# Technical Memorandum

*To:* *Pee Dee RBC*

*From:* *CDM Smith*

*Date:* *October 19, 2023*

*Subject:* *Evaluation of Demand-Side Surface Water Strategies*

## Background and Approach

The purpose of this Technical Memorandum is to document the results of SWAM modeling performed to evaluate the potential benefit of water conservation strategies in the Pee Dee River basin. Conservation, or demand-side strategies, are those that reduce water demand and/or prevent water loss. The Pee Dee RBC has previously considered a portfolio of conservation strategies for each water use sector. Examples that apply primarily to municipal water use include conservation pricing structures, landscape irrigation ordinances, and water efficiency standards for new construction. Agricultural demand-side strategies may include audits of center pivot sprinklers followed by nozzle retrofits, smart metering, soil management, and others. Industrial demand side strategies may include water reuse and recycling, implementing water efficient processes, and installing low flow fixtures, toilets, and appliances.

The modeling approach used reasonable estimates, based on professional judgement, of potential reductions in water demand following the implementation of a portfolio of conservation strategies. The **High Demand 2070 Scenario** was used as the baseline for comparing the effect of various portfolios of conservation strategies. Nine model scenarios were developed using adjusted **High Demand 2070 Scenario** demands, to account for reductions in demands from conservation strategies, and then simulated in the SWAM model over the entire hydrologic period of record. Output from the simulations (i.e., minimum, mean, and 5$^{th}$ percentile flows) were used as performance measures to evaluate the effect of the conservation strategies by comparing to the same **High Demand 2070 Scenario** streamflow statistics. All simulations were run using a monthly timestep. The nine scenarios are described below.

- **Scenario 1** evaluated the impact of agricultural conservation strategies that result in a 10 percent reduction in agricultural water demands. The 10 percent reduction was applied to both existing agricultural users and to future agricultural demands, as simulated at the outlet of select subbasins.

- **Scenarios 2a, 2b, and 2c** evaluated the impact of municipal conservation strategies that result in a 10, 15 or 20 percent reduction in municipal water demands from surface water. The percent reductions were applied to the three existing surface water users in the model domain (Bennettsville, Cheraw, and Florence).

- **Scenarios 3a, 3b, and 3c** evaluated the impact of municipal conservation strategies that result in a 10, 15 or 20 percent reduction in municipal demands from both surface water and groundwater. The percent reductions were applied to the three existing surface water users in the model domain (Bennettsville, Cheraw, and Florence) and to the 14 municipal groundwater users that discharge treated wastewater to surface water. The effect of demand reductions for municipal groundwater users is a reduction (by 10, 15 or 20 percent) in treated wastewater discharging to surface water. This will lower streamflows, and thus have the opposite of the intended effect, but may help improve groundwater levels and extend groundwater availability.

- **Scenario 4** evaluated the impact of industrial conservation strategies that result in a 5 percent reduction in industrial water demands, not including mining operations. The 5 percent reduction was applied to industries that withdrawal either surface water or groundwater.

- **Scenario 5** evaluated the cumulative impact of conservation strategies for all three water use sectors examined. A 10 percent reduction in agricultural water demands, 10 percent reduction in municipal demands, and 5 percent reduction in industrial demands was evaluated. The reductions in municipal and industrial demands applied to both surface and groundwater users.

## Results

The effectiveness of the conservation strategies was examined at six Strategic Nodes identified in Figure 1. The nodes were selected to be representative cumulative impacts to flows along the Pee Dee River and its major tributaries.

Table 1 provides the minimum, mean and 5$^{th}$ percentile flows at the six Strategic Nodes for the **High Demand 2070 Scenario**. These flow statistics served as the basis for comparison to simulated flows in scenarios 1 through 9.

Table 2 provides the minimum, mean and 5$^{th}$ percentile flows at the six Strategic Nodes for all nine scenarios, and lists the percent difference of these flow statistics, compared to the **High Demand 2070 Scenario flows** in Table 1. A positive percent difference means that the flow statistic increased compared to the same **High Demand 2070 Scenario** flow statistic. These cells are shaded light green in the table. A negative percent difference means that a flow statistic decreased. These cells are shaded a light red in the table. Negative percent differences are a result of reductions in demand for municipal and/or industrial groundwater users which result in a similar decrease in treated wastewater discharge to surface water.

