Optimization of Minimum Instream Flow Needs along the White Clay Creek at Stanton, Delaware

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Prepared for:

Delaware Water Supply Coordinating Council

Prepared by:

Gerald J. Kauffman P.E., State Water Coordinator
Kevin J. Vonck, Senior Research Assistant
University of Delaware
College of Human Services, Education, and Public Policy
Institute for Public Administration - Water Resources Agency
DGS Annex Academy Street
Newark, DE 19716
www.wr.udel.edu

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Introduction

The January 17, 2003 *Fifth Report to the Governor and General Assembly Regarding the Progress of the Delaware Water Supply Coordinating Council* recommended that United Water Delaware (UWD) modify the operating plan for the Tidal Capture Structure (TCS) to provide additional water supply capacity during drought at the White Clay Creek at Stanton Water Treatment Plant. The Delaware River Basin Commission is scheduled to hold a public hearing on January 19, 2005 to review UWD Docket D-96-50 CP-2 to modify the TCS operating plan to "include incremental passby flow targets in conjunction with salinity monitoring to protect the applicant's water supply and preserve depth of water downstream for aquatic habitat protection."

The modified TCS operating plan is designed to:

1. Operate the TCS more efficiently.
2. Increase water supply reliability during low flow conditions and provide more water supply during drought.
3. Provide sufficient stream flow for fishery and habitat at the tidal/freshwater interface.
4. Maintain tidal chloride levels in the creek below the USEPA secondary standard of 250 ppm during drought.

This report summarizes a technical basis for maintaining a tidal instream flow standard based on a principle of (a) minimum depth of flow for fishery habitat and (b) attenuation of chlorides. The proposal is to replace the existing 7Q10 flow rate standard as required by the DRBC with a 7Q10 flow depth equivalent to protect fishery habitat and chloride standards to address water quality concerns. The current 7Q10 flow rate standard is difficult to measure due to the two – way tidal nature of the White Clay Creek.

White Clay Creek at Stanton WTP

The 30-mgd UWD White Clay Creek at Stanton Water Treatment Plant is situated along the White Clay Creek just below the confluence with the Red Clay Creek (Figure 1). The WTP is influenced by fluvial freshwater from the upstream watersheds and the incoming tide from the Delaware Estuary. Ninety eight percent (98%) of the time the water is fresh when stream flow is above the 7Q10 flow of 17.2 million gallons per day (mgd). During droughts (about 2% of the time) the incoming tide elevates chloride levels in the creek to approach the USEPA secondary drinking water standard of 250 parts per million (ppm). UWD has installed a tidal capture structure (Figure 2) and implemented a chloride-monitoring plan (Appendix A) along the White Clay Creek and Christina River to attenuate chloride levels during drought. Chloride levels approached the 250 ppm standard in the White Clay Creek at Stanton during the droughts of 1995, 1999, and 2002.

Methods/Results

The 1997 *Report of the Joint Task Force, Instream Flow Needs Analysis for Northern New Castle County, Delaware, Phase Two: 7Q10 Assessment* summarizes an analysis to determine the adequacy of the 7Q10 flow as a minimum instream flow standard along the streams of the Christina Basin including the UWD White Clay Creek at Stanton Intake. The report determined minimum instream flow needs according to the following methods:

1. Select stream transects at various pool and riffle sections along the White Clay Creek within the vicinity of the UWD WTP intake (Figure 3).

2. Select critical riffle sections for the evaluation of fishery instream flow needs. The 1997 Joint Task Force selected the following transects (in feet upstream from the mouth of White Clay Creek) as critical riffle sections: transects 14073, 13843, and 10800.

3. Select key indicator fish species. The Delaware Division of Fish and Wildlife conducted a fish abundance survey in 1997 and sampled 744 fish from the White Clay Creek at Stanton. Thirty different species were represented including white suckers (16.0% of total catch), banded killifish (10.8%), American eel (10.0%), and redbreast sunfish (8.0%). Only 4.3% of the tidal stream reach was riffle habitat (when the tide was out) and 82.0 % consisted of pool habitat.

4. Determine the 7Q10 flow depth along the study reach. The Water Resources Agency calculated the 7Q10 flow depth for the study transects using the US Army Corps of Engineers HEC 2 hydraulic model. Table 1 summarizes the 7Q10 flow depth along the study reach at low tide as computed by HEC 2. The 7Q10 flow depths are 0.85, 0.96, and 0.90 at stream transects 14073, 13843, and 10800, respectively. The Instream Flow Needs Task Force determined that the minimum depth for fishery needs should be rounded to 1.0 foot.

5. Plot the low tide and high tide 7Q10 flow elevations on the stream transects (Figures 4, 5 and 6) and Stream Profile (Figure 7). The stream profile indicates that the critical transect for fishery passage is section 10800 which is located at a riffle section 500 feet downstream from the TCS adjacent to the Hale Byrnes House. The 7Q10 flow depth is 0.9 feet here at low tide when the stream flow is at 7Q10 of 17.2 mgd.

6. Plot the 7Q10 flow deaths for the 24-hour tidal cycle at transects 14073, 13843, and 10800. Table 2 indicates that the 7Q10 flow depth exceeds 1.0 foot for 20 to 21 hours per day (depending on the transect) due to the volume of water from the incoming tide. Figures 8, 9, 10 portray the tidal hydrograph for the 7Q10 flow at the three transects in question.

Chloride Attenuation

The proposed modification of the UWD TCS operating plan includes provisions for chloride attenuation during drought. Empirical data from the 1995, 1999, and 2002 droughts indicate when stream flow along the White Clay Creek at Stanton dips below the 7Q10 flow of 17.2 mgd for more than 5 to 7 consecutive days, chlorides in the stream begin to exceed 250 ppm (Figures 11, 12, and 13). For instance on August 7, 2002 chlorides exceeded 250 ppm when the stream flow at Stanton declined below the 7Q10 flow. Ten days later after rain, the stream flow increased above the 7Q10 flow and the chlorides decreased below 250 ppm through freshwater dilution.

