APPENDIX 6

FINAL ALTERNATIVES ANALYSIS RECOMMENDATIONS MEMO

Lehigh County Authority

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MEMORANDUM

TO: Kline's Island Sewer System (KISS) Municipalities
FROM: Phil DePoe, Senior Planning Engineer
DATE: February 8, 2024
RE: Act 537 Final Alternative Analysis (FAA) Recommendation Memos

Attached: KIWWTP Wet Weather Memo, KISS Relief Interceptor (KRI) Memo, Western Lehigh Interceptor (WLI) Memo

Background

As the Act 537 FAA concluded in December 2023, various workshops were held at LCA with the core engineering team (LCA, the City of Allentown, key consultants) to begin preparation of these three memos. Attached are the conclusions of that FAA effort.

The LCA Pre-treatment Plant (PTP) engineering analysis is nearing completion and a draft memo will likely be issued at the March 2024 KISS Meeting.

Key Items

All three memos should still be treated as "DRAFT" and will be finalized prior to September 2024 (assumed Act 537 Plan submission date to the local planning commissions).

In addition to the Arcadis WLI recommendation memo, an additional document is attached (authored by AECOM) which further describes that specific decision-making process.

During the final stages of the FAA, various modeling assumptions were adjusted to predict the final KIWWTP peak influent flow. Using the final solution selected (i.e. the KRI and WLI), these predicted peak flows range from approximately 132 MGD to 137 MGD. For planning purposes through the year 2035, an assumed peak flow rate of 132 MGD was selected for the KIWWTP wet weather solution.

Additional engineering reports and details on the various modeling assumptions are available upon request.

Lehigh County Authority

Kline's Island Sewer System
SERVING LEHIGH COUNTY

KIWWTP WET-WEATHER TREATMENT APPROACH

SUBJECT KIWWTP Wet-Weather Decision Memorandum	**TO** Philip DePoe, PE, LCA
DATE February 7, 2024	**NAME** Christopher Curran, PE, AECOM Timothy Bradley, PE, Kleinfelder Inc.

Background

The Lehigh County Authority (LCA) leases and operates the Kline's Island Wastewater Treatment Plant (KIWWTP), which is owned by the City of Allentown. KIWWTP has a permitted hydraulic capacity of 44.6 million gallons per day (MGD), and a peak wet weather capacity of 87 MGD, with a planned upgrade to initially increase wet weather capacity to 100 MGD.

The KIWWTP treats flow from the Kline's Island Sewer System (KISS), which serves the City of Allentown and the surrounding communities, and discharges into the Lehigh River. The plant has been in operation since 1928 and has undergone a series of improvements over its lifetime to expand its capacity, improve its effluent quality, and replace aging or outdated equipment and infrastructure. The plant performs secondary and tertiary treatment using biological trickling filters. Treated effluent is discharged into the Lehigh River through Outfall 001. The KIWWTP also has an emergency bypass, Outfall 003, which discharges untreated flow to Little Lehigh Creek and is used to prevent the plant from experiencing excessive flows during major rainfall events or maintenance emergencies. Due to capacity expansions over the years, the plant's peak flow has increased, reducing the frequency with which Outfall 003 has been used.

As part of the Act 537 planning effort, LCA evaluated several improvements to the KIWWTP to increase its wet-weather capacity to 132 MGD as there will be a significant increase in future flows to KIWWTP as the result of mitigating current upstream sanitary sewer overflows with proposed improvements to the core conveyance system resulting in a future higher peak flow reaching the treatment plant based on detailed modeling conducted by Arcadis. Please note that until the final determination of the basis of peak flow design was made for 132 MGD, opinions of probable costs, treatment modes, and figures were prepared for various flow scenarios illustrated in this document so the listed flows might vary but the future planning basis remains 132 MGD.

The existing KIWWTP consists of the following sequential unit processes: Influent screening and pumping, aerated grit chambers (AGCs), primary settling tanks (PSTs), primary effluent pumping, plastic media trickling filters (PMTFs), PMTF effluent pumping, intermediate settling tanks (ISTs), Rock media trickling filters (RMTFs), final settling tanks, a chlorine contact tank (CCT), and an effluent pumping system, which is used during flooding conditions in the Lehigh

River. Peak flows in excess of the present 87 MGD hydraulic capacity are relieved through the existing Outfall 003 located at the headworks of the facility.

Design Drivers

The goal of the wet weather treatment strategy for KIWWTP is to mitigate the occurrence of overflows at Outfall 003 under future conditions by a combination of source reduction of extraneous wet weather flows and increased wet weather capacity to process flows arriving at KIWWTP while achieving discharge limits to the Lehigh River. Table 1 below indicates the Key NPDES Permit Effluent Limits that presently govern discharge from the facility through the outfall.

The wet weather influent hydrograph is based on the Hurricane Ida event and consists of an extended run period as illustrated in Figure 1 below with the peak during the event reaching 132 MGD.

Figure 1: Influent Hydrograph to KIWWTP during Design Storm Event

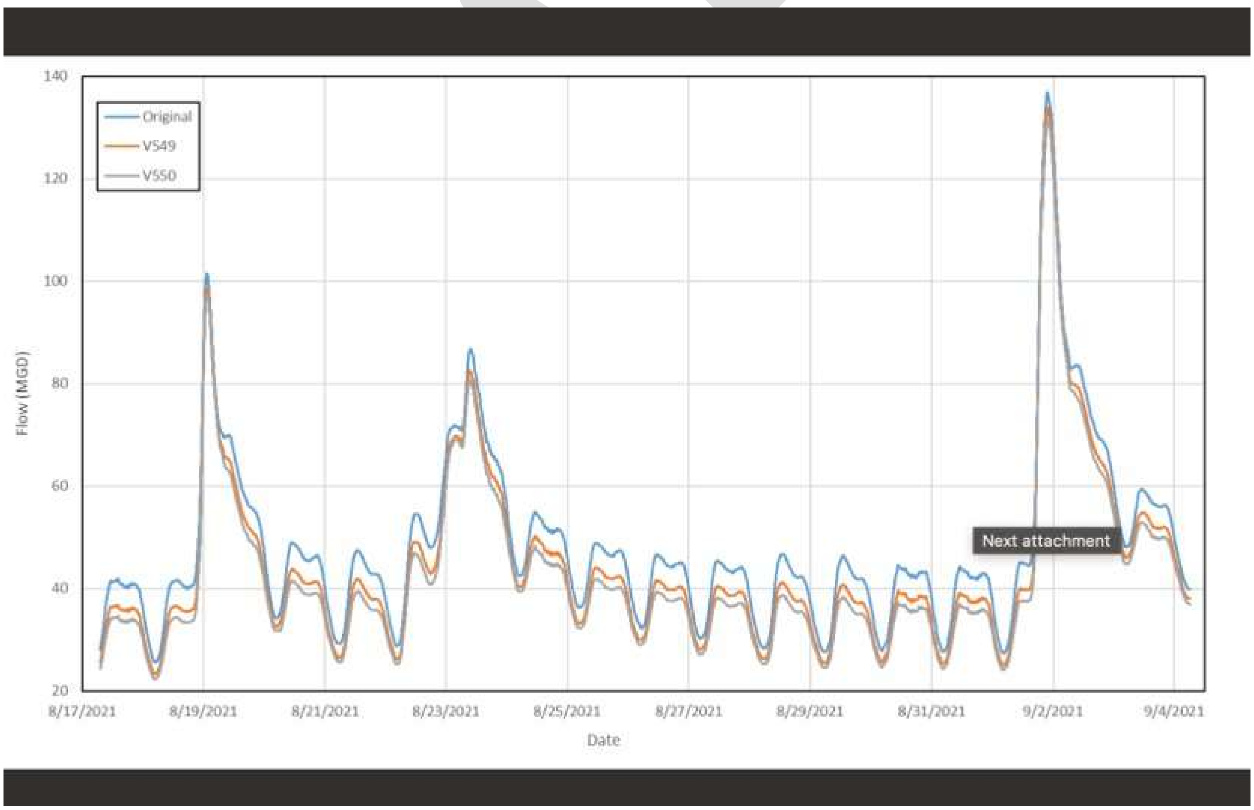


Table 1: KIWWTP NPDES Permit Limits

Parameter	Monthly Average Effluent Limit	Weekly Average Effluent Limit	Instantaneous (Daily) Maximum Effluent Limit
Flow	(1)	(1)	(1)
$CBOD_5$	20 mg/L & 6,672 lbs/day	30 mg/L & 10,008 lbs/day	40 mg/L
TSS	30 mg/L & 10,008 lbs/day	45 mg/L & 15,012 lbs/day	60 mg/L
NH_3 (5/1-10/31)	5 mg/L & 5,004 lbs/day	-	10 mg/L
NH_3 (10/1-4/30)	15 mg/L	-	30 mg/L
Fecal Coliform (5/1-9/30)	200/100 mL geometric mean (2)		
Fecal Coliform (10/1-4/30)	2,000/100 mL geometric mean (2)		
Residual Chlorine	0.5 mg/L	-	1.0 mg/L
pH	6.0 to 9.0		
Dissolved Oxygen	≥ 5.0 mg/L		

(1) Flow is not regulated by the NPDES permit but requires continuous monitoring

(2) No more than 10% of samples shall have a fecal coliform concentration greater than 1,000/100 mL

Alternatives Evaluated

Many alternatives have been screened during the planning evaluations to manage the projected 132 MGD peak weather event while meeting the PADEP requirements for treatment facilities serving separate sanitary systems (non-combined sewer systems). More specifically, this includes providing biological treatment of all future flow arriving KIWWTP during wet weather storm events as defined as 65% biochemical oxygen demand (BOD) removal and an effluent carbonaceous fraction (cBOD) of 40 mg/l or less. Alternatives considered during the evaluation included the addition of equalization storage at KIWWTP to attenuate peak flows, the addition of in-line peak flow storage within interceptors/tunnels, addition of high-rate treatment train(s) at KIWWTP, reconfiguration of existing facilities into a wet weather arrangement and adding wet weather pumping and clarification processes. The options were ultimately refined during the final alternatives analysis stage to 1) the addition of high-rate treatment and 2) implement improvements to allow for the temporary re-configuration of the trickling filters and clarification processes typically arranged in series for dry weather needs to a parallel wet weather mode. These final alternative approaches are the most cost-effective, will achieve regulatory acceptance, are scalable, and demonstrated technologies.

Alternative 1- High-Rate Treatment

The addition of a high-rate treatment process could increase the KIWWTP's wet-weather treatment capacity from 100 MGD to 132 MGD using the BIOACTIFLO® process, which would be implemented following construction of the initial project to first increase wet-weather treatment capacity of KIWWTP from approximately 87 MGD to 100 MGD by alleviating some hydraulic restrictions associated with pumping, piping and the headworks. BIOACTIFLO® is a side stream process that is activated during wet weather and provides a high-rate ballasted clarification process with a preceding biological contact stabilization step to provide both organic and total suspended solids removal though the system (BIOACTIFLO™ | Veolia Water Technologies).

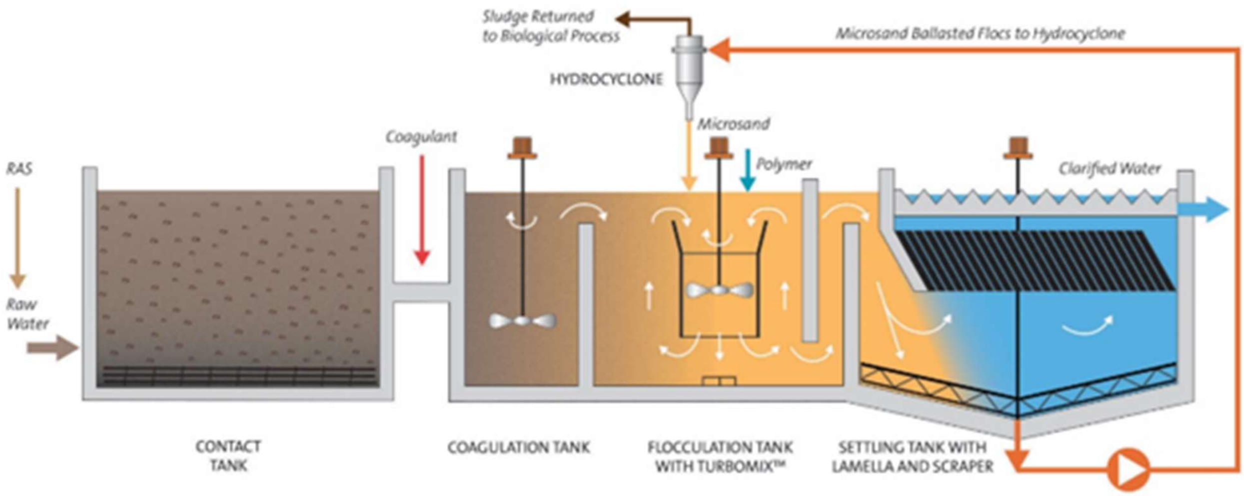
A 40 MGD BIOACTIFLO® system would be installed to achieve a wet-weather capacity up to 140 MGD. Influent to a BIOACTIFLO® system is passed through influent screens to remove large solids prior to entering the BIOACTIFLO® process. Thickened biological slough from the KIWWTP trickling filters would be used to provide biomass to seed the BIOACTIFLO® system. A thickened slough feed pipe will run from the existing Thickening Tank 3 and Tank 4 through the new screens to feed the BIOACTIFLO® system's Biological Tank.

The Tank will receive thickened slough and a portion of the wet-weather influent flow to provide pre-aeration for the biosolids. The Biological Contact Tank is where the wet-weather influent undergoes biological oxygen demand (BOD) removal. For Kline's Island, as confirmed by piloting, satisfactory BOD removal can be achieved to achieve compliance with PADEP.

Actiflo® is an enhanced clarification process which includes feeding and thoroughly mixing in a coagulant, then co-feeding a 'seed' or ballast of micro-sand along with polymer, followed by mixing to promote floc formation, and finally Lamella sedimentation. The flocs, ballasted with the microsand, settle rapidly. Settled mixed liquor from Actiflo® will pass through a hydrocyclone to separate the sludge from the microsand, recirculating the sludge to the Biological Tank and reusing the microsand in the Actiflo® process. The treated effluent would receive a dose of disinfectant (sodium hypochlorite) at the entrance to the effluent discharge pipe, which would provide contact time and then be discharged to the Lehigh River via the permitted Outfall 002.

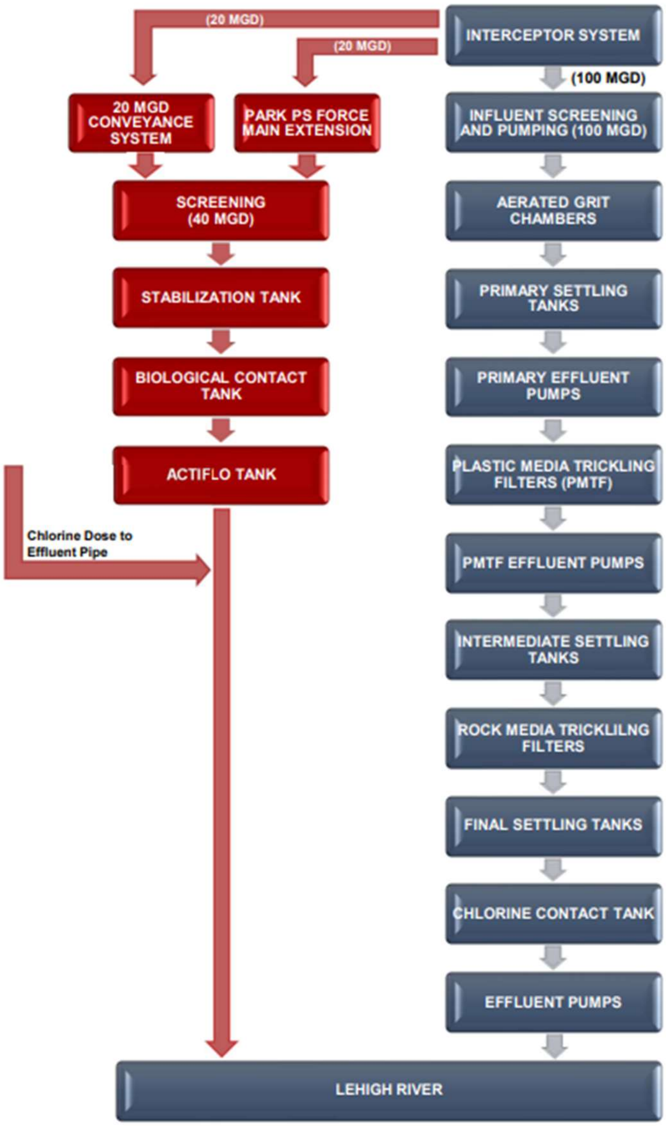
A flow diagram of the typical BIOACTIFLO® process follows. For KIWWTP, an aerated stabilization tank will be included and thickened trickling filter slough will replace RAS.

BIOACTIFLO™ Process

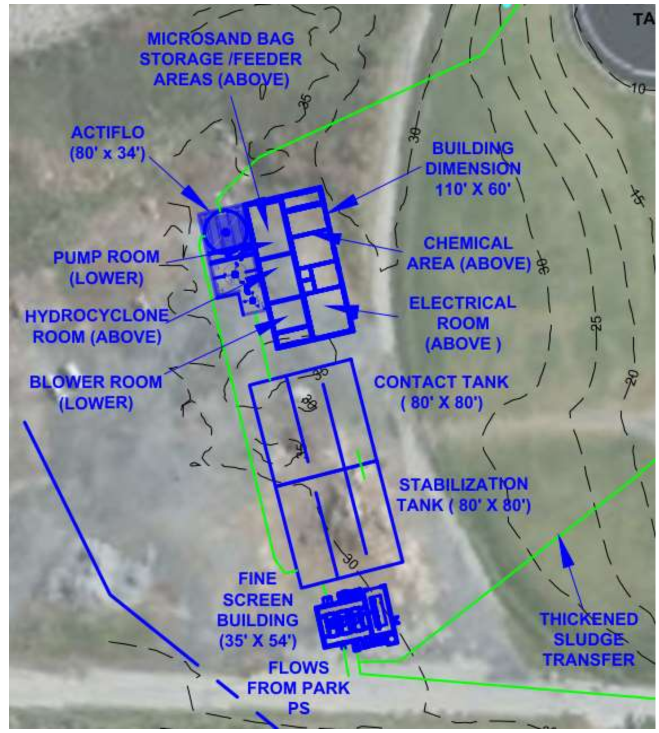


The PA Code requires that wet weather treatment systems provide secondary treatment to achieve a minimum of 65% removal of BOD/cBOD and weekly average effluent BOD/cBOD concentrations below 40 mg/L and weekly average effluent TSS concentrations below 30 mg/L. Bench-scale treatability testing and the subsequent field pilot study have shown that BIOACTIFLO® can consistently meet effluent BOD and TSS requirements using the KIWWTP's thickened trickling filter slough. The pilot study achieved BOD and cBOD removal efficiencies of 74% and 80% and average effluent concentrations of 27.5 mg/L and 27.0 mg/L, respectively. The average effluent TSS concentration was 25.5 mg/L with 76% removal efficiency. These values all meet the PADEP requirements.

The following flow diagram illustrates the necessary changes to the process flow arrangement to incorporate high-rate wet weather treatment. The two figures show the arrangement concept drawing on the site aerial photo for reference.



Lehigh County Authority



AECOM

Figure 3: Site Arrangement Drawing for High-rate Treatment Approach at 140 MGD.

The key attributes of the BIOACTIFLO® wet weather treatment system are detailed below:

1. The BIOACTIFLO® system requires the installation of biological treatment basin(s), aeration blowers and valving, and an ACTIFLO® basin.
2. Alum and polymer dosing are required for coagulation and flocculation.
3. Thickened trickling filter slough from the Gravity Thickeners can be used to provide biomass for the BIOACTIFLO® system and can provide reliable treatment to meet wet weather removal efficiency and effluent requirements.
4. Following a 2 - 4 hour activation period, the system can effectively respond to a rainfall event.

Alternative 1 - Advantages and Disadvantages:

PROS	CONS
Provides adaptability to phase additional units to expand with wet weather needs and spread CAPEX out	Operator maintenance required to maintain familiarity with process and test equipment periodically

over range of time to match conveyance improvements within the collection system	
Provides standalone treatment and some temporary plant redundancy	Ramp up time more extensive to bring system online ahead of peak flows arriving at plant
Can occupy available land on northern end of parcel	New process for operations to understand that relies on activated sludge and ballasted high-rate sedimentation which are not presently used at KIWWTP
Can accommodate higher strength loads	Chemical system and blowers required for new process
	Independent compliance sampling required for high-rate system using outfall 002 during events.

Alternative 2 – Parallel Trickling Filter Operation

In this alternative, the increase in wet-weather treatment capacity to 132 MGD would be achieved by implementing improvements to enable the Plastic Media Trickling Filters (PMTFs) and Rock Media Trickling Filters (RMTFs) to be temporarily operated in parallel during a storm event rather than in series.

In this approach, during significant storm events, 32 MGD of additional flow entering the KIWWTP will undergo grit removal in a new aerated grit chamber and primary treatment in two (2) new primary clarifiers and will be pumped via a new supplemental primary effluent pump station to the RMTFs for biological treatment following by clarification in the existing final clarifiers and disinfection in the existing chlorine contact tank (CCT).

Concurrently, the 100 MGD of flow that will enter the KIWWTP plant after implementation of the current project to increase the wet-weather pumping capacity will continue to undergo grit removal in the existing aerated grit chambers, primary treatment in the existing primary clarifiers, and biological treatment in the existing PMTFs. However, the biologically treated effluent from the PMTFs will be temporarily routed for clarification and disinfection as follows: approximately 50 MGD of PMTF effluent will be routed directly to the existing final clarifiers through the tertiary treatment diversion line which will be installed as part of the initial project to increase peak flow capacity to 100 MGD and following final clarification will receive disinfection in the existing CCT. The other approximately 50 MGD of PMTF effluent will be pumped by the existing PMFT effluent pumps to the ISTs for clarification, and the IST effluent will be routed directly to the CCT for disinfection.

In summary, 132 MGD will receive primary treatment followed by biological treatment. Approximately 82 MGD of the biologically treated flow will be clarified in the existing final clarifiers followed by disinfection in the existing CCT, and approximately 50 MGD will be clarified in the ISTs with the clarified IST effluent routed directly to the existing CCT for disinfection.

The wet-weather treatment system concept design is presented below by describing the modifications required to each existing unit process of the KIWWTP, as well as the new facilities required to implement the 132 and 150 MGD wet-weather treatment system scenarios.

1. Main and Auxiliary Pump Stations

The current combined firm capacity of the existing Main and Auxiliary Pump Stations is approximately 85 MGD. Improvements are currently being designed to the Main and Auxiliary pump stations that will increase the firm capacity to 100 MGD. No additional improvements are required for the 120 MGD wet-weather treatment system as the additional 20 MGD will arrive to KIWWTP via the Park PS force main extension.

2. Influent Screening

Coarse screening is currently provided upstream of the Main and Auxiliary Pump Stations via two (2) climber-type screens with ¾ inch spacing between bars, each with a capacity of 100 MGD, resulting in a firm capacity of 100 MGD.

The concept design includes new coarse screening facilities for the additional 20 MGD of wet-weather flow conveyed to the KIWWTP from an extension of the Park Pump Station Force Main to the KIWWTP. The extension of the Park Pump Station Force Main and the 120 MGD coarse screening facility are two of the common improvements for the wet-weather treatment system described in this concept design memorandum and for the Bioactiflo alternative.

3. Primary Settling Improvements

To achieve a peak flow primary treatment capacity of 132 mgd, 32 mgd of additional peak flow capacity is required and provided through two proposed 84-feet diameter primary clarifiers.

4. Additional Pumping Capacity

Increased pumping capacity is warranted during the 132 MGD condition. This includes supplemental primary effluent pumps and additional effluent pumping capacity.