**Table 1. Flow Statistics for the High Demand 2070 Scenario**

| Strategic Node | Minimum Flow (cfs) | 5th Percentile Flow (cfs) | Mean Flow (cfs) |
|---|---|---|---|
| PDE15 Pee Dee River below Pee Dee, SC | 928 | 1,974 | 8,964 |
| Great Pee Dee / Little Pee Dee Confluence | 1,547 | 3,464 | 14,450 |
| PDE13 Black Creek near Quinby, SC | 53 | 144 | 521 |
| PDE05 Lynches River at Effingham, SC | 71 | 196 | 1,005 |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 198 | 619 | 2,941 |
| PDE26 Black River and Kingstree, SC | 47 | 141 | 1,011 |

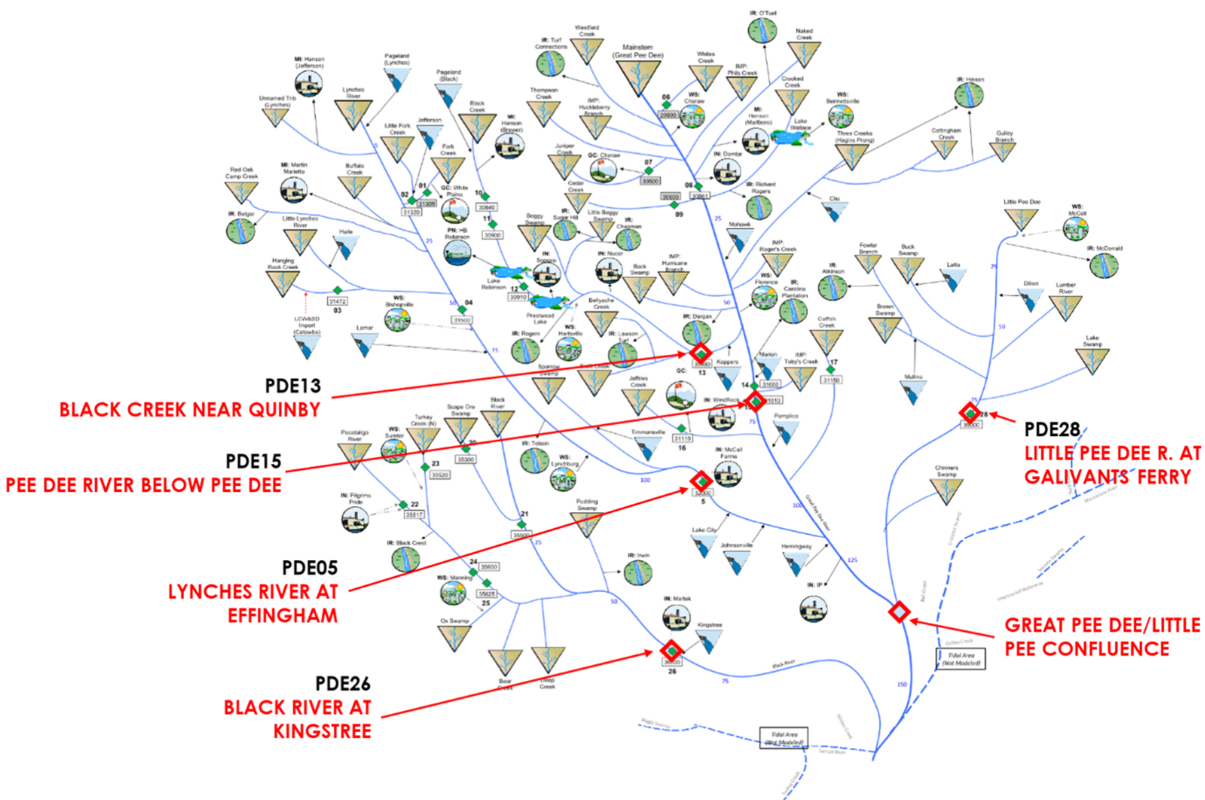


**Figure 1. Location of Strategic Nodes used to evaluate streamflow following implementation of conservation strategies.**