Based on recommendations in the December 3, 1999 *Report of the Governor's Water Supply Task Force*, United Water Delaware developed a chloride monitoring plan which is designed to provide early warning of increasing chloride levels during drought (Appendix A). The intent of the monitoring plan is to assist UWD in maintaining chloride levels below the USEPA secondary drinking water standard in the White Clay Creek at the intake during drought. During the 2002 drought, UWD was able to maintain chloride levels in the plant effluent (the treated drinking water) below 250 ppm by (a) blending water from elsewhere in the systems, (b) strategic operation of the TCS during the tidal cycle, and (c) freshwater releases from Wilmington-owned Hoopes Reservoir.

Conclusions

1. The White Clay Creek at the Stanton Water Treatment plant is tidal and thus it is difficult to measure the flow rate of the 7Q10 minimum instream standard during drought.

2. The 1997 Delaware Instream Flow Needs Task Force concluded that the 7Q10 flow standard (17.2 mgd) is the minimum needed to protect the fishery and habitat at the White Clay Creek at Stanton WTP. The Delaware River Basin Commission enforces the 7Q10 standard at this location by docket.

3. The 1997 Instream Flow Needs Task Force determined that the 7Q10 flow rate correlates to flow depths of 0.85, 0.96, and 0.90 feet at stream riffle sections 14073, 13843, and 10800, respectively. The Instream Flow Needs Task Force determined that the minimum depth for fishery needs should be rounded to 1.0 foot.

4. The critical transect for fishery passage along the White Clay Creek at Stanton is section 10800 which is located at a riffle section 500 feet downstream from the Tidal Capture Structure. The 7Q10 flow depth is 0.9 feet here at low tide when the stream flow is at 7Q10 of 17.2 mgd.

5. Tidal hydrographs at critical riffles sections 14073, 13843, and 10800 indicate that the tidal depth exceeds 1.0 foot at the 7Q10 flow for 20 to 21 hours in a day over two tidal cycles. That is, when a drought occurs at the severity of the 7Q10 flow, UWD must release water into the White Clay Creek from Hoopes Reservoir and/or blend water from the Tidal Capture Structure for 3 to 4 hours per day to maintain the minimum 1.0 feet flow depth minimum.

6. Since the configuration of the stream channel changes over time, these tidal hydrographs should be confirmed during drought operations by installing a real time USGS compatible tidal stream gage approximately 500 feet downstream from the TCS.

7. UWD operates a chloride-monitoring program that provides early warning of increasing chloride levels in the White Clay Creek at Stanton during drought. The intention of the chloride-monitoring plan is to maintain chloride levels below the USEPA secondary standard (250 ppm) in the drinking water supply at the Stanton intake during drought.

Recommendations

1. The DRBC docket and DNREC allocation permits for the United Water Delaware Tidal Capture Structure along the White Clay Creek at Stanton should be modified to include the following minimum instream flow criteria:

   "United Water Delaware may withdraw up to 30 mgd from the White Clay Creek at the Stanton Water Treatment Plant provided (a) the 7Q10 flow equivalent depth does not decline below 1.0 feet at the critical stream riffle section 500 feet downstream from the Tidal Capture Structure and (b) the chloride levels in the raw water at the Stanton intake do not exceed 250 ppm during drought."

2. United Water Delaware should install, maintain, and operate a United States Geological Survey /Delaware Geological Survey compatible real time tidal gage to measure stage and depth at the critical riffle section 500 feet downstream of the Tidal Capture Structure.

References

Donnelly, K., Lovell, S., Talley J., Baxter, S., Wozniak, S., Vonck, K., Wollaston, M., and Kauffman, G. J. January 2003. *Fifth Report to the Governor and the General Assembly Regarding the Progress of the Delaware Water Supply Coordinating Council (The Drought of 2002).*

Wollaston, M., Talley J., Lovell, S., Headd, M., and Kauffman, G. J. December 3, 1999. *Final Report of the Governor's Water Supply Task Force.*

Yaeck, D., Lovell, S., Greene, R., Stangl, M., Miller, R., and Kauffman, G.J. 1997. *Report of the Joint Task Force, Instream Flow Needs Analysis for Northern New Castle County, Delaware, Phase Two: 7Q10 Assessment.*