Figure 4: Site Arrangement Drawing for Parallel Trickling Filter Approach at 132 MGD. 150 MGD would require additional improvements

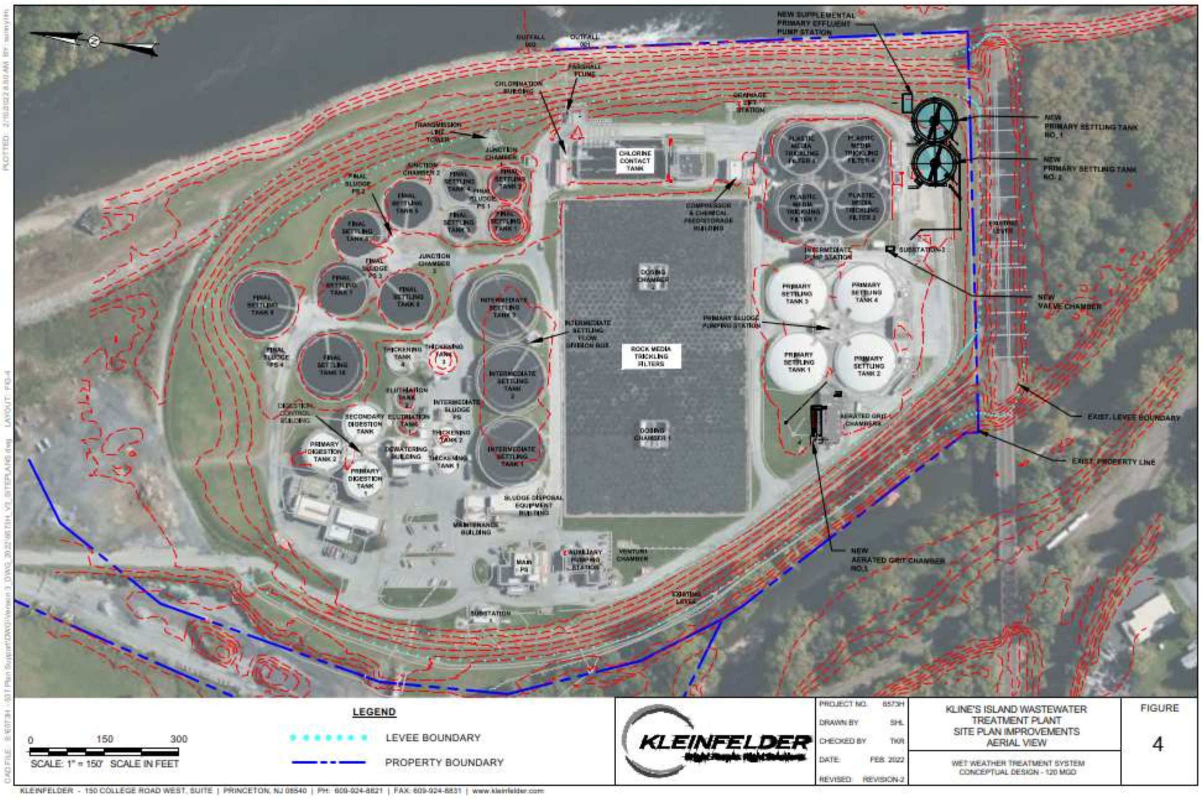
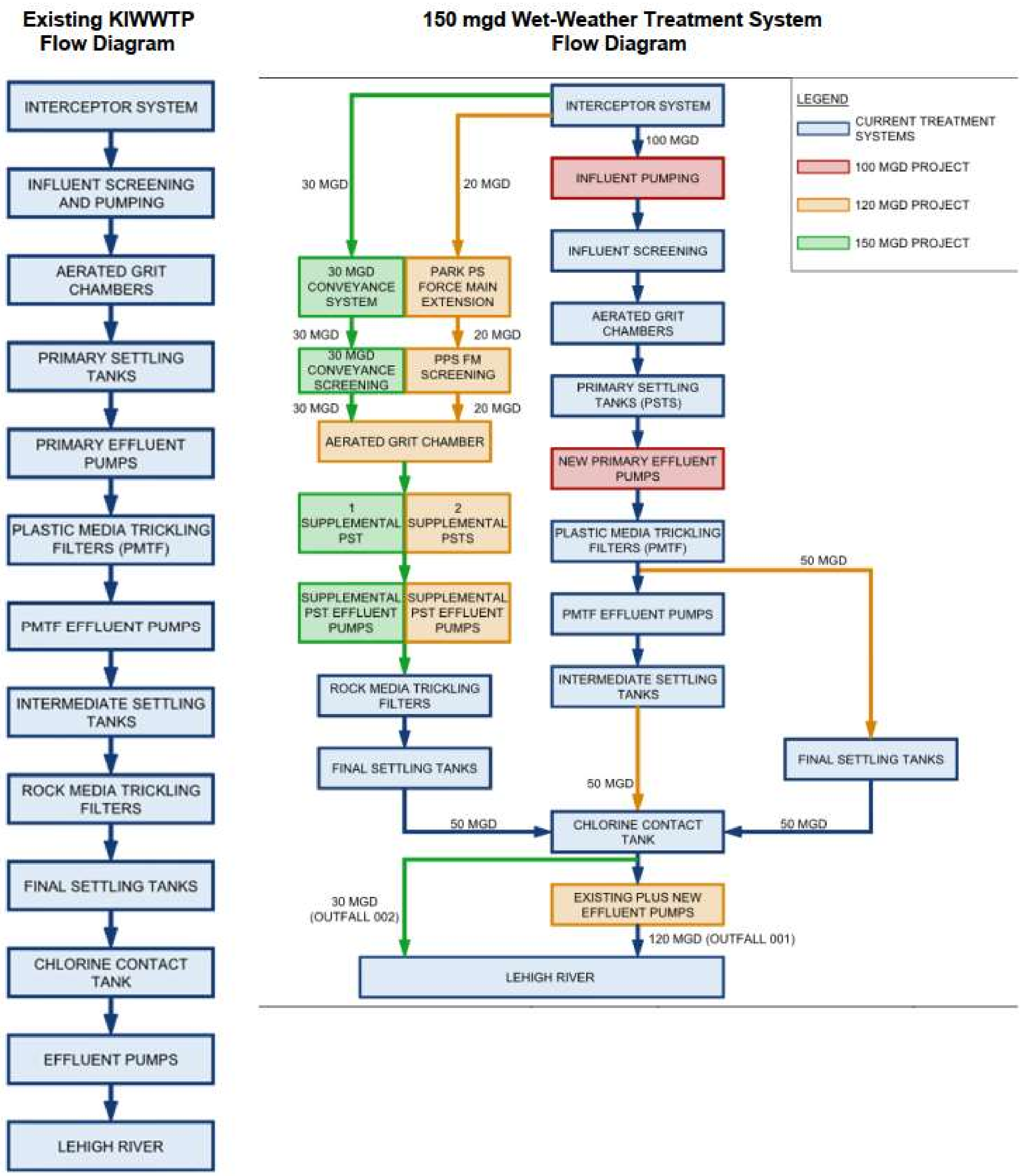


Figure 5: Process Schematic for Parallel Trickling Filter Approach at 120 MGD and 150 MGD



It would be possible to increase the capacity of the wet-weather treatment system from 120 MGD up to approximately 150 MGD by constructing the following additional improvements:

1. Addition of fourth aerated grit chamber.
2. Addition of a third primary clarifier of 84-feet diameter.
3. Expansion of the supplemental primary effluent pumping station.
4. Additional common improvements including increasing chlorine dosing capabilities and the primary effluent pumping system, construction of adequate interceptors to

convey 30 MGD of additional flow to the KIWWTP, and a coarse screening facility for the 30 MGD of additional wet-weather flow.

The key attributes of the wet-weather treatment system are listed below.

1. The wet-weather treatment system utilizes the existing treatment processes which the plant staff are familiar with which avoids the need to be trained and periodically re-trained on new treatment processes that may only be used once per year.

2. Chemicals are not required.

3. System startup is relatively simple and quick requiring only the re-positioning of three (3) motor-operated valves and verifying that the supplemental primary effluent pump station is ready for operation.

4. System shutdown is relatively simple requiring the re-positioning of three motor-operated valves and draining the two new primary clarifiers

Alternative 2 – Advantages and Disadvantages

PROS	CONS
Minimal operator maintenance required to maintain familiarity with process and test equipment periodically	Requires construction in area with potentially contaminated soils.
Ramp up time less extensive and more simple to bring system online ahead of peak flows arriving at plant	Does not offer adaptability to phase additional units to expand with wet weather needs
No new process for operations to understand.	More risk to accommodate higher strength loads
No Chemical system or blowers required for new arrangement	Confidence in performance is reduced as flow exceeds 140 MGD
Common compliance sampling during wet weather events.	

Opinion of Probable Costs

AECOM prepared cost estimates for wet weather treatment at Lehigh County Authority's (LCA) Kline's Island Treatment Plant (KIWWTP) in Allentown, PA under several scenarios using the Veolia's high-rate BIOACTIFLO^{TM} process, flow equalization, and parallel treatment using existing trickling filters under a wide range of flow scenarios.

Basis of Estimate

These preliminary cost estimates were developed using factoring and indexing based on existing cost estimates for the KIWWTP or similar facilities. For most process elements, components of these estimates were factored based on flow using the "six-tenths rule" in which the ratio of the flows is taken to the 0.6 power. This accounts for economies of scale achieved as process components increase in size. However, piping was not factored using the "six-tenths rule" and was instead factored directly based on the pipe diameter as is customary. To account for the impact of time on the cost of construction, the costs in the reference estimates were escalated to June 2023 using the Engineering News Record Construction Cost Index.

The following project cost estimating standards were used to develop the cost estimates:

• Construction cost based on June 2023

- 22.5% markup for Contractor Overhead and Profit
- 30% contingency for Class 5 estimates
- 20% for soft costs (engineering, legal, administrative, permitting, construction management)

Alt. #1 - High-rate Treatment

High-rate Treatment Opinion of Probable Cost using BIOACTIFLO

Total Wet Weather Peak Flow (MGD)	140
Main Plant Flow Capacity (MGF)	100
BIOACTIFLO Capacity	**40 MGD**
Influent Screening	$5,240,214
Stabilization Tank	$1,042,681
BIOACTIFLO System	$14,140,826
Chlorine Contact Tank	*$1,066,126*
Yard Piping	$1,864,651
Direct Cost Subtotal	**$22,288,372**
GC General Conditions	*$0*
GC Overhead and Profit	$5,014,884
Subtotal	**$27,303,256**
GC Permits, Bonds, Insurance	*$0*
Subtotal	**$27,303,256**
Contingency	$8,190,977
Construction Cost Subtotal	**$35,494,233**
Engineering and Soft Costs	$7,098,847
Subtotal	**$42,593,079**
Total Cost	**$42,593,079**

Alt.#2- Parallel Trickling Filters

For the parallel trickling filter approach, the costs were similar to the high-rate approach and for a 140 MGD case were $43.6 M and at 132 MGD $38.5 M. For comparative purposes, the estimates were compared at the 140 MGD peak flow condition as that was the basis for the high-rate evaluation.

As an alternate, equalization as either a companion technology or as a stand-alone was eliminated from consideration due to cost, extensive footprint required and general regulatory disapproval was not considered attractive and therefore excluded from the final analyses.

Although it was not fully calculated, the Bioactiflo® net present value (NPV) is appreciably greater than the parallel trickling filter approach due to the need to replace mechanical system components as they reach their life expectancy within the planning horizon, account for additional periods of operational resources relative to a parallel mode of operation, and increased staffing demands.

Factors Considered in Decision

Given the range of uncertainty with this level of estimating accuracy, which was based heavily on parametric analysis (i.e., factoring and indexing) it was recommended that a more detailed, head-to-head evaluation be made for BIOACTIFLO and Parallel Trickling Filter operation alternatives described herein. The evaluation included non-financial considerations as well, such as ease of operation and maintenance.

On October 6th, 2023 AECOM's Program Risk Management team was engaged to conduct a multi-criteria decision analysis for the Lehigh County Authority Kline's Island Sewer System Options. This multi-criteria decision analysis survey and assessment aims to provide measurable metrics for achieving consensus on complex decisions. This assessment provides a systematic methodology for defining specific criteria and relative criteria weights, rating the options against the criteria, and using the criteria weights to evaluate the options. The criteria used for the multicriteria decision analysis are listed below with respect to the Kline's Island Wet Weather Treatment Plant. To develop the decision criteria, as a first step AECOM developed a proposed list of criteria, which was presented to the team on October 27, 2023. Upon a thorough discussion of the criteria, the project team provided additional input on the decision criteria descriptions. An amended decision criteria description was developed using the combined input from the project team with expertise from planning; wastewater conveyance, treatment and operations; conveyance; and management; and presented on November 10, 2023. These criteria aim to cover various aspects of design such as financial, operation, compliance, project delivery, permits, adaptability and sustainability.

Criteria	Description
Financial - CAPEX	June 2023 basis - lower 2035 CAPEX costs
Financial - NPV	Lower 30-year NPV costs including O&M; Lower staffing costs
O&M	Ease of operations and maintenance; Lower lead time to activate; Lower operations complexity Greater redundancy; Greater ease of on-off; Less operator training; Easier to automate; Impacts on CMMS and operators' duties; More acceptable operational failure mode, need for testing
Timely project delivery	Project execution confidently completed on time; Least amount of specialty contracting/equipment; Contractor availability; Less susceptible to weather delays
Compliance	Confidence in meeting 65% BOD removal - at least 65% removal of BOD5 for a wet weather event, separate compliance sampling during wet weather activation. Fewer operations considerations that could result in SSOs at 003 during storm events (ultimate goal is no SSOs at 003)

Permitting and Environmental Considerations	Ease of permitting the project; Easier PADEP Part 2 permit acceptance; Easier DRBC acceptance
Impact to existing process	Minimal impact to existing operations; Fewer final clarifier settling characteristics changes; Other processing considerations
Adaptability	Maximize adaptability to meet uncertainty in future flows, growth, and potential regulations; Better ability to handle higher BOD and TSS loads; Better ability to accommodate PTP upsets; Higher resilience; Lower actual / physical footprint on space-limited KIWWTP property; Higher in-unit surge capacity
Construction Challenges	Minimize safety concerns; Fewer risks of Change Orders (less unknown geotechnical conditions); Lower risk of exposing hazardous materials; Smaller volume of nonreusable soils; Easier excavation; Less dewatering; Less Sheeting; Fewer utility crossings/relocations; Less bypass needs
Sustainability	Lower construction and operating carbon footprint; Better chance of meeting other green considerations

Multi-Criteria Decision Tool (MCDT) Results

On December 10, 2023, a survey was collected from 12 respondents to weight the above listed criteria from a scale of 1-10. The survey respondents' expertise included conveyance; wastewater conveyance, treatment and operations; wastewater treatment and conveyance; planning; compliance and operations; plant operations; GIS; engineering; and management. Upon completion of the survey, the decision criteria results, and their relative importance were discussed.

Criteria	Average Weight %
Financial – CAPEX	11
Financial – NPV	11
O&M	13
Timely project delivery	8
Compliance	13
Permitting and Environmental Considerations	9
Impact to existing process	8
Adaptability	11
Construction Challenges	8
Sustainability	7

Upon completion of the decision criteria weight survey, a second survey was distributed to 12 respondents containing the three questions listed below:

1. For Bioactiflo® how would you rank the criteria using a scale of 1-10? Please note that a lower criterion rating (i.e., 1) corresponds to a worse performance of the option against criterion while a higher score (i.e., 10) corresponds to a better performance of the option against criterion. A repetition of criteria scores is allowed, i.e., you are able to assign the same score to more than one criterion.

2. For Paralleling Trickling Filter how would you rank the criteria using a scale of 1-10? Please note that a lower criterion rating (i.e., 1) corresponds to a worse performance of the option against criterion while a higher score (i.e., 10) corresponds to a better performance of the option against criterion. A repetition of criteria scores is allowed, i.e., you are able to assign the same score to more than one criterion.
3. Do you prefer Bioactiflo® or Paralleling Trickling Filter?

The survey results are listed below:

- 12 out of 12 respondents responded to question 1 and question 2. However, one respondent missed to score the construction challenges criteria for question 2. With the 12 responses Bioactiflo® has a weighted average of 6.1 and Paralleling Trickling Filter has a weighted average of 7.1, out of a total score of 10. This translates to 61% and 71% weighted preference respectively for Bioactiflo® and Paralleling Trickling Filter. *This is showing that Paralleling Trickling Filter is preferred with a slight advantage of 10%.*

- 12 out of 12 respondents responded to question 3 where we asked about Bioactiflo® vs. Paralleling Trickling Filter preference. 11 out of 12 respondents selected Paralleling Trickling Filter and 1 out of 12 respondents selected Bioactiflo®. This is expected since when you ask for a comparison of two options respondents have a clear preference but when they are required to rate criterion against options and weight the criteria, the results may vary.

- Regarding the standard deviation of all voter responses for each criterion, for question 1 O&M had the most consensus and Financial - NPV had the least consensus. For question 2 O&M had the most consensus and adaptability had the least consensus. Overall, there was slightly better consensus among the various criteria in question 2 compared to question 1.

Recommendation

Based on the two survey results and discussions with the project team it was decided that Paralleling Trickling Filter is the preferred option. The basis was primarily a result of the presumed ease of operation, activation of the system, NPV, and familiarity to plant operators given the capital costs were equivalent. Based on discussions with PADEP, the monitoring of a parallel system would be much easier to measure compliance that a separate high-rate process likely warranting separate sampling and analyses during operation.

It has also been recommended to further investigate the cost-benefit of using the high-rate Actiflo® clarification process in lieu of the proposed conventional primary clarification tanks. As LCA staff is already considering use of chemicals for Chemically Enhanced Primary Treatment CEPT, the addition of the ballasted high-rate clarification process would occupy less space and avoid more intensive excavation into potentially contaminated soils. The approach also reserves the potential for adding the biological component at some point in the future as a risk management strategy in the event source reduction programs fail to keep the peak wet weather flow rate below the upper limit of parallel trickling filter capacity or future wet weather load conditions at KIWWTP require additional biological treatment beyond the capacity of the parallel mode of operation.

Considerations		
Criteria	Alt 1: High-rate Treatment	Alt 2: Parallel Trickling Filters
CAPEX*	140 MGD = $42.6 Million	140 MGD = $43.6 M
OPEX	Minor	Minor
Expandability (150 MGD)	Would require Phase 2 Expansion unless built upfront	Requires up-sizing screening and effluent pumping
Constructability	Poor Soils (Piles included in estimate)	Tight available footprint; questionable soils
Ease of Operation	More complex	Straightforward
Ease of Maintenance	Minor to Moderate	Minor
Permitting	WQM Part II Permit (DEP LIKELY OK). More Compliance Risk due to separate outfall monitoring	WQM Part II Permit (DEP LIKELY OK) Less Compliance Risk
Adaptability	ADDS TREATMENT CAPACITY	UNCERTAIN IF PTP ANAEROBIC ONLY
Environmental	Minor	Moderate – potential for excavating contaminated soils
Social	Minor	Minor

*Does not include common elements (Park PS FM Extension, 100 MGD through main plant, additional influent pumping if 100 MGD cannot be stretched to meet future peak flows)

Memo

SUBJECT KISS Relief Interceptor Route Selection	**TO** Phil DePoe
DATE February 6, 2024	**OUR REF** [Reference]
DEPARTMENT [Department]	**PROJECT NUMBER** 30179707 - LCA606 2023 KISS FAA
COPIES TO [Copies]	**NAME** Jim Shelton

Background

The City of Allentown's 30"- 36" cast in place Little Lehigh Interceptor (LLI) was constructed in 1928 to convey flow from the City of Allentown to the 1926 60" Jordan Creek Interceptor (JCI) immediately upstream of Kline's Island Wastewater Treatment Plant (KIWWTP). This interceptor connected planned tributary interceptors and trunklines.

- 1931 24" Trout Creek Interceptor
- 1935 18" Southside Trunkline
- 1942 24" Cedar Creek Interceptor

As the surrounding communities developed sewer systems and grew, additional interceptors connected to the LLI, including the:

- 1959 36" Allentown Emmaus Interceptor (AEI)
- 1972 36" Western Lehigh Interceptor
- 1998 30" South Whitehall Cedar Creek Relief Interceptor
- 19XX 18" Salisbury Trout Creek Relief Interceptor
- 1983 23 MGD Park Pump Station
- 1983 48" Little Lehigh Relief Interceptor

Growth has continued as these assets have aged, and current Act 537 planning studies show additional conveyance relief is required. Engineering evaluations and operations considerations have determined a new parallel gravity interceptor from the Robin Hood Bridge to KIWWTP is the desired solution. This new interceptor, which is needed to convey both dry day and wet day flows from all of the Signatories to the Kline's Island Sewer System (KISS), is called the KISS Relief Interceptor (KRI) and is to be designed to handle flows through at least the 2050 planning horizon and be capable of conveying all the peak wet weather flow during a 5 year design event from the KISS collection systems to KIWWTP without overflow and without causing any other connected interceptors or trunklines (notably, the Lehigh, Jordan Creek, Trout Creek, and Cedar Creek Interceptors and their current and planned relief interceptors).

Viable Alignments and Construction Methods

Several potentially viable alignments were identified as shown in Figure 1 below.

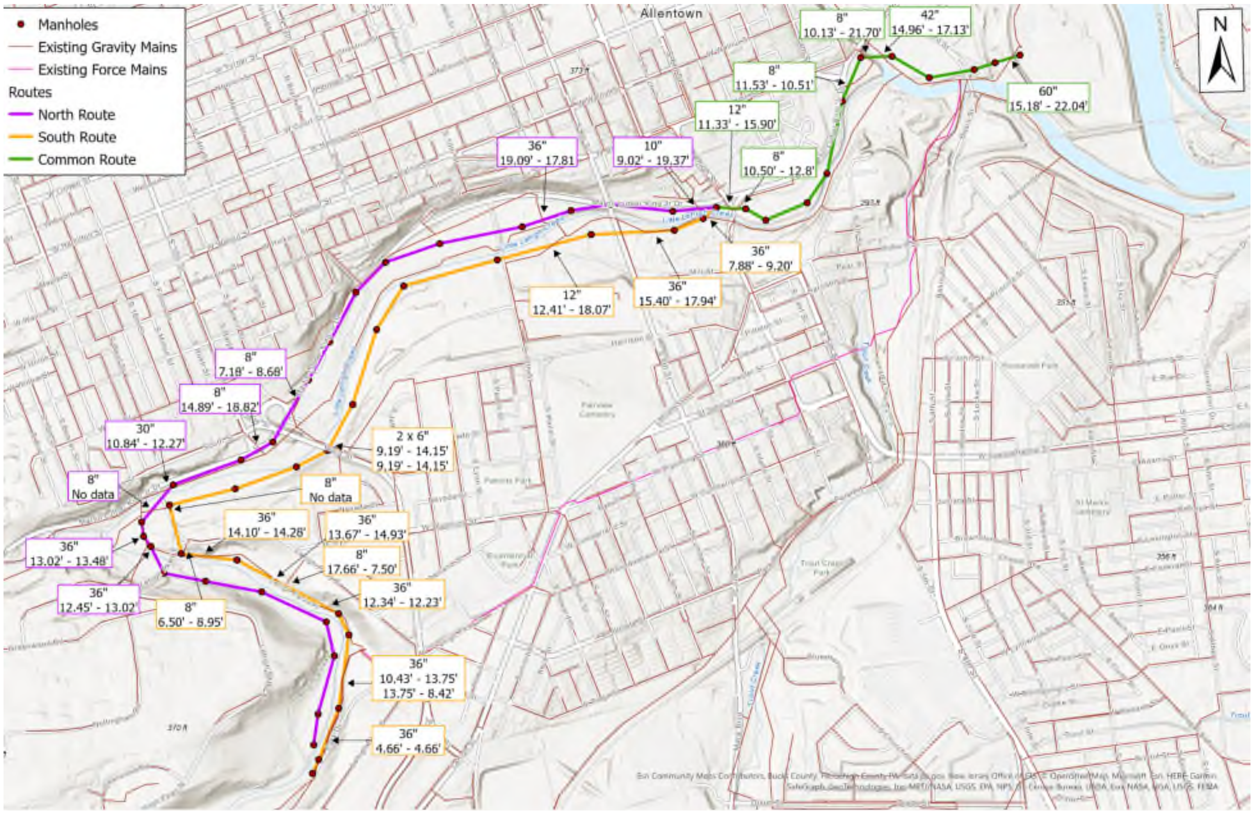


Figure 1 - Primarily Open Cut Potential Alignment Options Considered (Arcadis)

The City and Arcadis conducted initial alignment above ground assessment of a variety of open cut and trenchless construction methods for the KRI. These included review of available geological information, property ownership, past land uses (especially previous buildings and industrial uses), traffic, streams, and future land use plans. These walk-throughs served to identify the alignment shown in Figure 2 as the preferred alignment for open cut construction. This alignment identified certain sections of the work to be conducted as trenchless (jack and bore, microtunnelling, or tunnelling) including the Basin Street crossing, the railroad tracks outside of Kline's Island, and the Klines's Island flood retention dike. This alignment was selected based on known subsurface utilities, known property owners, known easements, traffic, impact to city residents and park users, stream crossings, elimination of inverted siphons, wetlands, and the planned construction of bike paths along old rail to trail sites.

Figure 2 - Pre-Alignment Study Selected Alignment

Installation of the KRI using microtunnelling and tunnelling techniques as the primary construction methodology were four of the 20 options considered during the Preliminary Screening of Alternatives (PSOA), as shown in Table 1. These options were eliminated at the PSOA stage due to their costs of construction being much higher than open cut construction.

		PSOA7	PSOA12	PSOA13	PSOA14	PSOA15
2023 COST	**2050 Total**	**$ 783,760,000**	**$ 878,560,000**	**$ 900,860,000**	**$ 861,860,000**	**$ 909,760,000**
	2035 Total	**$ 694,960,000**	**$ 784,560,000**	**$ 806,860,000**	**$ 772,460,000**	**$ 820,360,000**
	KIWWTP	**$ 199,500,000**	**$ 199,500,000**	**$ 200,800,000**	**$ 106,500,000**	**$ 154,400,000**
	PTP	**$ 327,800,000**	**$ 327,800,000**	**$ 327,800,000**	**$ 327,800,000**	**$ 327,800,000**
	NON-TREATMENT SUBTOTAL	**$ 256,460,000**	**$ 351,260,000**	**$ 372,260,000**	**$ 427,560,000**	**$ 427,560,000**
	SRPs	**$ 77,160,000**	**$ 77,160,000**	**$ 77,160,000**	**$ 77,160,000**	**$ 77,160,000**
	LTR&R	**$ 13,100,000**	**$ 13,100,000**	**$ 13,100,000**	**$ 13,100,000**	**$ 13,100,000**
	INT and FM Rehab	**$ 29,700,000**	**$ 34,900,000**	**$ 34,900,000**	**$ 34,900,000**	**$ 34,900,000**
	Gravity	**$ 122,200,000**	**$ 211,800,000**	**$ 232,800,000**	**$ 288,100,000**	**$ 288,100,000**
	Pumping	**$ 14,300,000**	**$ 14,300,000**	**$ 14,300,000**	**$ 14,300,000**	**$ 14,300,000**
SRP Actions		Benchmark 1 SRP	Benchmark 1 SRP	Benchmark 1 SRP	Benchmark 1 SRP	Benchmark 1 SRP
Conveyance Actions		Gravity	Gravity w/ Shallow Microtunnel	Gravity w/ Deep Microtunnel	Gravity w/ Tunnel Storage >100 MGD	Gravity w/ Tunnel Storage >120 MGD

Table 1 - PSOA Cost Estimates for Microtunneling and Tunneling Approaches vs. Open Cut Gravity Approaches

Microtunnelling Method Evaluation

Following the PSOA work, LCA's Director of Engineering requested AECOM conduct a separate study to evaluate installing the KRI using microtunnel techniques. The goals of the micro-tunnel evaluation were to:

- Evaluate both microtunneling and pressurized closed-face tunneling technologies for installing the new trunk sewer.
- Identify feasible horizontal and vertical alignments for the new pipeline.
- Identify the potential challenges and risks faced for the new pipeline installation (e.g., permits, easements, etc.)
- Assess benefit of a reduced impact to the community and environment during construction
- Prepare a conceptual plan and profile for the new pipeline and an estimate of potential construction cost.

