NVCOG REGIONAL WASTEWATER TREATMENT CONSOLIDATION STUDY
WORKSHOP #2
SUMMARY REPORT

Meeting Date: December 11, 2018 **Meeting Time:** 1:00 – 4:00 PM
Meeting Location: Seymour City Hall
1 First St, Seymour, CT 06483

Attendees:
(Refer to sign-in sheet – Attachment 1)

From: Black & Veatch
To: Workshop Attendees

Workshop #2 for the NVCOG Regional Wastewater Treatment Consolidation Study was held on December 11, 2018 at Seymour City Hall, 1 First St, Seymour, CT.

The following summary report follows the flow of information and discussion at the workshop. Attachment 2 is the PowerPoint presentation prepared for the workshop. It is emphasized that the notes below are a highlight of the workshop discussion.

A. Introduction & Roles

1. John DiCarlo opened the meeting with an overview of Workshop #1 and the work done by the team since then. He said that Phase 1 was nearing completion and Phase 2 was expected to begin soon.
2. Rick Dunne noted that Black & Veatch would be presenting the work associated with Phase 1. He stated that the long list of regional alternatives would be pared back in Phase 2. Phase 2 would focus on infrastructure and operations of the short-listed alternatives. Governance and administration would need to be addressed with the recommended alternative, but those aspects would be defined separately from the Phase 2 work.
3. Mario introduced the Black & Veatch team and the community representatives introduced themselves. Black & Veatch also acknowledged OPM and DEEP and the importance of their of their participation and contributions to this study. Interaction and discussion by all was encouraged.

B. Review Base Case – Condition Assessment & System Needs

Q: Rick Dunne asked how Black & Veatch arrived at the requirements for the Base Case evaluations?

A: Chuck Pike replied that the "Base Case" covers the capital facility needs over the planning period (to 2040) if no regionalization occurs. Essentially, what are the necessary investments in order to keep all 5 plants and wastewater systems running and in compliance with regulations?

1. Derby

a. Derby WPCF Base Case (Chuck Pike)

i. A 2015 Consent Order issued by DEEP called for Derby to either modernize the entire facility or redirect its wastewater to another facility, with construction to be complete by December 31, 2020.

ii. Very little capital improvements work has been done on the Derby plant in the last 20 years. The plant is overdue for a major upgrade or replacement of its treatment systems and equipment. Safety features upgrades are also needed. This includes:

1. Replacement of headworks facility.
2. Replacement/upgrade of grit removal facility.
3. Complete mechanical upgrades/replacement of influent pump station.
4. Replacement of primary clarifier mechanisms.
5. Full process upgrade for secondary treatment.
6. Improvement of flow split to secondary clarifiers. It was noted that the plant is underloaded in design but can't handle peak flows.
7. Upgrade/replacement of sludge processing systems.
8. Upgrade/replacement of plant electrical system and implementation of SCADA system.
9. Upgrade disinfection, dechlorination, and odor control systems.

b. Derby Collection System Base Case (Jeff Stillman)

i. The Derby collection system is very old and about 70% is vitrified clay (VC) pipe with serious defects. As a result, there is a large I/I problem where peak flows can exceed the plant capacity. In fact, it is not known what the peak flows are since the plant influent pump station pegs at 10 MGD.

ii. Black & Veatch recommends significant investment in improving the collection system in order to fix these problems. Five years of catch-up at a 2.5%/year system-wide renewal rate is recommended, followed by a more moderate annual investment to maintain the system. The basins with the largest I/I problems will be targeted.

2. Ansonia

a. Ansonia WPCF Base Case (Chuck Pike)

i. Extensive upgrades were completed in 2011 and therefore the overall plant condition is good.

ii. There are hydraulic restrictions at the tail end of the plant that limit peak flows going through the plant. This needs to be resolved.

iii. It is anticipated that mechanical upgrades will be required by approximately 2030. The plant is starting to age now and will be about 20 years old by then.

b. Ansonia Collection System Base Case (Jeff Stillman)

i. The Ansonia collection system is old and much of it is VC pipe. The Town has I/I flows. The collection system was worked on right after the 2004 Facilities Plan, but no significant work has occurred since.

ii. Black & Veatch recommends significant investment in improving the collection system in order to fix these problems and to bolster the system. Five years of catch-up at a 2%/year system-wide renewal rate is recommended, followed by a more moderate annual investment to maintain the system.

3. **Seymour**
    a. Seymour WPCF Base Case (Chuck Pike)
        i. The plant was built in the '70s and upgraded last in the '90s and is now due for a major upgrade. This includes:
            1. Replacement of screenings and grit removal facilities.
            2. Complete mechanical upgrade of influent pump station.
            3. Replace mechanisms on two primary clarifiers.
            4. Upgrade BNR system.
            5. Replace secondary clarifier mechanisms.
            6. Replace sludge thickening devices and make provisions for handling sludge in thickened liquid form, no need to dewater.
            7. Upgrade plant electrical system and full SCADA upgrade.
    b. Seymour Collection System Base Case (Jeff Stillman)
        i. Old collection system with 23% of it being VC pipe. The system is not as old as Ansonia and Derby but still has a significant I/I problem. We have no documentation on the condition of the system.
        ii. Black & Veatch recommends significant investment in improving the collection system in order to fix these problems. Five years of catch-up at a 2%/year system-wide renewal rate is recommended, followed by a more moderate annual investment to maintain the system.

4. **Beacon Falls**
    a. Beacon Falls WPCF Base Case (Chuck Pike)
        i. The plant was built in 1971 with the most recent upgrade in 1994. It is due for a major upgrade. This includes:
            1. Replacement of headworks.
            2. Mechanical upgrade of influent pump station.

3. Upgrade of BNR system.
4. Replacement of sludge pumping system.
5. Replacement or upgrade of clarifiers.
6. The Town's engineer, DPC, has been developing design plans to cover a large portion of the systems identified above.

b. Beacon Falls Collection System Base Case (Jeff Stillman)

i. Compared to the collection systems in Derby, Ansonia and Seymour, Beacon Falls' collection system is in newer condition with approximately 2/3 of it installed within the past 20 years. Beacon Falls currently allocates $15,000 a year to emergency collection system repairs. The Town plans to turn its focus to the collection system after the plant upgrade is completed.

ii. Black & Veatch recommends an investment of 0.75%/year system-wide renewal rate.

5. Naugatuck

a. Naugatuck WPCF Base Case (Chuck Pike)

i. The Naugatuck plant was built in the 1970s and has a significant regional solids processing operation. The plant is due for a mechanical upgrade and improvements for phosphorus control are underway. The borough's wastewater treatment Facilities Plan from 2017 indicates the following system improvements are necessary:

1. Addition of grit and screenings removal upstream of influent pump station.
2. Replacement of scum collection system on primary clarifiers.
3. Upgrades to BNR system.
4. Addition of phosphorus treatment systems (underway).
5. Upgrade of secondary clarifier mechanisms, RAS pumps, WAS pumps, and other equipment from '70s.

b. Naugatuck Collection System Base Case (Jeff Stillman)

i. The Naugatuck collection system is old and much of it is VC pipe. As a result, there is a significant I/I problem. The Borough also has an Order from DEEP with focus on the collection system.

ii. The recent facilities plan identified some areas of focus, but Black & Veatch recommends even more investment with five years of catch-up at a 1.5%/year system-wide renewal rate, followed by a more moderate annual investment to maintain the system.

6. Base Case Scenario Costs (Mario Francucci)

a. Mario noted that we are still working on the capital costs for the Base Case of each community. For several communities there is no design available which can be quantified for construction cost development. Therefore, for these municipalities we will develop capital costs using a gross $/gal basis. The costs should be considered as high level and for budgetary purposes. The total approximate capital costs to bring all 5 plants up to satisfactory condition and to maintain that through 2040 is on the order of $200 million. The total investment required for collection systems is estimated at roughly $20 million, not including costs associated with pump stations. These costs will be defined for each community by approximately mid-January 2019.

C. Review Long List of Alternatives (Jeff Stillman)

1. Identification of Alternatives

a. Jeff described the evaluation criteria that Black & Veatch will use to compare the wastewater system regionalization alternatives. The criteria are grouped into three main categories as outlined below:

i. **Managing Peak Flows**

1. Jeff described these criteria as a complex relationship between:

a. Aggressive I/I Control

b. Treatment Capacity

c. Storage

These factors were taken into account when developing the regional wastewater alternatives.

ii. **Aging Facilities**

1. The current state of each of the plants and the necessary upgrades required are important to consider. Jeff noted the following about each of the respective plants:

   a. Naugatuck → Adequate capacity. Improvements necessary but not all of these are extremely urgent.

   b. Beacon Falls → Plant is due for major upgrade.

   c. Seymour → Plant is due for major upgrade.

   d. Ansonia → Fairly recent upgrade. Equipment updates will be necessary in planning period.

   e. Derby → Plant is due for major upgrade.

iii. **Upstream to Downstream**

1. Elevation differences between plants was also an important factor to consider. Jeff noted that pumping would be required in all scenarios, but that it is much easier and less expensive to pump in a southerly direction in the study areas. Thus, regional alternatives discharging in the south reaches of the study area are preferred from a phosphorus control perspective, particularly if the discharge is to the Housatonic River.

2. Jeff also noted that there are phosphorus discharge requirements on the Naugatuck River but not on the Housatonic River, which Derby discharges to.

iv. **Conveyance Corridors**

Beyond elevation differences, the topography and available rights of way were also important factors to consider in the identification and defining of the conveyance routes.

b. **Long List of Alternatives**

i. Jeff briefly introduced each of the alternatives that Black & Veatch identified and some of their characteristics and strengths/weaknesses.

1. Beacon Falls → Naugatuck
    a. Decommission Beacon Falls WPCF.
    b. Naugatuck has adequate capacity.
    c. Conveyance routes are challenging (four were identified).
2. Beacon Falls → Seymour
    a. Decommission Beacon Falls WPCF.
    b. Peak flows are a constraint.
    c. Conveyance route is challenging, but less so than the Beacon Falls → Naugatuck routes.
3. Derby → Ansonia
    a. Decommission Derby WPCF.
    b. Peak flows are a constraint.
    c. Phosphorus treatment required.
4. Derby → Ansonia, Effluent Pumped to Housatonic
    a. Decommission Derby WPCF.
    b. Peak flows are a constraint.
    c. Additional conveyance cost to pump to Housatonic.

Q: Brian Capozzi asked if the state plans on putting phosphorus requirements on the Housatonic?

A: Mario noted that DEEP has required phosphorus control at plants discharging to freshwater rivers and streams. The Housatonic is tidal at Derby and is not under this constraint. This question regarding possible future regulations will be considered further in Phase 2.

5. Derby + Seymour → Ansonia
    a. Decommission Derby and Seymour WPCFs.
    b. Plant upgrade required.
    c. Peak flow management needed.

d. Phosphorus treatment required.

6. Derby → Seymour + Ansonia
    a. Decommission Derby WPCF.
    b. Smaller plant upgrades required.
    c. Peak flow management needed.
    d. Phosphorus treatment required.
7. Derby → Seymour + Ansonia + Derby
    a. Maintain smaller plant at Derby.
    b. Smaller plant upgrades required.
    c. Peak flow management needed.
    d. Phosphorus treatment required for flow not treated in Derby.
8. Ansonia → Derby
    a. Decommission Ansonia WPCF in future (rather than rehabilitating).
    b. Size Derby WPCF to accommodate future Ansonia flows.
    c. Peak flow management needed.
    d. Eliminates need for phosphorus treatment.
9. Seymour + Ansonia → Derby
    a. Decommission Ansonia WPCF in future.
    b. Decommission Seymour WPCF.
    c. Size Derby WPCF to accommodate future Ansonia and Seymour flows.
    d. Peak flow management needed.
    e. Eliminates need for phosphorus treatment.
10. Seymour → Ansonia, Part of Ansonia → Derby
    a. Decommission Seymour WPCF.
    b. Peak flow management needed.
    c. Decommission Ansonia Bartholomew PS and the Coe Lane PS.
    d. Convey flow to Derby and size Derby WPCF to accommodate flows.
    e. Phosphorus treatment not required.

11. Beacon Falls + Seymour → Ansonia, Part of Ansonia → Derby
    a. Decommission Beacon Falls and Seymour WPCFs.
    b. Convey flow to Ansonia.
    c. Peak flow management needed.
    d. Decommission Ansonia Bartholomew PS
    e. Convey flow to Derby and size Derby WPCF to accommodate flows.
    f. Phosphorus treatment not required.
12. Beacon Falls + Seymour + Ansonia → Derby
    a. Decommission Beacon Falls and Seymour WPCFs.
    b. Decommission Ansonia WPCF in future.
    c. Convey flow to Derby and size Derby WPCF to accommodate flows.
    d. Peak flow management needed.
    e. Eliminates need for phosphorus treatment.

2. Conveyance Routes

a. Jeff described the wastewater pipeline conveyance routes between each of the neighboring communities and the initial characteristics and strengths/weaknesses of each one.
    i. Beacon Falls → Naugatuck
        1. Railroad ROW is the most direct path but may be difficult to get approval.
        2. Route 8 ROW is less direct but has more favorable topography.
        3. Other routes require going over or around Toby's Rock Mountain.
        4. Length: Approximately 3.5 to 5.5 miles.
        5. Rick noted that the railroad ROW is not favorable because the Towns would have to pay to use it and

disrupt the service. He said that the Route 8 ROW has more promise.

6. Jim Stewart noted that there is an existing river crossing that could probably be used and would shorten the route.

ii. Beacon Falls → Seymour

1. Railroad ROW is most direct option.
2. Route 8 is less direct alternative.
3. Avoiding existing ROW adds significant length and elevation.
4. Length: Approximately 5 to 9 miles.
5. Jim Galligan noted that "Haynes" owns a significant parcel of land between Beacon Falls and Seymour.
6. Jim Galligan also noted that the path from #2 down to the Seymour WPCF is the existing Seymour collection system.

iii. Seymour to/from Ansonia

1. Multiple town roads available for alternative alignments.
2. Elevation constraints less significant.
3. Length: Approximately 2.5 to 3 miles.
4. Jim Galligan said that there is a new Route 334 planned for construction which may be a good ROW.

iv. Ansonia to/from Derby

1. Routes have been previously investigated.
2. Multiple routes available.
3. Length: Approximately 1.5 to 2 miles.

v. Seymour to/from Derby

1. Likely most desirable to pass through Ansonia WPCF for flexibility.
2. Length: Approximately 4 to 5 miles.

3. Evaluation Criteria

a. Black & Veatch will use the following criteria to evaluate and screen out the long list of regional alternatives during Phase 2. We will also develop the alternatives more where that can be readily accomplished, including the conveyance corridors.

i. WPCF Site Constraints

1. Adequate space at the WPCF site.
2. Ease or difficulty of implementing changes at the plant.

ii. Other Constraints

1. Complexity in operation and maintenance.
2. Environmental restrictions.
3. Regulatory and permitting requirements.
4. Community benefits.

iii. Cost and Difficulty of Implementation

1. Implementation Schedule
2. Capital and O&M costs, and overall life cycle cost.
3. Topographic or right-of-way constraints in interconnection communities.

4. Conclusions and Recommendations

a. Using the above criteria, Black & Veatch completed a rough screening of the regional wastewater alternatives. Green signifies favorable attributes while red shows unfavorable attributes toward this criterion. The results are shown in the figure below.