**Table 2. Flow statistics for conservation scenarios and percent difference compared to the High Demand 2070 Scenario**

| Strategic Node | Minimum Flow (cfs) | 5th Perc. Flow (cfs) | Mean Flow (cfs) | Minimum Flow (% change) | 5th Perc. Flow (% change) | Mean Flow (% change) |
|---|---|---|---|---|---|---|
| **Scenario 1 - 10% Agriculture Demand Reduction** | | | | | | |
| PDE15 Pee Dee River below Pee Dee, SC | 929 | 1,974 | 8,965 | **0.1%** | **0.0%** | **0.0%** |
| Great Pee Dee / Little Pee Dee Confluence | 1,548 | 3,464 | 14,451 | **0.1%** | **0.0%** | **0.0%** |
| PDE13 Black Creek near Quinby, SC | 54 | 145 | 521 | **0.5%** | **0.1%** | **0.0%** |
| PDE05 Lynches River at Effingham, SC | 71 | 196 | 1,005 | **0.1%** | **0.0%** | **0.0%** |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 198 | 619 | 2,941 | **0.0%** | **0.0%** | **0.0%** |
| PDE26 Black River and Kingstree, SC | 48 | 141 | 1,011 | **1.1%** | **0.0%** | **0.0%** |
| **Scenario 2a - 10% Municipal Demand Reduction (Surface Water Users Only)** | | | | | | |
| PDE15 Pee Dee River below Pee Dee, SC | 932 | 1,978 | 8,968 | **0.4%** | **0.2%** | **0.0%** |
| Great Pee Dee / Little Pee Dee Confluence | 1,548 | 3,465 | 14,451 | **0.1%** | **0.0%** | **0.0%** |
| PDE13 Black Creek near Quinby, SC | 53 | 144 | 521 | **-0.5%** | **-0.2%** | **0.0%** |
| PDE05 Lynches River at Effingham, SC | 71 | 196 | 1,005 | **0.0%** | **0.0%** | **0.0%** |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 198 | 619 | 2,941 | **0.0%** | **0.0%** | **0.0%** |
| PDE26 Black River and Kingstree, SC | 47 | 141 | 1,011 | **0.0%** | **0.0%** | **0.0%** |
| **Scenario 2b - 15% Municipal Demand Reduction (Surface Water Users Only)** | | | | | | |
| PDE15 Pee Dee River below Pee Dee, SC | 934 | 1,980 | 8,970 | **0.7%** | **0.3%** | **0.1%** |
| Great Pee Dee / Little Pee Dee Confluence | 1,549 | 3,466 | 14,452 | **0.2%** | **0.1%** | **0.0%** |
| PDE13 Black Creek near Quinby, SC | 53 | 144 | 520 | **-0.7%** | **-0.3%** | **-0.1%** |
| PDE05 Lynches River at Effingham, SC | 71 | 196 | 1,005 | **0.0%** | **0.0%** | **0.0%** |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 198 | 619 | 2,941 | **0.0%** | **0.0%** | **0.0%** |
| PDE26 Black River and Kingstree, SC | 47 | 141 | 1,011 | **0.0%** | **0.0%** | **0.0%** |

**Table 2. Flow statistics for conservation scenarios and percent difference compared to the High Demand 2070 Scenario (continued)**