AECOM conducted an independent site walk through as well as desktop geotechnical evaluations and identified several potential alignments. These are shown in Figure 3.

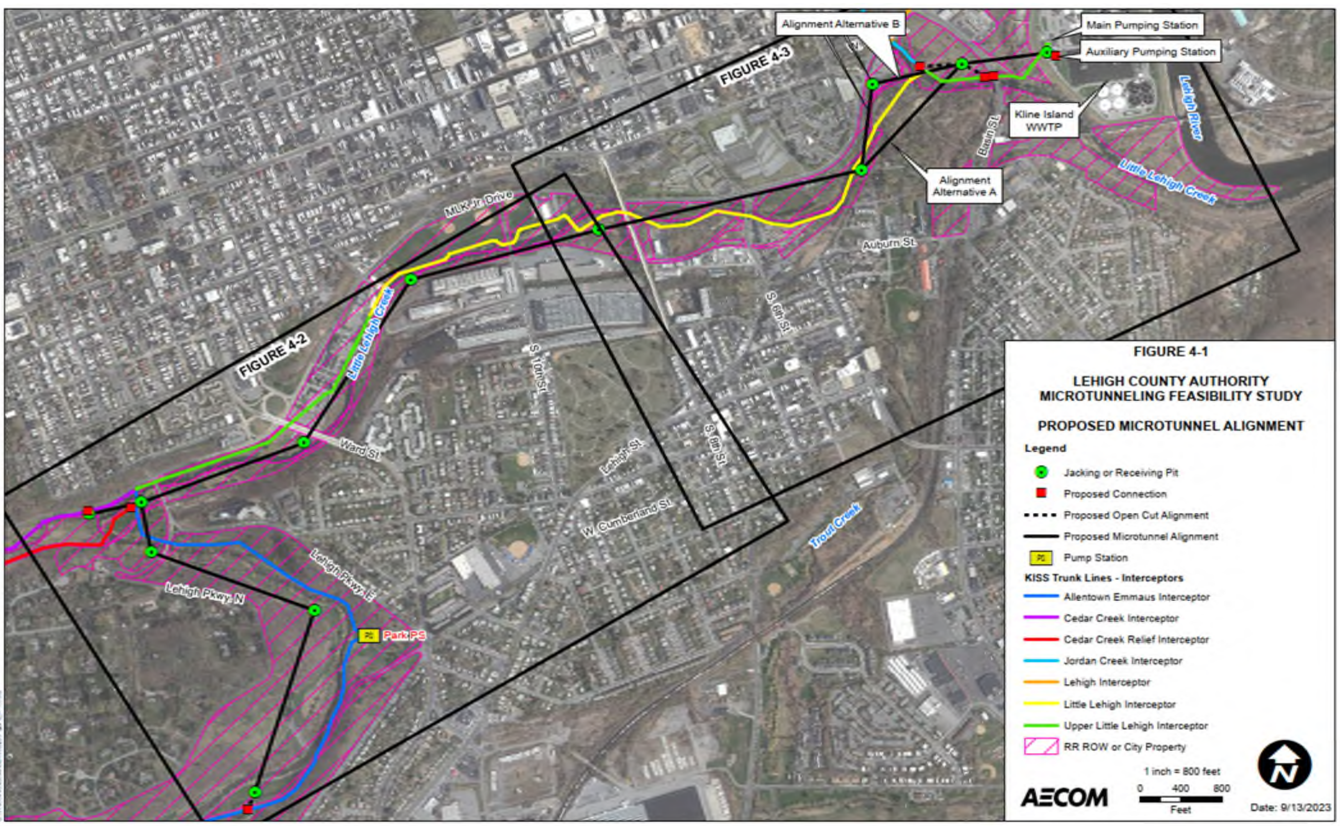


Figure 3 - Microtunnel Potential Alignments Considered (AECOM)

This alignment considered the use of microtunneling or soft ground tunneling methods with likely diameters in the 4 to 6-ft range. The sewer would extend from the KIWWTP, generally running in the vicinity of MLK Jr. Drive along City-owned property or old rail bed easements where practical and paralleling Little Lehigh Creek for a total length of approximately 2-3/4 miles.

A comparison of costs between a primarily microtunnel approach and a primarily open cut approach was conducted jointly by Arcadis and AECOM, as shown in Table 2. The microtunnel approach was again found to be much more expensive.

Primarily Microtunneling of KRI	$91M-$119M
Primarily Open Cut of KRI	$29M

Table 2 - Cost Comparison between Open Cut and Microtunneling for KRI

The salient constraint to design and construction of the KRI is its end point. Because current plans do not include a new pump station with a deeper wet well, the KRI end point can be no deeper than the entry point into the wet well of the KIWWTP Auxiliary Influent Pump Station (AIPS). As the suction line to the AIPS pumps has a crown elevation of 223.4, the end point elevation of the KRI should be no lower than elevation 223.0, as shown in Figure 4. (This is 3' deeper than existing pipe entry into the KIWWTP Main Influent Pump Station (MIPS) at elevation 226.0).

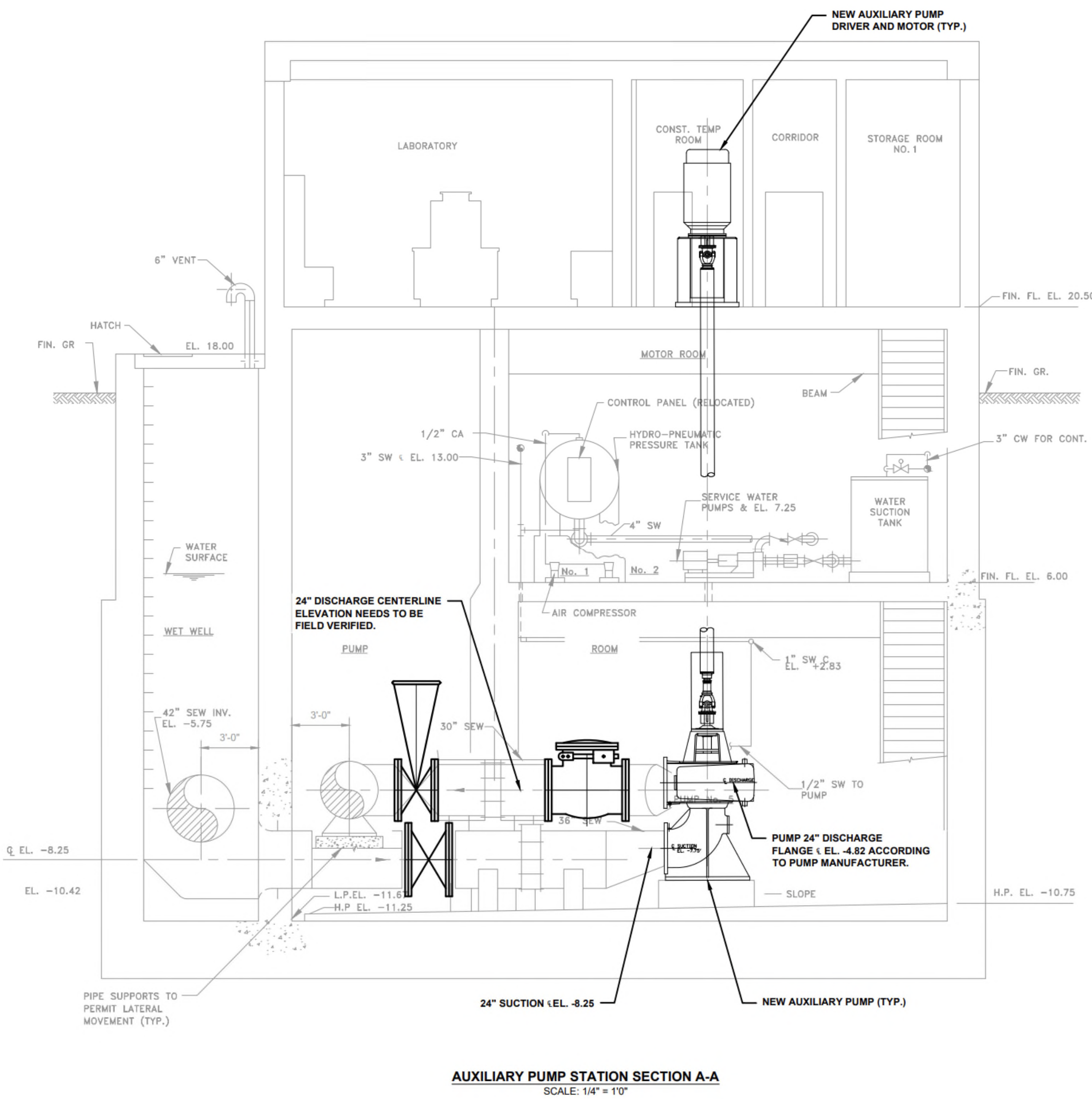


Figure 4 - Auxiliary Pump Station

Because of the relatively shallow depth cause by this endpoint constraint, the opportunities for installing the KRI using micro tunnel techniques are limited due to the need for having sufficient cover over the tunnel boring machine during construction to prevent frack out of drilling fluids. This is especially limiting in areas of the multiple stream crossings of the Little Lehigh River. Additionally, the cost for installing the KR using microtunnel techniques was found to be 10's of millions of dollars more expensive than for open cut. For this reason, micro tunneling as the primary means of construction was abandoned.

Recommendation

Based on these evaluations, the open cut method with targeted use of trenchless technologies for crossing under key geography (Basin Street crossing, the railroad tracks outside of Kline's Island, and the Klines's Island flood retention dike) is selected. The estimated construction cost of this approach is approximately $29M.

Remaining KRI Planning Issues

The vertical alignment of the KRI was determined using the KISS model's physical attributes. The sizing of the pipes based on their site-condition compelled slopes and hydraulic demand were determined using the KISS model's hydraulic capabilities. With an invert elevation of 223.0 at the AIPS wet well, the KRI must intersect the existing 60-inch diameter JCI between the MIPS-AIPS and the railroad tracks just west of the site. There are three options for crossing the JCI as described below and as shown in Figure 5:

A. Cut into the JCI (Green) at its springline, creating a 3' deep drop chamber just outside the AIPS-MIPS in the grass at the toe of the dike (Pink).
B. Siphon under the JCE in the area between the tracks and the dike (Blue).
C. Transition from 72" round to multiple 36"x60" flat-laid ovals under the JCI in the area between the tracks and the dike (Orange).

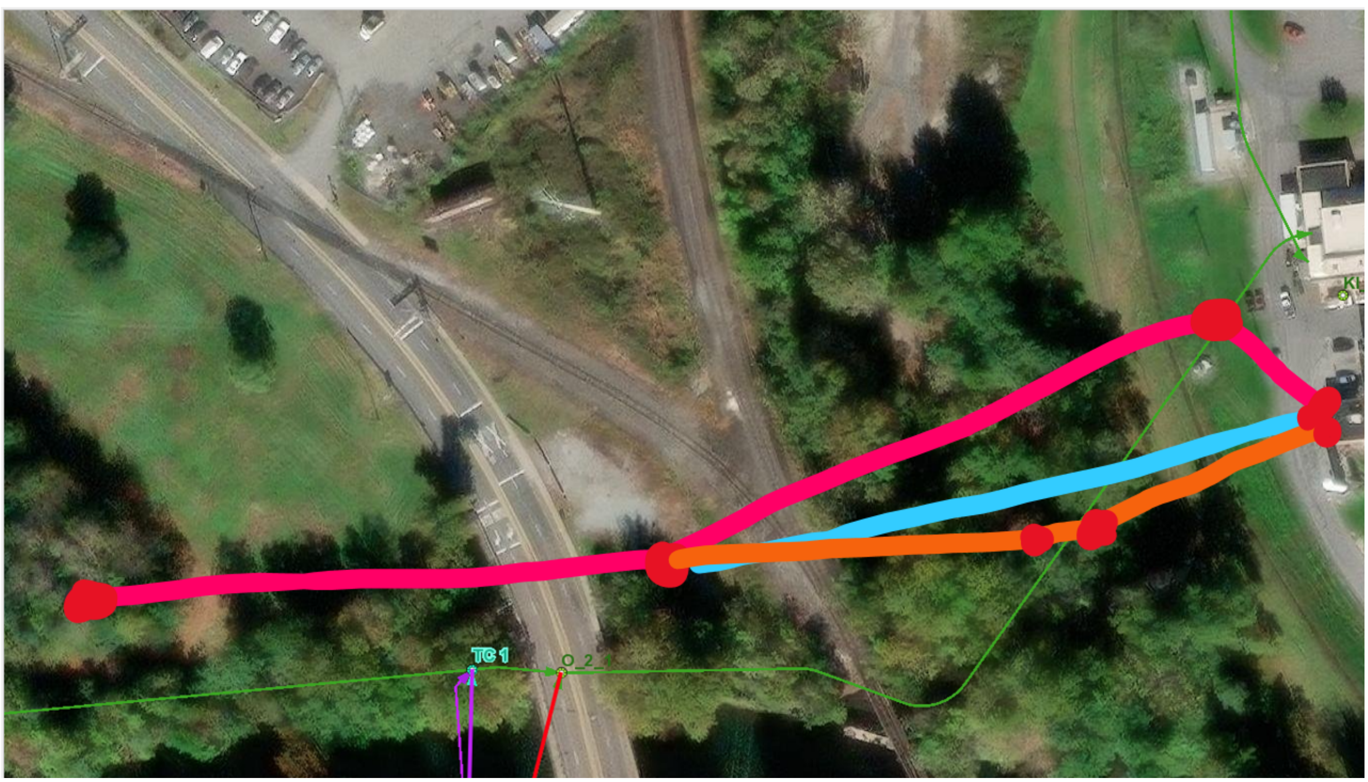


Figure 5 - KRI Entry into KIWWTP Options

Regardless of which KIWWTP entry option is selected, then KRI also needs to cross under the JCI (blue line in Figure 6) approximately 1600 feet upstream of KIWWTP. The JCI invert at this crossing is approximately 231.00. Providing 2' of separation between crown of the KRI and invert of the JCI compels a KRI slope between Jordan Creek and KIWWTP of just 0.0005 ft/ft, which in turn dictates a KRI diameter of 72-inches to provide the needed hydraulic capacity in the KRI.

Figure 6 - Alignment from Basin Street to MLK Boulevard

Once the Jordan Creek is crossed at this location, surface grade increases significantly, allowing for a steeper KRI pipe slope and a decrease in KRI pipe diameter to 54-inches, as shown in Figure 7.

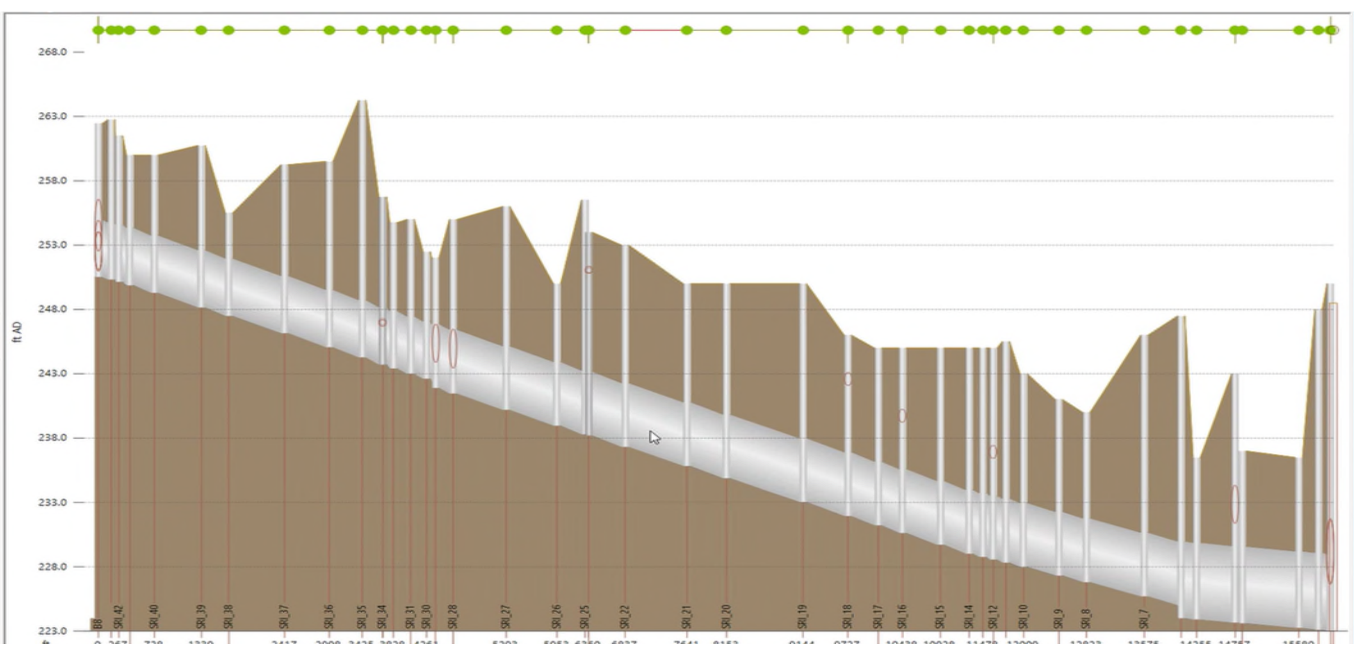


Figure 7 - Profile of KRI

KRI Planning Recommendations

The alignment described above is preliminary until the Alignment Planning Study needed to finalize alignment is completed. With an assumed 537 Plan approval from PADEP in July 2026, the compelling need to complete the 537 projects as soon as possible for both regulatory and growth drivers, and the fact that the KRI needs to be constructed before the much larger LCA projects can be constructed/commissioned, the KRI Planning Study needs to be initiated in February 2024 to be completed by the end of 2028. (This schedule assumes all easements can be acquired in 40 weeks, which is probably too little time).

The Alignment Planning Study will provide:

- Easement research
- Property ownership and bounds demarcations
- Subsurface utility location and depth below grade
- Subsurface structures (bridge abutments in particular)
- Survey of entire alignment corridor that identifies primary road corridors and adjoining roads, existing features, buildings, paving, curbs, sidewalks, pervious areas, light poles, fencing, utility poles, manholes, catch basins, water valves, fire hydrants, trees, swales, streams, etc.
    - Accurate location of subsurface utilities and structures will need to be surveyed to confirm proposed pipe alignment is constructable.
- Subsurface soil types
- Subsurface rock depths and quality
- Groundwater
- Permitting requirements related to:
    - PA Department of Environmental Protection (PA DEP)
    - US Fish and Wildlife
    - PA Historical and Museum Commission (artifacts)
    - US Army Corps of Engineers
    - PA Department of Transportation
    - Lehigh County
    - City of Allentown
    - Norfolk Southern Railroad
- Wetland delineation
- Stream, floodway, and floodplain delineation
- Planned walking/biking paths
- Planned developments

Memo

SUBJECT	TO
Western Lehigh Interceptor Relief Conveyance Selection	Phil DePoe

DATE
February 6, 2024

OUR REF
[Reference]

DEPARTMENT
[Department]

PROJECT NUMBER
30179707 - LCA606 2023 KISS FAA

COPIES TO
[Copies]

NAME
Jim Shelton

Background

The Lehigh County Authority's (LCA) 26-mile-long interceptor system was constructed in 1972 to serve the industrial core in Fogelsville, the burgeoning commercial and residential developments in Upper Macungie and Lower Macungie, and the existing systems in Macungie and Alburtis, as well as minor portions of Weisenberg, Lowhill, and Upper Milford Townships. Collectively, this grouping is known as the Western Lehigh Sewerage Partnership (WLSP) and the sewer system they flow through known as the Western Lehigh Interceptor (WLI) System. Within this system are 11 miles of trunklines (Alburtis Macungie, Breinigsville, Upper Milford, and Upper Iron Run) connected to the primary WLI pipeline. The WLI increases in diameter from 24" at its upstream to 48" at its downstream terminus along its 15-mile length before connecting to the City of Allentown's 1959-constructed 36" diameter Allentown Emmaus Interceptor (AEI) at Kecks Bridge, where LCA's Meter Station 5 was constructed. From there, flow travelled through the AEI to the City's 1928-constructed 30" Little Lehigh Interceptor (LLI) into the Kline's Island Wastewater Treatment Plant (KIWWTP).

As the WLSP communities expanded their collector sewers through developments, and as the collector and interceptor systems aged and brought in ever-increasing inflow and infiltration (I&I), relief conveyance facilities were constructed, including the:

- 1987 20" Spring Creek Road Relief Trunkline
- 1998 Spring Creek Pump Station/Force Main

Growth has continued as these assets have aged, and current Act 537 planning studies show significant additional conveyance relief is required. This new infrastructure is needed to convey both dry day and wet day flows from WLSP Partners to the end of the WLI at LCA's Meter Station 5. Through evaluations conducted in 2022, the WLSP selected a Level of Protection goals for the system to handle dry weather flows through at least the 2050 planning horizon without surcharging the pipe ***and*** be capable of conveying the peak wet weather flow during a 5-year design event without overflow. Level of Service goals were set for individual manholes to prevent basement backups into home near the interceptor and to maintain at least 2' of freeboard in unsealed manholes during the peak flow periods during the 5-year event.

As shown in the highlighted segments in Figure 1, there are six components of the LCA interceptor system and three components of the Upper Macungie Township conveyance system (Rabenold Pump Station, Upper Macungie Trunkline, and Industrial Boulevard Trunkline) that need to be relieved.

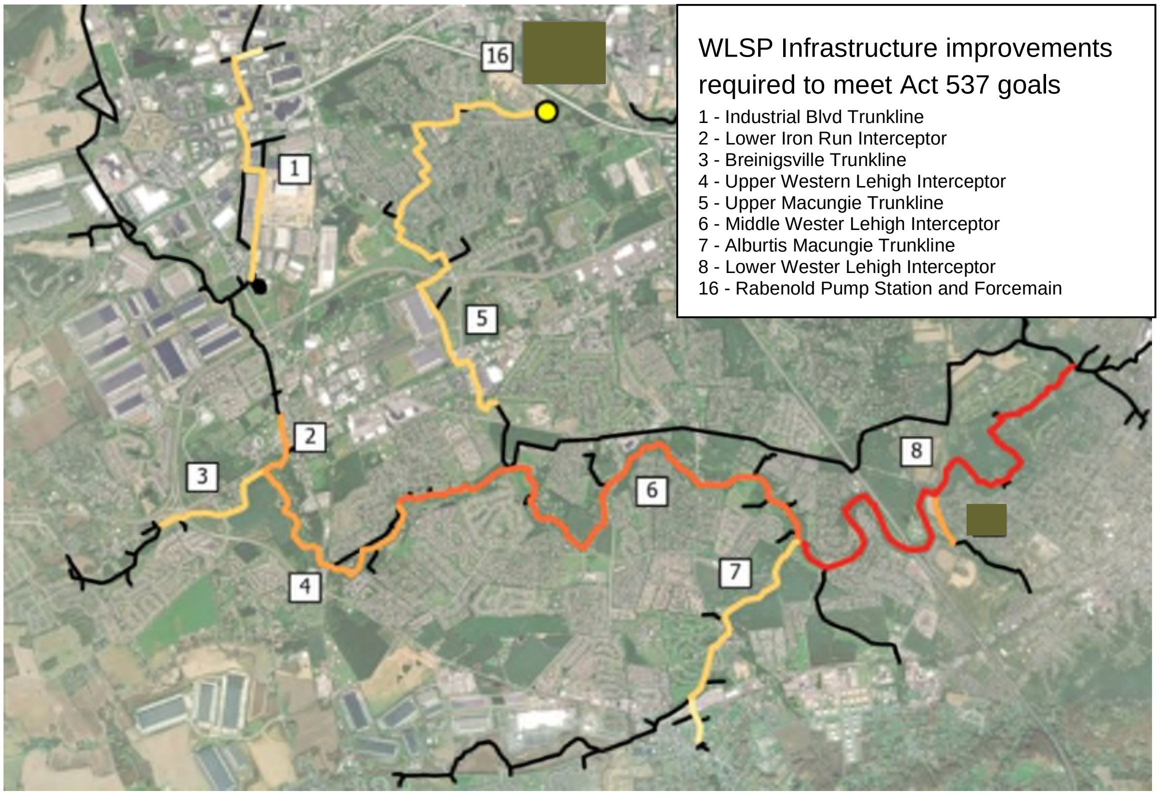


Figure 1 - WLSP Infrastructure Improvements required to meet Act 537 Goals

Preliminary Screening of Alternatives

Several viable relief alignments were identified and evaluated during the Preliminary Screening of Alternatives (PSOA) phase of the planning work. These broke out into three groups of PSOA alternatives.

- ❖ **Parallel Interceptor Construction** - The lines highlighted in Figure 2 would be paralleled by second interceptors of equal or larger diameter/capacity (as well as a tripling of capacity of the UMT Rabenold Pump Station and forcemain).
- ❖ **Pretreatment Plan Effluent Pump Station and Forcemain** – The primary interceptors are relieved via construction of a new pump station at the discharge of the Pretreatment Plant and a new forcemain discharging into new infrastructure to be constructed at the border of the City of Allentown. As shown in Figure 3, the tributary trunklines and pump stations requiring relief would be paralleled.
- ❖ **Krick's Lane Pump Station and Forcemain** – Using a combination of the above two solution sets, a new pump station and forcemain at Krick's Lane would either eliminate Spring Creek Pump Station or eliminate paralleling of the Lower WLI, as shown in Figures 4 and 5.