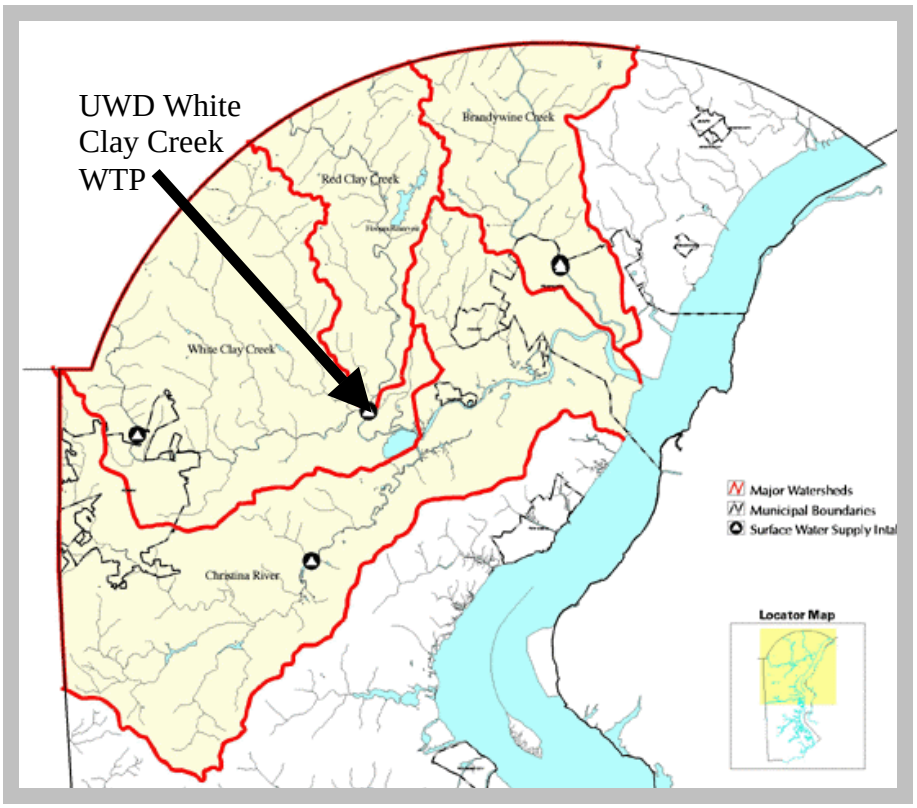

Figure 1. Location of the United Water Delaware White Clay Creek at Stanton Water Treatment Plant.

Figure 2. The UWD Tidal Capture Structure along the White Clay Creek at Stanton looking upstream.

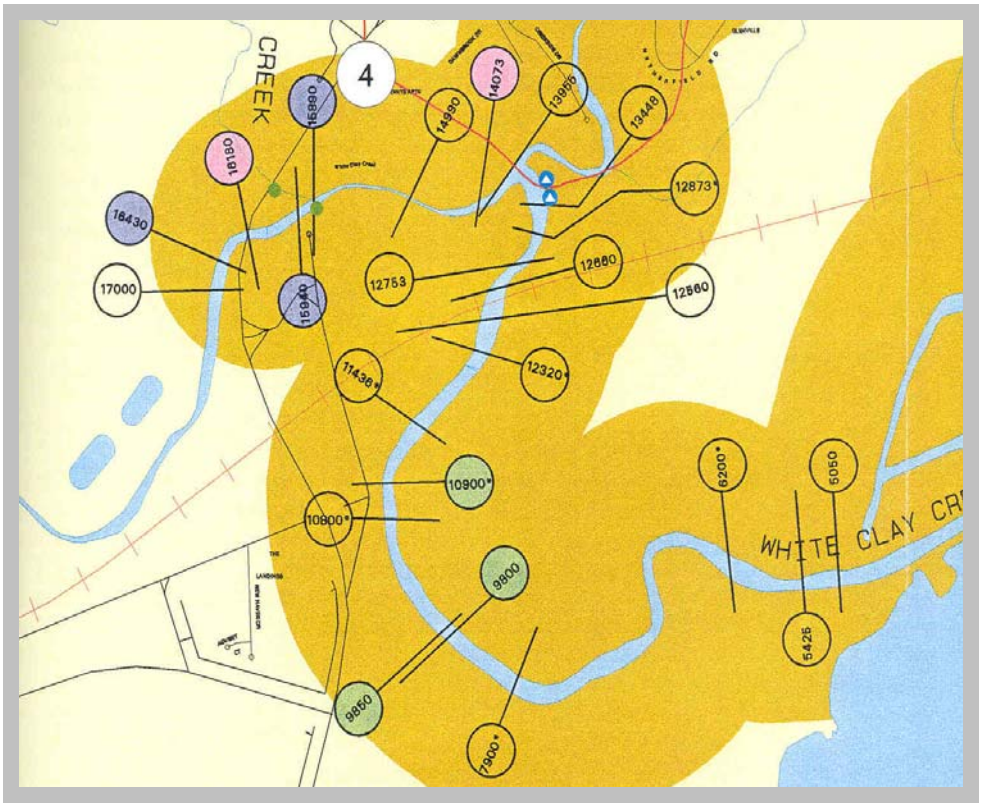

Figure 3. Stream transects along the White Clay Creek at Stanton instream flow study area.