| Strategic Node | Minimum Flow (cfs) | 5th Perc. Flow (cfs) | Mean Flow (cfs) | Minimum Flow (% change) | 5th Perc. Flow (% change) | Mean Flow (% change) |
|---|---|---|---|---|---|---|
| **Scenario 2c - 20% Municipal Demand Reduction (Surface Water Users Only)** | | | | | | |
| PDE15 Pee Dee River below Pee Dee, SC | 936 | 1,982 | 8,972 | **0.9%** | **0.4%** | **0.1%** |
| Great Pee Dee / Little Pee Dee Confluence | 1,550 | 3,466 | 14,452 | **0.2%** | **0.1%** | **0.0%** |
| PDE13 Black Creek near Quinby, SC | 53 | 144 | 520 | **-0.9%** | **-0.3%** | **-0.1%** |
| PDE05 Lynches River at Effingham, SC | 71 | 196 | 1,005 | **0.0%** | **0.0%** | **0.0%** |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 198 | 619 | 2,941 | **0.0%** | **0.0%** | **0.0%** |
| PDE26 Black River and Kingstree, SC | 47 | 141 | 1,011 | **0.0%** | **0.0%** | **0.0%** |
| **Scenario 3a - 10% Municipal Demand Reduction (Surface Water and Groundwater Users)** | | | | | | |
| PDE15 Pee Dee River below Pee Dee, SC | 931 | 1,977 | 8,967 | **0.4%** | **0.2%** | **0.0%** |
| Great Pee Dee / Little Pee Dee Confluence | 1,546 | 3,463 | 14,449 | **0.0%** | **0.0%** | **0.0%** |
| PDE13 Black Creek near Quinby, SC | 53 | 144 | 520 | **-1.1%** | **-0.4%** | **-0.1%** |
| PDE05 Lynches River at Effingham, SC | 70 | 196 | 1,004 | **-0.6%** | **-0.2%** | **0.0%** |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 197 | 618 | 2,940 | **-0.3%** | **-0.1%** | **0.0%** |
| PDE26 Black River and Kingstree, SC | 45 | 139 | 1,008 | **-5.4%** | **-1.9%** | **-0.3%** |
| **Scenario 3b - 15% Municipal Demand Reduction (Surface Water and Groundwater Users)** | | | | | | |
| PDE15 Pee Dee River below Pee Dee, SC | 933 | 1,979 | 8,969 | **0.6%** | **0.2%** | **0.1%** |
| Great Pee Dee / Little Pee Dee Confluence | 1,546 | 3,462 | 14,449 | **0.0%** | **0.0%** | **0.0%** |
| PDE13 Black Creek near Quinby, SC | 52 | 143 | 520 | **-1.7%** | **-0.6%** | **-0.2%** |
| PDE05 Lynches River at Effingham, SC | 70 | 196 | 1,004 | **-0.8%** | **-0.3%** | **-0.1%** |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 197 | 618 | 2,940 | **-0.4%** | **-0.1%** | **0.0%** |
| PDE26 Black River and Kingstree, SC | 43 | 137 | 1,007 | **-8.1%** | **-2.8%** | **-0.4%** |

**Table 2. Flow statistics for conservation scenarios and percent difference compared to the High Demand 2070 Scenario (continued)**

| Strategic Node | Minimum Flow (cfs) | 5th Perc. Flow (cfs) | Mean Flow (cfs) | Minimum Flow (% change) | 5th Perc. Flow (% change) | Mean Flow (% change) |
|---|---|---|---|---|---|---|
| **Scenario 3c - 20% Municipal Demand Reduction (Surface Water and Groundwater Users)** | | | | | | |
| PDE15 Pee Dee River below Pee Dee, SC | 935 | 1,980 | 8,970 | **0.8%** | **0.3%** | **0.1%** |
| Great Pee Dee / Little Pee Dee Confluence | 1,546 | 3,462 | 14,448 | **0.0%** | **0.0%** | **0.0%** |
| PDE13 Black Creek near Quinby, SC | 52 | 143 | 519 | **-2.2%** | **-0.9%** | **-0.3%** |
| PDE05 Lynches River at Effingham, SC | 70 | 196 | 1,004 | **-1.1%** | **-0.4%** | **-0.1%** |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 197 | 618 | 2,940 | **-0.5%** | **-0.2%** | **0.0%** |
| PDE26 Black River and Kingstree, SC | 42 | 136 | 1,005 | **-10.8%** | **-3.8%** | **-0.6%** |
| **Scenario 4 - 5% Industrial Demand Reduction (Surface Water and Groundwater Users)** | | | | | | |
| PDE15 Pee Dee River below Pee Dee, SC | 939 | 1,986 | 8,976 | **1.3%** | **0.6%** | **0.1%** |
| Great Pee Dee / Little Pee Dee Confluence | 1,550 | 3,467 | 14,454 | **0.2%** | **0.1%** | **0.0%** |
| PDE13 Black Creek near Quinby, SC | 53 | 145 | 522 | **0.0%** | **0.3%** | **0.2%** |
| PDE05 Lynches River at Effingham, SC | 71 | 196 | 1,005 | **-0.1%** | **0.0%** | **0.0%** |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 198 | 619 | 2,941 | **0.0%** | **0.0%** | **0.0%** |
| PDE26 Black River and Kingstree, SC | 47 | 141 | 1,011 | **-0.1%** | **0.0%** | **0.0%** |
| **Scenario 5 - 10% Agricultural, 5% Industrial, and 10% Municipal Demand Reduction (Surface Water and Groundwater Users)** | | | | | | |
| PDE15 Pee Dee River below Pee Dee, SC | 944 | 1,989 | 8,980 | **1.8%** | **0.8%** | **0.2%** |
| Great Pee Dee / Little Pee Dee Confluence | 1,551 | 3,467 | 14,453 | **0.3%** | **0.1%** | **0.0%** |
| PDE13 Black Creek near Quinby, SC | 53 | 144 | 521 | **-0.6%** | **0.0%** | **0.0%** |
| PDE05 Lynches River at Effingham, SC | 71 | 196 | 1,004 | **-0.5%** | **-0.2%** | **0.0%** |
| PDE28 Little Pee Dee River at Galivants Ferry, SC | 197 | 618 | 2,940 | **-0.3%** | **-0.1%** | **0.0%** |
| PDE26 Black River and Kingstree, SC | 45 | 139 | 1,008 | **-4.4%** | **-1.9%** | **-0.3%** |