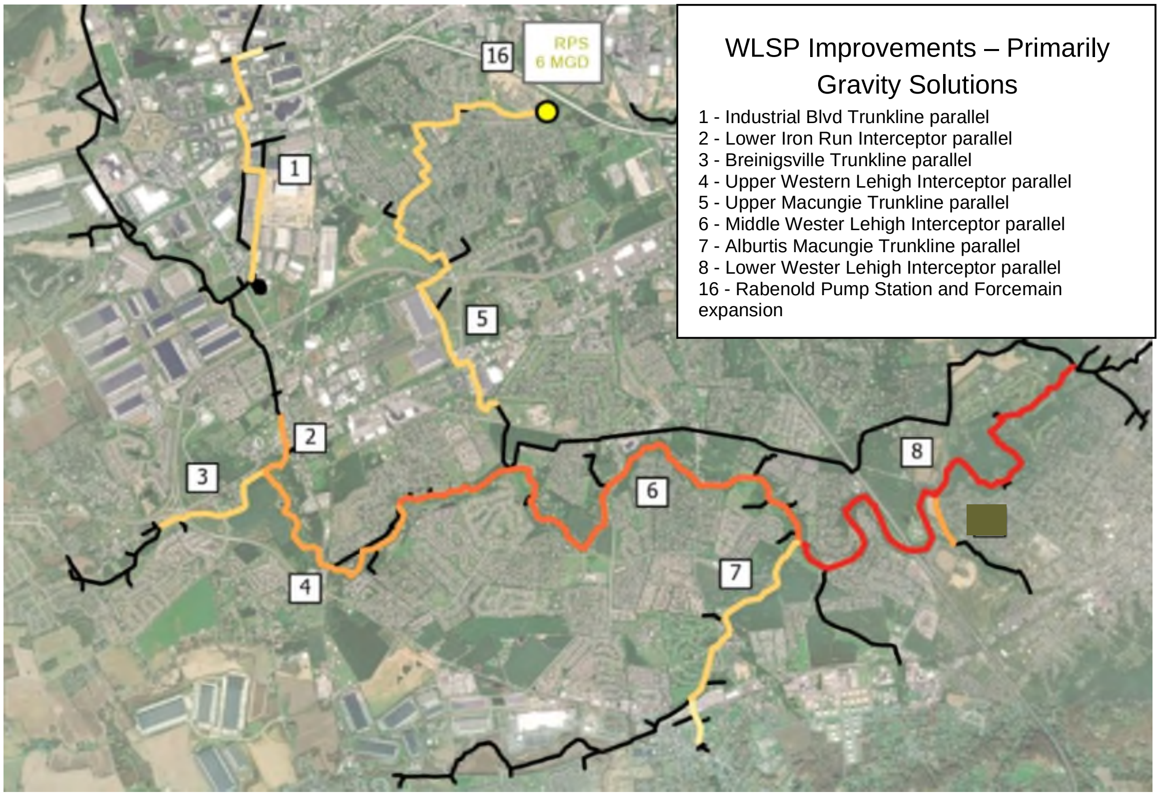


Figure 2 - WLSP Infrastructure Improvements required to meet Act 537 Goals

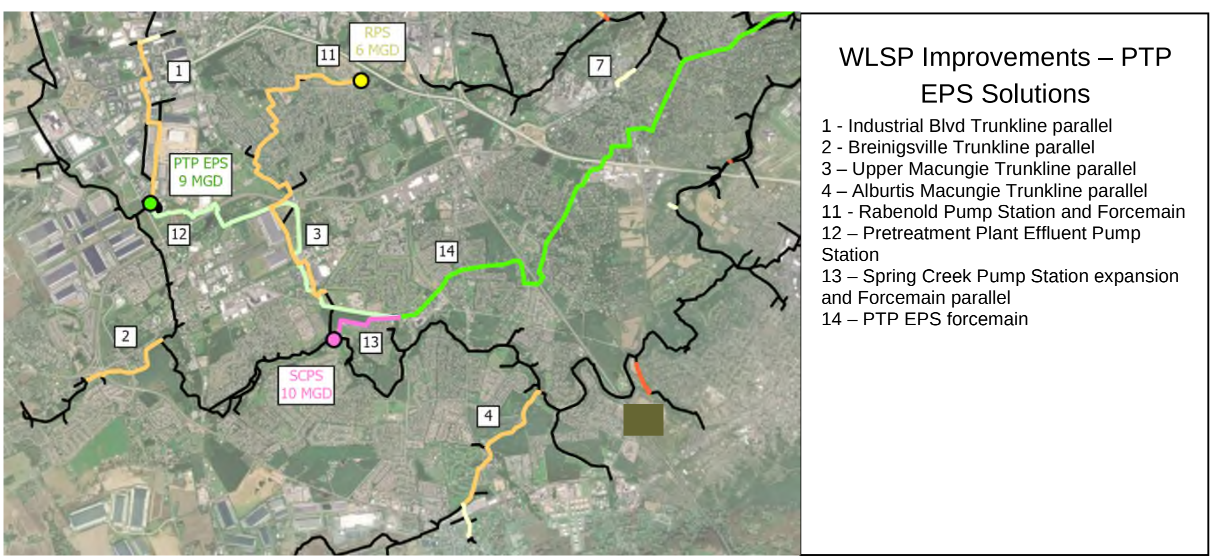


Figure 3 – WLSP Improvements – Primarily Pumped Solutions

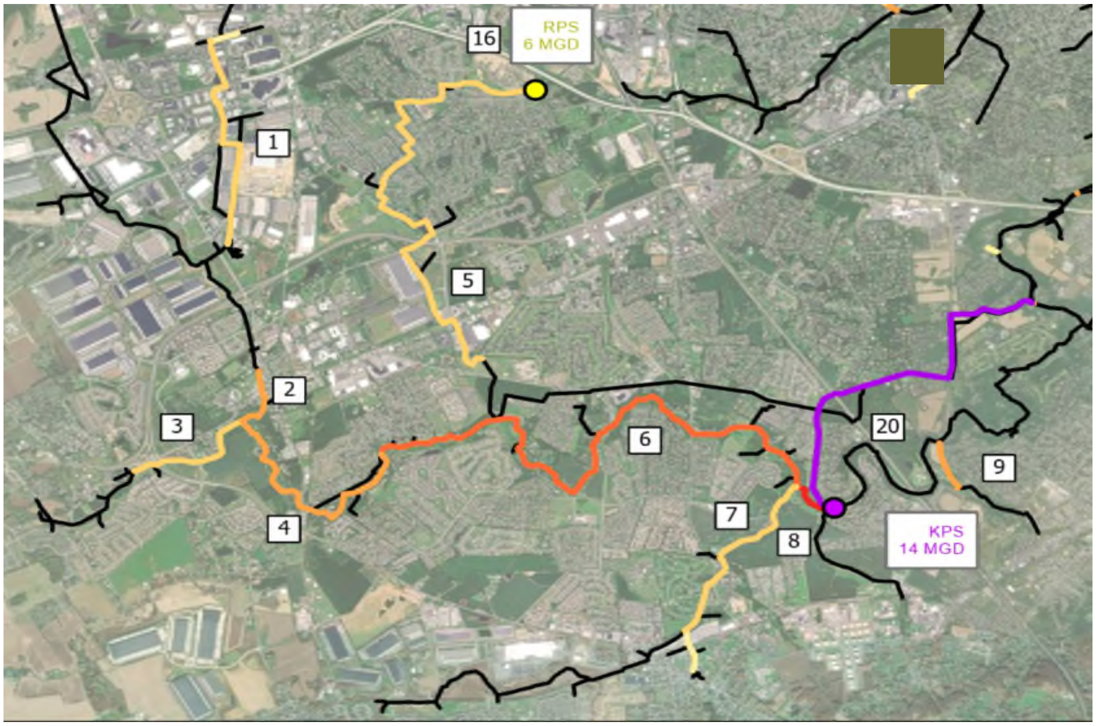


Figure 4 - Krick's Lane Pump Station to eliminate paralleling of Lower WLI

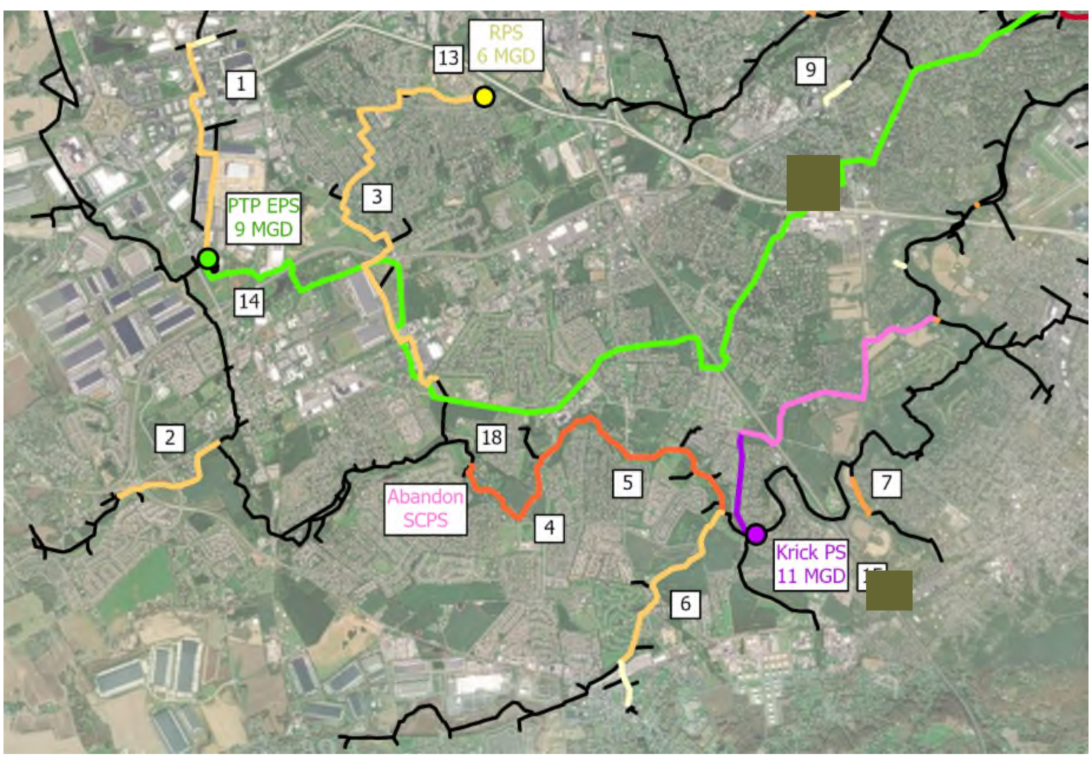


Figure 5 - Krick's Lane Pump Station to eliminate SCPS

As shown in Table1 (which contains the total Act 537 costs as estimated during the PSOA stage of the evaluation, including KIWWTP treatment, PTP treatment, Signatory Source Reduction Plans, and Long-term interceptor and collection systems rehabilitation costs through 2050), there is little difference in cost between these various conveyance options. The concept of constructing new pump station at Krick's Lane (PSOA 4 and 6) was removed from consideration as a variable at this stage of the evaluation; it may be re-introduced during the alignment planning stage of the project.

		PSOA2	PSOA4	PSOA5	PSOA6
2023 COS	2050 Total	$ 795,260,000	$ 812,260,000	$ 781,860,000	$ 798,360,000
	Gravity	$ 132,000,000	$ 101,900,000	$ 60,800,000	$ 81,000,000
	Pumping	$ 14,300,000	$ 69,500,000	$ 77,600,000	$ 67,200,000
Conveyance Actions		Gravity	Gravity	Gravity	Gravity
		SCPS	SCPS	SCPS to EPS FM	
		PPS	PPS	PPS	PPS
			LSPS		
			KLPS to LSPS		KLPA to EPS FM
				PTP EPS	PTP EPS
Physical Results	*Peak Flow to KI (mgd)*	147	154	149	149
	Recovered Dry Day Capacity (mgd)				
	KI EQ (MG)	3.8	4.3	3.6	4
	MLK (inch)	48	36	42	48
	LSPS (mgd)	No LSPS	28	No LSPS	No LSPS
	MLS (mgd)	27	4	16	25
	Shaft LS (mgd)				
	PTP EPS (mgd)			9	9
	KLPS (mgd)		14		11
	SBPS (mgd)				
	SCPS			2 MGD additional Q @ SCPS/FM	SCPS abandoned
	PPS				
	Gravity Pipe (miles)	28	24	16	20
	Forcemain (miles)	1.5	10	14	15

Table 1 - PSOA Cost Comparison for WLSP Conveyance Options

Final Alternative Analysis

The Final Alternatives Analysis (FAA) then focused on the pros and cons of variations on pumping versus gravity flow for the primary conveyance of the WLSP flows. (The focus of the FAA is the relief of the WLI; the UMT projects are unaffected by this stage of the evaluation). This round of analyses included evaluating two different discharge locations for the PTP EPS forcemain. The summaries of those analyses are shown in Table 2 (which contains the total Act 537 costs including KIWWTP treatment, PTP treatment, Signatory Source Reduction Plans, and Long-term interceptor and collection systems rehabilitation costs through 2050).

		Gravity	PTP EPS to Schreibers Bridge	PTP EPS to SCPS FM Discharge
		FAA1a	FAA2	FAA3
2023 COST	Total NPW	$ 924,464,000	$ 940,731,000	$ 955,281,000
	2050 Capital	$ 868,564,000	$ 825,281,000	$ 835,581,000
	2035 Capital	$ 693,623,000	$ 666,923,000	$ 677,223,000
	KIWWTP	$ 216,600,000	$ 196,000,000	$ 194,200,000
	PTP	$ 273,211,000	$ 273,211,000	$ 273,211,000
	NON-TREATMENT SUBTOTAL	$ 378,753,000	$ 356,070,000	$ 368,170,000
	SRPs	$ 89,750,000	$ 89,750,000	$ 89,750,000
	LTR&R	$ 58,520,000	$ 58,520,000	$ 58,520,000
	INT and FM Rehab	$ 57,383,000	$ 40,800,000	$ 40,800,000
	Gravity	$ 168,000,000	$ 150,800,000	$ 162,900,000
	Pumping	$ 5,100,000	$ 16,200,000	$ 16,200,000
	Total O&M and Life Cycle Replacement NPW	$ 55,900,000	$ 115,450,000	$ 119,700,000
	PS O&M NPW	$ 13,800,000	$ 24,500,000	$ 23,700,000
	Gravity Sewer O&M NPW	$ 7,700,000	$ 6,800,000	$ 7,400,000
	PS Life Cycle Replacement NPW	$ 30,000,000	$ 41,250,000	$ 46,500,000
	FM Life Cycle Replacement NPW	$ 4,400,000	$ 42,900,000	$ 42,100,000
Conveyance Actions		Gravity	Gravity	Gravity
		SCPS	SCPS	SCPS
		PPS Abandon	PPS Abandon	PPS Abandon
		MLK to 60"	MLK to 60"	MLK to 60"
		AEI US of PPS 48"		
		AEI DS of PPS 48"		
			PTP EPS	PTP EPS
Physical Results	*Peak Flow to KI (mgd)*	134	139	144
	Recovered Dry Day Capacity (mgd)			
	MLK (inch)	60	60	60
	MLS (mgd)	34	39	27
	PTP EPS (mgd)		9	9
	SCPS		8 + 2	8 + 2
	PPS	Abandoned	Abandoned	Abandoned
	Gravity Pipe (miles)	28	22	18
	Forcemain (miles)	1	13	11

Table 2 - FAA Analysis Summary

This FAA analysis showed that a PTP EPS discharge upstream of Schrieber's Bridge would trigger paralleling of the AEI, leading to an increase in costs; for that reason, the PTP EPS alternative was limited to a discharge into the to-be-constructed KISS Relief Interceptor between Robin Hood Bridge and Schrieber's Bridge.

This FAA analysis also showed that gravity parallelling provided flow modulation at KIWWTP because the transit time via gravity is slower than via pumping and the gravity pipe system provides significant in-line storage, reducing peak flow rates to KIWWTP by approximately 5%.

Selection of Solution – Western Lehigh Interceptor Relief

The gravity and the pumped solutions were carried through to the Selection of Solution (SOS) stage. These broke out into two SOS alternatives.

- **<u>SOS 1 - Parallel interceptor construction</u>** - The lines highlighted in Figure 6 (which show all needed conveyance expansions for the entire KISS system) would be paralleled by second interceptors of equal or larger diameter/capacity. The peak flow rate to KIWWTP for SOS 1 is 137 MGD.

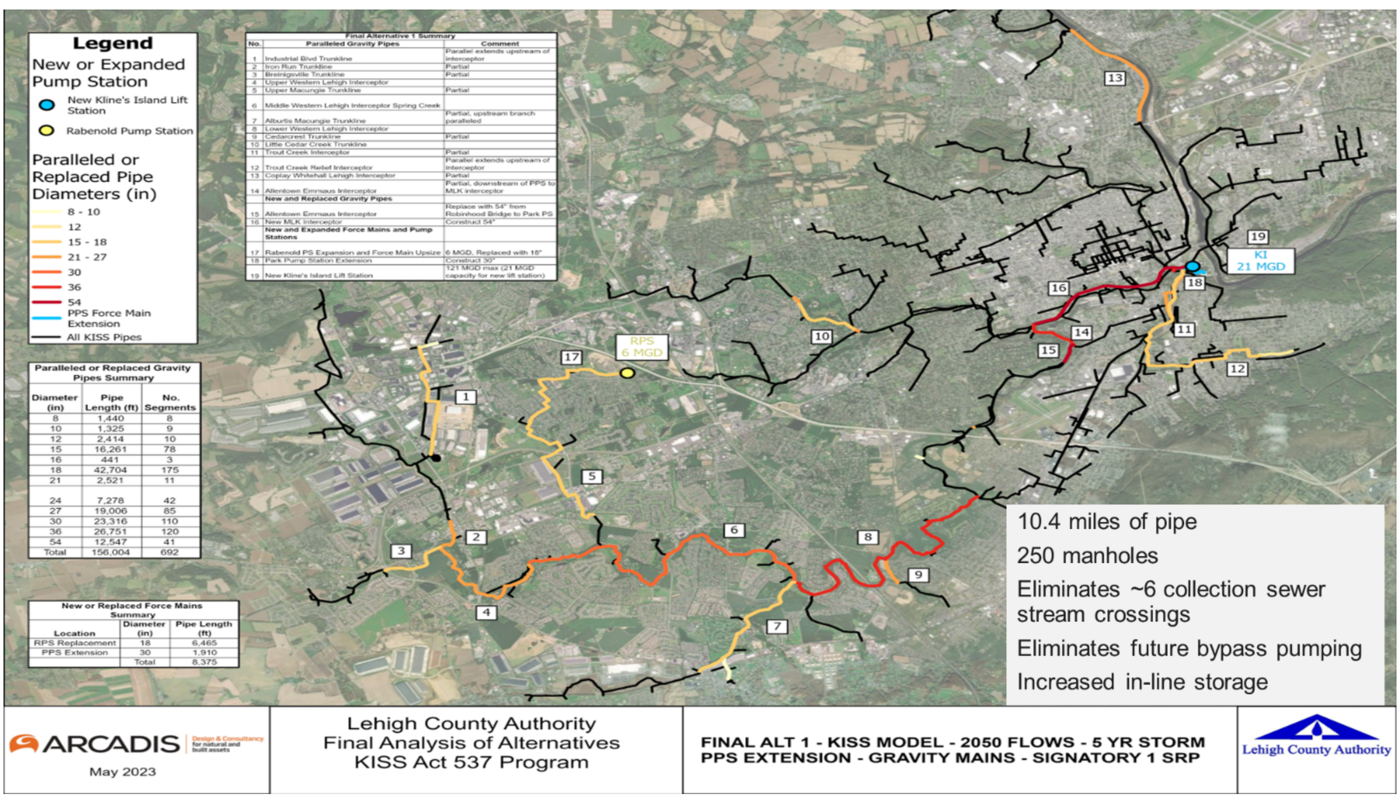


Figure 6 - SOS 1 - Gravity Parallel of WLI

- **<u>SOS2 - Pretreatment Plan Effluent Pump Station and Forcemain</u>** – The primary interceptors are relieved via construction of a new pump station at the discharge of the Pretreatment Plant and a new forcemain discharging into the to-be-constructed KISS Relief Interceptor at Schrieber's Bridge as shown in Figure 7 (which show all conveyance expansions for the entire KISS system). The peak flow rate to KIWWTP for SOS 2 is 144 MGD.

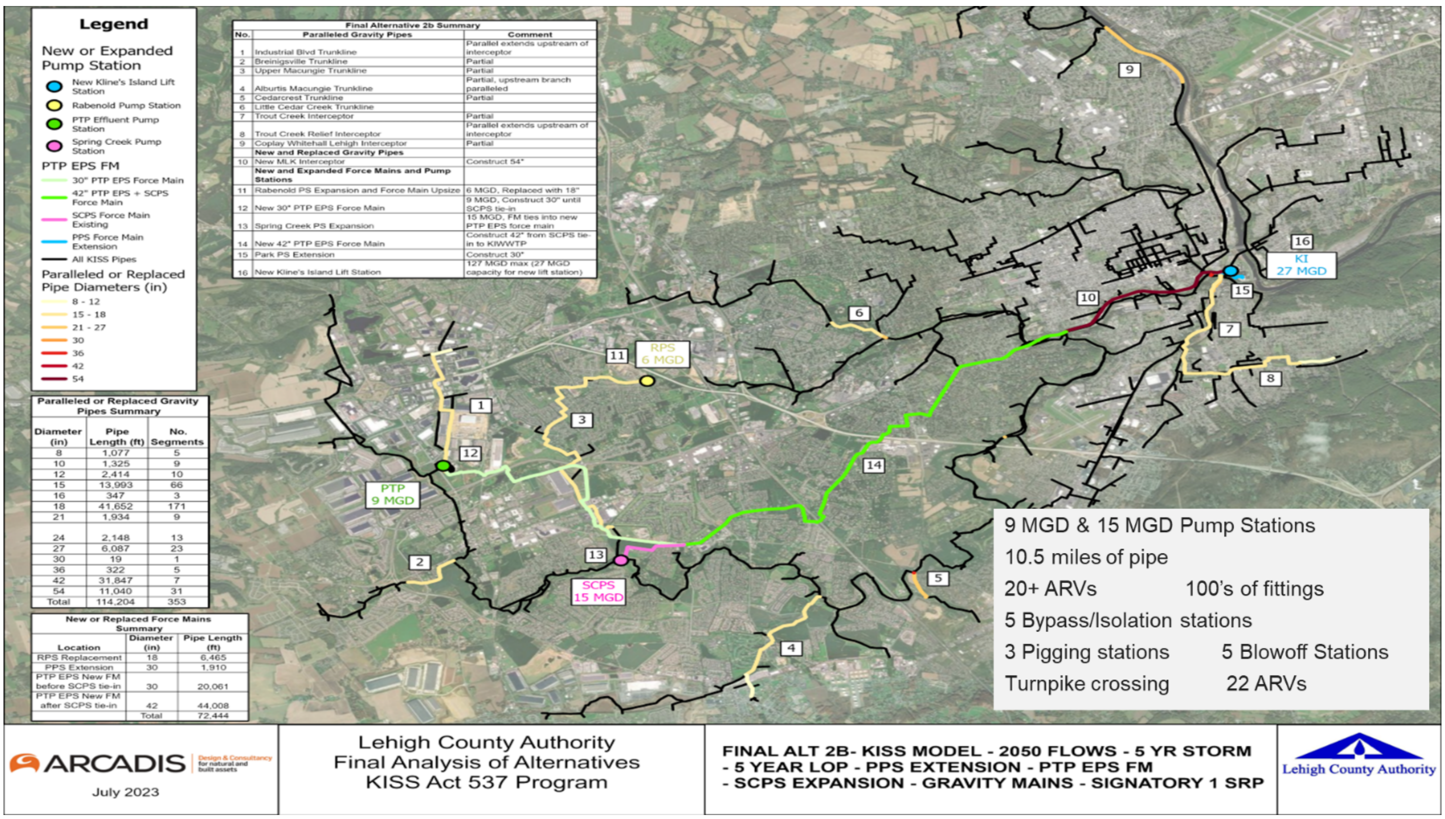


Figure 8 - SOS 2 - PTP EPS and Forcemain

As shown in Table 3, *considering only the relief of the WLI* (i.e., not including the cost of the UMT expansions required regardless of the WLI solution) the conveyance construction cost difference between these two options is $11M higher (18%) for the pumped solution. This does not include additional costs for larger diameter of the KISS Relief Interceptor and the larger capacity and forcemain for the KIWWTP main lift station (144 MGD vs. 136 MGD). More significantly, the pumped solution has much higher life cycle rehabilitation/replacement costs (pump stations and forcemains degrade at roughly three times faster than

SOS Summary										
		Pump Station	Gravity Sewers	Force Main	Capital Cost	PS O&M NPW	PS Refurbishments	Gravity Sewer O&M NPW	Force Main O&M NPW	Total Alternative Cost
2023 COSTS	PTP EPS PS and FM	$ 18,700,000	-	$ 54,800,000	$ 73,500,000	$ 8,000,000	$ 11,000,000	-	$ 22,400,000	$ 114,900,000
	WLI Parallel Gravity	-	$ 62,400,000	-	$ 62,400,000	-	$ 4,500,000	$ 2,800,000	-	$ 69,700,000

Table 3 - SOS Analysis - WLSP Pumped vs Gravity Solution Costs

gravity sewers) and much much higher energy costs than the gravity option. The total net present worth comparison shows the gravity solution is 60% the life cycle cost of the pumped solution ($114.9M vs $69.7M).

A non-cost comparison of the two WLI relief pumped versus gravity alternatives was also conducted. This comparison is shown in Table 4.