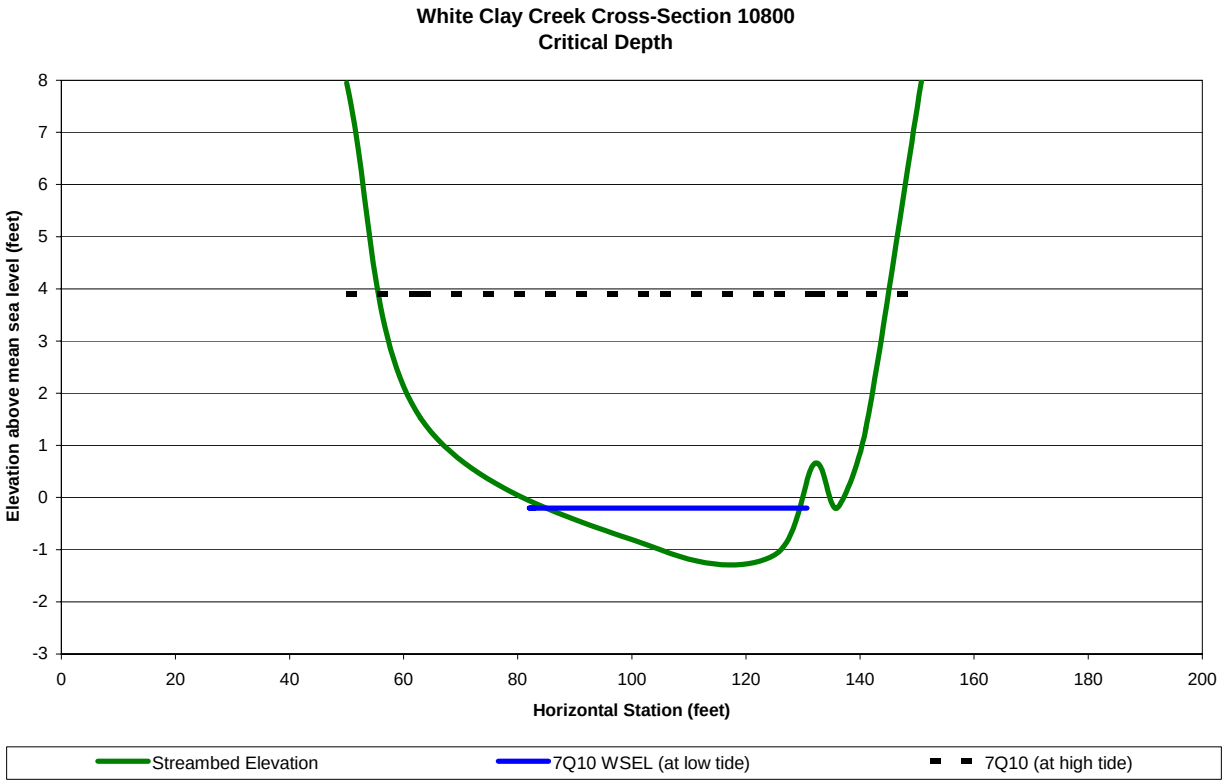

Figure 4. White Clay Creek Cross Section 10800.

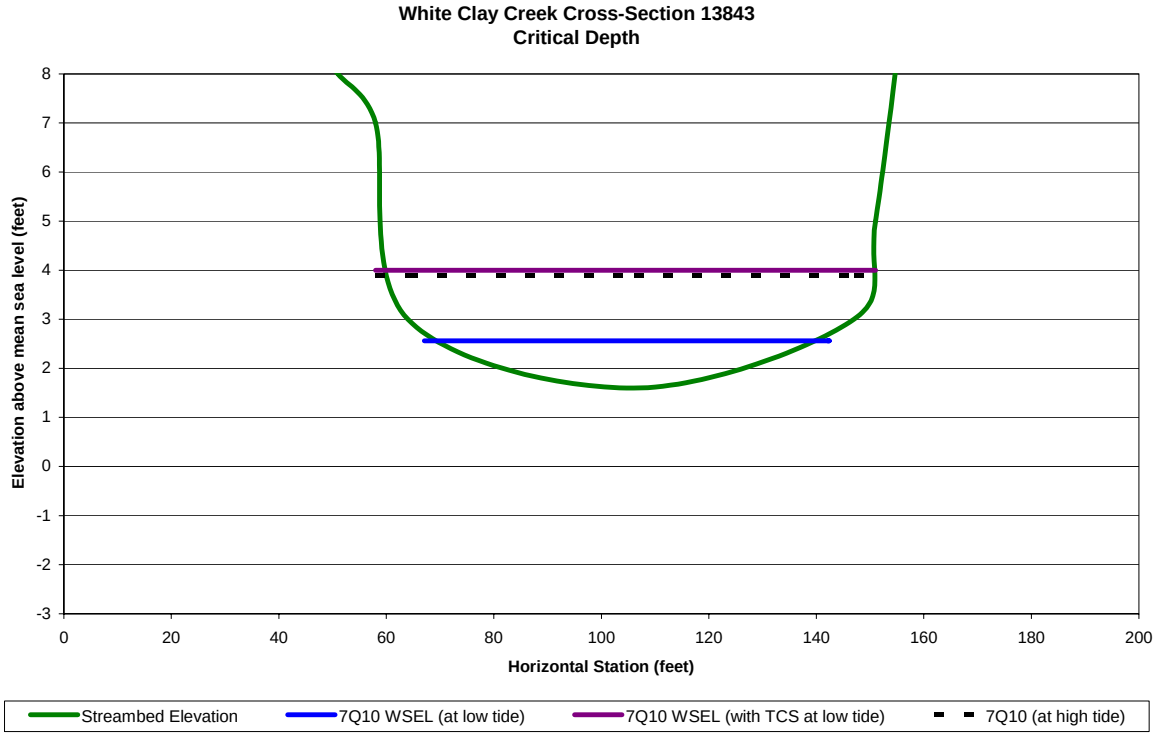

Figure 5. White Clay Creek Cross Section 13843.