Alt No.	Abbreviated Description	Space/ Constraint	Existing Facilities	O&M	Schedule	Env	Reg	Benefits	Relative Cost
1	BF→N	◉	◉	◉	◉	◉	◉	◉	◉
2	BF→S	◉	◉	◉	◉	◉	◉	◉	◉
2a	BF→S, I/I	◉	◉	◉	◉	◉	◉	◉	◉
3	D→A	◉	◉	◉	◉	◉	◉	◉	◉
3a	D→A, I/I	◉	◉	◉	◉	◉	◉	◉	◉
4	D→A→H	◉	◉	◉	◉	◉	◉	◉	◉
4a	D→A→ H, I/I	◉	◉	◉	◉	◉	◉	◉	◉
5	D&S→A	◉	◉	◉	◉	◉	◉	◉	◉
5a	D&S→A, I/I	◉	◉	◉	◉	◉	◉	◉	◉
5b	D&S→A→H	◉	◉	◉	◉	◉	◉	◉	◉
5c	D&S→A→H, I/I	◉	◉	◉	◉	◉	◉	◉	◉
6	D→S, D→A	◉	◉	◉	◉	◉	◉	◉	◉
6a	D→S, D→A, I/I	◉	◉	◉	◉	◉	◉	◉	◉
7	D→S, D→A, D→D	◉	◉	◉	◉	◉	◉	◉	◉
7a	D→S, D→A, D→D, I/I	◉	◉	◉	◉	◉	◉	◉	◉
8	A→D	◉	◉	◉	◉	◉	◉	◉	◉
8a	A→D, I/I	◉	◉	◉	◉	◉	◉	◉	◉
9	S&A→D	◉	◉	◉	◉	◉	◉	◉	◉
9a	S&A→D, I/I	◉	◉	◉	◉	◉	◉	◉	◉
10	S→A, A→D	◉	◉	◉	◉	◉	◉	◉	◉
10a	S→A, A→D, I/I	?	◉	◉	◉	◉	◉	◉	◉
11	BF,S→A, A→D	?	◉	◉	◉	◉	◉	◉	◉
11a	BF,S→A, A→D, I/I	?	◉	◉	◉	◉	◉	◉	◉
12	BF,S,A→D	?	◉	◉	◉	◉	◉	◉	◉
12a	BF,S,A→D, I/I	?	◉	◉	◉	◉	◉	◉	◉

b. Jeff explained the ratings further as follows:
    i. Space/Constraints
        1. Most plants will be able to accommodate additional flow from a neighboring community. However, some can handle this better than others.
        2. Naugatuck can handle Beacon Falls without expansion.
        3. Seymour can handle Beacon Falls if peak flow conditions are controlled.
    ii. Existing Facilities
        1. Naugatuck and Seymour may be able to receive flow from Beacon Falls.
        2. Alternative 7 does not provide any benefit since this alternative does not eliminate any treatment plants through consolidation.
        3. All other alternatives required upgrades to existing facilities in order to handle their flows.
    iii. Operations & Maintenance
        1. Consolidating plants will generally reduce O&M needs, but pumping needs associated with the conveyance of wastewater flows must also be considered.
        2. Differences in O&M will be assessed in Phase 2.
    iv. Schedule
        1. All alternatives have similar schedule constraints due to immediate improvement needs.
        2. Alternative 7 poses additional constraints.
    v. Environmental
        1. Consolidating plants eliminates permitted outfalls.
    vi. Regulatory
        1. Consolidating plants eliminates permitted outfalls and regulatory oversight and management.

vii. Benefits

1. Most alternatives provide benefits of consolidating facilities; however, Alternative 7 does not.

viii. Relative Cost

1. Alternative 7 is clearly not favorable.
2. Cost will be further evaluated in Phase 2.

c. Black & Veatch noted that Alternative 7 will be eliminated based on this rough screening. The resulting list represents the long list of regional wastewater alternatives going into Phase 2.

D. What's Next?

1. Questions/Comments

a. What is the time frame for implementing a regional alternative? (Edward Abel, Derby WPCA)

i. Mario answered that we should recognize that a period on the order of 10 years may be needed to fully implement a regional wastewater alternative.

ii. He emphasized that everyone has to be on board in order for the project to go forward.

iii. Edward noted that the timing could work with Ansonia upgrades.

iv. Brian Capozzi noted that Ansonia residents may be reluctant to abandon the plant they just spent $52M upgrading.

b. Why is I/I not a bigger focus?

i. Black & Veatch answered that most alternatives include I/I controls and investment. The most cost effective option will be found, including analysis of I/I investment.

c. How will this be funded? (Annmarie Drugonis, Town of Seymour)

i. John answered that nothing will go forward unless it makes sense financially for all involved. He also said that there will have to be considerable thought about proper representation

and governance for each of the Towns should regionalization take place.

d. How will alternatives be filtered? (Anita Dugan, City of Derby)
    i. Black & Veatch answered that we will go into more detail on the regional alternatives during Phase 2. We will want to get those down to a more manageable group and then spend more time/resources evaluating those. However, this will not include the engineering for the selected alternative.

e. Is there any consideration on parity between Towns? (Ansonia resident)
    i. The participant noted that Ansonia just paid for a new plant and some towns haven't paid at all in decades.
    ii. John again emphasized that the solution has to make sense for everyone and that it will not be forced on anyone.

f. Does OPM have to approve Phase 2? And when?
    i. Black & Veatch answered that yes OPM has to approve the next phase, and this will be decided after the completion of Phase 1 in early 2019.

2. John DiCarlo and Black & Veatch thanked all attendees for their participation in the workshop and noted that we are looking forward to more meaningful discussions and sharing of information throughout the study.

Attachment 1 – Sign-In Sheet

NVCOG Regional Wastewater Treatment Consolidation Study
Workshop #2
December 11, 2018
SIGN-IN SHEET

Name	Affiliation	Phone # / E-mail
Ben Lueders	Black & Veatch	781-856-0644 LuedersBM@bv.com
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SIGN-IN SHEET

Name	Affiliation	Phone # / E-mail
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Annmarie Daigneault	Town of ~~City~~ Seymour.	203-400-3588
Walter Royals	Seymour WPCF Veolia	203-735-0288 walter.royals@veolia.com
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Bart Flaherty	Resident Ansonia	
Jim Galli	Seymour BF	NYEng@nafisandyoung.com
Edward R. Abel	Derby WPCA	eabel@derbyct.gov 203-673-7128

Attachment 2 – Workshop #2 Presentation

Regional Wastewater Treatment Consolidation Study Workshop #2

11 December 2018

Naugatuck Valley Council of Governments

BUILDING A WORLD OF DIFFERENCE®

BLACK & VEATCH

Agenda

- Introduction & Roles
- Review Base Case
- Review Long List of Alternatives
- What's Next

Introduction & Roles

NVCOG
Black & Veatch
Participating Communities
OPM, DEEP

Review Base Case

Derby
Ansonia
Seymour
Beacon Falls
Naugatuck

Derby WPCF Base Case – Summary Points

- Plant upgraded to secondary treatment in 1972; limited modifications since that time (some upgrades in 1998).
- Overall condition is poor; overdue for major overhaul, approaching full replacement.
- Significant safety hazards must be remedied.
- Capital program should start as soon as practical.

DEEP Consent Order (8/3/2015) requires: “modernization of entire treatment facility or abandonment and redirection of wastewater to another facility”, with construction to be completed by 12/31/2020.

Derby WPCF Base Case

1. Replace existing headworks, to provide reliable screening facility upstream of influent pump station.

2. Replace/ upgrade the grit removal facility.

3. Complete mechanical upgrade of influent pump station (pumps, motors, valves, piping, controls, major upgrade of buildings).

Derby WPCF Base Case

4. Replace primary clarifier mechanisms, review concrete structures

5. Full process upgrade of secondary treatment (high efficiency blowers, air distribution system, etc.)

6. Improve flow spit to secondary clarifiers. Replace mechanisms. Modify clarifiers/ add a third.

Derby WPCF Base Case

7. Upgrade sludge pumping system. Store thickened sludge onsite, to be trucked offsite for dewatering and incineration.

8. Upgrade plant electrical system and provide plant SCADA.

9. Upgrade other plant systems, including disinfection, dechlorination, odor control.

Derby Collection System Base Case

- Old collection system; about 70% is vitrified clay (VC) pipe, characteristically with serious defects.
- System is leaky, with very high I/I. Peak wet weather flows can exceed plant capacity.
- Significantly higher expenditures are required for sewer replacement/ repairs due to poor condition of system and years of deferred replacement.
- USEPA Order required collection system improvements, including I/I Control Plan and CMOM Corrective Action Plan.

Recommended: Five years of catch-up at a 2.5%/yr system-wide renewal rate (= 1.0 miles/yr), followed by a more moderate annual investment for system strengthening/ maintenance.

Ansonia WPCF Base Case – Summary Points

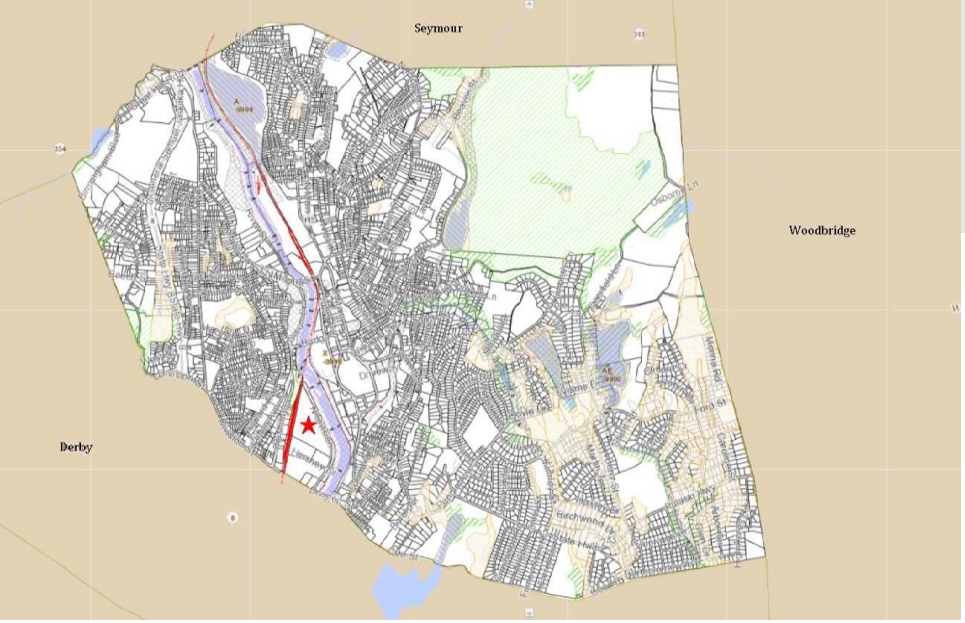
- Extensive plant upgrade completed in 2011.
- Overall condition of the plant is good.
- Hydraulic restrictions limit peak flows that can be handled by plant – this needs to be resolved asap.

Anticipate that mechanical equipment upgrades will be required by approximately 2030, as existing systems reach projected life expectancy.

Ansonia WPCF Base Case

- Treatment performance and condition of relatively new equipment is good at this time.
- Plan for replacement of pumps, mixers, other mechanical systems later in the 20-year planning period.

Ansonia Collection System Base Case



- Old collection system, much of which is VC pipe.
- System is leaky, with very high I/I.
- While some I/I work was done in the past, overall much work needs to be done to catch up and to maintain this very old pipe system.

Recommended: Five years of catch-up at 2%/yr system-wide renewal rate (= 1.3 miles/yr), followed by a more moderate annual investment for system strengthening/ maintenance

Seymour WPCF Base Case Summary Points

Plant is now due for a major upgrade. Under base case, capital program should start as soon as practical.

- Plant built in the 1970's, with most recent upgrade in the early 1990's.
- At minimum, replace/rehab: headworks screening, grit removal, influent pump station, primary clarifiers/mechanisms, secondary clarifier upgrade, BNR system upgrade including aeration blowers, sludge processing, plant-wide electrical, SCADA

Seymour WPCF Base Case

1. Replace screenings and grit removal facilities at headworks.

2. Complete mechanical upgrade of influent pump station (all pumps, motors, valves, piping, controls, etc.)

3. Replace mechanisms on two primary clarifiers; review condition of concrete structure.

Seymour WPCF Base Case

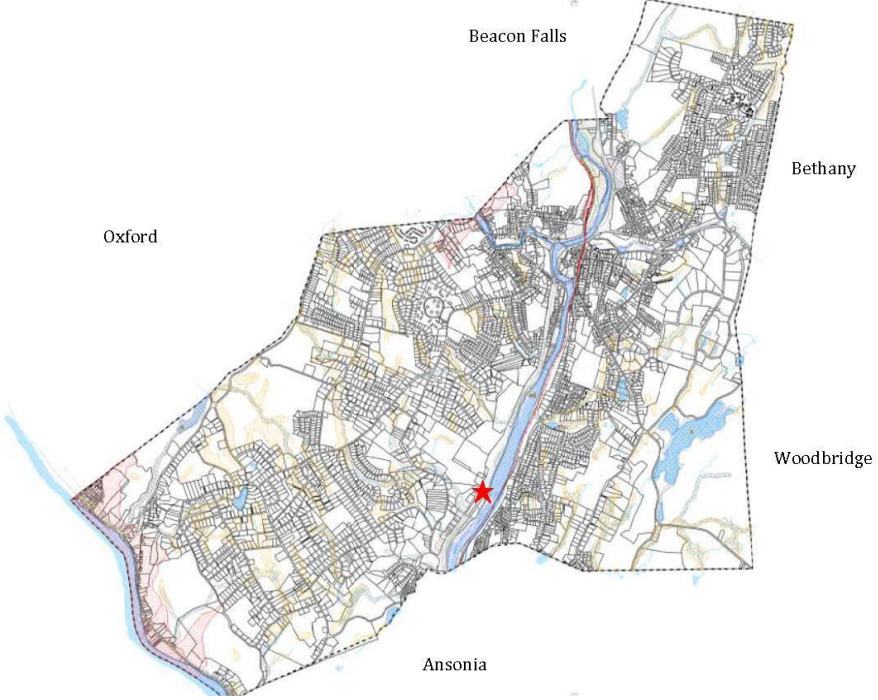
4. Upgrade BNR system. Replace diffusers, old blowers; fix HVAC and segregation issues for blowers.

5. Replace secondary clarifier mechanisms.

6. Replace RDT's, provide liquid sludge storage onsite for offsite dewatering and incineration.

7. Upgrade plant electrical system, replace MCC's and old panels. Provide full SCADA upgrade.

Seymour Collection System Base Case



- Old collection system (23% of which is VC pipe)
- Limited maintenance or inspections.
- System is leaky, with very high I/I.
- Significantly higher expenditures are required for sewer replacement/ repairs due to poor condition of system and years of deferred replacement/upgrade.