GRAVITY SYSTEM	PUMPED SYSTEM
1. More stream and wetland permits	1. Fewer stream and wetland permits
2. Fewer highway permits	2. More highway permits
3. More time of year construction constraints	3. Fewer time of year construction constraints
4. Easier maintenance	4. Harder maintenance
5. More redundancy	5. No redundancy
6. More susceptible to construction weather delays	6. Less susceptible to construction weather delays
7. Less traffic	7. More traffic
8. Provides trail network	8. No community improvements
9. Same impact to property owners	9. Same impact to property owners
10. Better positive recreational impact	10. No recreational impact
11. More safety concerns	11. Fewer safety concerns
12. More stream crossings	12. Fewer stream crossings
13. Fewer highway crossings	13. More highway crossings
14. Same bypass needs	14. Same bypass needs
15. Same easements	15. Same easements
16. Less carbon	16. More carbon
17. No energy consumption	17. Higher energy consumption
18. Higher hydraulic capacity	

Table 4 - Non-Cost Comparison of Pumped vs. Gravity Conveyance for WLSP

An exercise was led by AECOM to allow the program team to first weigh various non-cost criteria and then rank those criteria for these two SOS options. The result of this voting was 12 to 1 in favor of the gravity solution for the Western Lehigh Interceptor.

Recommendation

Based on these evaluations, the recommendation for the WLI relief conveyance is to install parallel gravity interceptors (WLI Relief Interceptors) as shown in Figure 2.

WLI Relief Interceptors Planning Recommendations

The alignment described above is preliminary until the Alignment Planning Studies needed to finalize alignments are completed. With an assumed 537 Plan approval from PADEP in July 2026, the compelling need to complete the 537 projects as soon as possible for both regulatory and growth drivers, and the large number of easements that will need to be acquired to install the new WLI Relief Interceptors, the WLI Relief Interceptors Planning Study needs to be initiated in August 2024 if the lowest portion of the WLI Relief Interceptors (Horseshoes) is to be completed by the end of 2029. (This schedule assumes all easements can be acquired in one year, which is probably too little time).

The Alignment Planning Study will provide:

- Easement research

- Property ownership and bounds demarcations
- Subsurface utility location and depth below grade
- Subsurface structures (bridge abutments in particular)
- Survey of entire alignment corridor that identifies primary road corridors and adjoining roads, existing features, buildings, paving, curbs, sidewalks, pervious areas, light poles, fencing, utility poles, manholes, catch basins, water valves, fire hydrants, trees, swales, streams, etc.
    - Accurate location of subsurface utilities and structures will need to be surveyed to confirm proposed pipe alignment is constructable.
- Subsurface soil types
- Subsurface rock depths and quality
- Groundwater
- Permitting requirements related to:
    - PA Department of Environmental Protection (PA DEP)
    - US Fish and Wildlife
    - PA Historical and Museum Commission (artifacts)
    - US Army Corps of Engineers
    - PA Department of Transportation
    - Lehigh County
    - Norfolk Southern Railroad
    - Upper Macungie Township
    - Lower Macungie Township
    - City of Allentown
- Wetland delineation
- Stream, floodway, and floodplain delineation
- Planned walking/biking paths
- Planned developments

Factors Considered in Decision

On October 6th, 2023 AECOM's Program Risk Management team was engaged to conduct a multi-criteria decision analysis for the Lehigh County Authority Kline's Island Sewer System Options. This multi-criteria decision analysis survey and assessment aims to provide measurable metrics for achieving consensus on complex decisions. This assessment provides a systematic methodology for defining specific criteria and relative criteria weights, rating the options against the criteria, and using the criteria wights to evaluate the options against the criteria. The criteria used for the multicriteria decision analysis are listed below with respect to FAA 1 versus FAA 2b - Terminal Location at Confluence of Cedar and Little Lehigh Creeks. To develop the decision criteria, as a first step AECOM developed a proposed list of criteria, which was presented to the team on October 27, 2023. Upon a thorough discussion of the criteria, the project team provided additional input on the decision criteria descriptions through November 8, 2023. An amended decision criteria description was developed using the combined input from the project team with expertise from planning; management; wastewater conveyance, treatment and operations; and conveyance; and presented on November 10, 2023. The expert names are provided in Appendix A. These criteria aim to cover various aspects of design such as financial, operation, project delivery, permits, and sustainability.

Criteria	Description
Financial - CAPEX	June 2023 basis - lower 2035 CAPEX costs
Financial - NPV	Lower 50-year NPV costs including O&M; Lower staffing costs
Permitting and Environmental Considerations	Ease of permitting the project; Less in-stream construction; Preserving wetlands and habitats; Fewer time of year constraints - trout, Falcon, and PNDI
O&M	Ease of operations and maintenance; Less debris settling; Better operational access (easier to clean/inspect); More redundancy
Timely project delivery	Project execution confidently completed on time; Least amount of specialty contracting/equipment; Contractor availability; Less susceptible to weather delays
Community Impacts	Minimal impacts to surrounding community, traffic, odors, city parks, and travel; Less pressure created by environmental advocates; Better acceptance by community; Better synergies with other community projects (i.e., trails) routes; Less impact on adjacent property owners; More EJ improvements; Fewer recreational impacts
Construction Challenges	Minimize safety concerns; Fewer risks of Change Orders (less unknown geotechnical conditions); Lower risk of exposing hazardous materials; Smaller volume of nonreusable soils; For micro tunnel vs. gravity option, Less risk of Boring Machine Rescue and Less boring frac out; Easier excavation; Less dewatering; Less Sheeting; Fewer utility crossings/relocations; Fewer Stream Crossings; Lower Traffic Impacts; Less bypass needs
Easements	Fewest easements required; Fewer new permanent easements; Fewer temporary access agreements; Fewer difficult easement/access properties
Sustainability	Lower construction and operating carbon footprint; Better chance of meeting other green considerations
Adaptability	Lower impact on floodplain or level of service due to assets sitting in a floodplain; Higher hydraulic capacity; Higher in-line storage capacity; Lower peak flow to KIWWTP; More acceptable operational failure mode

Multi-Criteria Decision Tool (MCDT) Results

On November 10, 2023, a survey was collected from 11 respondents to weight the above listed criteria from a scale of 1-10. The survey respondents' expertise included conveyance; wastewater conveyance, treatment and operations; wastewater treatment and conveyance; planning; compliance and operations; plant operations; GIS; and engineering. Please refer to Appendix A for survey respondent names. Upon completion of the survey, the decision criteria results, and their relative importance were discussed on November 10, 2023.

Criteria	Average Weight %
Financial - CAPEX	13
Financial - NPV	12
Permitting and Environmental Considerations	10
O&M	9
Timely project delivery	10
Community impacts	10
Construction challenges	10
Easements	7
Sustainability	7
Adaptability	9

Upon completion of the decision criteria weight survey, a second survey was distributed on November 17, 2023, to 13 respondents with expertise from engineering; compliance and operations; wastewater conveyance, treatment, and operations; GIS; plant operations; conveyance; management; wastewater treatment; operations; and planning. Please refer to Appendix A for survey respondent names. This survey contained three questions listed below:

1. For FAA 1 (parallel) - Terminal Location at Confluence of Cedar and Little Lehigh Creeks how would you rank the following criteria using a scale of 1-10? Please note that a lower criterion rating (i.e., 1) corresponds to a worse performance of the option against criterion while a higher score (i.e., 10) corresponds to a better performance of the option against criterion. A repetition of criteria scores is allowed, i.e., you are able to assign the same score to more than one criterion.
2. For FAA 2b (pumping) - Terminal Location at Confluence of Cedar and Little Lehigh Creeks how would you rank the following criteria using a scale of 1-10? Please note that a lower criterion rating (i.e., 1) corresponds to a worse performance of the option against criterion while a higher score (i.e., 10) corresponds to a better performance of the option against criterion. A repetition of criteria scores is allowed, i.e., you are able to assign the same score to more than one criterion.
3. Do you prefer FAA 1 (parallel) or FAA 2b (pumping)?

It should be noted that one respondent only responded to the last question (i.e., Do you prefer FAA 1 (parallel) or FAA 2b (pumping)). The survey results are listed below:

- 12 out of 13 respondents responded to question 1 and question 2. With the 12 responses FAA1 has a weighted average of 7 and FAA2b has a weighted average of 6, out of a total score of 10. This translates to 70% and 60% preference respectively for FAA1 and FAA2b. This is showing that FAA1 is preferred with a slight advantage of 10%.
- 13 out of 13 respondents responded to question 3 and 12 out of 13 respondents selected FAA1 and 1 out of 13 respondents selected FAA2b. This is expected since when you ask for a

comparison between two options respondents have a clear preference but when they are required to rate criterion against options, the results may vary.

- Regarding the standard deviation of all voter responses for each criterion, for question 1 O&M had the most consensus and community impact had the least consensus. For question 2 permitting and environmental considerations had the most consensus and O&M had the least consensus. Overall, there was slightly better consensus among the various criteria in question 2 compared to question 1.

KIWWTP PERFORMANCE AND CAPACITY REVIEW

SUBJECT
KIWWTP Performance at Increased Loads

DATE
August 16, 2024

TO
Albert Capuzzi, Lehigh County Authority
Phil DePoe, Lehigh County Authority

FROM
Christopher Curran, PE, AECOM
Ralph Eschborn, PE, AECOM
Jim McQuarrie, PE, AECOM

The Lehigh County Authority is evaluating options for the future of the industrial pretreatment plant (PTP). Options are under consideration that eliminate the PTP or reduce the organic loading currently offloaded via pre-treatment at the PTP. Either approach will send this increased load down to the Kline's Island Wastewater Treatment Plant (KIWWTP). Both technical and regulatory considerations arise when contemplating moving these loads to the KIWWTP for treatment. The purpose of this memorandum is to offer technical opinions on the implications of these PTP options on KIWWTP. Four topic areas are covered in this memorandum:

- Future potential loading conditions at KIWWTP
- Capacity analysis of the main liquid stream process
- Capacity improvement needs for 70,000 lb-BOD/d loading
- Regulatory requirements for wasteload management

Finally, this memorandum presents a summary list of concluding remarks and recommended steps moving forward.

Loading Conditions at KIWWTP under Alternative 8b and 5c

Pretreatment plant options Alternative 8b and 5c shift a portion of BOD loads to the KIWWTP, reducing the required improvements at the PTP. Under Alternative 8b, the organic load pretreatment at the PTP is relaxed because the majority of industrial load from BBC and Ocean Spray will be treated by the upflow anaerobic sludge blanket (UASB) reactors. The remaining loads from other commercial, industrial, and residential sources will be split. About 11,000 lb-BOD/d will bypass the PTP and be treated at the KIWWTP (see Attachment 1), while the remaining loads will be fully treated at the existing PTP. The anticipated influent organic loading conditions with Alternative 8b are within the permitted capacity of KIWWTP, which has a maximum monthly load of 70,000 lb-BOD/day.

With the latest Alternative 5c (See Attachment 2), the loads from the top five industries (BBC, Ocean Spray, KDP, Coke and SunOpta) will be treated by the UASB reactors, while the remaining load, mainly domestic wastewater, will bypass the PTP. The existing PTP secondary will be mothballed, leaving the primary settling tanks and solids dewatering process. As a result, the total influent MM organic loads to KIWWTP in 2035 are anticipated to be around 73,800 lb-BOD/d (see Attachment 2). For reference, the 200 mg-BOD/L condition at Keck's Bridge is projected to result in an influent MM load of 66,000 lb-BOD/d to the KIWWTP in 2035 (See Attachment 3), which is similar to Alternative 8b (involves bringing secondary back online operating on air).

Capacity Analysis of the KIWWTP Main Liquid Stream Process

Two scenarios were evaluated to assess the ability of the main liquid stream to handle increased organic loads. The evaluations summarized here are from the *Kline's Island WWTP BOD Loading Sensitivity Analysis* memo updated November 2023 (See Attachment 4). The evaluations, which are based on industry best practice modeling protocols, show that influent organic capacity at KIWWTP is governed by the period of the year (from May 1 to October 31) when the more stringent effluent ammonia limit of 5 mg NH_3-N/L is in place, and wastewater temperature coming out of winter is still cool (May). Without any changes to the main liquid stream process, the model analysis predicts the KIWWTP can receive up to **56,000 lb-BOD/d** during this time of year and keep effluent ammonia at around 5 mg-NH_3-N/L under spring-time wastewater temperature conditions (See Figure 1). It is important to note that variability intrinsic to wastewater treatment such as wastewater temperature, air temperature, ammonia loading, and the nature of organic loadings all combine to strongly influence actual effluent ammonia performance. Risk of ammonia exceedance each spring increases as BOD loadings push toward 56,000 lb-BOD/d (See Figure 1). For reference, the COD:BOD ratio of the influent wastewater character is 2.08.

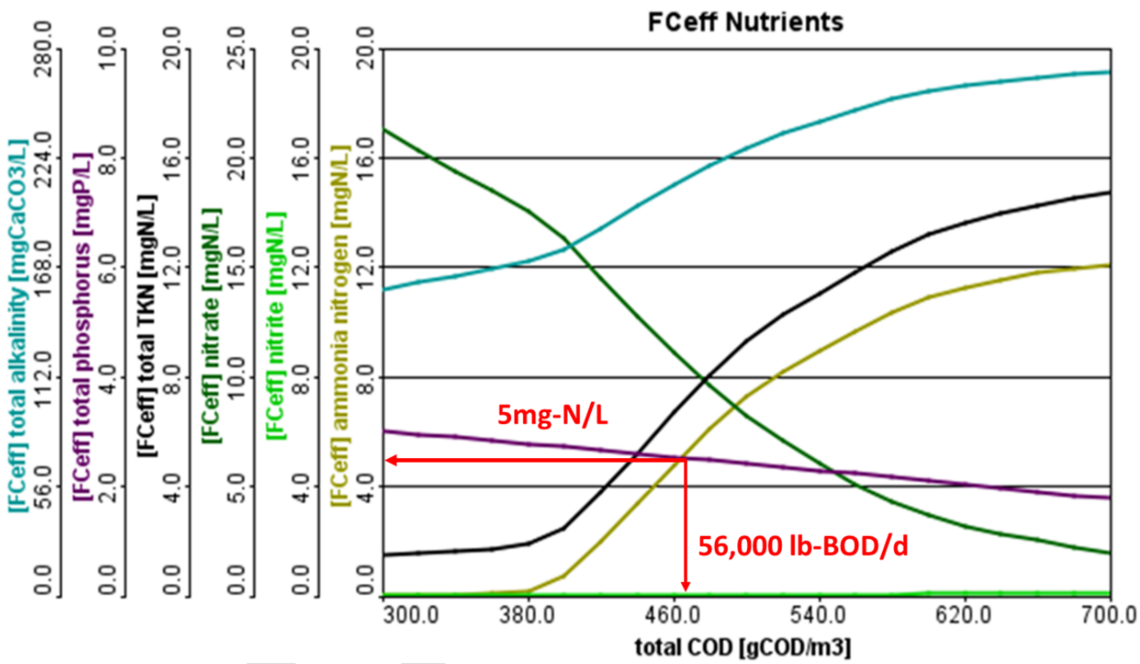


Figure 1 – Sensitivity analysis results: predicted effluent ammonia at 56,000 lb-BOD/d and 17°C temperature.

In a second analysis scenario depicted in Figure 2 below, chemically enhanced primary treatment (CEPT) is used to preserve the above-described mainstream biological capacity during springtime by intercepting substantially more organic load at the primary treatment step. Under ideal CEPT-enhanced performance conditions, primary TSS removal could be pushed up to as high as 85%. At this level of primary treatment performance, the treatment capacity of the KIWWTP would be comfortably in excess of 70,000 lbs-BOD/d, while preserving nitrification efficacy at the rock media trickling filters RMTFs (see Figure 2). However, the actual realized consistent performance benefit of CEPT can only be determined at full-scale and under site-specific conditions. Therefore, it is crucial to conduct a structured technical analysis and full-scale demonstration to confirm the actual full-scale capability of CEPT to improve BOD capture performance.

This modeling analysis helps to bracket the organic loading capacity of the mainstream treatment processes. At up to 56,000 lb-BOD/d on a monthly average basis, the KIWWTP can meet permit during the governing Spring (May) shoulder season condition without CEPT. Additional loading as under the Alternative 8b, would require CEPT or some other means of achieving advanced primary treatment. **A modest boost in primary treatment performance in the range of 70 to 75% would help to manage loads up to the current permitted 70,000 lb-BOD/d capacity and still maintain effluent ammonia compliance under springtime conditions.**

Setup of the model used for this mainstream capacity assessment includes a mass balance analysis around the whole plant and is an important standard procedure for process modeling. A “closed” mass balance helps reconcile data gaps, error, and bias that may be existing with the historical plant data. For KIWWTP, the raw influent sample location is located downstream of in-plant recycle streams, including the filtrate from dewatering operations as well as the wetting recycle flow associated with the RMTF. This recycle flow in addition to the heterogeneous nature of wastewater can result in bias in terms of influent load that are recorded in the historical data. Attachment 5 includes two mass balance analyses which help to show the measured versus the calculated influent BOD and TSS loading conditions and the influence of return streams on the physical influent sample location. These mass balances indicate that influent BOD loading has been over-reported in the past, but sampling adjustments taken by the staff have rectified.

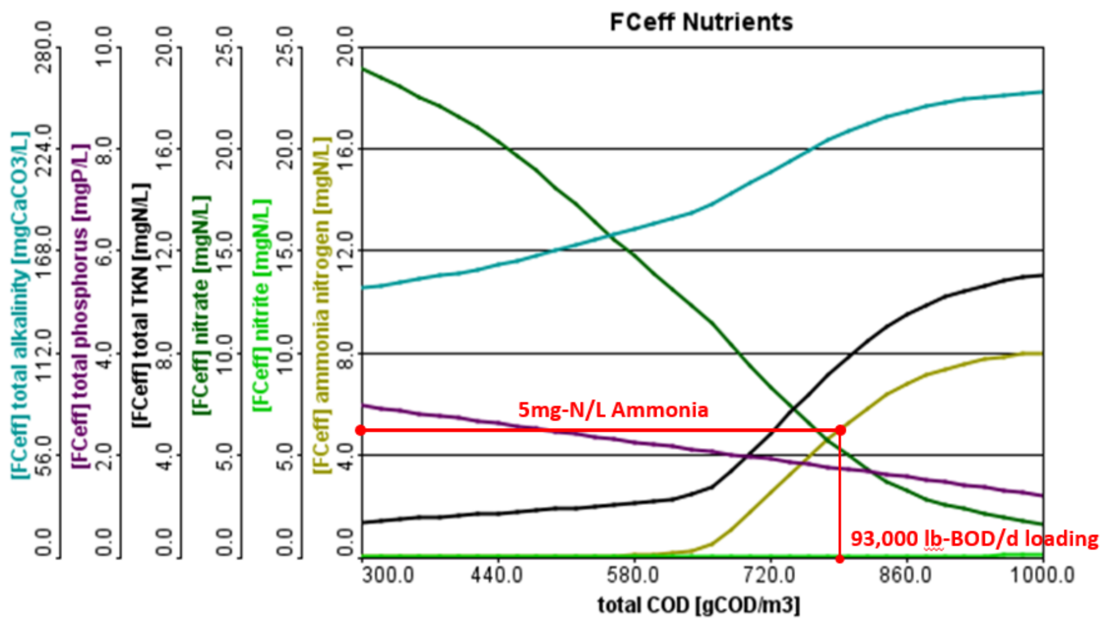


Figure 2 – Sensitivity analysis results with CEPT: predicted effluent ammonia at 93,000 lb-BOD/d and 17°C temperature.

Capacity Improvement Needs for 70,000 Lb-BOD/D Loading

Under the anticipated demonstrated performance improvements with CEPT, no upgrades to the liquid stream treatment process are required. Mainstream treatment performance under the governing springtime condition can be pushed to the permitted 70,000 lb-BOD/d capacity with a reasonable enhancement in primary performance via advanced treatment strategies, such as CEPT.

Improvements are needed on the solids handling facilities side of the KIWWTP to build out the balance of facility capacity. One of the main capacity bottlenecks at 70,000 lb-BOD/d is anerobic digestion. Two digesters need to be in service when the influent load reaches 70,000 lb-BOD/d to keep the solids loading rate within the typical range of 100 to 300 lb-TVS/kcf/d for mesophilic digesters (as shown in Figure 3). Consequently, a third primary digester is necessary to handle the load when one of the primary digesters is undergoing maintenance.

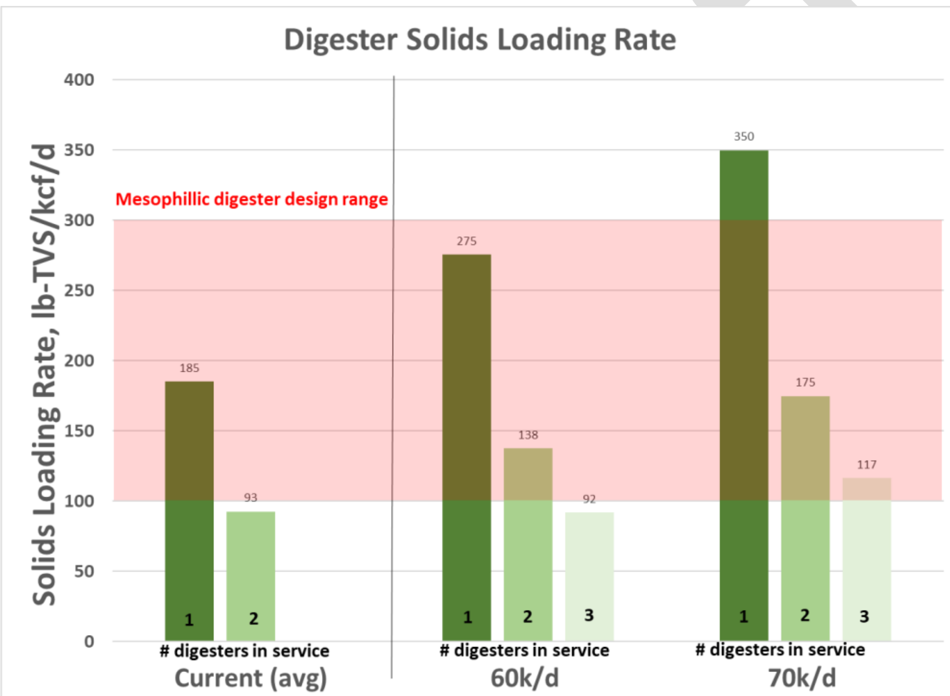


Figure 3 – Digester Capacity Analysis based on Solids Loading Rate

Figure 4 shows the residence time at the influent 70,000 lb-BOD/d loading condition under anticipated improved sludge feed concentrations stemming from improvements (i.e., glass-lined primary to digester transfer pipe) that are currently underway that will allow for improved thickening of sludge in the primary clarifiers. Under the 70,000 lb-BOD/d influent loading scenario, the two existing primary digesters do not provide sufficient residence time and particularly during periods when one digester is taken out of service for maintenance (Figure 4). The PADEP Design of Wastewater Facilities Manual calls for a minimum solids retention time of 15 days for digesters. In consideration of digester maintenance, typical industry practice (and as required under the lease agreement) is to take a given digester out of service for cleaning and inspection once every 5 years. Digester cleaning and maintenance activities typically require that a digester be out of service for an extended period of time from three to six months. A third primary digester is necessary and will bring the residence time to above 15 days when all digesters are in service (Figure 4). With optimal sludge feed, one of the three digesters can be taken out of service for maintenance and still provide an 11-day residence time which can still meet 503-regulation but would require special testing protocols to prove compliance.

The LCA has confirmed that the existing secondary digester can be operated as a primary digester when one of primary digesters is taken out of service. For the permanent conversion of the secondary digester, a new digested sludge holding tank will be needed between the digesters and the dewatering system to allow coordination of daily operations with continuous digester throughput. Reliable and firm capacity sludge digestion and management is critical to avoid the cascading impact on mainstream treatment performance that happens if firm facility capabilities are lacking. For proper digestion performance at the anticipated increased solids loading, it is also recommended that mixing and refurbishment improvements forecasted in the Klines's Island Master Plan are also completed to the other two primary digesters.

Figure 4 – Digester Capacity Analysis based on Retention Time

Note - Retention time calculation is based on the blended primary and secondary sludge feed improved to 4.65% with sludge piping improvements and the combined feed flow (primary plus secondary) of 200,000 gpd.

The second capacity bottleneck is with sludge dewatering. At loadings of 70,000 lb-BOD/d, the dewatering flow rate is around 200,000 gallons per day. It has been confirmed that the average hydraulic throughput of one of the existing BFP units is 72 gpm, which is below the original throughout of 100 gpm. Figure 5 shows that with the current dewatering capacity, production run time is nearly continuous, with firm capacity requiring seven-day operation. This leaves insufficient margin for machine downtime for service and coordination of operations. Therefore, rehabilitating or rebuilding the three existing units can no longer meet the future needs of dewatering capacity, flexibility, and redundancy, unless original throughput can be restored. The age of the BFPs makes this challenging.

To provide reliable daily capability for operations to move solids out of the process and off-site, higher throughput capacity is necessary. This can be achieved through a combination of higher capacity units and/or the addition of a fourth dewatering unit. Since the current dewatering room lacks sufficient space for a fourth BFP unit, it is recommended to replace the existing BFPs with alternative dewatering technologies, such as screw presses or centrifuges, to avoid the need and cost for a new building.

Figure 5 – Dewatering Capacity Analysis

Notes – The group of bars on the left are firm capacity (2 units) at 72 gpm/unit. The graph on the right is one additional unit (3 firm units) at 72 gpm/unit.

Table 1 summarizes the solids digestion and handling improvements recommended to provide consistent and reliable solids stabilization and management of sludge at 70,000 lb-BOD/d loading. The estimated added operating cost for CEPT is in the range of $1M to $1.5M per year.

Table 1 – Summary of Solids Handling Improvements for 70,000 lb-BOD/d Loading

Item	CAPEX	Basis for Requirement
CEPT improvements	$2.39M	Increase primary clarifier removal performance and manage downstream loading to secondary process
Construct 0.6 MG sludge holding tank and associated pumps/piping	$5.25M	Re-purpose secondary digester to higher-value function (primary digester) and construct smaller holding tank in its place for sludge storage and stable feed to dewatering operation
Mixing improvements to three existing digesters	$3.5M	Provide total firm primary digestion capacity that meets 15-day requirement that prevents digesters from going sour while one unit is OOS for maintenance
Dewatering capacity improvements	$6.22M	Level of service improvement with four new centrifuges to secure coordinated operations for machine downtime and operational logistics

Regulatory Requirements for Wasteload Management

KIWWTP must meet requirements under 25 PA § 94 that are intended to protect against hydraulic, organic and industrial wastewater overloads from sewerage facilities. Facilities must submit an annual report in accordance with 25 PA § 94.12 that includes wasteload management information for the Facility, including line graphs that depict: a) monthly average flows for each month for the past 5 years and projections for the next 5 years, with a clear indication of the hydraulic design flow approved in the Water Quality Management (WQM) Part II Permit; and b) monthly average organic loading for each month and projections for the next 5 years, with a clear indication of the organic loading design approved in the WQM Part II Permit. 25 PA § 94.21 and § 94.22 require action for an existing or projected Facility overload, respectively, either as hydraulic or organic overload.