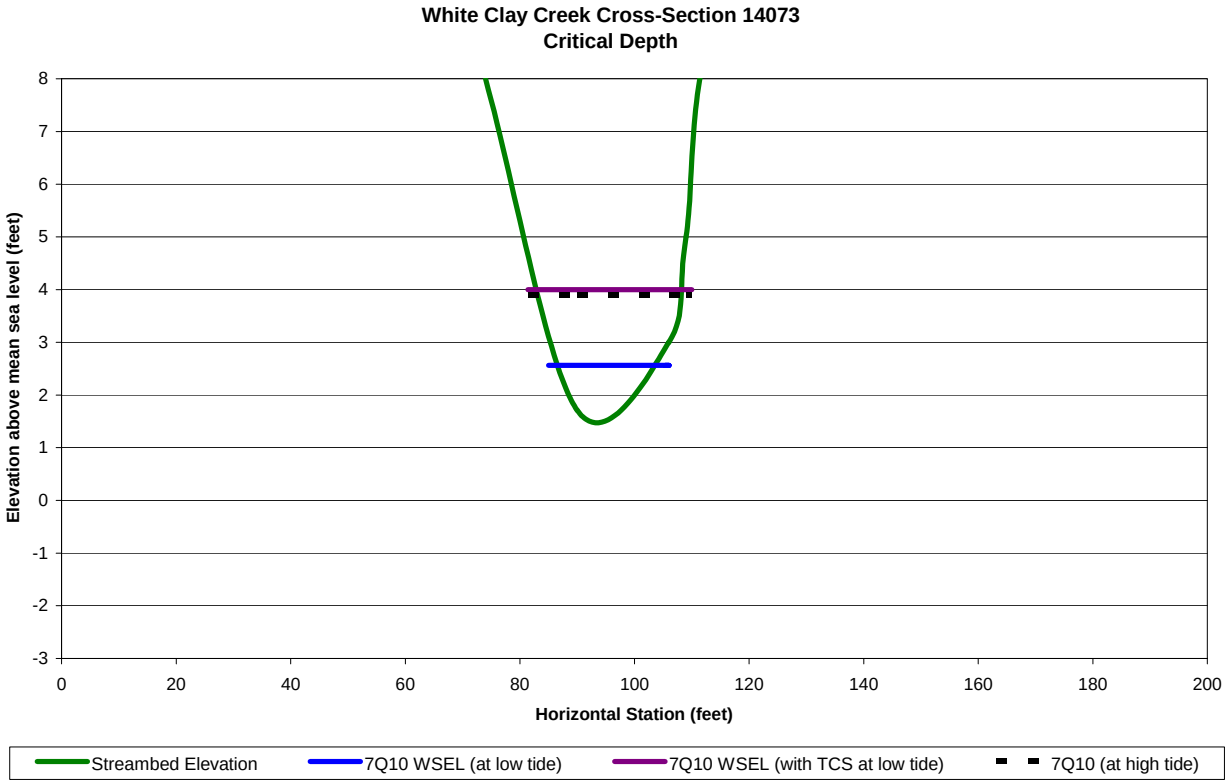

Figure 6. White Clay Creek Cross Section 14073.

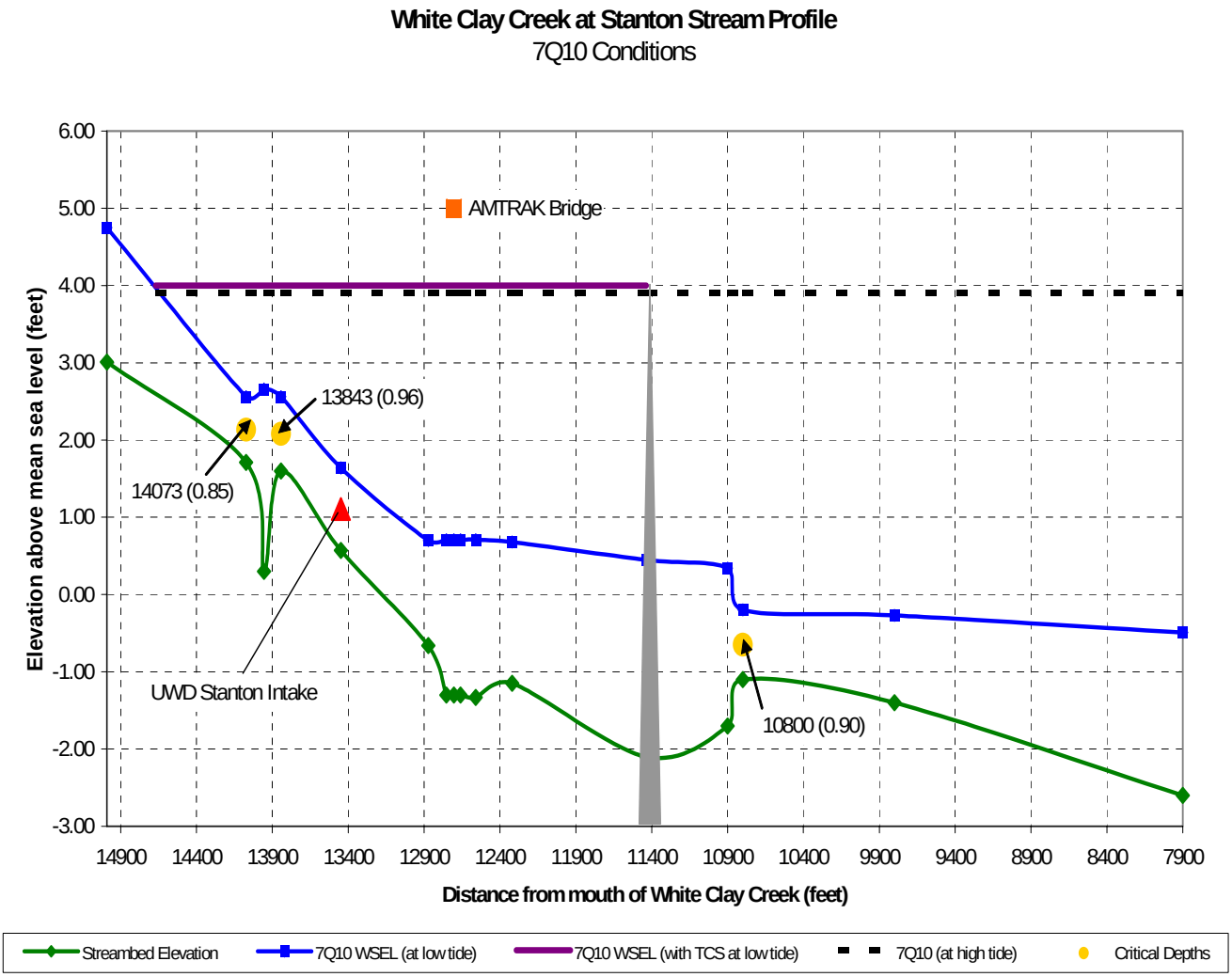

Figure 7. White Clay Creek at Stanton Stream Profile at 7Q10 Streamflow.