Recommended: Five years of catch-up at 2%/yr system-wide renewal rate (= 1.3 miles/yr), followed by a more moderate annual investment for system strengthening/ maintenance

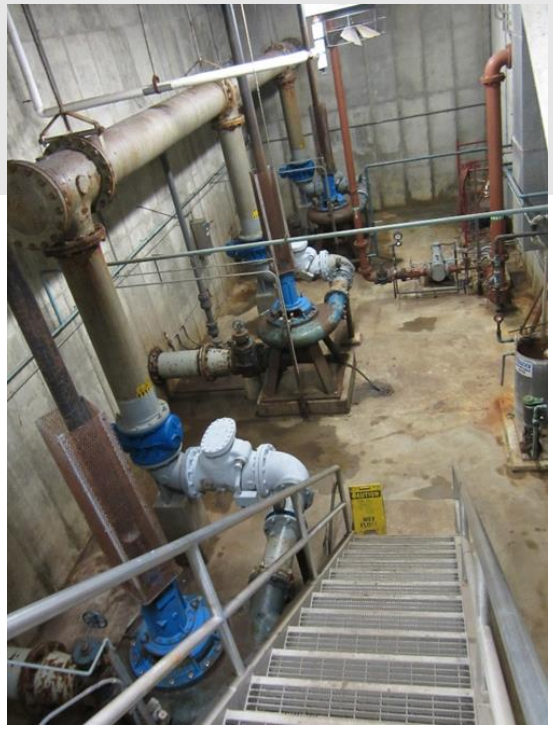
Beacon Falls WPCF Base Case Summary Points

Town is planning to undertake plant upgrade in the near term.

- Plant built in 1971, with the most recent upgrade in 1994.
- Plant is due for a major upgrade.
- At minimum, upgrade or replace: influent pump station, headworks, clarifiers, aeration system, sludge pumping, rotary drum thickener, plant-wide electrical, SCADA

Beacon Falls WPCF Base Case

1. Mechanical upgrade of influent pump station; replace headworks.
2. Upgrade BNR system.
3. Replace sludge pumping system.
4. Replace or upgrade clarifiers; issues with old, shallow, partially buried units.



Beacon Falls Collection System Base Case

- Approx. 2/3 installed within the past 20 years.
- Currently spending very little for system maintenance ($15k/year).
- Town plans to focus on collection system after plant upgrade.

Recommended: Plan maintenance of 0.75%/yr system-wide renewal rate (= 0.25 miles/yr), for sustained performance

Naugatuck WPCF Base Case Summary Points

Plant is due for a mechanical upgrade. Improvement for phosphorus control are underway.

- Secondary treatment plant from the 1970's, with significant regional solids processing operation.
- Recent Facilities Plan (12/2017) identified upgrades with capital costs through 2026. Upgrades needed include: grit removal, septage receiving, dewatering and phosphorus removal.
- In view of the age of the facility, additional capital expenditures should be programmed for during the 2027-2040 period.

Naugatuck WPCF Base Case

1. No headworks grit and screenings removal upstream of influent PS causes operational challenges.

2. Scum collection on primary clarifiers not functional.

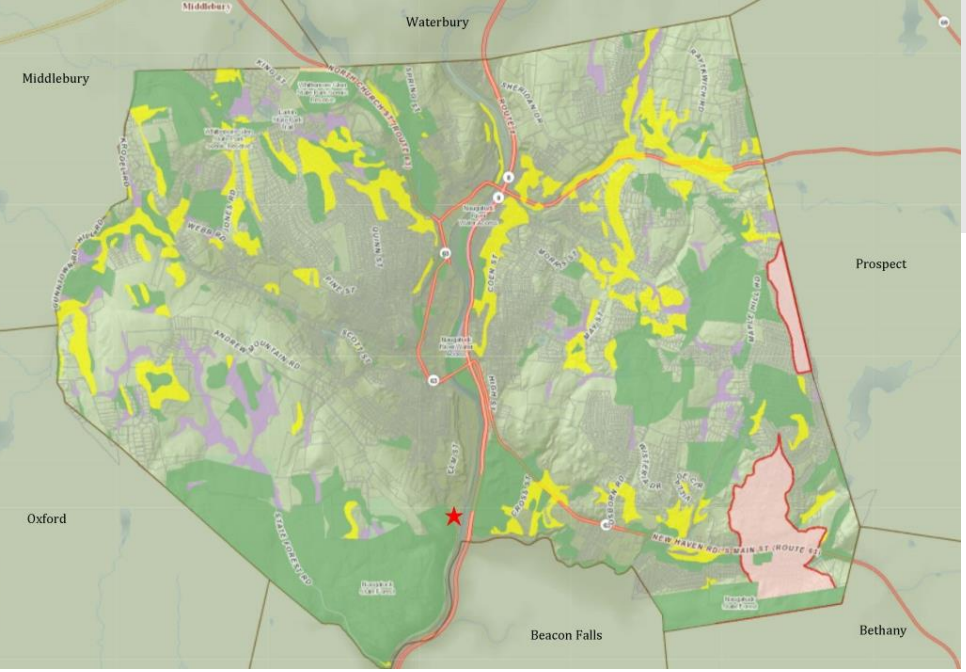
3. Upgrade to optimize BNR system to improve treatment and energy efficiencies; deficiencies noted in Facilities Plan.

Naugatuck WPCF Base Case

4. Phosphorus treatment systems required; this is underway.

5. Secondary clarifiers collectors, drives, RAS pumps WAS pumps, etc. from 1970's need to be replaced.

Naugatuck Collection System Base Case



- Old collection system, much of which is VC pipe.
- Under a Consent Order regarding collection system O&M and I/I control.

Recommended: Five years of catch-up at 1.5%/yr system-wide renewal rate (= 2.3 miles/yr), followed by a more moderate annual investment for system strengthening/ maintenance

Review Long List of Alternatives

- Identification of Alternatives
- Conveyance Routes
- Evaluation Criteria
- Conclusions and Recommendations

Identification of Alternatives

- **Managing Peak Flows**
- Aging Facilities
- Upstream to Downstream
- Conveyance Corridors

Aggressive rehabilitation is costly but may be the best long-term solution

Aggressive I/I Control

Building extra plant capacity for infrequent events

Treatment Capacity ⟺ **Storage**

Storage can be cost-effective but pose operational headaches

High Peaking Factors are costly to manage and will require balancing approaches for an optimal solution

Identification of Alternatives

- Managing Peak Flows
- **Aging Facilities**
- Upstream to Downstream
- Conveyance Corridors

Naugatuck	Adequate capacity. Improvements will be required, but not all are urgent.
Beacon Falls	Plant is due for major upgrade
Seymour	Plant is due for major upgrade
Ansonia	Fairly recent upgrade. Equipment updates will be needed in planning period.
Derby	Plant is due for major upgrade

Aging facilities require immediate attention, but they also provide opportunity for economies of scale

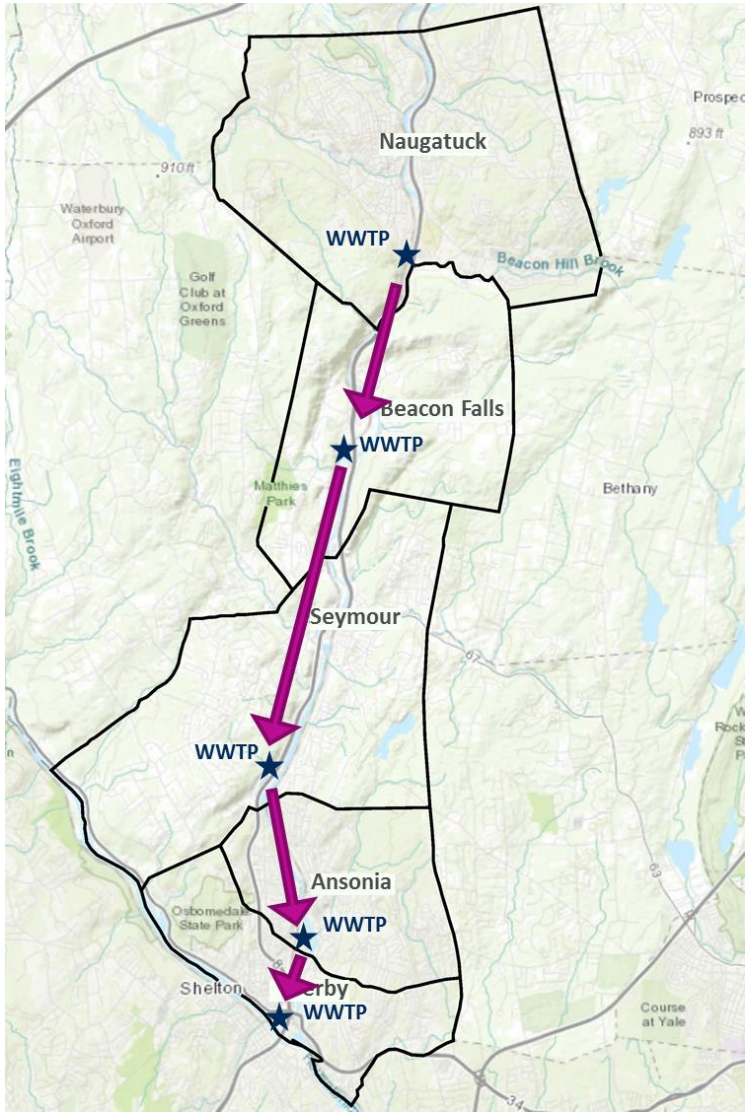
Managing Peak Flows

Aging Facilities

Upstream to Downstream

Conveyance Corridors

Identification of Alternatives



- Although pumping will be required, it is easier to pump it downhill
- Neighboring communities are easier to interconnect
- Phosphorus discharge requirements on Naugatuck River
- Derby does not have phosphorus discharge requirements (Housatonic River)

Managing Peak Flows

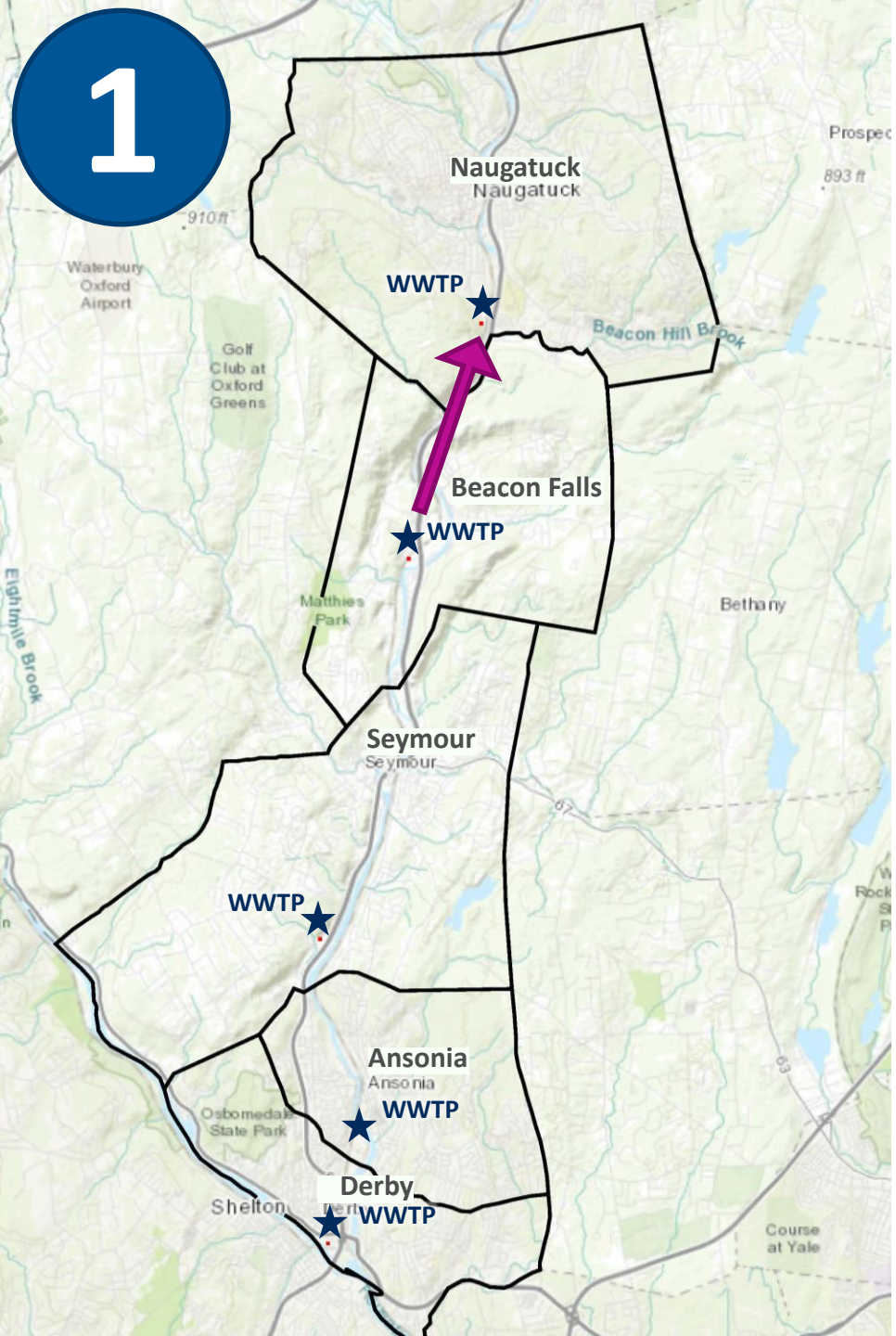
Aging Facilities

Upstream to Downstream

Conveyance Corridors

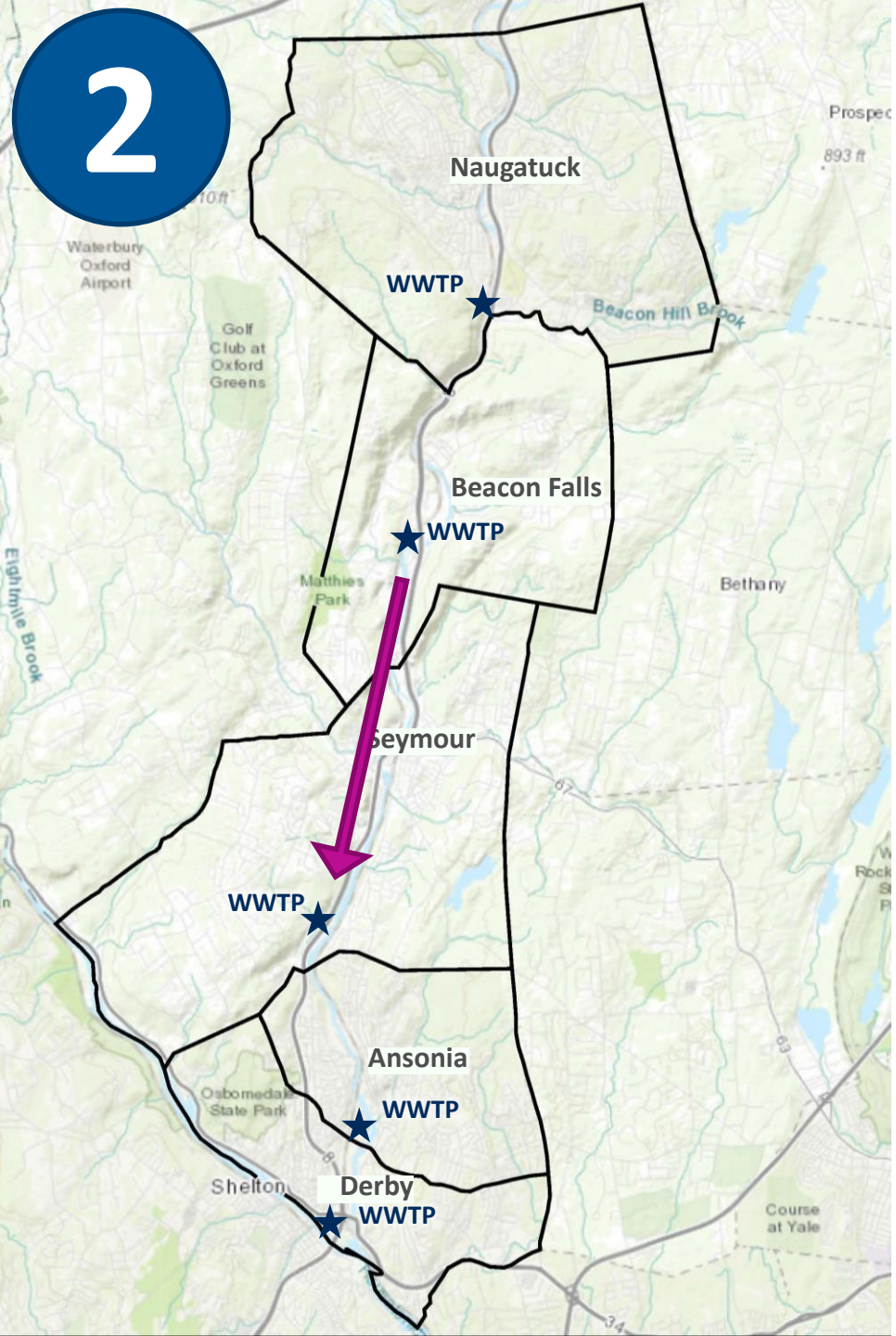
Identification of Alternatives

- **Topography poses significant constraints in some alternatives**
- **Distance is relatively long in some alternatives**
- **Existing rights of way (railroad, Route 8) can be challenging**
- **Construction on town roads can be disruptive**