An existing *hydraulic overload* is identified by an exceedance of the permitted hydraulic design capacity of the treatment plant for three consecutive months or which otherwise results in an overflow of a treatment unit, whereas an existing ***organic overload*** **is identified by an exceedance of the organic design capacity of the treatment plant in any given month**. A projected hydraulic overload is identified if the *maximum three-month average flow rate* will exceed the permitted hydraulic design capacity in the next five years, whereas **a projected organic overload is identified if the *maximum monthly average organic load* entering the system will exceed the treatment system design capacity in the next five years.**

According to CH 94 regulations, the owners of the facility are required to take immediate and appropriate measures to either reduce the overload at the facilities or commence the planning (ACT 537) and design/permitting/construction to eliminate the overload and provide capacity for the anticipated future conditions. This process requires review/docket approval by DRBC, which would, based on previous DRBC feedback, trigger substantial alteration. Prior dialogue with DRBC indicates this to be the case (See Attachment 6), since they indicated a change in the permitted Design Organic Capacity would trigger Substantial Alteration.

The WQM Part II permit for KIWWTP currently lists the following design capacities:

- Annual Average Flow = 40 MGD (not a permit limit; used to calculate Design Organic Capacity)
- Design Hydraulic Capacity = 44.6 MGD
- Design Organic Capacity = 70,000 lbs/day

Thus, for KIWWTP, any projection of a maximum monthly organic load > 70,000 lbs/day entering the system will trigger Regulatory review and approval by both PADEP and the DRBC, and would likely be considered by the DRBC as a 'Substantial Alteration'.

Concluding Remarks

The following are summary remarks based on the information provided here with this memorandum:

- The combination of influent organic loading, springtime season conditions (May), and the 5 mg NH_3-N/L ammonia limit, sets the governing capacity condition for KIWWTP.
- With the addition of CEPT and reasonable gains in improved primary treatment performance, the influent organic loading under the above governing capacity condition can be increased to the Design Organic Capacity of 70,000 lb-BOD/d. With CEPT, the liquid stream capacity of the current

mainstream treatment unit processes is fully restored. It is important that a structured technical analysis of CEPT with full-scale demonstration be conducted to quantify and confirm the performance improvements gained with CEPT on the KIWWTP primary clarifier facilities.

- Improvements are necessary to firm up sludge stabilization and dewatering to build out the balance of KIWWTP and align with the KIWWTP's permitted capacity of 70,000 lb-BOD/d. Capital improvement planning for CEPT improvements and sludge stabilization and dewatering capacity improvements is $17.36M.
- Under Alternative 8b or similar PTP scenarios (such as Alternative 5c), the influent organic loading to KIWWTP is projected to increase immediately to approximately 56,000 lb-BOD/d once the load shift is initiated, potentially reaching in the range of 70,000 lb-BOD/d by the year 2035, depending on the future growth of the signatories.
- Improvements to add permanent CEPT facilities and build out the balance of the solids management facilities to 70,000 lb-BOD/d capacity is not likely to trigger capacity expansion or Substantial Alteration based on a precedent similar digestion capacity firming project and separate CEPT project at the Bethlehem WWTP both did not trigger substantial alteration. Updated feedback from DRBC is in order.

Moving Forward – Further Study

Sedimentation and Hydrolysis in Sewer Collection Systems

The potential increase in sedimentation and hydrolysis within sewer collection systems due to the PTP load shift may significantly impact hydraulic conditions, odor production, and the influent wastewater quality at KIWWTP. Further study is recommended to d assess impacts and mitigation measures when the current key evaluations are complete, and a plan is firmed up.

- Sedimentation leads to the accumulation of solids at the bottom of sewer pipes, reducing their effective diameter. This restriction can decrease the sewer's flow capacity, resulting in slower flow rates and potential backflows, especially during heavy rainfall or peak flow periods.
- The buildup of sediments increases the pipe's interior roughness, creating additional frictional resistance to flow. This requires more energy or pressure to maintain the same flow rate, leading to increased head loss and higher operational costs due to more frequent pumping or cleaning needs. There was a discussion about whether installing a new KI influent pump station would be an appropriate approach to lower the HGL.
- Sedimentation can create stagnant conditions, promoting anaerobic environments where hydrogen sulfide gas is produced, causing unpleasant odors and corrosion of sewer infrastructure.
- In the long-distance sewer collection system from PTP Effluent to KIWWTP Influent pump station, extended transit time can lead to hydrolysis, particularly in warm temperatures. Hydrolysis can cause odor issues and the accumulation of biofilms in the sewer intercept.
- From a KI capacity standpoint, hydrolysis poses a problem because some of the colloidal BOD captured by CEPT may become solubilized and pass through primary treatment in spite of CEPT and compromise the load shift of BOD directly to digesters.

Digester Mixing

Previous CFD modeling from 2010 indicated the impact of increasing percent solids on digester mixing performance and how the active volume significantly decreases at higher solids concentrations, where digester rheology shifts from “watery” to “ketchup.” While the glass-lined primary sludge pipe and CEPT would increase the capacity of existing digesters, improved mixing is necessary due to the increased solids concentration.

Operations staff have expressed satisfaction with the existing Pearth™ Digester Gas Mixing system, so refurbishment remains the base case. However, a future evaluation of alternative mixing systems, such as LM™ (Linear Motion) Mixers, Vaughan Chopper Pumps/Scum Busters, is recommended.

Dewatering Upgrade

There are several options for upgrading the existing dewatering equipment, including adding a fourth belt filter press or replacing it with newer dewatering technologies. However, the current building likely cannot accommodate an additional belt filter press. The cost estimate provided is based on installing four centrifuges, which will fit within the existing structure. To optimize economies of scale and leverage existing pumping and piping infrastructure, choosing three larger centrifuges or screw presses would reduce CAPEX.

It is recommended to discuss alternative dewatering technologies with the DRBC as a preferred option over replacing aging equipment with similar units. Their confirmation is necessary to ensure that such an upgrade does not trigger a Substantial Alteration.

Sludge Holding Tank between Digesters and Dewatering

Since the existing secondary digester is proposed to be converted into a primary digester, a new digested sludge holding tank is included in the cost estimate to coordinate daily operations with continuous digester throughput. Despite some concern regarding the need for a buffer to decouple digestion from dewatering, AECOM recommends maintaining this flexibility to handle unexpected events.

Ammonia Leveling

Ammonia leveling is primarily influenced by the dewatering schedule. Leveling is achieved through 24/7 dewatering, not by using a holding tank buffer between digesters and dewatering. For true leveling, a holding tank for filtrate (or centrate) is required.

Alternative Technologies

AECOM suggests proceeding with CEPT and the glass-lined pipe as the base case, optimizing and establishing a new baseline. Alternative technologies would then be evaluated to determine whether OPEX savings justify the investment or if additional capacity is needed when influent organic loading approaches 70,000 lbs BOD/day.

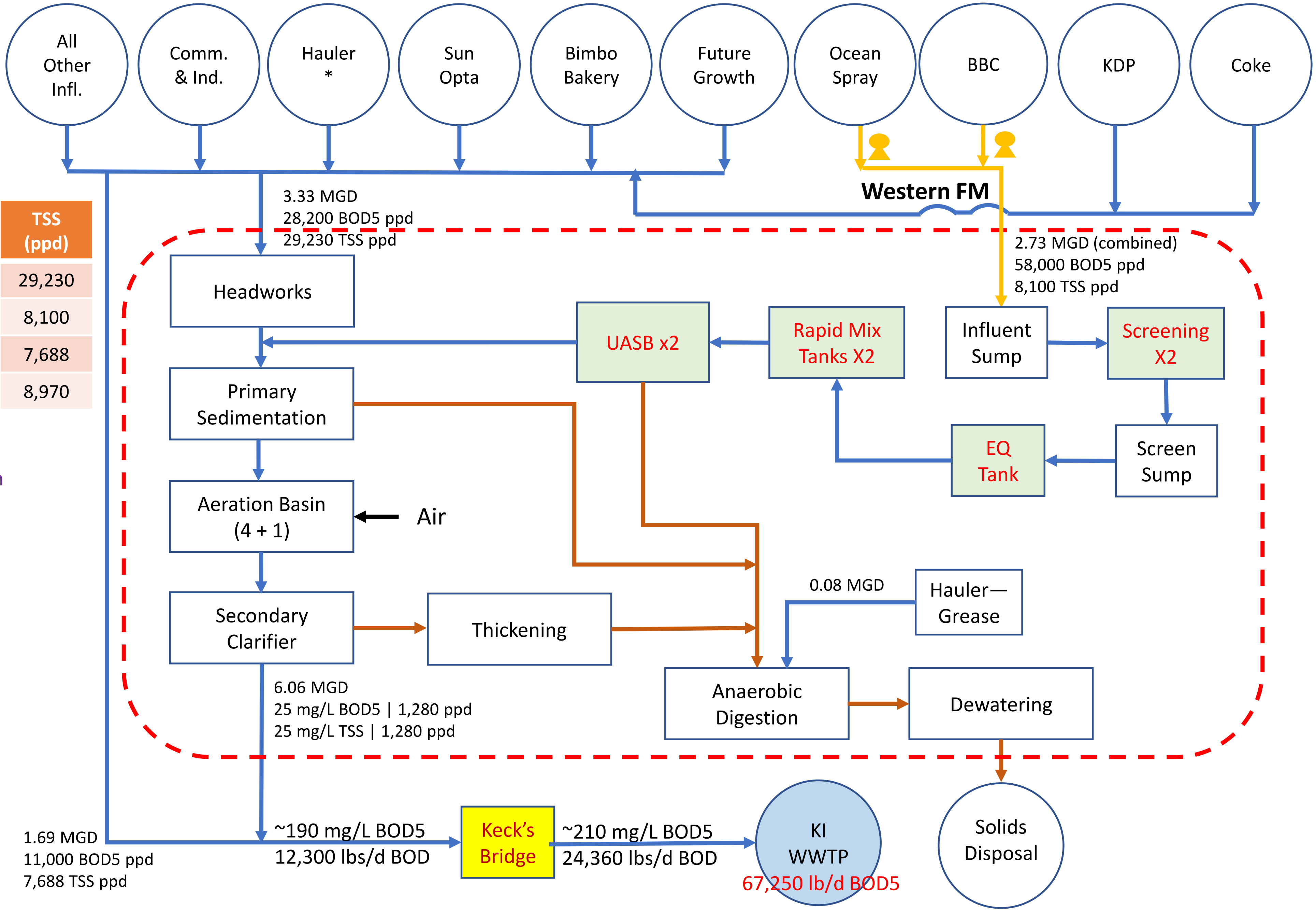
Overall, if changes to the PTP are expected by 2027, design efforts, including those at Kline’s Island WWTP, must begin soon.

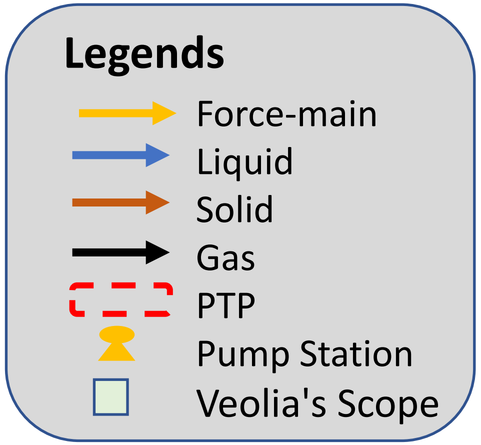
Attachment 1

Alt 8b — BBC/OS to High-rate ANA. West FM. Atmospheric Air-Secondary. Revised on July 5, 2024.

	Flow (MGD)	BOD5 (ppd)	TSS (ppd)
To PTP Headworks	3.33	28,200	29,230
To PTP Pre-ANA	2.73	58,000	8,100
Bypass to KI WWTP	1.69	11,000	7,688
Total to KI WWTP	7.84	12,280	8,970

* Assuming all hauler revenue retained with adding septage receiving station (70% to Headworks or 30% to digesters).



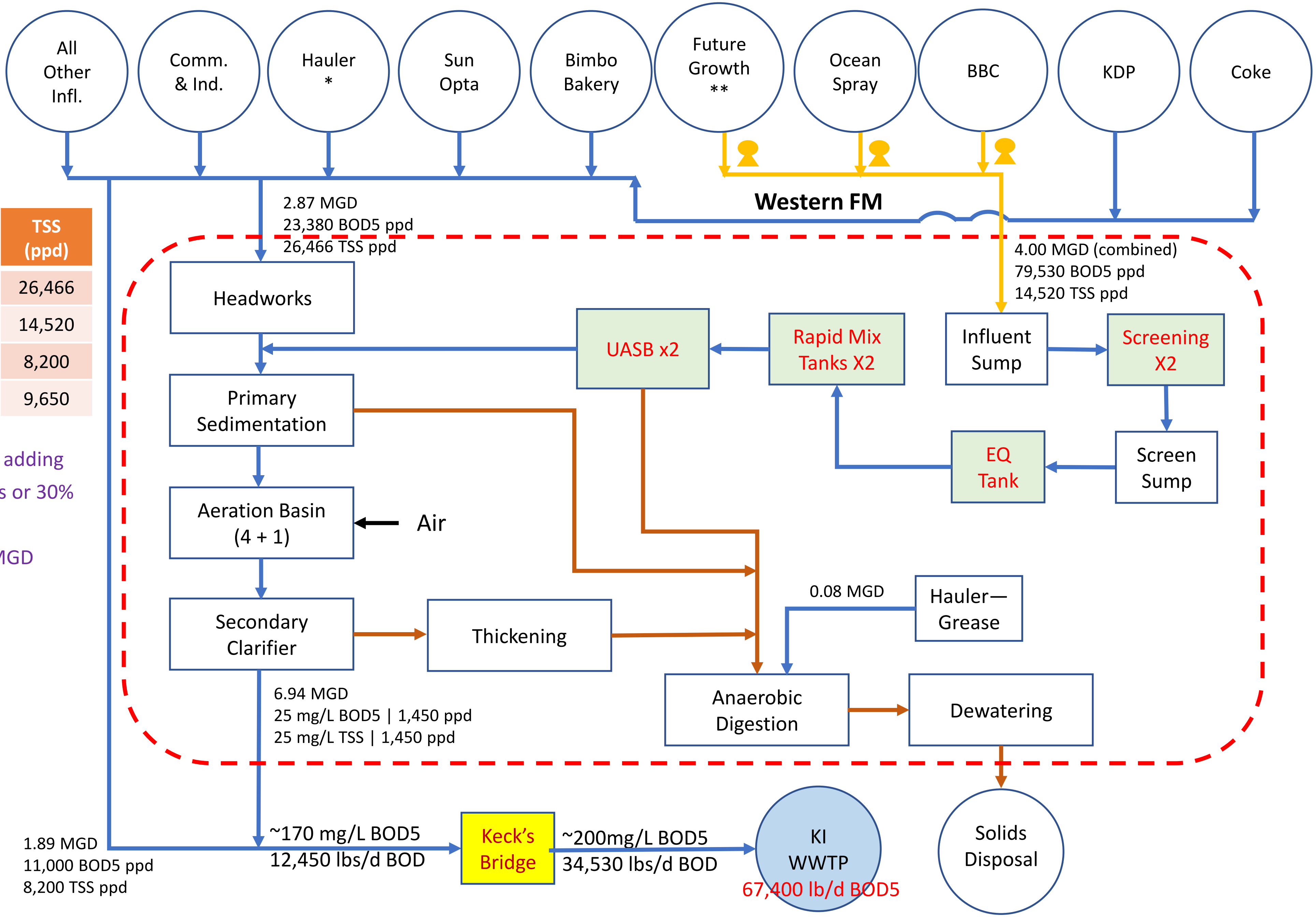


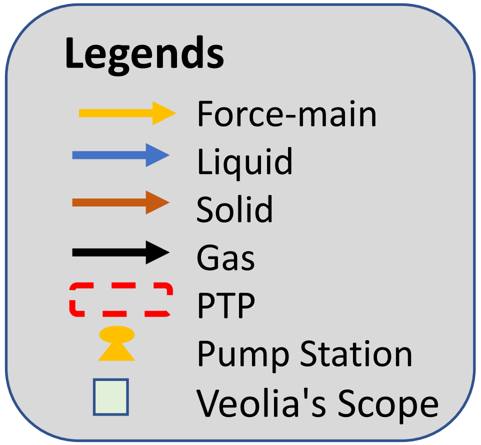
Alt 8b^ — BBC/OS/Future Growth to High-rate ANA. West FM. Atmospheric Air-Secondary. Revised on July 5, 2024.

	Flow (MGD)	BOD5 (ppd)	TSS (ppd)
To PTP Headworks	2.87	23,380	26,466
To PTP Pre-ANA	4.00	79,530	14,520
Bypass to KI WWTP	1.89	11,000	8,200
Total to KI WWTP	8.84	12,450	9,650

* Assuming all hauler revenue retained with adding septage receiving station (70% to Headworks or 30% to digesters).

** Assuming all future growth (including 1 MGD adder) will be treated by UASB.



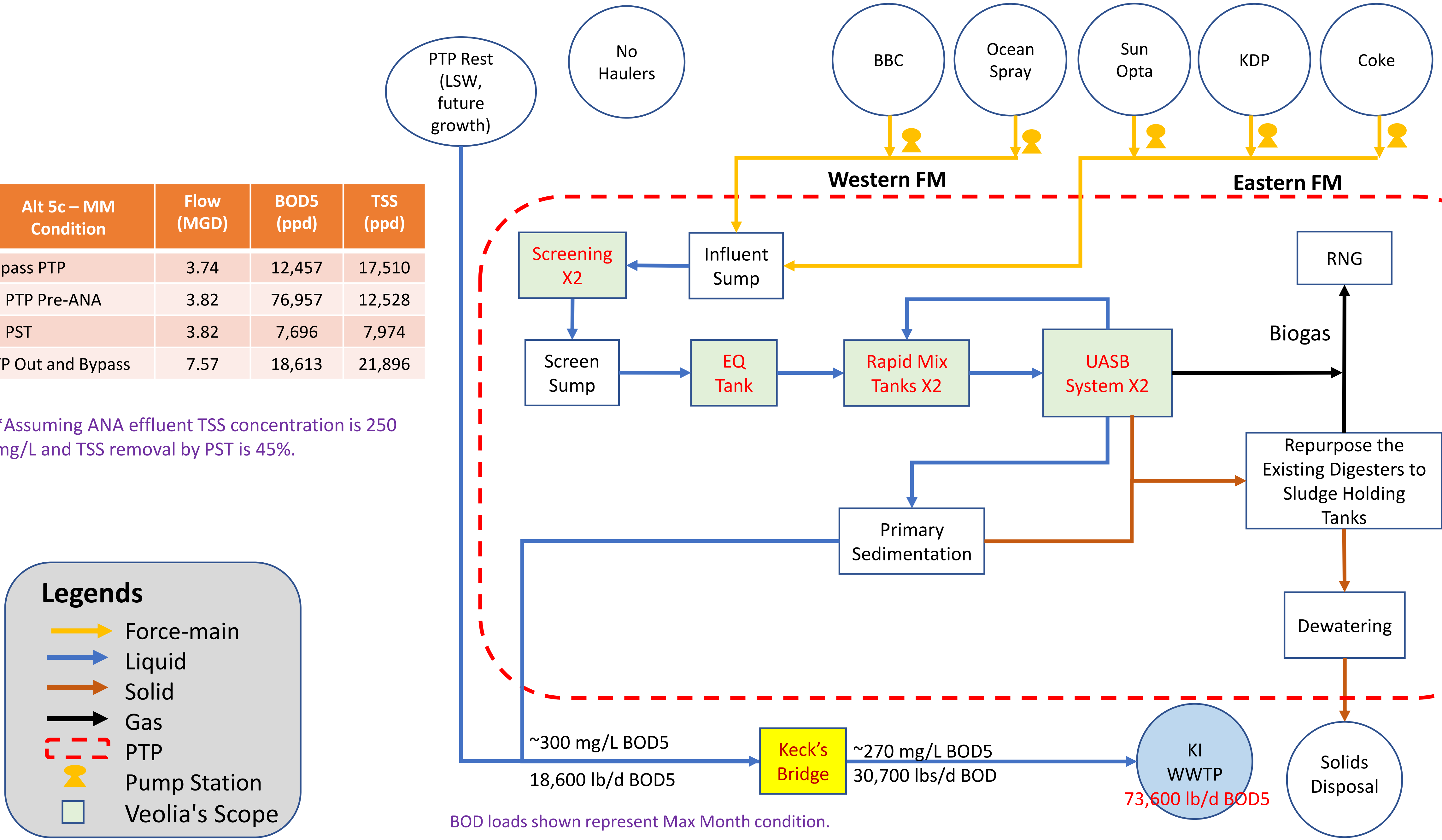


Attachment 2

Alt 5c — Top 5 Industries treated by UASB, w/ Primaries. Revised on July 5, 2024.

Alt 5c – MM Condition	Flow (MGD)	BOD5 (ppd)	TSS (ppd)
Bypass PTP	3.74	12,457	17,510
To PTP Pre-ANA	3.82	76,957	12,528
To PST	3.82	7,696	7,974
PTP Out and Bypass	7.57	18,613	21,896

*Assuming ANA effluent TSS concentration is 250 mg/L and TSS removal by PST is 45%.

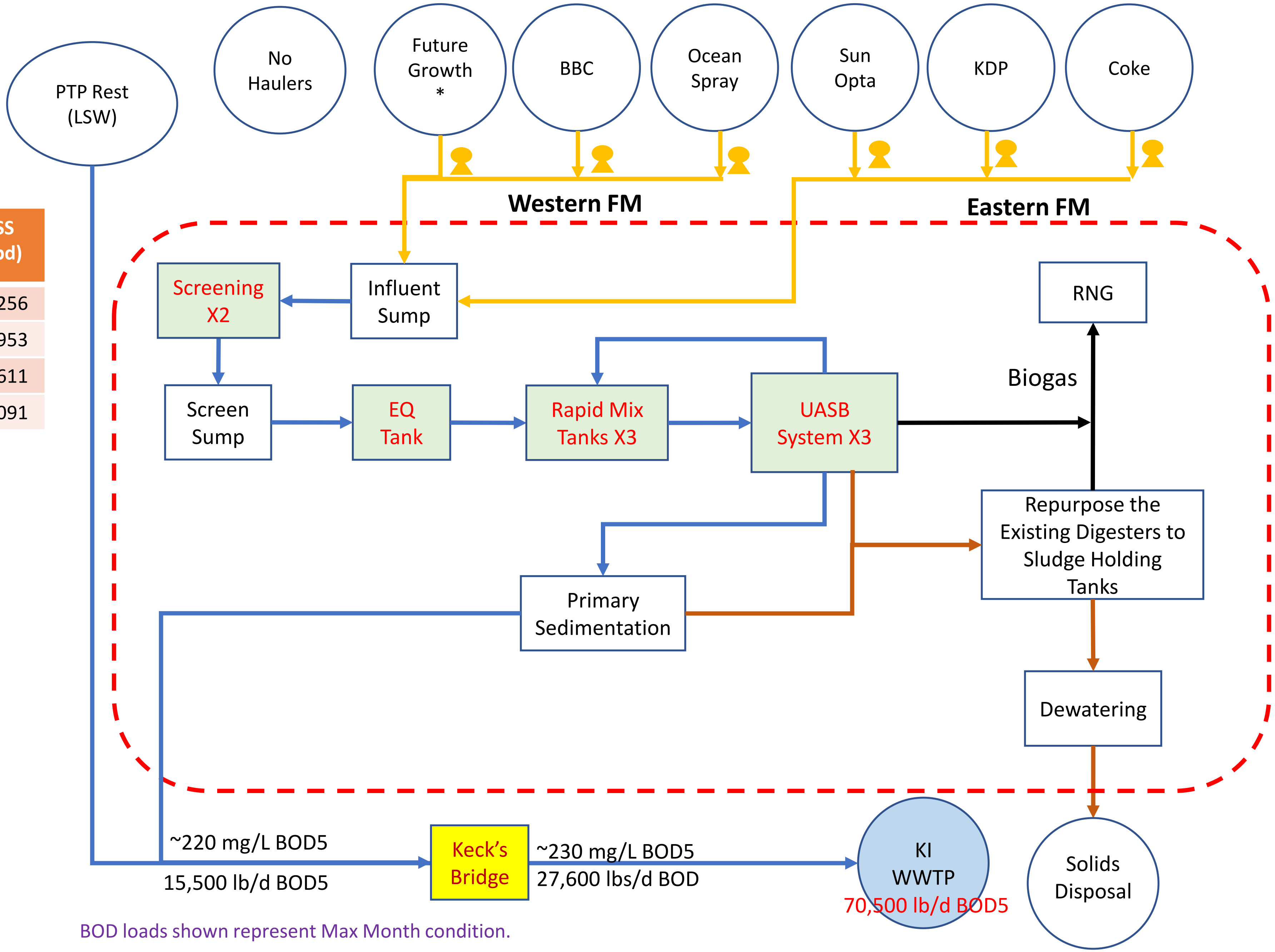


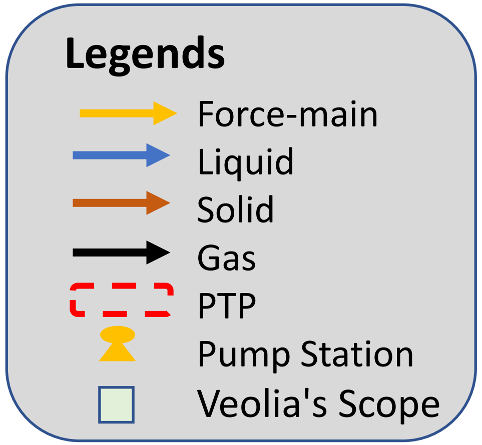
BOD loads shown represent Max Month condition.