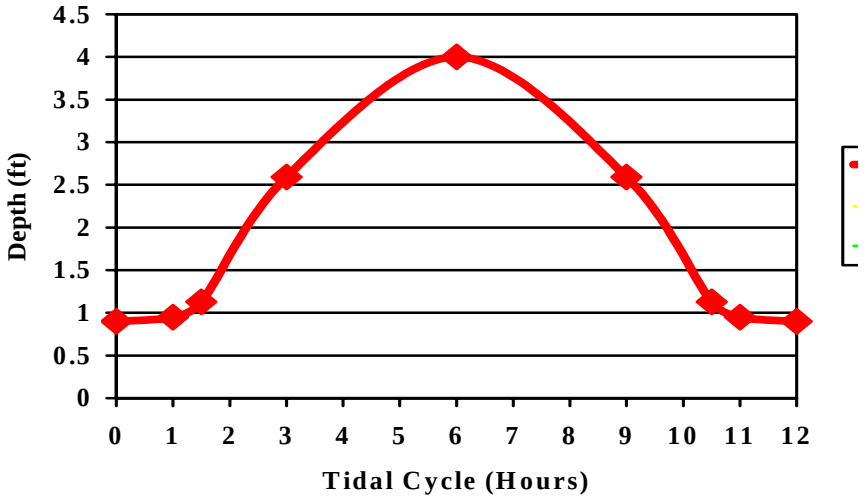

Figure 8. White Clay Creek at Stanton Station 10800 at 7Q10 = 17.2 mgd, TCS uninflated.

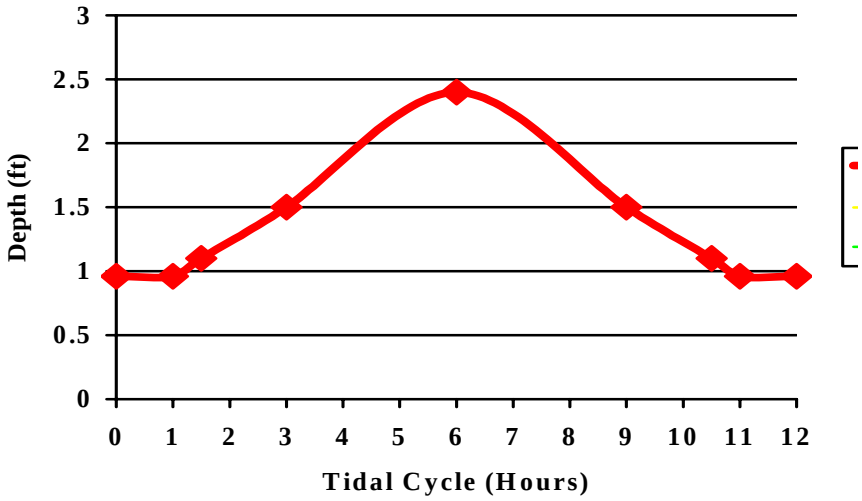

Figure 9. White Clay Creek at Stanton Station 13843 at 7Q10 = 17.2 mgd, TCS uninflated.

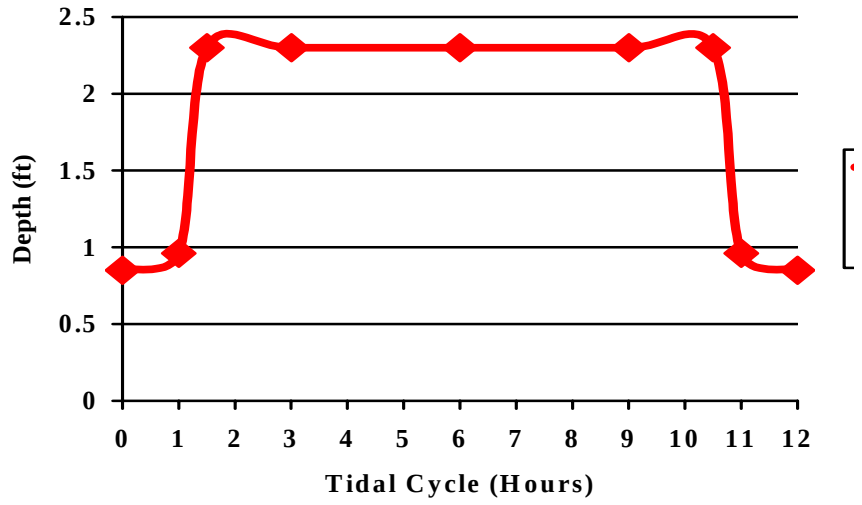

Figure 10. White Clay Creek at Stanton Station 14073 at 7Q10 = 17.2 mgd, TCS uninflated.