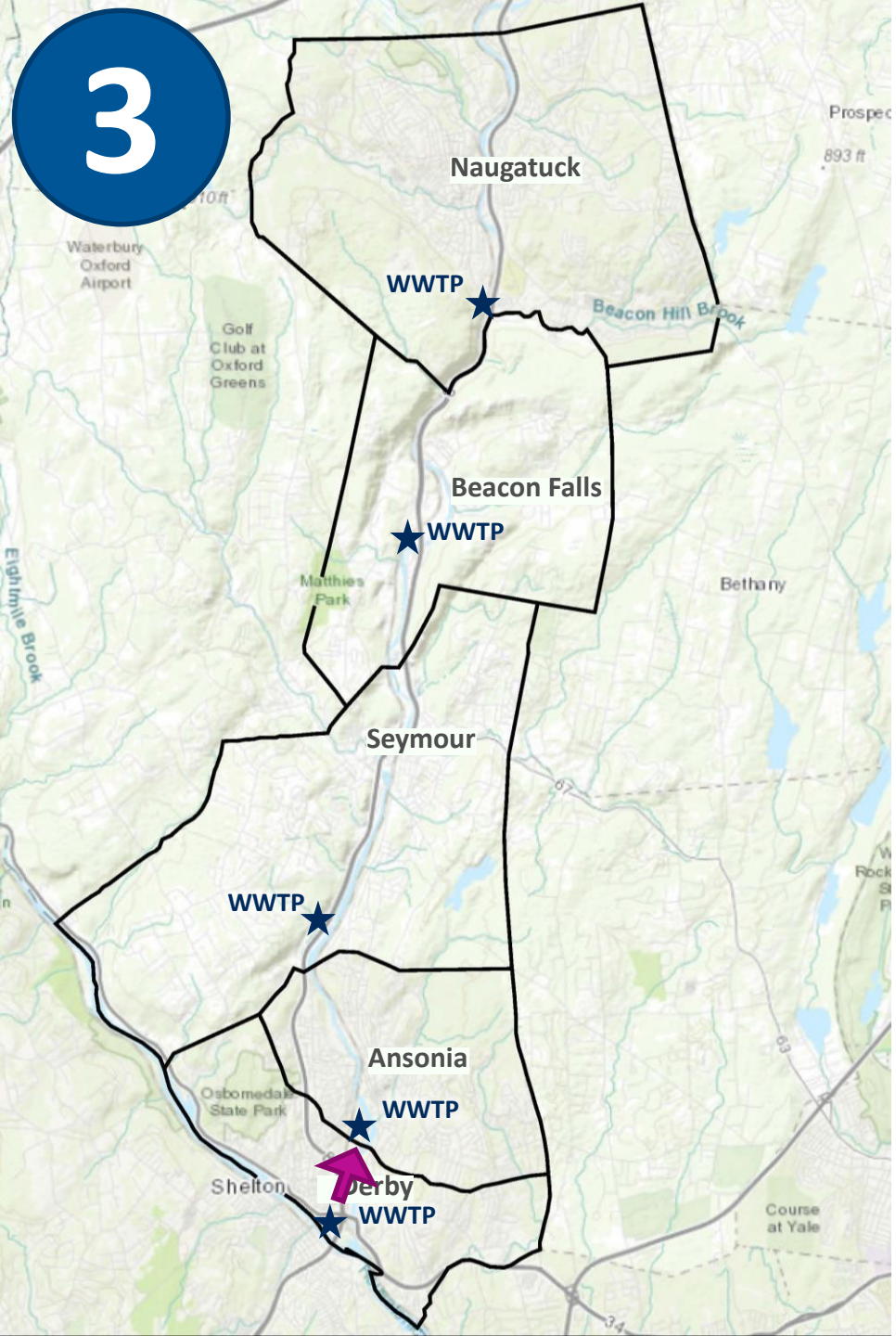
Beacon Falls to Naugatuck

- Decommission Beacon Falls WPCF
- Convey flow to Naugatuck (adequate capacity)
- Conveyance route is challenging



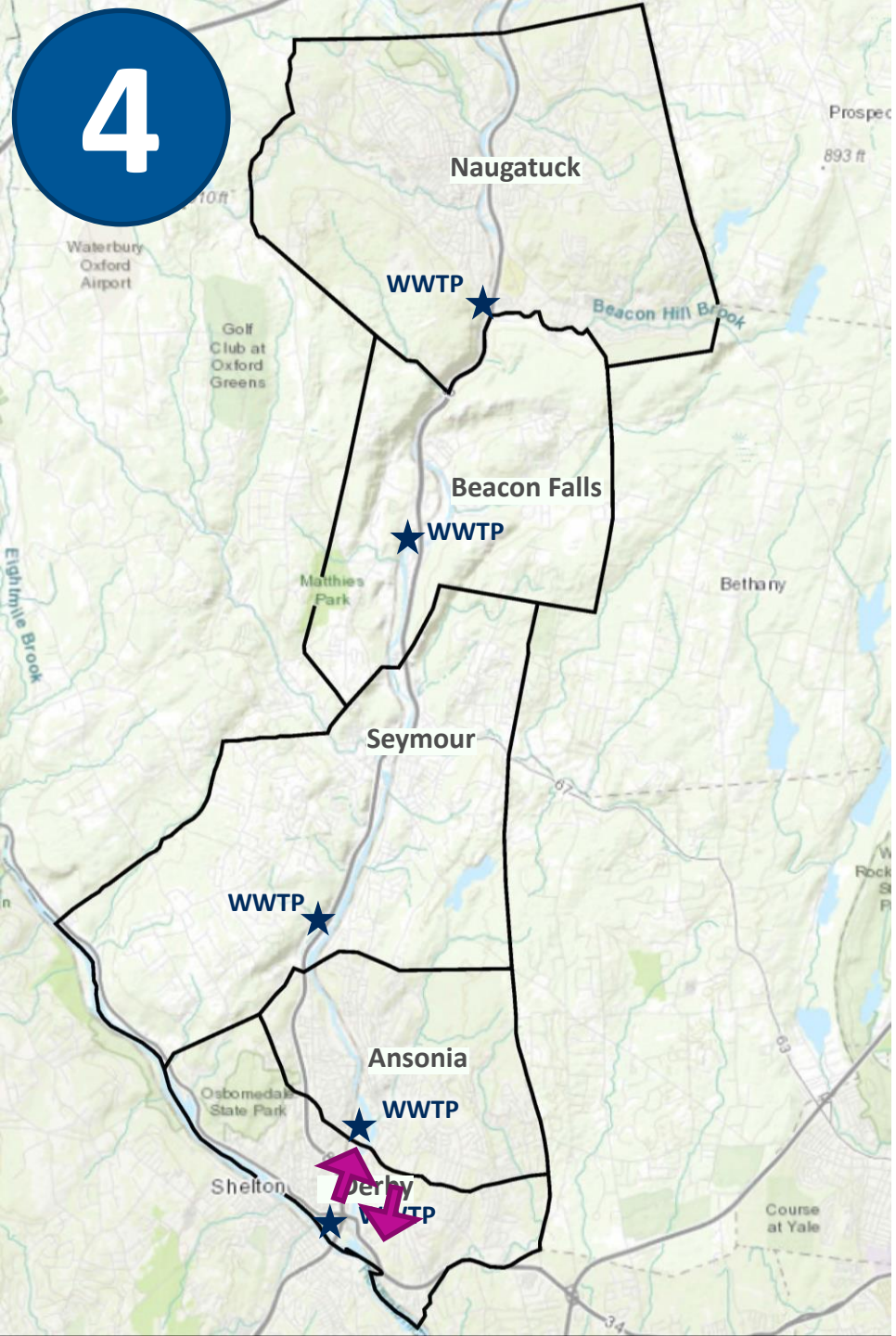
Beacon Falls to Seymour

- Decommission Beacon Falls WPCF
- Convey flow to Seymour
  - Peak flows are constraint
  - Plant capacity, I/I removal, and/or storage
- Conveyance route is challenging



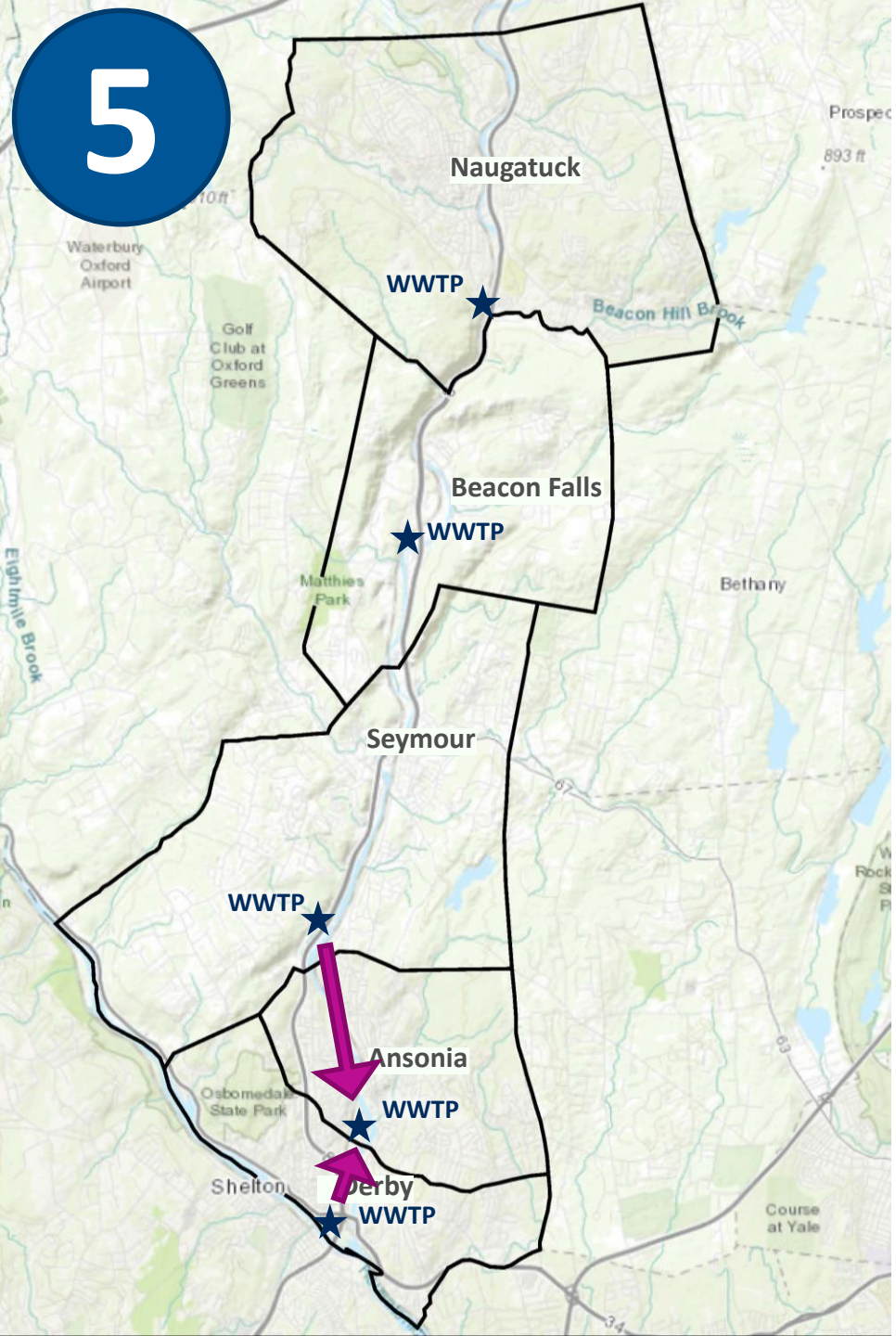
Derby to Ansonia

- Decommission Derby WPCF
- Convey flow to Ansonia
  - Peak flows are constraint
  - Plant capacity, I/I removal, and/or storage
- Phosphorus treatment required



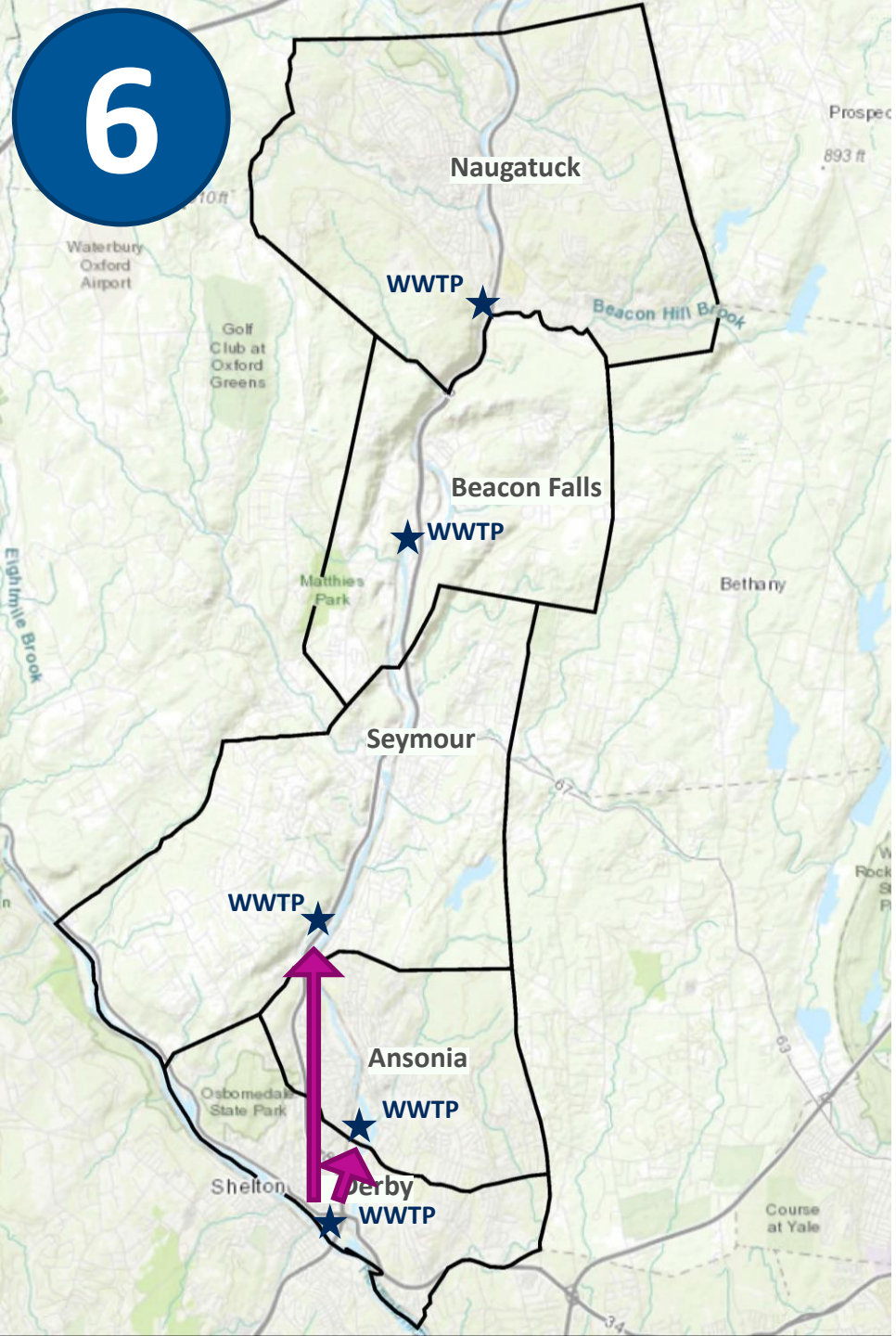
Derby to Ansonia
Effluent Pumped to Housatonic