Alt 5c^ — Top 5 Industries + future growth treated by UASB, w/ Primaries. Revised on July 5, 2024.

Alt 5c – MM Condition	Flow (MGD)	BOD5 (ppd)	TSS (ppd)
Bypass PTP	3.48	7,626	15,256
To PTP Pre-ANA	5.09	98,468	18,953
To PST	5.09	9,847	10,611
PTP Out and Bypass	8.57	15,503	21,091

*Assuming all future growth (including 1 MGD adder) will be treated by UASB in Phase 2, ANA effluent TSS concentration is 250 mg/L and TSS removal by PST is 45%.





BOD loads shown represent Max Month condition.

Attachment 3

Actual data obtained from PTP and KIWWTP annual reports, as well as the 2021 PTP Master Plan
Future projections derived from the KIWWTP Future Flow Projections and the most recent 2035 PTP Industry Flows and Loads Projection.
Assumptions

Assumptions:

ANA BOD removal %	90%	
BOD concentration for the future growth of LCA Rest (LCA Sig less PTP) and KIWWTP Sig In	250	mg/L
MM/AA Load PF - domestic ww	1.11	7 year avg MM/AA ratio according to Chapter 94 Spreadsheet
MM/AA Flow PF - domestic ww	1.19	7 year avg MM/AA ratio according to Chapter 94 Spreadsheet
MM/AA Load PF for PTP Non-BBC WW	1.31	

	PTP Out			WLI at Keck's Bridge			WLI Less PTP			Non-WLI			Total to KIWWTP		
	AA Flow	AA BOD Load	BOD Conc.	AA Flow	AA BOD Load	BOD Conc.	AA Flow	AA BOD Load	BOD Conc.	AA Flow	AA BOD Load	BOD Conc.	AA Flow	AA BOD Load	BOD Conc.
2021	5.18	1,591	37	9.43	10,142	129	4.25	8,551	241	22.84	32,139	169	32.26	42,281	157
2035	5.95			10.99			5.04	10,200	243	26.32	39,400	180	37.31		

	200 mg/L at Keck's Bridge								
	WLI at Keck's Bridge			Non-WLI			Total to KIWWTP		
	Flow	BOD Load	BOD Conc.	Flow	BOD Load	BOD Conc.	Flow	BOD Load	BOD Conc.
2021 AA	9.43	15,726	200	22.84	32,139	169	32.26	**47,865**	178
2021 MM	11.69	19,494	200	25.90	35,615	165	37.59	**55,108**	176
2035 AA	10.99	18,334	200	26.32	39,400	180	37.31	**57,734**	186
2035 MM	13.55	22,609	200	31.24	43,661	168	44.79	**66,271**	177

Attachment 4

AECOM

Memorandum

Date:	June 26, 2023 – **UPDATED NOVEMBER 14, 2023**
From:	Kevin Frank, PE
To:	Chris Curran, PE, Ralph Eschborn, PE
Subject:	Kline’s Island WWTP BOD Loading Sensitivity Analysis

INTRODUCTION

The Kline’s Island WWTP is a two-stage trickling filter plant with primary treatment, plastic media trickling filters, intermediate clarifiers, fixed-nozzle rock media trickling filters, and final clarifiers. The plant’s annual average and maximum month average flows are respectively about 30 and 40 MGD. The annual average and maximum month average BOD_5 loading have historically been about 37,000 lbs/d and 40,000 lbs/d. The Kline’s Island WWTP service area also includes a high purity oxygen (HPO) pretreatment plant that pretreats industrial wastewater prior to discharge to the Kline’s Island WWTP. The pretreatment plant is currently faced with high upgrade and expansion capital costs to handle projected industrial loadings.

METHODOLOGY

A preliminary investigation of the BOD_5 loading capacity of the Kline’s Island WWTP was carried out to determine how much additional BOD loading the plant can handle, which could possibly offset the expansion requirements at the pretreatment plant. A process model of the Kline’s Island WWTP was developed in GPS-X version 6 in 2014. The model was developed, calibrated, and validated to multiple historical datasets of varying temperatures and loadings as part of evaluating potential new effluent limits associated with the Delaware River Basin Commission (DRBC). For this preliminary BOD capacity investigation, the model was updated to GPS-X version 8 and checked for dynamic calibration with one of the original dynamic datasets (February 2012). The version 8 model’s calibration performance was nearly identical to that of version 6 developed in 2014. The GPS-X version 8 existing plant process model layout is illustrated in **Figure 1**.

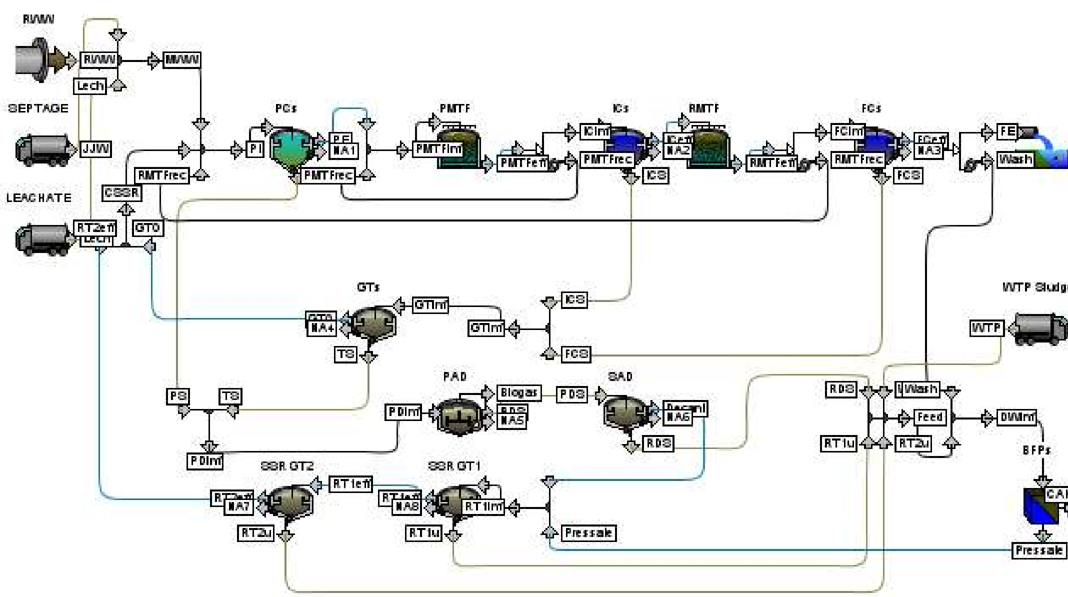


Figure 1. Kline’s Island WWTP process model updated to GPS-X Version 8

The Kline's Island WWTP NPDES effluent BOD_5 limits are 20 mg/L and 30 mg/L, respectively expressed as monthly and weekly averages. The NPDES cold weather (November through April) and warm weather (April through October) effluent ammonia limits are respectively 15 mg/L and 5 mg/L, both expressed as monthly averages. The cold weather period temperatures have historically ranged from about 11°C to 16°C and the warm weather period temperatures have typically ranged from about 16°C to 24°C.

To conduct the preliminary BOD loading capacity analysis, the GPS-X "Analyze" feature was employed to conduct a performance sensitivity analysis on the raw wastewater (RWW) COD concentration for various temperatures and plant upgrade scenarios. The GPS-X analyze feature enabled a series of steady-state simulations, where the COD was incrementally increased by 10 mg/L until a modeled permit violation was observed (either due to effluent BOD or ammonia). The RWW COD was then converted to BOD with the historical RWW BOD/COD factor of 0.48.

EXISTING WWTP CAPACITY

The RWW COD sensitivity analysis for the existing WWTP at 11°C showed that the NPDES cold weather effluent ammonia limit of 15 mg/L would be exceeded at a RWW COD of 800 mg/L, which is equivalent to about 96,000 lbs/d of BOD as illustrated in **Figure 2**. The RWW COD sensitivity analysis for the existing WWTP at 17°C showed that the NPDES warm weather effluent ammonia limit of 5 mg/L would be exceeded at a RWW COD of 470 mg/L, which translates to about 56,000 lbs/d of BOD as shown in **Figure 3**.

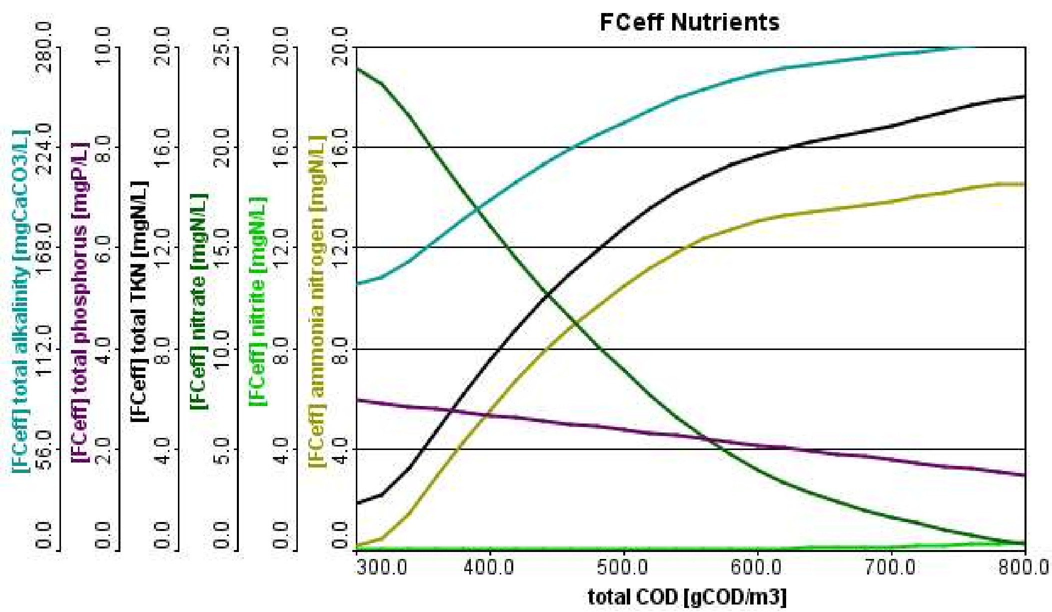


Figure 2. Existing WWTP RWW COD sensitivity analysis at 11°C

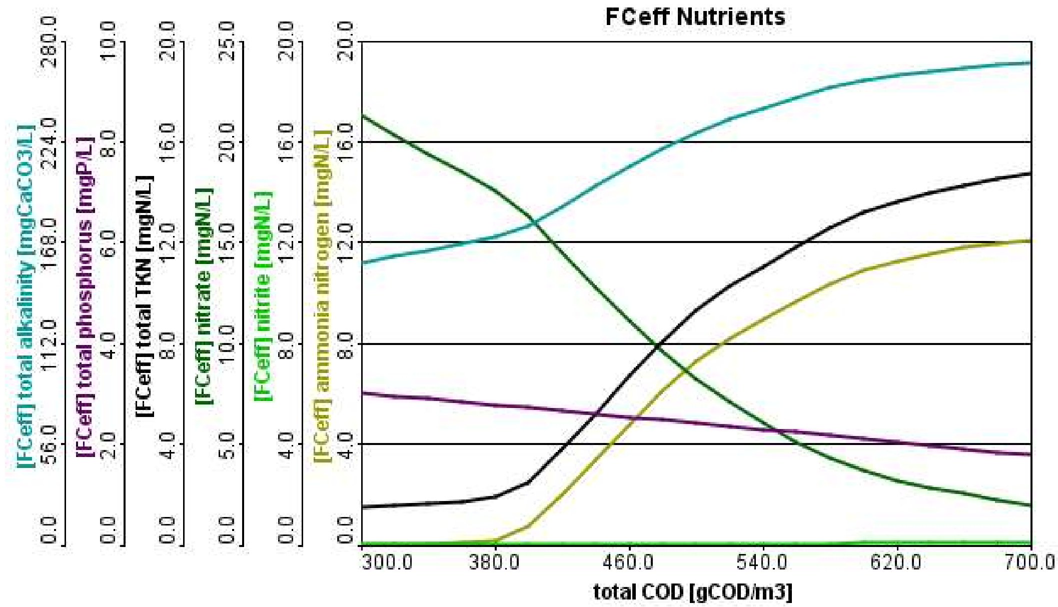


Figure 3. Existing WWTP RWW COD sensitivity analysis at 17°C

CHEMICALLY ENHANCED PRIMARY TREATMENT

CEPT is a proven upgrade for primary treatment where a combination of anionic polymer and ferric chloride is added to the primary influent. Dosages of each are typically around 3 mg/L and 0.5 mg/L, respectively. At these dosages, solids removal is normally increased by a factor of 1.4 and BOD removal can be doubled relative typical primary treatment. This will have a beneficial cascading effect of lowering the PMTF BOD loading and increase its BOD and ammonia removal performance. This will, in turn, lower the RMTF BOD loading and provide similar benefits. To model CEPT, the primary clarifier object's solids removal was simply increased to 85%.

The CEPT simulation was run for both 11°C and 17°C. For the 11°C simulation, the effluent ammonia did not reach the cold weather NPDES permit limit of 15 mg/L for RWW COD concentrations up to 1,000 mg/L but leveled out at about 10 mg/L as illustrated in **Figure 5**. This translates to a BOD loading of 120,000 lbs/d. The 17°C CEPT simulation showed that the NPDES warm weather effluent ammonia limit of 5 mg/L would be exceeded at a RWW COD of 780 mg/L as shown in **Figure 6**, which is equivalent to about 93,000 lbs/d of BOD.

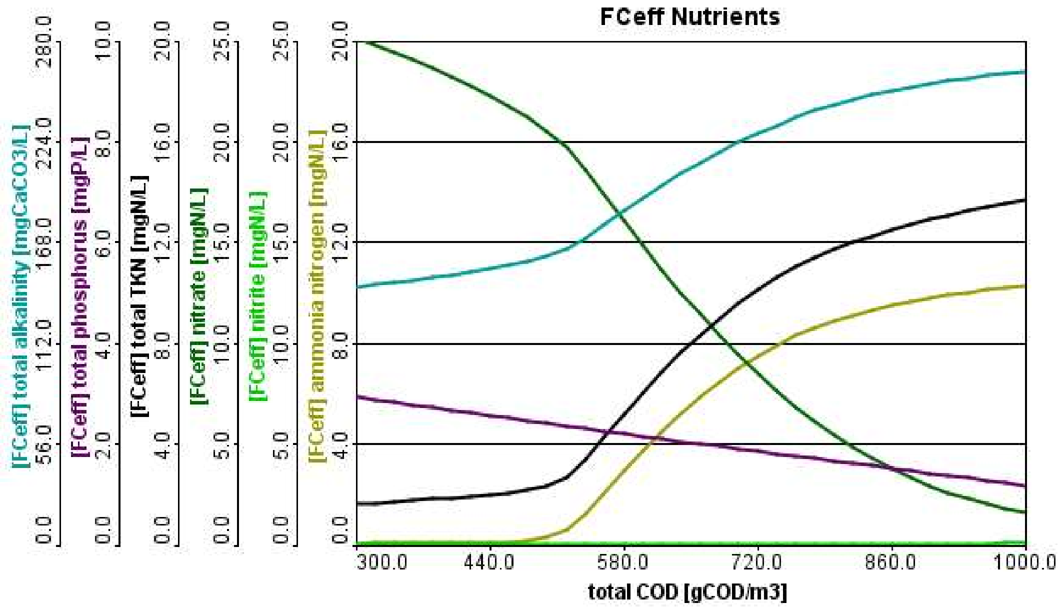


Figure 5. RWW COD sensitivity analysis at 11°C with the addition of CEPT

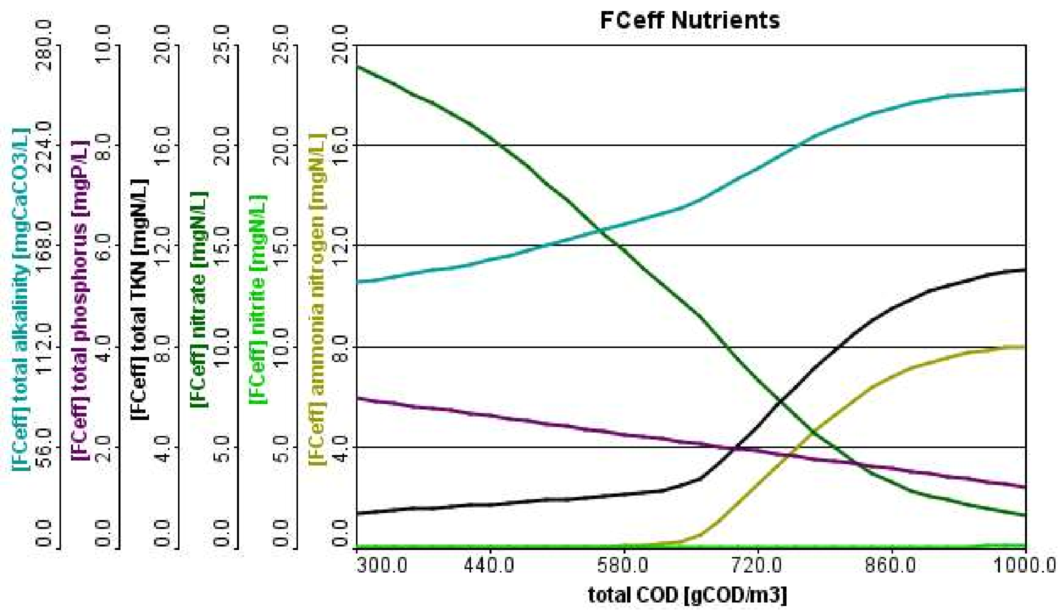


Figure 6. RWW COD sensitivity analysis at 17°C with the addition of CEPT

PLANT UPGRADES ASSOCIATED WITH DRBC LIMITS

Lastly, simulations were carried out with the upgrades developed for meeting the DRBC limits in 2014. This model reflected the addition of CEPT, the changeout of a fraction of the rock media with Brentwood Industries CF-1900 plastic cross flow media (specific surface area = 48 ft^2/ft^3), as shown in **Figure 7**, and the addition of a side-stream treatment system that can remove 90% of the side-stream ammonia loading. Simulations were carried out that assumed a 50% changeout of rock media to provide an overall specific surface area of 32.5 ft^2/ft^3 and a complete 100% changeout of rock media to provide 48 ft^2/ft^3. **Figure 8** illustrates the upgraded Kline's Island WWTP process model updated to GPS-X version 8.

Figure 7. Brentwood Industries CF-900 cross flow media (specific surface area = 48 ft^2/ft^3)

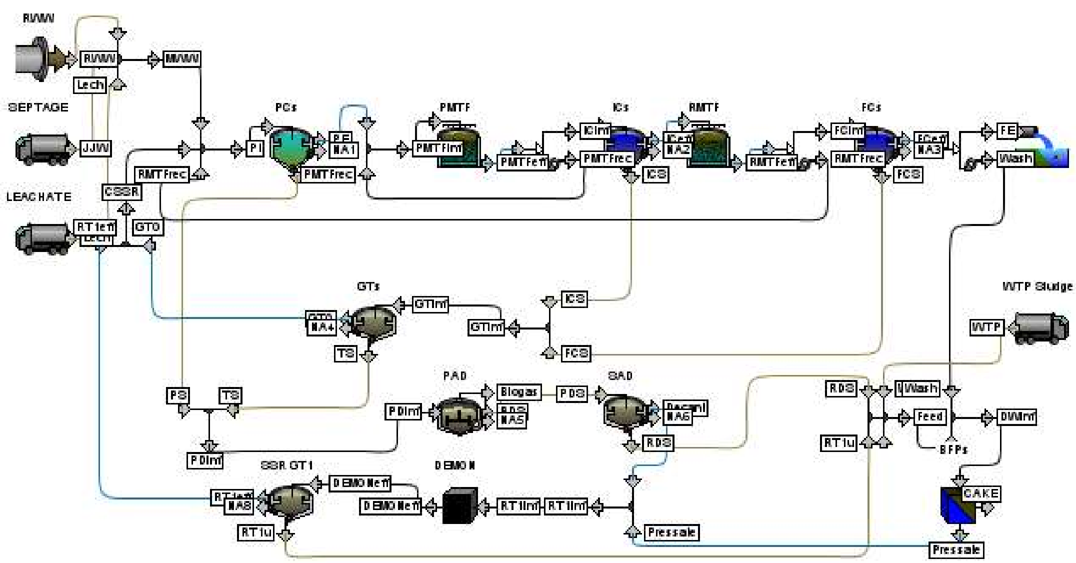


Figure 8. Kline's Island WWTP with upgrades process model updated to GPS-X Version 8

The RWW COD sensitivity analysis for the WWTP with the aforementioned upgrades were conducted at both 11°C and 17°C. The effluent performance showed a very abrupt and sharp increase in effluent carbonaceous material as the trickling filters became overloaded shortly after the RWW COD reached 1,000 mg/L, so the practical acceptable RWW COD is probably less. At respective cold weather and warm weather RWW COD concentrations of 850 mg/L and 900 mg/L, which reflects a point prior to the rapid increase in effluent carbonaceous material or the "knee of the curve", translates to a RWW BOD loading of about 150,000 lbs/d and 158,000 lbs/d. **Figure 9** shows the effluent BOD sensitivity analysis results for 17°C.

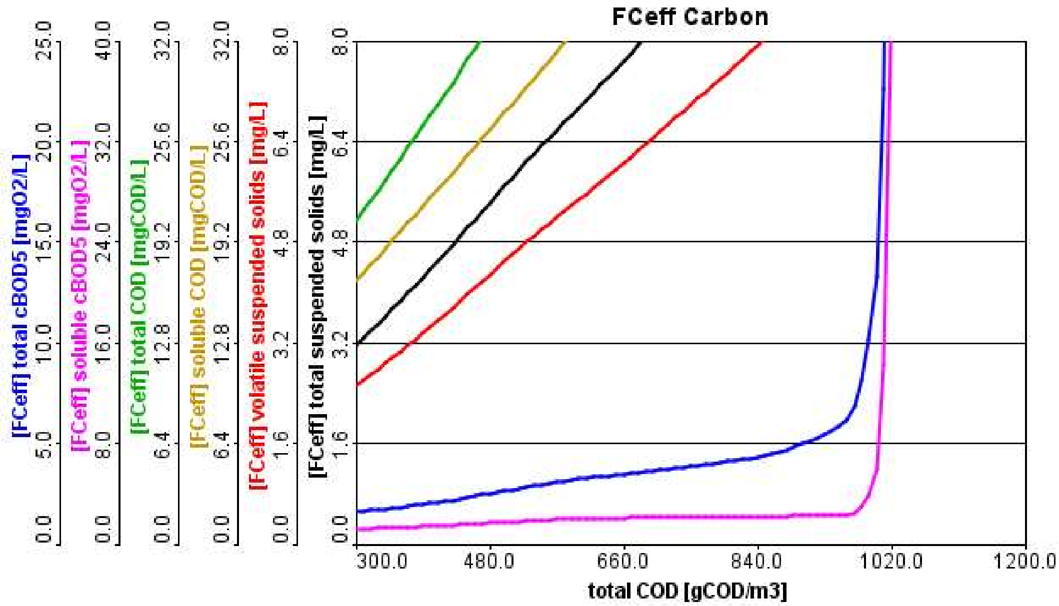


Figure 9. RWW COD sensitivity analysis at 17°C with the addition of CEPT, 50% change out of rock media with CF-1900 plastic crossflow media, and side-stream treatment

CONCLUSIONS

The aforementioned BOD capacity findings have been tabulated in **Table 1** below. Note that these are preliminary simulation results that were determined by simply applying the previously developed process models (existing plant and upgraded plant models) and running a RWW COD concentration sensitivity analysis. The simulations do not account for a change in annual average flow different than that in the model files (30 MGD for existing plant and CEPT, and 44 MGD for the upgraded plant).