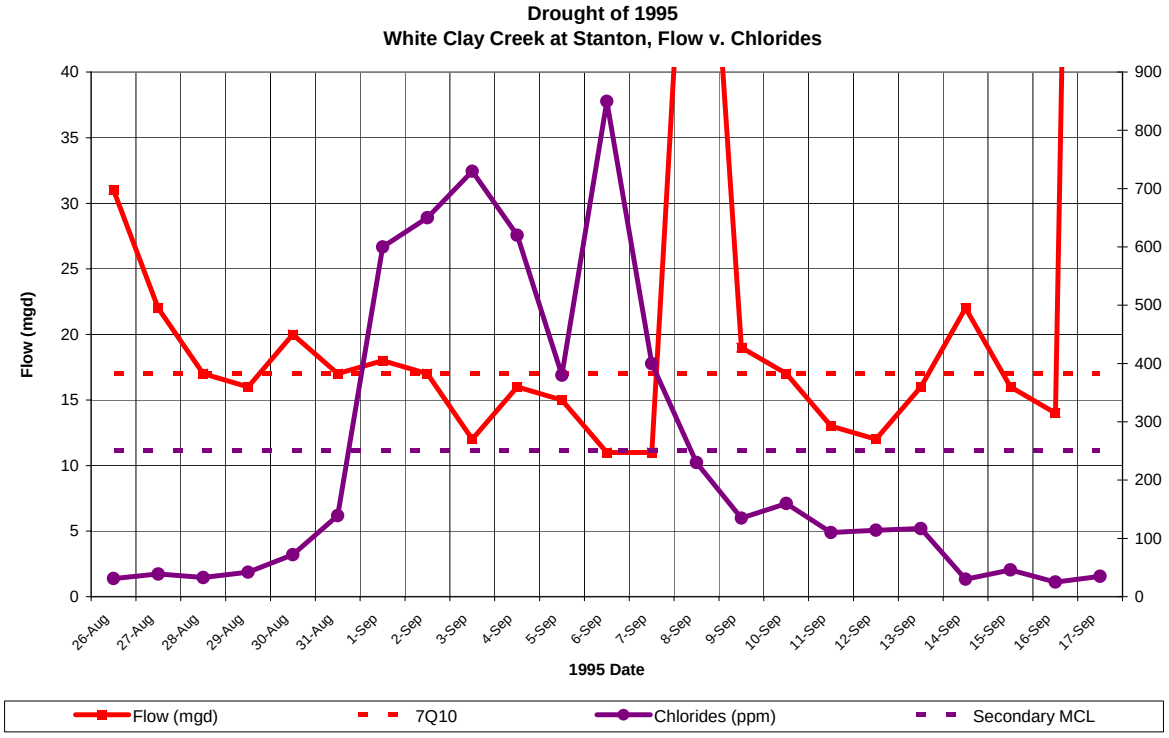

Figure 11. White Clay Creek at Stanton streamflow versus chlorides during drought of 1995.

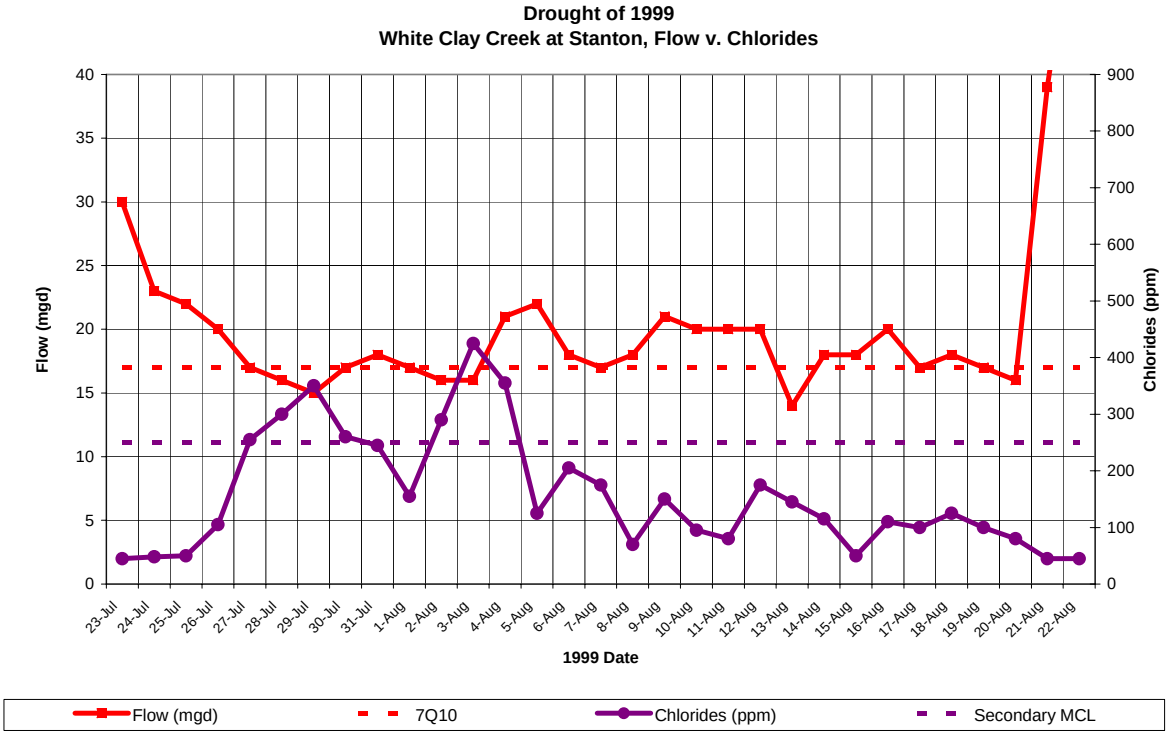

Figure 12. White Clay Creek at Stanton streamflow versus chlorides during the drought of 1999.