- Decommission Derby WPCF
- Convey flow to Ansonia
  - Peak flows are constraint
  - Plant capacity, I/I removal, and/or storage
- Additional conveyance costs to pump to Housatonic



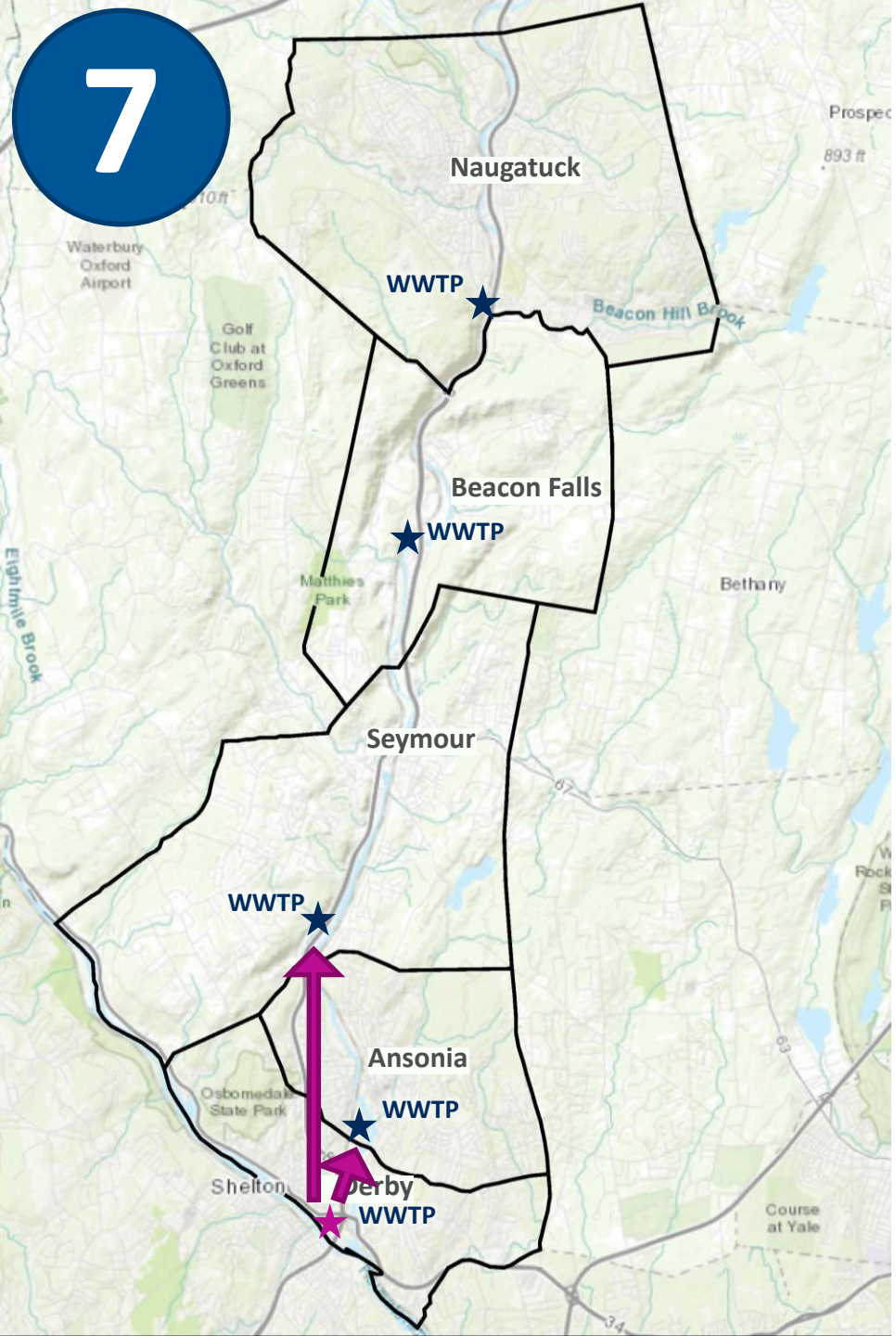
Derby and Seymour to Ansonia

- Decommission Derby and Seymour WPCFs
- Convey flow to Ansonia
  - Plant upgrade required
  - Peak flow management needed
  - Plant capacity, I/I removal, and/or storage
- Phosphorus treatment required



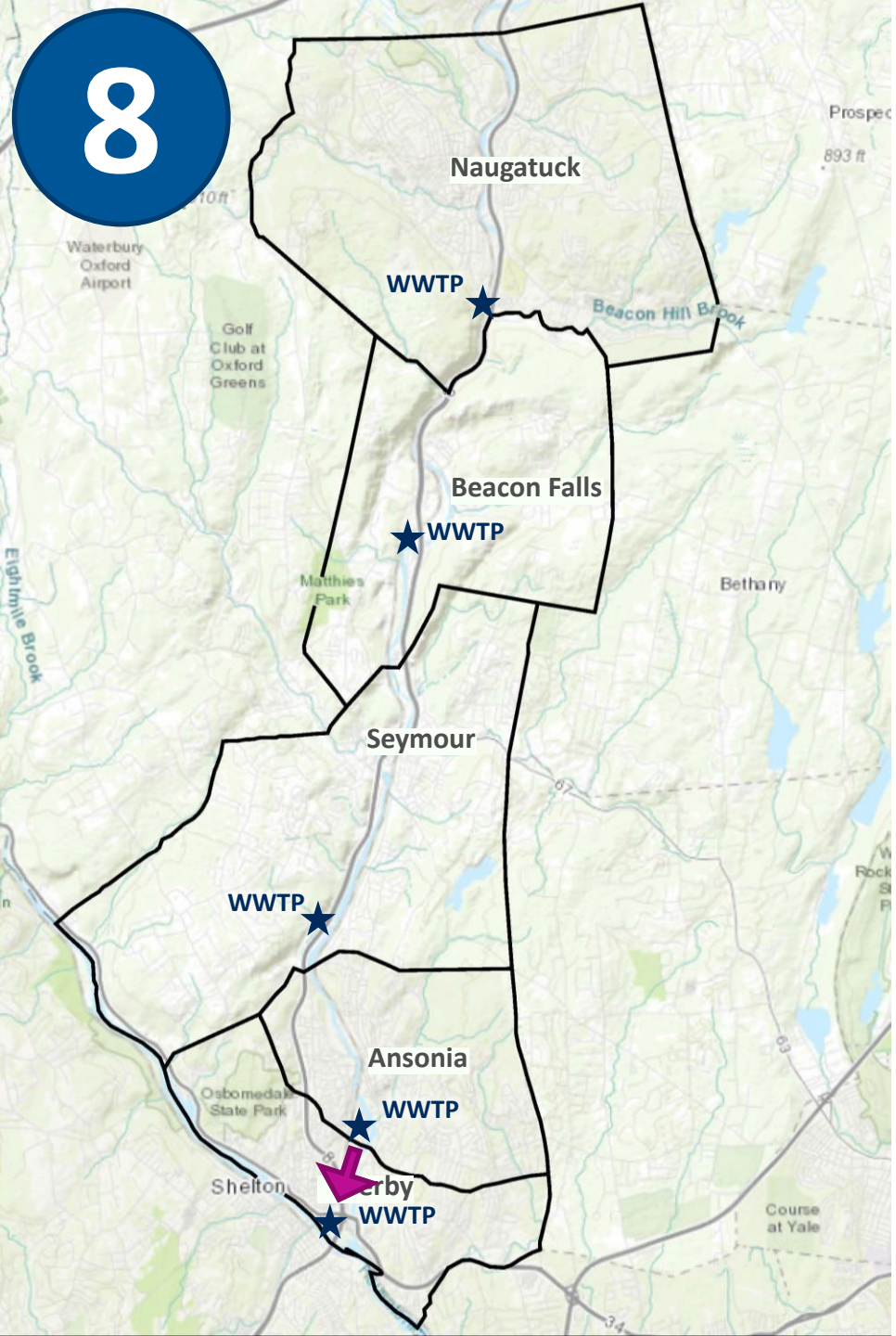
Derby to Seymour and Ansonia

- Decommission Derby WPCF
- Convey flow to Ansonia and Seymour
  - Smaller plant upgrades required
  - Peak flow management needed
  - Plant capacity, I/I removal, and/or storage
- Phosphorus treatment required



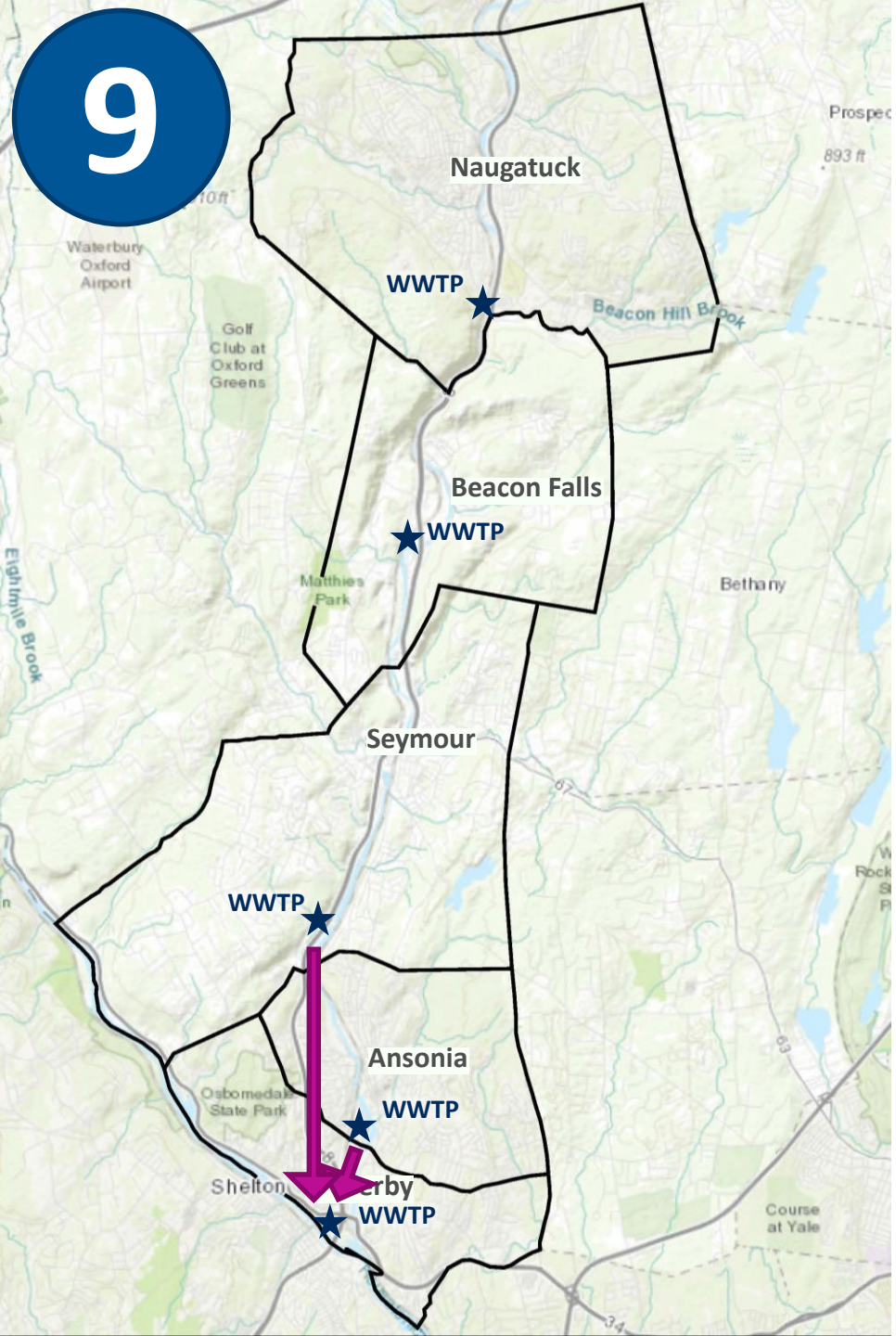
Derby to Seymour and Ansonia and Derby

- Maintain smaller plant at Derby
- Convey excess flow to Ansonia and Seymour
  - Smaller plant upgrades required
  - Peak flow management needed
  - Plant capacity, I/I removal, and/or storage
- Phosphorus treatment required for flow not treated in Derby



