from the Susquehanna still derive mostly from upstream sources, not from scouring. According to a USGS analysis of data from 1900 to 2012, 70 percent of Conowingo sediment loads derive from direct flows from the watershed and 30 percent derive from scouring. Thus dredging to increase storage volume behind the dam will constantly be filled by new sediment. The study estimates that dredging the Conowingo reservoir to the level of the bathymetry that existed in the mid-1990s (when declining sediment and TP trends appear to have begun to reverse themselves) would cost $0.496 to 2.8 billion and maintenance dredging to address annual inputs would cost another $15 to 270 million dollars annually. The LSRWA estimated the amount of water quality improvement from dredging at only about .01 -.04 mg/L.

Figure 6 . Computed effect of dredging back to 96 bathymetry on DO bottom values (at station CB3.3C); positive values indicate improvement.



Computed effect of dredging back to 96 bathymetry on DO bottom values (at station CB3.3C); positive values indicate improvement.

Figure 7. Computed effect of maintenance dredging (3 million cubic yards/year) on DO bottom values (at station CB3.3C); positive values indicate improvement.



Computed effect of maintenance dredging (3 million cubic yards/year) on DO bottom values (at station CB3.3C); positive values indicate improvement.

Source: LSRWA Report Appendix C

Impact on Chesapeake Bay TMDL

Because the 2010 TMDL was developed and assigned to jurisdictions under previous assumptions about the trapping efficiency of the Conowingo dam system, Bay Program staffers are in the process of modifying their models to account for the new understanding of dynamic equilibrium.

Unless dredging or another management option is adopted as part of the relicensing process, which appears unlikely, the dam system's impact on increasing non-attainment in deep channel DO segments will have to be addressed during the 2017 mid-point assessment process for the Bay TMDL. The one-percent increase in deep channel DO nonattainment shown in Figure 5 means that the load reductions projected for the TMDL attainment scenario will no longer meet water quality standards under the various rules that EPA has adopted for calculating attainment. Thus, the TMDL would require jurisdictions to make additional nutrient reductions to offset the dams' loss in sediment-trapping capacity impact.

A preliminary modeling assessment that was shared with various Bay Program committees last year indicates that an additional reduction of 4.4 million pounds of total nitrogen / 0.41 million pounds of total phosphorus would be needed if the reductions are distributed across the from entire Bay watershed as a whole or2.4 million pounds of nitrogen / 0.27 million pounds of phosphorus would be needed if the reductions were focused solely in the Susquehanna watershed.

Next Steps for COG

As noted earlier, in late 2014 Exelon withdrew its relicensing request and agreed to help Maryland fund further studies of the changing dynamics of the dam system. These include increased monitoring, sediment particle analysis, and the fate and effect of particulate nutrients. In the end, it is likely that Exelon gets a new license, but perhaps it agrees to provide funds for BMPs upstream of the dams in the Susquehanna watershed. **COG staff recommends that the Water Resources Technical Committee (WRTC) track these developments, but does not recommend that COG provide any comments.**

In regard to a decision on the Bay Program TMDL, further research is underway and likely to generate somewhat new modeling results. However, the basic framework of requiring additional nutrient reductions upstream in the Susquehanna or elsewhere in the watershed is almost sure to remain the major choice for the Bay Program to make.

This decision is set to be made under the Bay TMDL Mid-Point Assessment process in 2017. Since it has the potential to increase the reductions that local governments are being required to make under the TMDL, the COG region has a stake in its outcome. **COG staff recommends that the WRTC track this process closely and make a recommendation for COG comment by the Chesapeake Bay and Water Resources Policy Committee at the appropriate time.**

For more information:

The LSRWA and associated materials are available at:
http://mddnr.chesapeakebay.net/LSRWA/index.cfm.

U.S. Geological Survey Scientific Investigations Report 2012–5185 is available at:
http://pubs.usgs.gov/sir/2012/5185/

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Region Forward
Greater Washington 2050

As part of COG's Region Forward sustainability goal, a target has been set to achieve 100% of the Chesapeake Bay Program's Water Quality Implementation Goals by 2025. Visit www.mwcog.org for more information.

COG's Water Resources

The Department of Environmental Programs (DEP), Water Resources Program assists COG's local government members, and affiliated wastewater treatment and drinking water utilities, with protecting, restoring, and conserving the region's water resources as well as addressing the policy and technical implications of various state and federal initiatives that have water quality impacts. Visit our Web Site for additional information about our program and regional activities.