## Discussion

In all conservation scenarios, increases in mean flows compared to the **2070 High Demand Scenario** were very small, as would be expected given that only 5 to 20 percent reductions in demands were evaluated. At some Strategic Nodes, mean flows decreased for certain scenarios which assumed reductions in groundwater demands for municipal and industrial users and a corresponding decrease in wastewater discharges.

Changes in the 5$^{th}$ percentile flows (a low flow performance measure) were only slightly larger than changes in mean flows, when comparing the conservation strategy scenarios to the **2070 High Demand Scenario**. The increase in 5$^{th}$ percentile flows was less than 1 percent at all Strategic Nodes. On Black Creek, Black River, Lynches River and Little Pee Dee River Strategic Nodes, 5$^{th}$ percentile flows decreased in certain scenarios, owing to the reduction in groundwater demands and corresponding decrease in wastewater discharges.

Changes in the minimum flow (a low flow performance measure) simulated over the entire hydrologic period of record ranged from -10.8 percent (Scenario 3c, Black River Strategic Node) to 1.8 percent (Scenario 5, Pee Dee River Strategic Node). The -10.8 percent change in flow reflects the 20 percent reduction in groundwater demands for municipal users Sumter and Manning, and their correspond 20 percent reduction in treated wastewater discharge to surface water. The largest, beneficial impacts to surface water flows from conservation strategies were observed in Scenario 5, which included conservation by agricultural, municipal, and industrial water users, but the impact was limited to the Strategic Nodes on the Pee Dee River. At that location, the Scenario 5 minimum flow was 944 cfs, compared to 928 cfs for the **2070 High Demand Scenario** (a 1.8 percent increase).

While some reductions in stream flows may occur due to additional water conservation because of reduced wastewater discharges, the reductions in streamflow are very minor and would not be expected to pose additional risk to the ecological health of the streams. It's also worth noting that the assumed reduction in stream flows from lower discharges from groundwater-dependent communities is probably conservative given that conservation measures applied to outdoor water needs would not necessarily reduce wastewater discharges.

Although the level of conservation and water efficiency strategies evaluated resulted in relatively small impact on stream flows, these strategies are still worth pursuing for several important reasons:

- They can reduce costs of water for irrigation and possibly improve crop yields
- They can lower costs of water for homeowners and reduce or delay a municipality's need to develop more water supplies
- Conservation in groundwater dependent communities may be important for sustaining groundwater supplies
- Water users that withdraw surface water from small tributaries, and especially near the headwaters, may experience shortages during prolonged and/or severe drought, regardless of whether they have impoundments that provide storage. Implementing conservation strategies

even before drought occurs will help extend their supply and reduce the risk of a water shortage.