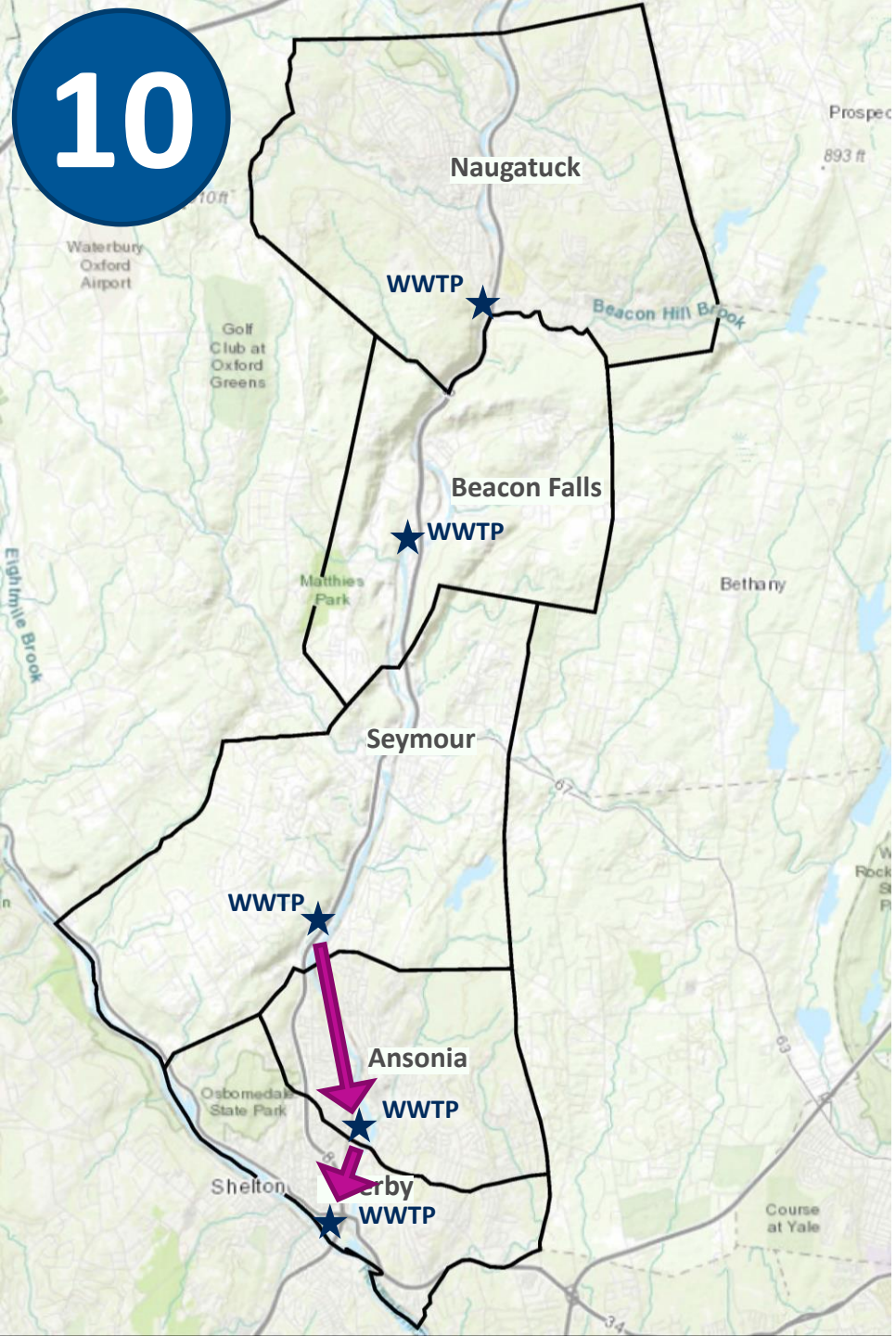
Ansonia to Derby

- Decommission Ansonia WPCF in future (rather than rehabilitating)
- Convey flow to Derby
  - Size Derby WPCF to accommodate future Ansonia flows
  - Peak flow management needed
  - Plant capacity, I/I removal, and/or storage
- Eliminates need for phosphorus treatment



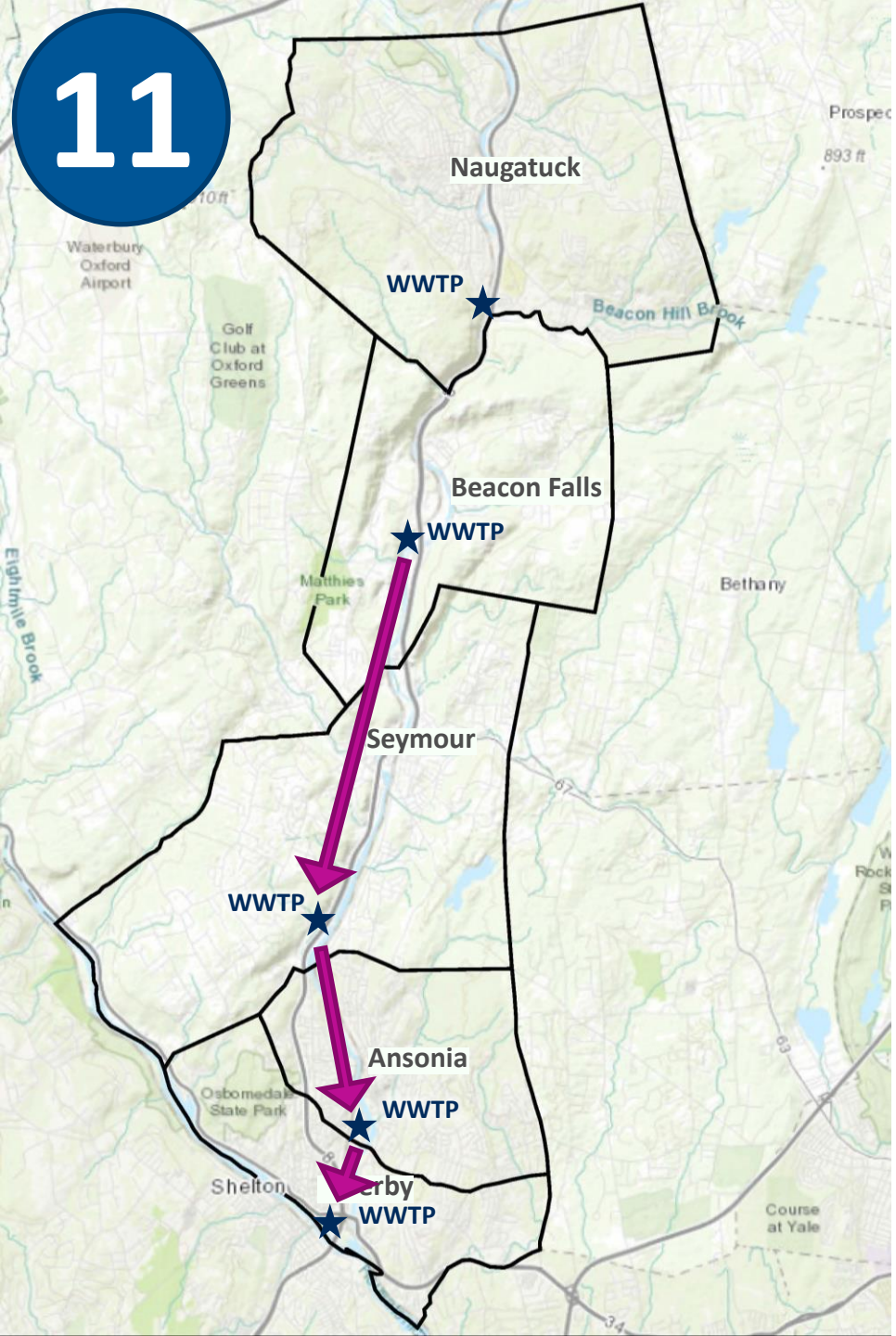
Seymour and Ansonia to Derby

- Decommission Ansonia WPCF in future (rather than rehabilitating)
- Decommission Seymour WPCF
- Convey flow to Derby
  - Size Derby WPCF to accommodate future Ansonia and Seymour flows
  - Peak flow management needed
  - Plant capacity, I/I removal, and/or storage
- Eliminates need for phosphorus treatment



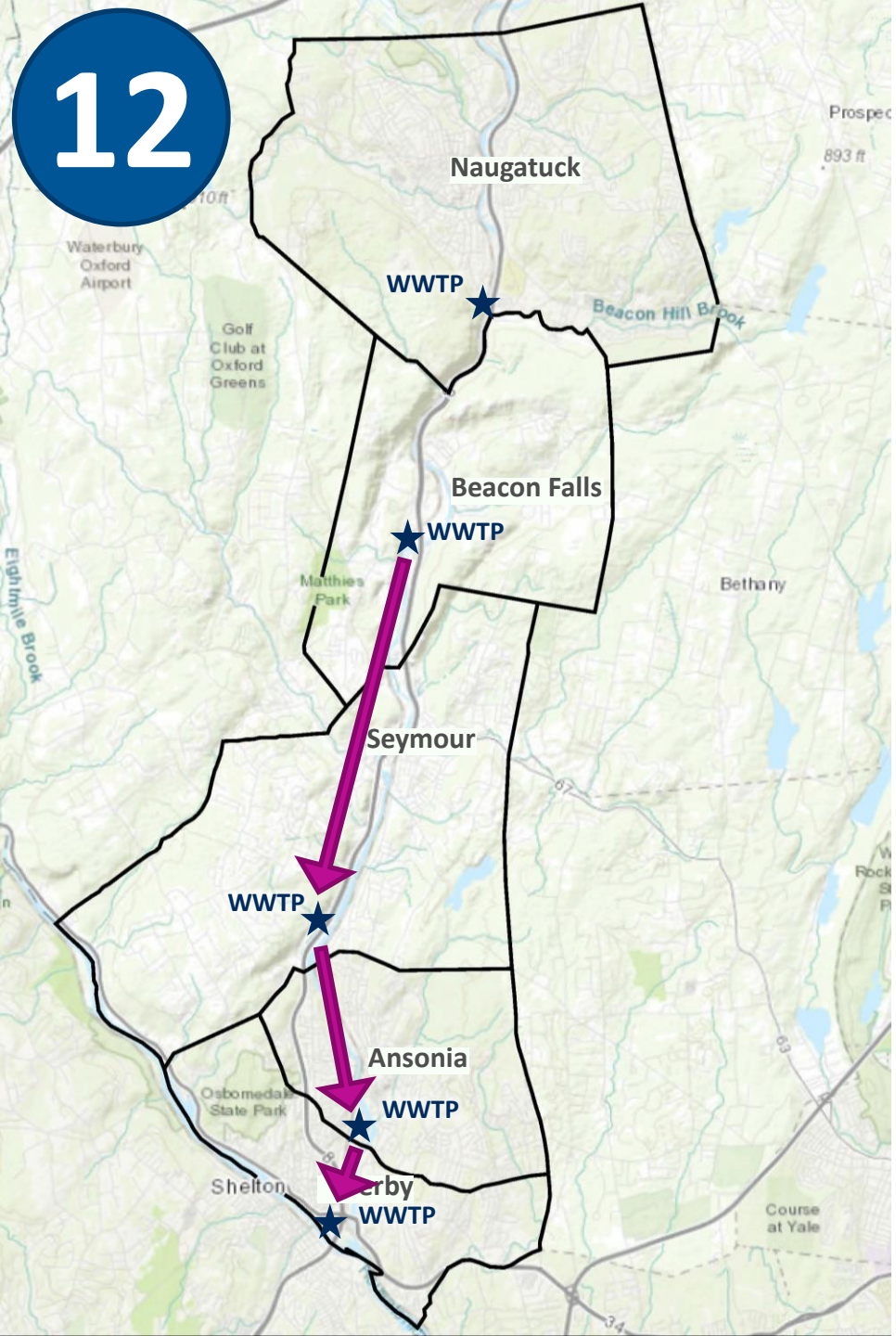
Seymour to Ansonia
Part of Ansonia to Derby

- Decommission Seymour WPCF
- Convey flow to Ansonia
  - Peak flow management needed
  - Plant capacity, I/I removal, and/or storage
- Decommission Ansonia Bartholomew PS
  - Convey flow to Derby
  - Size Derby WPCF to accommodate flows
- Phosphorus treatment not required for flows to Derby



Beacon Falls and Seymour to Ansonia Part of Ansonia to Derby

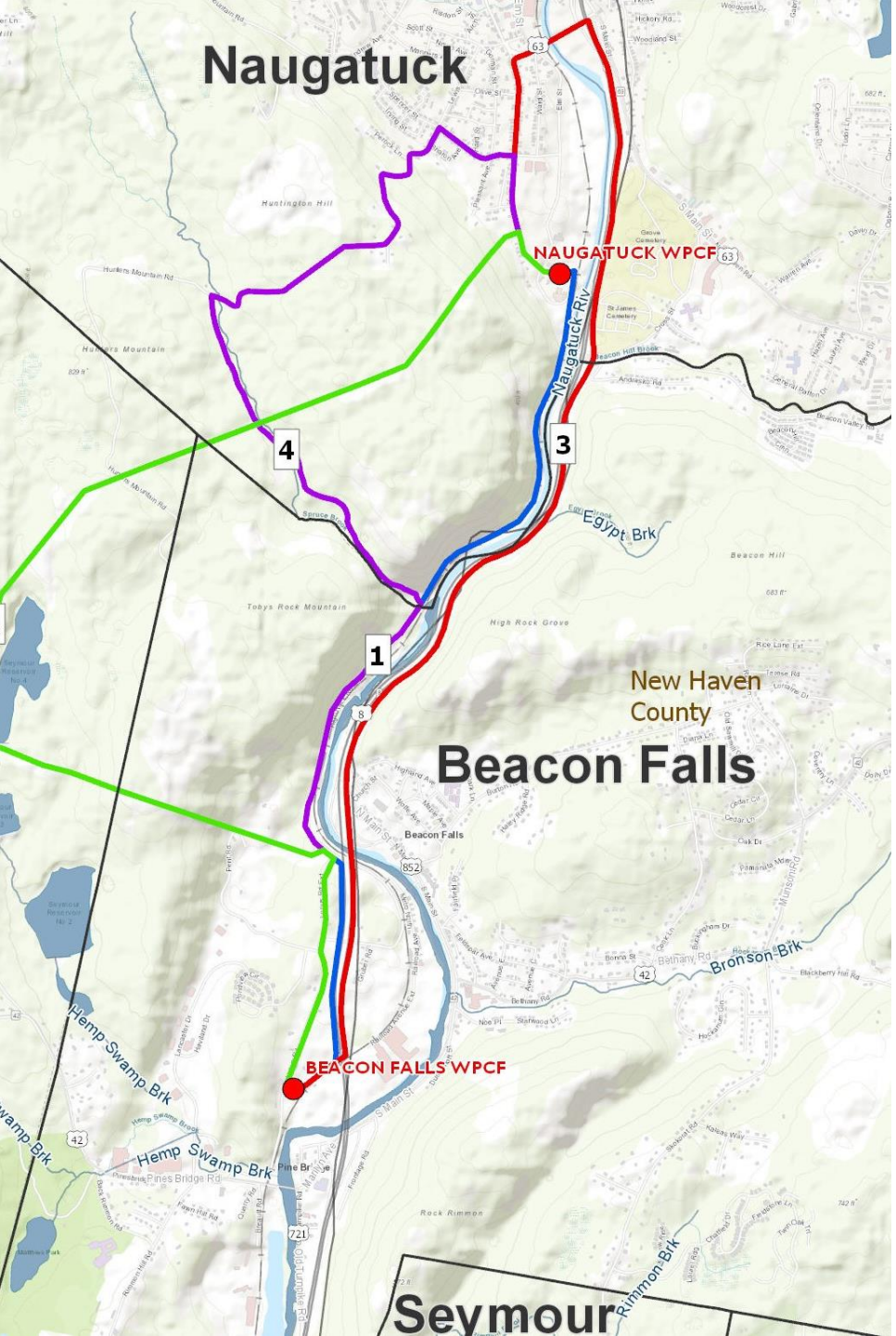
- Decommission Beacon Falls and Seymour WPCFs
- Convey flow to Ansonia
  - Peak flow management needed
  - Plant capacity, I/I removal, and/or storage
- Decommission Ansonia Bartholomew PS
  - Convey flow to Derby
  - Size Derby WPCF to accommodate flows
- Phosphorus treatment not required for flows to Derby