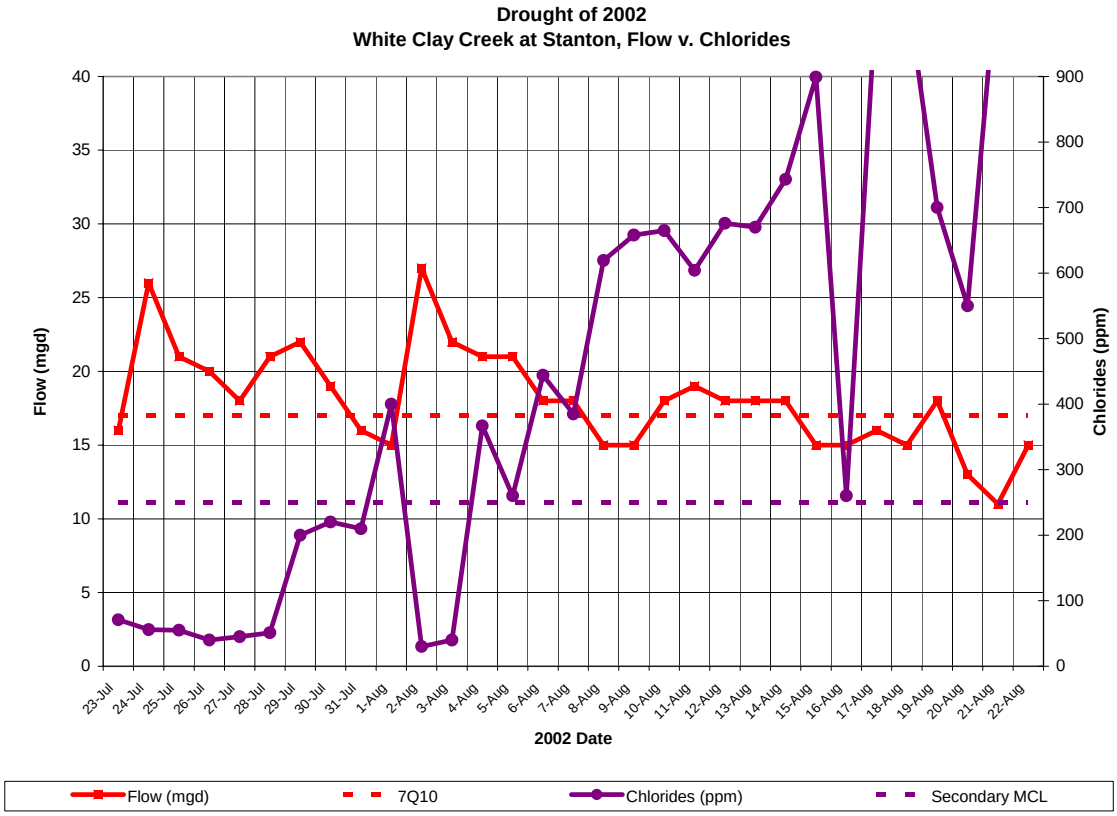

Figure 13. White Clay Creek at Stanton streamflow versus chlorides drought of 2002.

Table 1. 7Q10 flow depth along the study reach at low tide as computed by HEC 2.

Section	Streambed Elevation	7Q10 WSEL (at low tide)	Depth
feet from mouth of White Clay Creek	*feet above mean sea level*	*feet above mean sea level*	*feet*
14990.00	3.01	4.75	1.74
14073.00	1.71	2.56	0.85
13955.00	0.30	2.66	2.36
13843.00	1.60	2.56	0.96
13448.00	0.57	1.64	1.07
12873.00	-0.66	0.70	1.36
12753.00	-1.30	0.71	2.01
12703.00	-1.30	0.71	2.01
12660.00	-1.30	0.71	2.01
12560.00	-1.33	0.71	2.04
12320.00	-1.15	0.68	1.83
11436.00	-2.10	0.45	2.55
10900.00	-1.70	0.34	2.04
10800.00	-1.10	-0.20	0.90
9800.00	-1.40	-0.27	1.13
7900.00	-2.60	-0.49	2.11

Source: HEC-2 Water Surface Profile Model. *Report of the Joint Task Force, Instream Flow Needs Analysis for Northern New Castle County, Delaware, Phase Two: 7Q10 Assessment,* David Yaeck, Stewart Lovell, Richard Greene, Mike Stangl, Roy Miller, and Gerald Kauffman. 1997.

Table 2. White Clay Creek at Stanton tidal depth of flow at 7Q10 from HEC 2 results.

Station 10800			**Station 13843**			**Station 14073**		
Hour	Depth		Hour	Depth		Hour	Depth	
0	0.9	Low Tide	0	0.96	Low Tide	0	0.85	Low Tide
1	0.95		1	0.96		1	0.96	
1.5	1.13		1.5	1.1		1.5	2.3	
3	2.59		3	1.5		3	2.3	
6	4	High Tide	6	2.4	High Tide	6	2.3	High Tide
9	2.59		9	1.5		9	2.3	
10.5	1.13		10.5	0.96		10.5	2.3	
11	0.95		11	0.96		11	0.96	
12	0.9	Low Tide	12	0.96	Low Tide	12	0.85	Low Tide

Appendix A
By United Water Delaware
White Clay Creek Salinity Monitoring Procedure May 21, 2000

In order to provide advance notice of a potential chloride problem at the Stanton WTP, UWD proposes to measure specific conductance according the procedure below. All measurements will be timed to approximately match peak high tide, as this is believed to be the time when chlorides would be at their highest levels. The conductivity measurements can be correlated to chloride concentrations using the following formula established during the UWD chloride study.

[Cl] = ([SC]-310) x 0.28

Where:
[Cl] is chloride concentration in ppm
[SC] is specific conductance in micro ohms/cm

- When the natural stream flow at the Stanton WTP = or < 37 mgd for five consecutive days, United Water Delaware will commence twice weekly conductivity measurements at the bridge over the Christina River near Ciba Specialty Chemicals at Newport.

Stream Flow at Stanton WTP = (White Clay Creek Flow near Newark USGS Gauge # 01479000 x 1.11) + (Red Clay Creek Stream Flow at Stanton USGS Gauge # 01480015)

- When specific conductance at the bridge over the Christina River near Ciba Specialty Chemicals correlates to 250 ppm chloride concentration, United Water will notify the State Water Coordinator and begin daily measurements at the DNREC Churchman's Marsh Boat Ramp (along the Christina River), the downstream side of the Tidal Capture Structure (TCS), and the Stanton WTP Low Service #1 Pump House Intake (both along the White Clay Creek).

- When specific conductance begins to show an upward trend at the Churchman's Marsh Boat Ramp and the TCS, United Water Delaware will notify the City of Wilmington of an impending request for releases from Hoopes Reservoir. The goal is to utilize freshwater from Hoopes Reservoir for salt front maintenance and keep chloride levels below 250 ppm in the tidal White Clay Creek at the TCS.

- The monitoring frequency may revert back to the twice-weekly schedule at Ciba Specialty Chemicals after stream flows at the Stanton WTP exceed 37 mgd for 5 days.

- The monitoring frequency may cease after significant rainfall events indicate chlorides are at normal background levels around 50 ppm at the Bridge near the Churchman boat ram along the Christina River.

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