Beacon Falls, Seymour, and Ansonia to Derby

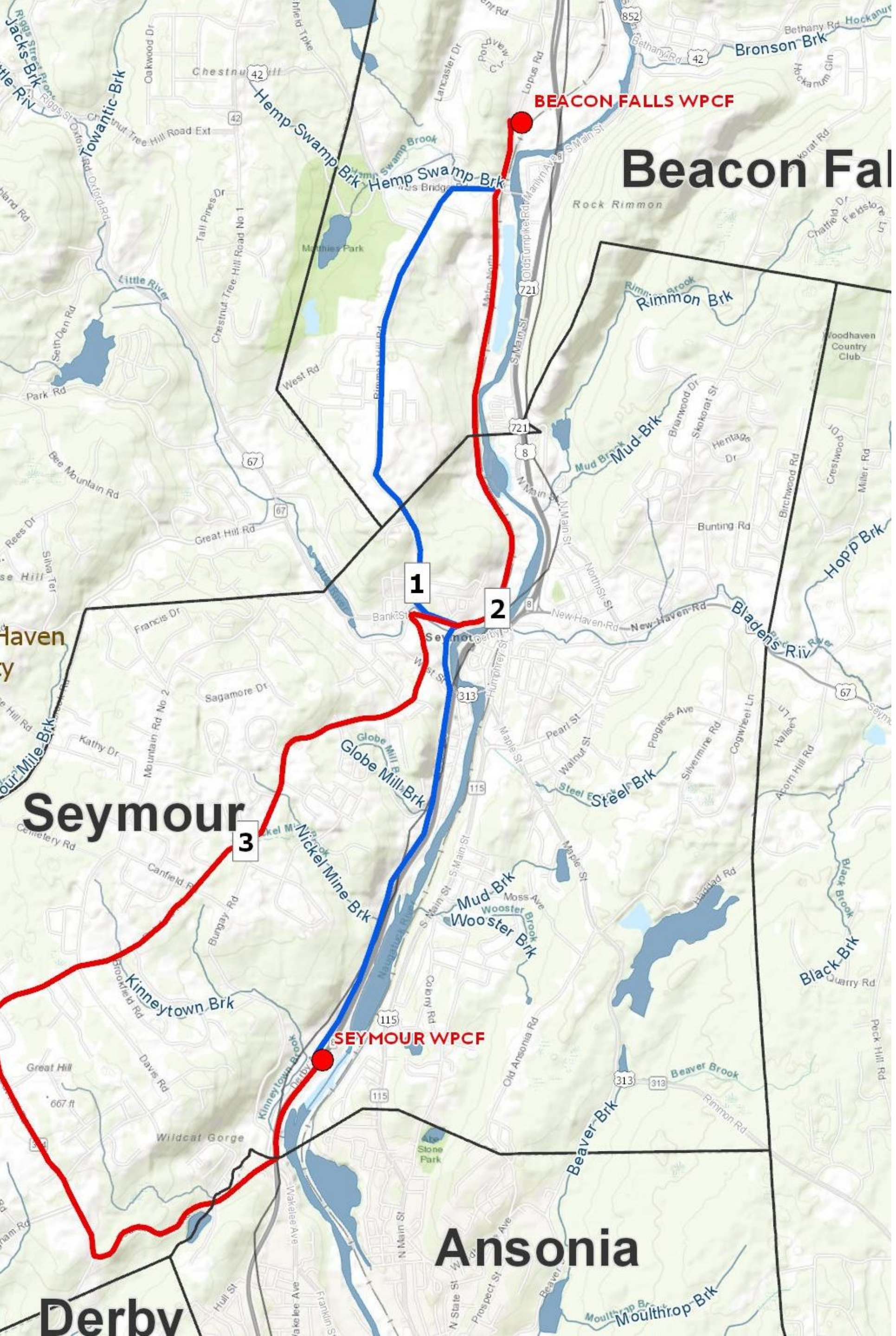
- Decommission Beacon Falls and Seymour WPCFs
- Decommission Ansonia WPCF in future (rather than rehabilitating)
- Convey flow to Derby
  - Peak flow management needed
  - Plant capacity, I/I removal, and/or storage
  - Size Derby WPCF to accommodate flows
- Eliminates need for phosphorus treatment

Conveyance Routes



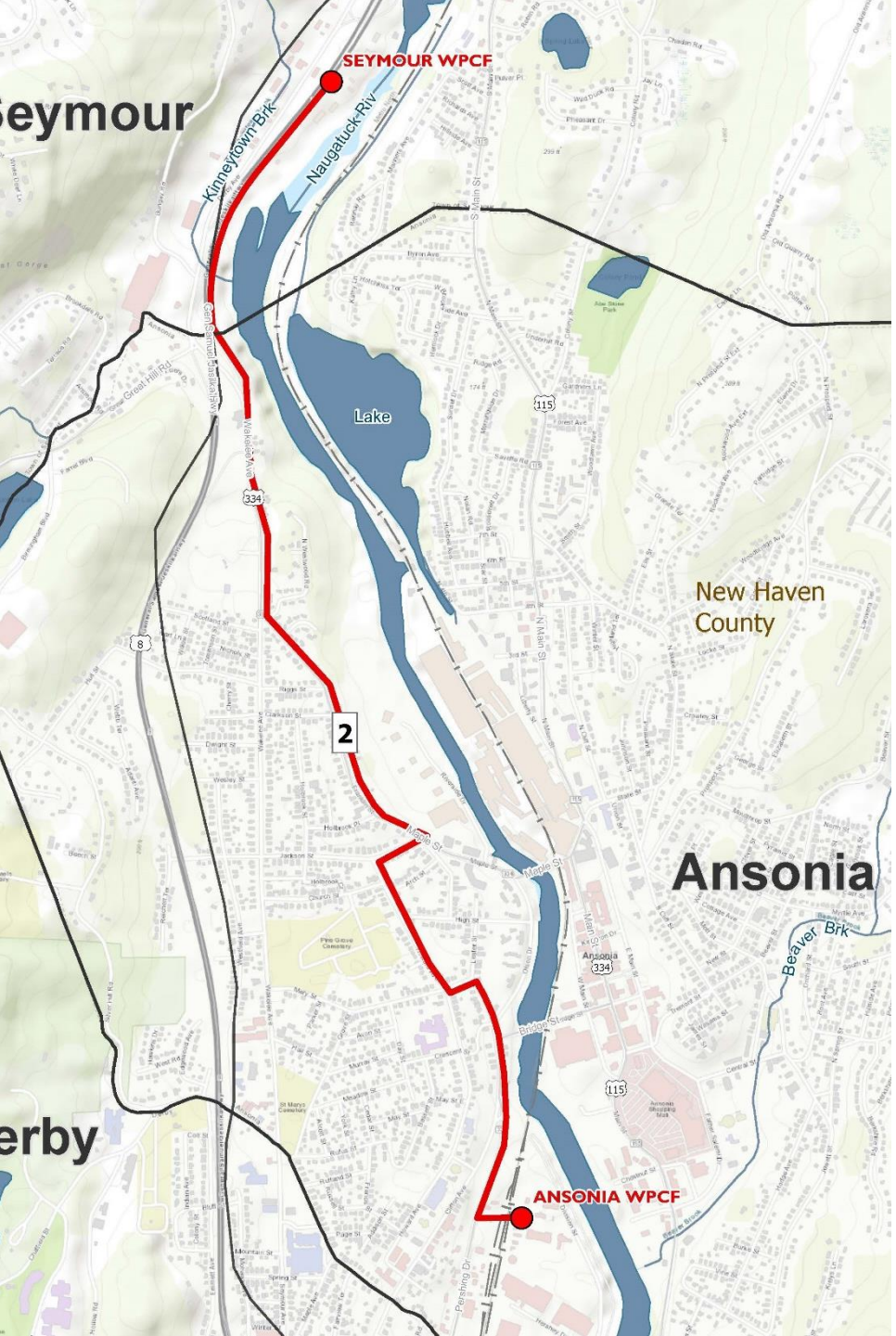
Beacon Falls to Naugatuck

- Railroad ROW is most direct path
- Route 8 ROW is less direct, but still provides more favorable topography
- Other routes require going over or around Toby's Rock Mountain
- Length: Approx. 3.5 to 5.5 miles



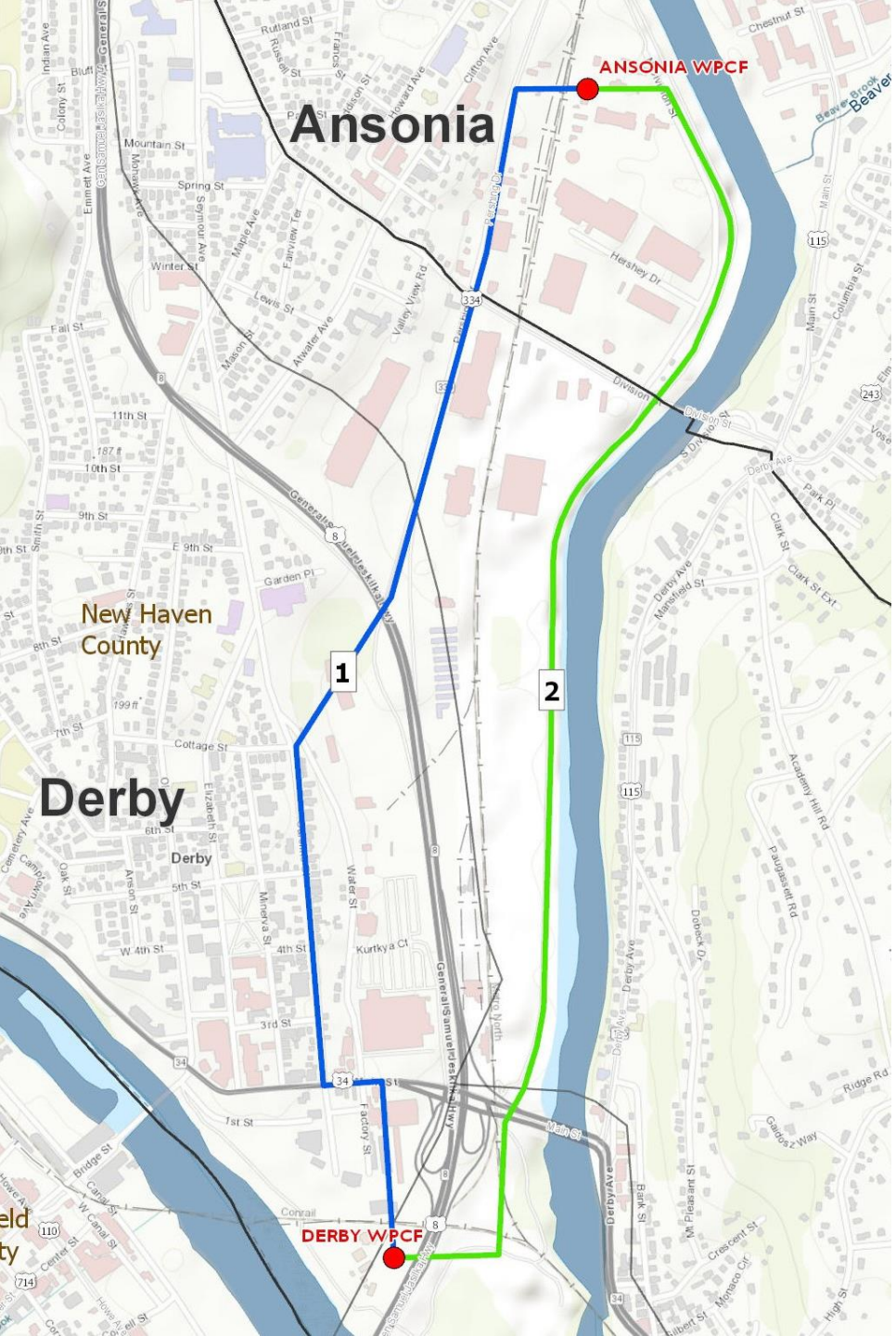
Beacon Falls to Seymour

- Railroad ROW is most direct option
- Route 8 ROW is less direct alternative
- Avoiding existing ROW adds significant length and elevation
- Length: Approx. 5 to 9 miles



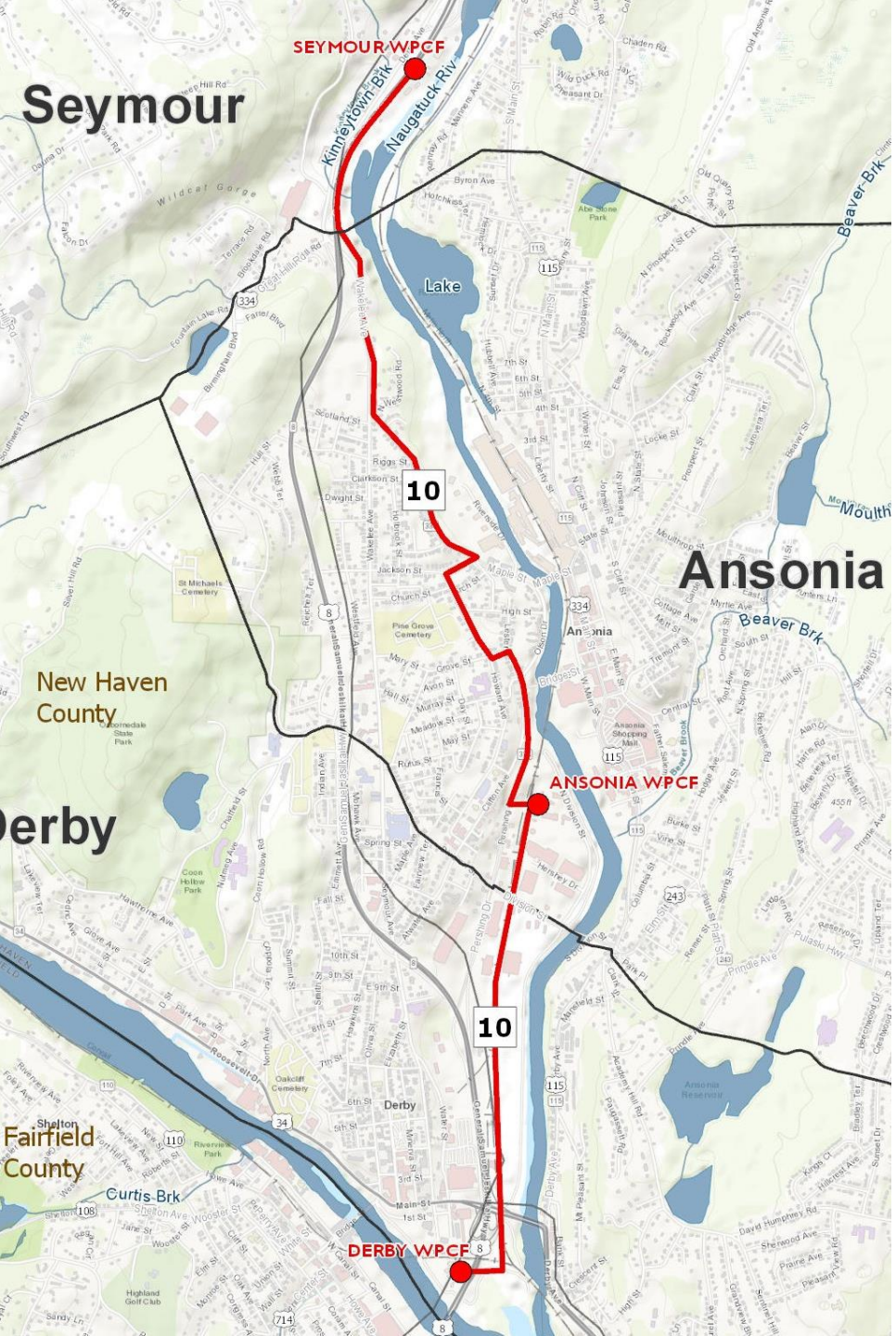
Seymour to/from Ansonia

- Multiple town roads available for alternative alignments
- Elevation constraints less significant
- Length: Approx. 2.5 to 3 miles



Ansonia to/from Derby

- Routes have been previously investigated
- Multiple routes are available
  - Pershing Street and town roads
  - Along Naugatuck River
- Length: Approx. 1.5 to 2 miles



Seymour to/from Derby

- Likely most desirable to pass through Ansonia WPCF for flexibility
- Similar routing options to individual segments Seymour → Ansonia → Derby
- Length: Approx. 4 to 5 miles

Rough Screening of Alternatives

Screening Criteria – Rough Screening of Alternatives

WPCF Site Constraints

- Adequate space at the WPCF site
- Ease or difficulty of implementing changes at the plant

Other Constraints

- Complexity in operation and maintenance
- Environmental restrictions
- Regulatory and permitting requirements
- Community benefits

Cost and Difficulty of Implementation

- Implementation schedule
- Capital and O&M costs, and overall life cycle cost
- Topographic or right-of-way constraints in interconnecting communities

Rough Screening of Alternatives

- Space/ Constraints
  - Most plants will have constraints to be overcome for expansion
  - Naugatuck can handle Beacon Falls without expansion
  - Seymour can handle Beacon Falls if peak flow conditions are controlled

Alt No.	Abbreviated Description	Space/ Constraint
1	BF→N	◉
2	BF→S	◉
2a	BF→S, I/I	◉
3	D→A	◉
3a	D→A, I/I	◉
4	D→A→H	◉
4a	D→A→ H, I/I	◉
5	D&S→A	◉
5a	D&S→A, I/I	◉
5b	D&S→A→H	◉
5c	D&S→A→H, I/I	◉
6	D→S, D→A	◉
6a	D→S, D→A, I/I	◉
7	D→S, D→A, D→D	◉
7a	D→S, D→A, D→D, I/I	◉
8	A→D	◉
8a	A→D, I/I	◉
9	S&A→D	◉
9a	S&A→D, I/I	◉
10	S→A, A→D	◉
10a	S→A, A→D, I/I	◉
11	BF,S→A, A→D	◉
11a	BF,S→A, A→D, I/I	◉
12	BF,S,A→D	◉
12a	BF,S,A→D, I/I	◉

Rough Screening of Alternatives

- Existing Facilities
  - Naugatuck and Seymour may be able to receive flow from Beacon Falls
  - Alternative 7 does not provide any benefit regarding facilities
  - All other alternatives require upgrades to existing facilities

Alt No.	Abbreviated Description	Space/ Constraint	Existing Facilities
1	BF→N	◉	◉
2	BF→S	◉	◉
2a	BF→S, I/I	◉	◉
3	D→A	◉	◉
3a	D→A, I/I	◉	◉
4	D→A→H	◉	◉
4a	D→A→ H, I/I	◉	◉
5	D&S→A	◉	◉
5a	D&S→A, I/I	◉	◉
5b	D&S→A→H	◉	◉
5c	D&S→A→H, I/I	◉	◉
6	D→S, D→A	◉	◉
6a	D→S, D→A, I/I	◉	◉
7	D→S, D→A, D→D	◉	◉
7a	D→S, D→A, D→D, I/I	◉	◉
8	A→D	◉	◉
8a	A→D, I/I	◉	◉
9	S&A→D	◉	◉
9a	S&A→D, I/I	◉	◉
10	S→A, A→D	◉	◉
10a	S→A, A→D, I/I	◉	◉
11	BF,S→A, A→D	◉	◉
11a	BF,S→A, A→D, I/I	◉	◉
12	BF,S,A→D	◉	◉
12a	BF,S,A→D, I/I	◉	◉

Rough Screening of Alternatives

- Operations & Maintenance
  - Consolidating plants will generally reduce O&M needs, but pumping needs must be considered
  - Differences in O&M will require more detailed assessment in Phase 2

Alt No.	Abbreviated Description	Space/ Constraint	Existing Facilities	O&M
1	BF→N	◉	◉	◉
2	BF→S	◉	◉	◉
2a	BF→S, I/I	◉	◉	◉
3	D→A	◉	◉	◉
3a	D→A, I/I	◉	◉	◉
4	D→A→H	◉	◉	◉
4a	D→A→ H, I/I	◉	◉	◉
5	D&S→A	◉	◉	◉
5a	D&S→A, I/I	◉	◉	◉
5b	D&S→A→H	◉	◉	◉
5c	D&S→A→H, I/I	◉	◉	◉
6	D→S, D→A	◉	◉	◉
6a	D→S, D→A, I/I	◉	◉	◉
7	D→S, D→A, D→D	◉	◉	◉
7a	D→S, D→A, D→D, I/I	◉	◉	◉
8	A→D	◉	◉	◉
8a	A→D, I/I	◉	◉	◉
9	S&A→D	◉	◉	◉
9a	S&A→D, I/I	◉	◉	◉
10	S→A, A→D	◉	◉	◉
10a	S→A, A→D, I/I	◉	◉	◉
11	BF,S→A, A→D	◉	◉	◉
11a	BF,S→A, A→D, I/I	◉	◉	◉
12	BF,S,A→D	◉	◉	◉
12a	BF,S,A→D, I/I	◉	◉	◉

Rough Screening of Alternatives

- Schedule
  - All alternatives have significant schedule constraints due to immediate improvement needs
  - Alternative 7 poses additional schedule constraints

Alt No.	Abbreviated Description	Space/ Constraint	Existing Facilities	O&M	Schedule
1	BF→N	◉	◉	◉	◉
2	BF→S	◉	◉	◉	◉
2a	BF→S, I/I	◉	◉	◉	◉
3	D→A	◉	◉	◉	◉
3a	D→A, I/I	◉	◉	◉	◉
4	D→A→H	◉	◉	◉	◉
4a	D→A→ H, I/I	◉	◉	◉	◉
5	D&S→A	◉	◉	◉	◉
5a	D&S→A, I/I	◉	◉	◉	◉
5b	D&S→A→H	◉	◉	◉	◉
5c	D&S→A→H, I/I	◉	◉	◉	◉
6	D→S, D→A	◉	◉	◉	◉
6a	D→S, D→A, I/I	◉	◉	◉	◉
7	D→S, D→A, D→D	◉	◉	◉	◉
7a	D→S, D→A, D→D, I/I	◉	◉	◉	◉
8	A→D	◉	◉	◉	◉
8a	A→D, I/I	◉	◉	◉	◉
9	S&A→D	◉	◉	◉	◉
9a	S&A→D, I/I	◉	◉	◉	◉
10	S→A, A→D	◉	◉	◉	◉
10a	S→A, A→D, I/I	◉	◉	◉	◉
11	BF,S→A, A→D	◉	◉	◉	◉
11a	BF,S→A, A→D, I/I	◉	◉	◉	◉
12	BF,S,A→D	◉	◉	◉	◉
12a	BF,S,A→D, I/I	◉	◉	◉	◉

Rough Screening of Alternatives

- Environmental
  - Consolidating plants eliminates outfalls
  - Further evaluation required in Phase 2

Alt No.	Abbreviated Description	Space/ Constraint	Existing Facilities	O&M	Schedule	Env
1	BF→N	◉	◉	◉	◉	◉
2	BF→S	◉	◉	◉	◉	◉
2a	BF→S, I/I	◉	◉	◉	◉	◉
3	D→A	◉	◉	◉	◉	◉
3a	D→A, I/I	◉	◉	◉	◉	◉
4	D→A→H	◉	◉	◉	◉	◉
4a	D→A→ H, I/I	◉	◉	◉	◉	◉
5	D&S→A	◉	◉	◉	◉	◉
5a	D&S→A, I/I	◉	◉	◉	◉	◉
5b	D&S→A→H	◉	◉	◉	◉	◉
5c	D&S→A→H, I/I	◉	◉	◉	◉	◉
6	D→S, D→A	◉	◉	◉	◉	◉
6a	D→S, D→A, I/I	◉	◉	◉	◉	◉
7	D→S, D→A, D→D	◉	◉	◉	◉	◉
7a	D→S, D→A, D→D, I/I	◉	◉	◉	◉	◉
8	A→D	◉	◉	◉	◉	◉
8a	A→D, I/I	◉	◉	◉	◉	◉
9	S&A→D	◉	◉	◉	◉	◉
9a	S&A→D, I/I	◉	◉	◉	◉	◉
10	S→A, A→D	◉	◉	◉	◉	◉
10a	S→A, A→D, I/I	◉	◉	◉	◉	◉
11	BF,S→A, A→D	◉	◉	◉	◉	◉
11a	BF,S→A, A→D, I/I	◉	◉	◉	◉	◉
12	BF,S,A→D	◉	◉	◉	◉	◉
12a	BF,S,A→D, I/I	◉	◉	◉	◉	◉

Rough Screening of Alternatives

- Regulatory
  - Consolidating plants eliminates outfalls
  - Further evaluation required in Phase 2

Alt No.	Abbreviated Description	Space/ Constraint	Existing Facilities	O&M	Schedule	Env	Reg
1	BF→N	◉	◉	◉	◉	◉	◉
2	BF→S	◉	◉	◉	◉	◉	◉
2a	BF→S, I/I	◉	◉	◉	◉	◉	◉
3	D→A	◉	◉	◉	◉	◉	◉
3a	D→A, I/I	◉	◉	◉	◉	◉	◉
4	D→A→H	◉	◉	◉	◉	◉	◉
4a	D→A→ H, I/I	◉	◉	◉	◉	◉	◉
5	D&S→A	◉	◉	◉	◉	◉	◉
5a	D&S→A, I/I	◉	◉	◉	◉	◉	◉
5b	D&S→A→H	◉	◉	◉	◉	◉	◉
5c	D&S→A→H, I/I	◉	◉	◉	◉	◉	◉
6	D→S, D→A	◉	◉	◉	◉	◉	◉
6a	D→S, D→A, I/I	◉	◉	◉	◉	◉	◉
7	D→S, D→A, D→D	◉	◉	◉	◉	◉	◉
7a	D→S, D→A, D→D, I/I	◉	◉	◉	◉	◉	◉
8	A→D	◉	◉	◉	◉	◉	◉
8a	A→D, I/I	◉	◉	◉	◉	◉	◉
9	S&A→D	◉	◉	◉	◉	◉	◉
9a	S&A→D, I/I	◉	◉	◉	◉	◉	◉
10	S→A, A→D	◉	◉	◉	◉	◉	◉
10a	S→A, A→D, I/I	◉	◉	◉	◉	◉	◉
11	BF,S→A, A→D	◉	◉	◉	◉	◉	◉
11a	BF,S→A, A→D, I/I	◉	◉	◉	◉	◉	◉
12	BF,S,A→D	◉	◉	◉	◉	◉	◉
12a	BF,S,A→D, I/I	◉	◉	◉	◉	◉	◉

Rough Screening of Alternatives

- Benefits
  - Most alternatives provide benefits of consolidating treatment facilities
  - Some alternatives conveying to Ansonia are less beneficial because of necessary upgrades to a relatively new plant

Alt No.	Abbreviated Description	Space/ Constraint	Existing Facilities	O&M	Schedule	Env	Reg	Benefits
1	BF→N	◉	◉	◉	◉	◉	◉	◉
2	BF→S	◉	◉	◉	◉	◉	◉	◉
2a	BF→S, I/I	◉	◉	◉	◉	◉	◉	◉
3	D→A	◉	◉	◉	◉	◉	◉	◉
3a	D→A, I/I	◉	◉	◉	◉	◉	◉	◉
4	D→A→H	◉	◉	◉	◉	◉	◉	◉
4a	D→A→ H, I/I	◉	◉	◉	◉	◉	◉	◉
5	D&S→A	◉	◉	◉	◉	◉	◉	◉
5a	D&S→A, I/I	◉	◉	◉	◉	◉	◉	◉
5b	D&S→A→H	◉	◉	◉	◉	◉	◉	◉
5c	D&S→A→H, I/I	◉	◉	◉	◉	◉	◉	◉
6	D→S, D→A	◉	◉	◉	◉	◉	◉	◉
6a	D→S, D→A, I/I	◉	◉	◉	◉	◉	◉	◉
7	D→S, D→A, D→D	◉	◉	◉	◉	◉	◉	◉
7a	D→S, D→A, D→D, I/I	◉	◉	◉	◉	◉	◉	◉
8	A→D	◉	◉	◉	◉	◉	◉	◉
8a	A→D, I/I	◉	◉	◉	◉	◉	◉	◉
9	S&A→D	◉	◉	◉	◉	◉	◉	◉
9a	S&A→D, I/I	◉	◉	◉	◉	◉	◉	◉
10	S→A, A→D	◉	◉	◉	◉	◉	◉	◉
10a	S→A, A→D, I/I	◉	◉	◉	◉	◉	◉	◉
11	BF,S→A, A→D	◉	◉	◉	◉	◉	◉	◉
11a	BF,S→A, A→D, I/I	◉	◉	◉	◉	◉	◉	◉
12	BF,S,A→D	◉	◉	◉	◉	◉	◉	◉
12a	BF,S,A→D, I/I	◉	◉	◉	◉	◉	◉	◉

Rough Screening of Alternatives

- Relative Cost
  - Alternative 7 is clearly not favorable
  - Further evaluation required in Phase 2

Alt No.	Abbreviated Description	Space/ Constraint	Existing Facilities	O&M	Schedule	Env	Reg	Benefits	Relative Cost
1	BF→N	◉	◉	◉	◉	◉	◉	◉	◉
2	BF→S	◉	◉	◉	◉	◉	◉	◉	◉
2a	BF→S, I/I	◉	◉	◉	◉	◉	◉	◉	◉
3	D→A	◉	◉	◉	◉	◉	◉	◉	◉
3a	D→A, I/I	◉	◉	◉	◉	◉	◉	◉	◉
4	D→A→H	◉	◉	◉	◉	◉	◉	◉	◉
4a	D→A→ H, I/I	◉	◉	◉	◉	◉	◉	◉	◉
5	D&S→A	◉	◉	◉	◉	◉	◉	◉	◉
5a	D&S→A, I/I	◉	◉	◉	◉	◉	◉	◉	◉
5b	D&S→A→H	◉	◉	◉	◉	◉	◉	◉	◉
5c	D&S→A→H, I/I	◉	◉	◉	◉	◉	◉	◉	◉
6	D→S, D→A	◉	◉	◉	◉	◉	◉	◉	◉
6a	D→S, D→A, I/I	◉	◉	◉	◉	◉	◉	◉	◉
7	D→S, D→A, D→D	◉	◉	◉	◉	◉	◉	◉	◉
7a	D→S, D→A, D→D, I/I	◉	◉	◉	◉	◉	◉	◉	◉
8	A→D	◉	◉	◉	◉	◉	◉	◉	◉
8a	A→D, I/I	◉	◉	◉	◉	◉	◉	◉	◉
9	S&A→D	◉	◉	◉	◉	◉	◉	◉	◉
9a	S&A→D, I/I	◉	◉	◉	◉	◉	◉	◉	◉
10	S→A, A→D	◉	◉	◉	◉	◉	◉	◉	◉
10a	S→A, A→D, I/I	◉	◉	◉	◉	◉	◉	◉	◉
11	BF,S→A, A→D	◉	◉	◉	◉	◉	◉	◉	◉
11a	BF,S→A, A→D, I/I	◉	◉	◉	◉	◉	◉	◉	◉
12	BF,S,A→D	◉	◉	◉	◉	◉	◉	◉	◉
12a	BF,S,A→D, I/I	◉	◉	◉	◉	◉	◉	◉	◉

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