Table 1. Preliminary BOD loading capacity estimations for the Kline's Island WWTP

NPDES Limit Parameter	**Unit**	**11°C**	**17°C**	**Limiting Capacity Parameter**
NPDES Effluent BOD Limit	(mg/L)	30	30	
NPDES Effluent Ammonia Limit	(mg/L)	15	5	
BOD Loading Capacity @ NPDES Limits				
Existing Plant	(lbs/d)	96,000	56,000	Exceeded Ammonia Permit
Existing Plant + CEPT	(lbs/d)	120,000	93,000	Exceeded Ammonia Permit
DRBC Limit Parameter				
DRBC Limit	(lbs/d)	439	439	
DRBC Limit @ 44 MGD	(mg/L)	1.2	1.2	
BOD Loading Capacity @ DRBC Limit and 30 mg/L NPDES BOD Limit				
CEPT + 50% RMTF Media Change out + Sidestream Treatment	(lbs/d)	150,000	158,000	Exceeded BOD Permit (DRBC ammonia limit not exceeded due to excessive biomass ammonia assimilation)
CEPT + 100% RMTF Media Change out + Sidestream Treatment	(lbs/d)	186,000	188,000	Exceeded BOD Permit (DRBC ammonia limit not exceeded due to excessive biomass ammonia assimilation)

Attachment 5

PROJECT: LEHIGH COUNTY AUTHORITY ACT 537 PLAN UPDATE
SUBJECT: QUANTIFIED MASS-FLOW DIAGRAM OF KLINE ISLAND WWTP HISTORICAL DATA
TIME FRAME: 1/1/10 THROUGH 12/31/12
COLOR CODING: BLUE VALUES INDICATE HISTORICAL MEASUREMENTS, RED VALUES ARE CALCULATED/ESTIMATED

PROJECT NO. : 60289047.2
DATE: 24-Oct-2023
COMPTED BY: K. FRANK

AECOM

RMTF RECIRCULATION		
Q (MGD)	2.56	
	(mg/L)	(lbs/d)
TSS	12	251
VSS	9.3	198
BOD	6.9	148
TKN	3.3	71
NH4-N	0.8	18
TP	3.3	71
OP	2.9	63
ALK	181	3,870

PRIMARY CLARIFIERS		
AREA	(ft^2)	45,239
VOLUME	(MG)	4.08
SOR	(gpd/ft^2)	820
HRT	(h)	2.6
TSS RE	(%)	60
BOD RE	(%)	39

PLASTIC MEDIA TFs	
TOP SURFACE (ft^2)	31,416
MEDIA VOLUME (ft^3)	1.01E+06
MEDIA AREA (ft^2)	2.71E+07
BOD Loading (lbs/d/kft^3)	24
Nit. Rate (gN/m^2•d)	0.47
HLR (gpd/ft^2)	1,394
BOD η (%)	66
NH4-N η (%)	54

INTERMEDIATE CLARIFIERS		
AREA	(ft^2)	46,181
VOLUME	(MG)	4.15
SOR	(gpd/ft^2)	784
TSS RE	(%)	69

ROCK MEDIA TFs	
TOP SURFACE (ft^2)	232,030
MEDIA VOLUME (ft^3)	2.32E+06
MEDIA AREA (ft^2)	3.94E+07
BOD Loading (lbs/d/kft^3)	3.5
Nit. Rate (gN/m^2•d)	0.21
HLR (gpd/ft^2)	156
BOD η (%)	82
NH4-N η (%)	75

FINAL CLARIFIERS		
AREA	(ft^2)	69,194
VOLUME	(MG)	6.21
SOR	(gpd/ft^2)	482
TSS RE	(%)	55

RAW WASTEWATER		
Q (MGD)	32.81	
	(mg/L)	(lbs/d)
TSS	152	41,714
VSS	134	36,702
BOD	139	38,051
TKN	28	7,705
NH4-N	15	4,230
TP	4.1	1,123
OP	2.4	669
ALK	288	78,794

Calculated w/ measured return loadings

RAW WASTEWATER		
Q (MGD)	32.81	
	(mg/L)	(lbs/d)
TSS	148	40,517
VSS	131	35,762
BOD	134	36,734
TKN	25.5	6,977
NH4-N	12.7	3,462
TP	4.1	1,123
OP	2.4	669
ALK	288	78,794

Calculated w/ calculated return loadings

PRIMARY INFLUENT		
Q (MGD)	37.16	
	(mg/L)	(lbs/d)
TSS	140	43,511
VSS	123	38,081
BOD	125	38,872
TKN	29	8,871
NH4-N	16.5	5,120
TP	4.9	1,533
OP	3.3	1,023
ALK	287	89,045
TEMP	(°C)	16.0
pH	(S.U.)	7.3

PRIMARY EFFLUENT		
Q (MGD)	37.08	
	(mg/L)	(lbs/d)
TSS	56	17,218
VSS	49	15,069
BOD	77	23,894
TKN	25	7,742
NH4-N	15.6	4,836
TP	4.0	1,223
OP	3.3	1,021
ALK	282	87,335

PMTF RECIRC	
Q (MGD)	6.72

PMTF EFFLUENT		
Q (MGD)	37.08	
	(mg/L)	(lbs/d)
TSS	59	18,144
VSS	46	14,352
TKN	14	4,331
NH4-N	7.4	2,296
TP	4.0	1,223
OP	3.0	936
ALK	225	69,593

IC EFFLUENT		
Q (MGD)	36.21	
	(mg/L)	(lbs/d)
TSS	18	5,500
VSS	14	4,350
BOD	27	8,228
TKN	11.1	3,364
NH4-N	7.4	2,221
TP	3.3	1,001
OP	3.0	914
ALK	225	67,964
TEMP	(°C)	18.5

RMTF EFFLUENT		
Q (MGD)	33.65	
	(mg/L)	(lbs/d)
TSS	12	3,300
VSS	9.3	2,610
BOD	6.9	1,949
TKN	3.3	937
NH4-N	0.8	233
TP	3.3	930
OP	2.9	826
ALK	181	50,902
TEMP	(°C)	17.1

FINAL EFFLUENT		
Q (MGD)	33.21	
	(mg/L)	(lbs/d)
TSS	5.3	1,471
VSS	4.2	1,164
BOD	5.4	1,484
TN	19	5,399
TKN	4.3	1,183
NH4-N	2.0	564
NO2-N	0.2	57
NO3-N	15.0	4,159
TP	3.1	872
OP	2.9	815
ALK	181	50,238

RETURN STREAMS (Meas.)		
Q (MGD)	1.74	
	(mg/L)	(lbs/d)
TSS	68	983
VSS	53	772
BOD	38	551
TKN	73	1,059
NH4-N	60	868
TP	23	329
OP	20	290
ALK	438	6,361

PRIMARY SLUDGE		
Q (MGD)	0.078	
	(mg/L)	(lbs/d)
TSS	37,012	24,180
VSS	32,393	21,162

xTKN/VSS
2144 10.1%
309 1.5%

IC SLUDGE		
Q (MGD)	0.87	
	(mg/L)	(lbs/d)
TSS	1,747	12,645
VSS	1,382	10,002
Yobs (VSS/BOD)		0.92

FC SLUDGE		
Q (MGD)	0.32	
	(mg/L)	(lbs/d)
TSS	674	1,823
VSS	533	1,442
Yobs (VSS/BOD)		0.39

SEPTAGE		
Q (MGD)	0.0057	
	(mg/L)	(lbs/d)
TSS	11,768	564
VSS	8,535	409
BOD	2,555	122
TKN	753	36
NH4-N	87	4.2
TP	226	10.8
OP	3.2	0.2
ALK	411	20

RETURN STREAMS (Calc.)		
Q (MGD)	1.39	
TSS	188	2,180
VSS	148	1,712
BOD	161	1,868
TKN	154	1,787
NH4-N	141	1,635
TP	28	329
OP	25	290
ALK	550	6,361

THICKENER SUP		
Q (MGD)	1.15	
	(mg/L)	(lbs/d)
TSS	221	2,114
VSS	175	1,672
BOD	190	1,814
TKN	21	200
NH4-N	5.9	56
TP	6.9	66
OP	3.0	29
ALK	213	2,039
CAPTURE (%)		85.4

TOTAL TF SLUDGE		
Q (MGD)	1.19	
	(mg/L)	(lbs/d)
TSS	1,455	14,468
VSS	1,151	11,444

PRIMARY DIGESTERS		
VOLUME	(MG)	2.1
SRT	(d)	17
TEMP	(°C)	38
VSS DES	(%)	61
BIOGAS	(ft^3/d)	343,738
CH4	(%)	67
CO2	(%)	33
GAS/VSS	(ft^3/lb)	18

THICKENED TF SLUDGE		
Q (MGD)	0.046	
	(mg/L)	(lbs/d)
TSS	32,444	12,354
VSS	25,662	9,772

xTKN 833 8.5%

BFP WW	
Q (MGD)	0.114

WTP SLUDGE		
Q (MGD)	0.0027	
	(mg/L)	(lbs/d)
TSS	24,982	556
VSS	12,491	278

LEACHATE		
Q (MGD)	0.042	
	(mg/L)	(lbs/d)
TSS	74	26
VSS	37	13
BOD	60	21
TKN	320	111
NH4-N	309	108
TP	2.2	0.8
OP	1.1	0.4
ALK	1,000	348

TOTAL SLUDGE		
Q (MGD)	0.124	
	(mg/L)	(lbs/d)
TSS	35,330	36,533
VSS	29,915	30,934

9.6%
1.7%

PDG SLUDGE		
Q (MGD)	0.124	
	(mg/L)	(lbs/d)
TSS	17,161	17,746
VSS	11,561	11,955
ALK	3,704	3,831
VFA	261	270
pH	(S.U.)	7.11

SUPERNATANT		
Q (MGD)	0.0055	
	(mg/L)	(lbs/d)
TSS	6,047	276
VSS	4,259	194
pH	(S.U.)	7.26

BFP FEED SLUDGE (W/ WTP)		
Q (MGD)	0.10	
	(mg/L)	(lbs/d)
TSS	20,181	16,043
VSS	13,592	10,805

SDG SLUDGE		
Q (MGD)	0.119	
	(mg/L)	(lbs/d)
TSS	23,000	22,734
VSS	15,634	15,453
ALK	3843	3,798
VFA	257	254
pH	(S.U.)	7.16

BFP FEED SLUDGE (WWTP)		
Q (MGD)	0.093	
	(mg/L)	(lbs/d)
TSS	20,043	15,487
VSS	13,624	10,527

2ND SST EFFLUENT		
Q (MGD)	0.199	
	(mg/L)	(lbs/d)
TSS	24	40
VSS	16	27
BOD	20	33
TKN	890	1,475
NH4-N	888	1,471
TP	158	262
OP	158	261
ALK	2,398	3,974

2ND SST SLUDGE		
Q (MGD)	0.0009	
	(mg/L)	(lbs/d)
TSS	30,000	225
VSS	20,349	153
CAPTURE (%)		85.0

1ST SST EFFLUENT		
Q (MGD)	0.200	
	(mg/L)	(lbs/d)
TSS	159	265
VSS	108	180

1ST SST SLUDGE		
Q (MGD)	0.006	
	(mg/L)	(lbs/d)
TSS	30,000	1,500
VSS	20,349	1,017
CAPTURE (%)		85.0

SUP + PRESSATE		
Q (MGD)	0.206	
	(mg/L)	(lbs/d)
TSS	1,029	1,764
VSS	698	1,197

SST SLUDGE		
Q (MGD)	0.0069	
	(mg/L)	(lbs/d)
TSS	30,000	1,725
VSS	20,349	1,170

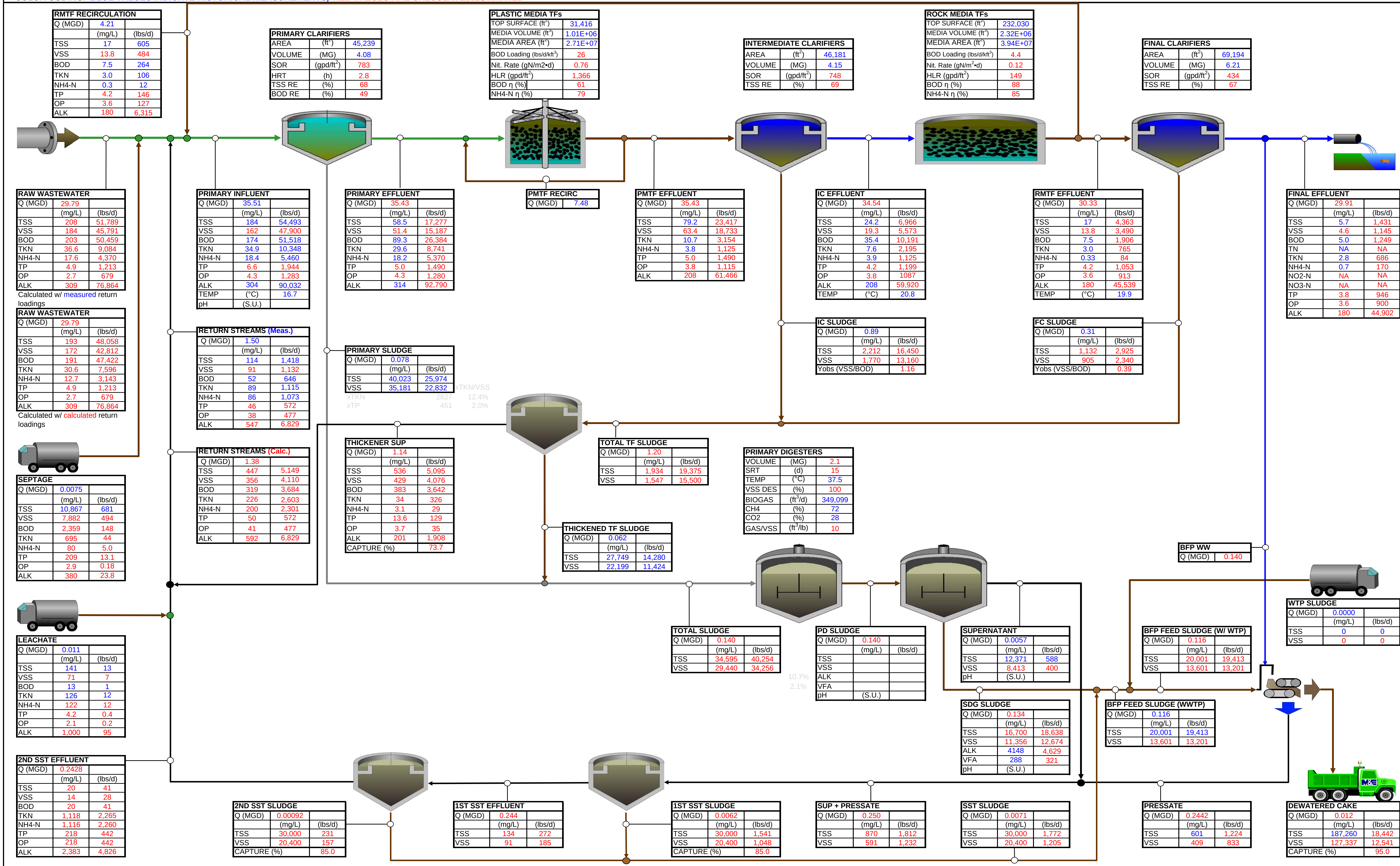
PRESSATE		
Q (MGD)	0.200	
	(mg/L)	(lbs/d)
TSS	892	1,488
VSS	601	1,002

DEWATERED CAKE		
Q (MGD)	0.010	
	(mg/L)	(lbs/d)
TSS	187,629	14,946
VSS	126,371	10,066
CAPTURE (%)		93.2

PROJECT: LEHIGH COUNTY AUTHORITY ACT 537 PLAN UPDATE
SUBJECT: QUANTIFIED MASS-FLOW DIAGRAM OF KLINE ISLAND WWTP HISTORICAL DATA
TIME FRAME: SEPTEMBER 2011
COLOR CODING: BLUE VALUES INDICATE HISTORICAL MEASUREMENTS, RED VALUES ARE CALCULATED/ESTIMATED

PROJECT NO.: 60289047.2
DATE: 24-Oct-2023
COMPTED BY: K. FRANK

AECOM



RMTF RECIRCULATION

Q (MGD)	4.21	
	(mg/L)	(lbs/d)
TSS	17	605
VSS	13.8	484
BOD	7.5	264
TKN	3.0	106
NH4-N	0.3	12
TP	4.2	146
OP	3.6	127
ALK	180	6,315

PRIMARY CLARIFIERS

AREA	(ft^2)	45,239
VOLUME	(MG)	4.08
SOR	(gpd/ft^2)	783
HRT	(h)	2.8
TSS RE	(%)	68
BOD RE	(%)	49

PLASTIC MEDIA TFs

TOP SURFACE (ft^2)	31,416
MEDIA VOLUME (ft^3)	1.01E+06
MEDIA AREA (ft^2)	2.71E+07
BOD Loading (lbs/d/kft^3)	26
Nit. Rate (gN/m2•d)	0.76
HLR (gpd/ft^2)	1,366
BOD η (%)	61
NH4-N η (%)	79

INTERMEDIATE CLARIFIERS

AREA	(ft^2)	46,181
VOLUME	(MG)	4.15
SOR	(gpd/ft^2)	748
TSS RE	(%)	69

ROCK MEDIA TFs

TOP SURFACE (ft^2)	232,030
MEDIA VOLUME (ft^3)	2.32E+06
MEDIA AREA (ft^2)	3.94E+07
BOD Loading (lbs/d/kft^3)	4.4
Nit. Rate (gN/m^2•d)	0.12
HLR (gpd/ft^2)	149
BOD η (%)	88
NH4-N η (%)	85

FINAL CLARIFIERS

AREA	(ft^2)	69,194
VOLUME	(MG)	6.21
SOR	(gpd/ft^2)	434
TSS RE	(%)	67

RAW WASTEWATER

Q (MGD)	29.79	
	(mg/L)	(lbs/d)
TSS	208	51,789
VSS	184	45,791
BOD	203	50,459
TKN	36.6	9,084
NH4-N	17.6	4,370
TP	4.9	1,213
OP	2.7	679
ALK	309	76,864

Calculated w/ measured return loadings

PRIMARY INFLUENT

Q (MGD)	35.51	
	(mg/L)	(lbs/d)
TSS	184	54,493
VSS	162	47,900
BOD	174	51,518
TKN	34.9	10,348
NH4-N	18.4	5,460
TP	6.6	1,944
OP	4.3	1,283
ALK	304	90,032
TEMP	(°C)	16.7
pH	(S.U.)	

PRIMARY EFFLUENT

Q (MGD)	35.43	
	(mg/L)	(lbs/d)
TSS	58.5	17,277
VSS	51.4	15,187
BOD	89.3	26,384
TKN	29.6	8,741
NH4-N	18.2	5,370
TP	5.0	1,490
OP	4.3	1,280
ALK	314	92,790

PMTF RECIRC

Q (MGD)	7.48

PMTF EFFLUENT

Q (MGD)	35.43	
	(mg/L)	(lbs/d)
TSS	79.2	23,417
VSS	63.4	18,733
TKN	10.7	3,154
NH4-N	3.8	1,125
TP	5.0	1,490
OP	3.8	1,115
ALK	208	61,466

IC EFFLUENT

Q (MGD)	34.54	
	(mg/L)	(lbs/d)
TSS	24.2	6,966
VSS	19.3	5,573
BOD	35.4	10,191
TKN	7.6	2,195
NH4-N	3.9	1,125
TP	4.2	1,199
OP	3.8	1087
ALK	208	59,920
TEMP	(°C)	20.8

RMTF EFFLUENT

Q (MGD)	30.33	
	(mg/L)	(lbs/d)
TSS	17	4,363
VSS	13.8	3,490
BOD	7.5	1,906
TKN	3.0	765
NH4-N	0.33	84
TP	4.2	1,053
OP	3.6	913
ALK	180	45,539
TEMP	(°C)	19.9

FINAL EFFLUENT

Q (MGD)	29.91	
	(mg/L)	(lbs/d)
TSS	5.7	1,431
VSS	4.6	1,145
BOD	5.0	1,249
TN	NA	NA
TKN	2.8	686
NH4-N	0.7	170
NO2-N	NA	NA
NO3-N	NA	NA
TP	3.8	946
OP	3.6	900
ALK	180	44,902

RAW WASTEWATER

Q (MGD)	29.79	
	(mg/L)	(lbs/d)
TSS	193	48,058
VSS	172	42,812
BOD	191	47,422
TKN	30.6	7,596
NH4-N	12.7	3,143
TP	4.9	1,213
OP	2.7	679
ALK	309	76,864

Calculated w/ calculated return loadings

RETURN STREAMS (Meas.)

Q (MGD)	1.50	
	(mg/L)	(lbs/d)
TSS	114	1,418
VSS	91	1,132
BOD	52	646
TKN	89	1,115
NH4-N	86	1,073
TP	46	572
OP	38	477
ALK	547	6,829

PRIMARY SLUDGE

Q (MGD)	0.078		
	(mg/L)	(lbs/d)	
TSS	40,023	25,974	
VSS	35,181	22,832	xTKN/VSS
xTKN		2827	12.4%
xTP		451	2.0%

IC SLUDGE

Q (MGD)	0.89	
	(mg/L)	(lbs/d)
TSS	2,212	16,450
VSS	1,770	13,160
Yobs (VSS/BOD)		1.16

FC SLUDGE

Q (MGD)	0.31	
	(mg/L)	(lbs/d)
TSS	1,132	2,925
VSS	905	2,340
Yobs (VSS/BOD)		0.39

RETURN STREAMS (Calc.)

Q (MGD)	1.38	
TSS	447	5,149
VSS	356	4,110
BOD	319	3,684
TKN	226	2,603
NH4-N	200	2,301
TP	50	572
OP	41	477
ALK	592	6,829

THICKENER SUP

Q (MGD)	1.14	
	(mg/L)	(lbs/d)
TSS	536	5,095
VSS	429	4,076
BOD	383	3,642
TKN	34	326
NH4-N	3.1	29
TP	13.6	129
OP	3.7	35
ALK	201	1,908
CAPTURE (%)		73.7

TOTAL TF SLUDGE

Q (MGD)	1.20	
	(mg/L)	(lbs/d)
TSS	1,934	19,375
VSS	1,547	15,500

PRIMARY DIGESTERS

VOLUME	(MG)	2.1
SRT	(d)	15
TEMP	(°C)	37.5
VSS DES	(%)	100
BIOGAS	(ft^3/d)	349,099
CH4	(%)	72
CO2	(%)	28
GAS/VSS	(ft^3/lb)	10

SEPTAGE

Q (MGD)	0.0075	
	(mg/L)	(lbs/d)
TSS	10,867	681
VSS	7,882	494
BOD	2,359	148
TKN	695	44
NH4-N	80	5.0
TP	209	13.1
OP	2.9	0.18
ALK	380	23.8

THICKENED TF SLUDGE

Q (MGD)	0.062	
	(mg/L)	(lbs/d)
TSS	27,749	14,280
VSS	22,199	11,424

BFP WW

Q (MGD)	0.140

WTP SLUDGE

Q (MGD)	0.0000	
	(mg/L)	(lbs/d)
TSS	0	0
VSS	0	0

LEACHATE

Q (MGD)	0.011	
	(mg/L)	(lbs/d)
TSS	141	13
VSS	71	7
BOD	13	1
TKN	126	12
NH4-N	122	12
TP	4.2	0.4
OP	2.1	0.2
ALK	1,000	95

TOTAL SLUDGE

Q (MGD)	0.140	
	(mg/L)	(lbs/d)
TSS	34,595	40,254
VSS	29,440	34,256

10.7%
2.1%

PD SLUDGE

Q (MGD)	0.140	
	(mg/L)	(lbs/d)
TSS		
VSS		
ALK		
VFA		
pH	(S.U.)	

SUPERNATANT

Q (MGD)	0.0057	
	(mg/L)	(lbs/d)
TSS	12,371	588
VSS	8,413	400
pH	(S.U.)	

BFP FEED SLUDGE (W/ WTP)

Q (MGD)	0.116	
	(mg/L)	(lbs/d)
TSS	20,001	19,413
VSS	13,601	13,201

SDG SLUDGE

Q (MGD)	0.134	
	(mg/L)	(lbs/d)
TSS	16,700	18,638
VSS	11,356	12,674
ALK	4148	4,629
VFA	288	321
pH	(S.U.)	

BFP FEED SLUDGE (WWTP)

Q (MGD)	0.116	
	(mg/L)	(lbs/d)
TSS	20,001	19,413
VSS	13,601	13,201

2ND SST EFFLUENT

Q (MGD)	0.2428	
	(mg/L)	(lbs/d)
TSS	20	41
VSS	14	28
BOD	20	41
TKN	1,118	2,265
NH4-N	1,116	2,260
TP	218	442
OP	218	442
ALK	2,383	4,826

2ND SST SLUDGE

Q (MGD)	0.00092	
	(mg/L)	(lbs/d)
TSS	30,000	231
VSS	20,400	157
CAPTURE (%)		85.0

1ST SST EFFLUENT

Q (MGD)	0.244	
	(mg/L)	(lbs/d)
TSS	134	272
VSS	91	185

1ST SST SLUDGE

Q (MGD)	0.0062	
	(mg/L)	(lbs/d)
TSS	30,000	1,541
VSS	20,400	1,048
CAPTURE (%)		85.0

SUP + PRESSATE

Q (MGD)	0.250	
	(mg/L)	(lbs/d)
TSS	870	1,812
VSS	591	1,232

SST SLUDGE

Q (MGD)	0.0071	
	(mg/L)	(lbs/d)
TSS	30,000	1,772
VSS	20,400	1,205

PRESSATE

Q (MGD)	0.2442	
	(mg/L)	(lbs/d)
TSS	601	1,224
VSS	409	833

DEWATERED CAKE

Q (MGD)	0.012	
	(mg/L)	(lbs/d)
TSS	187,260	18,442
VSS	127,337	12,541
CAPTURE (%)		95.0

Attachment 6

Act 537 Planning
Delaware River Basin Commission Discussion and Kline's Island Site Visit
October 18, 2022 Meeting Minutes

Meeting Date: October 18, 2022
Location: Kline's Island Wastewater Treatment Plant
Subject: Planning Update for Delaware River Basin Commission (DRBC) Representatives

Attendees: DRBC: David Kovach; Kendria Henson

Lehigh County Authority (LCA):
Liesel Gross, Phil DePoe, Andrew Moore

CITY OF ALLENTOWN:
Brian Chamberlain, Dan Koplish

AECOM: Chris Curran, Joella Posey, Ralph Eschborn

Notes:

This meeting was convened to provide DRBC representatives (Kendria Henson and David Kovach) with as update on the ACT 537 Planning effort for the Kline's Island Sewer System (KISS). The meeting was held at the Kline's Island WasteWater Treatment Plant (KIWWTP) and was followed by a tour of the facility.

Handouts and the agenda (attached) were distributed, and the following items were discussed:

- Mr. Eschborn gave an overall update on the status of Act 537 Planning –
  - The concept of using an Intermunicipal Transfer of DRBC-approved loading from the KIWWTP to the LCA Pre-Treatment Plant (PTP) under a direct discharge scenario, which was discussed at length at the January meeting between the parties is no longer being pursued;
  - An in-depth analysis of direct discharge from the PTP (including employing an Intermunicipal Agreement) did not yield attractive results compared with all flows continuing to the KIWWTP;
  - A key input into this recent analysis is the projected DRBC effluent limits that would be placed on the KIWWTP and a PTP direct discharge. Planning has been based on the 2014 DRBC Memorandum[1], which provided expected future limits with Substantial Alteration taking place and application of the No Measurable Change standard.
  - A key planning focus has been on refining the KISS conveyance modeling using extensive monitoring data collected on dry and wet weather flows and calibrating the model. Calibration is complete and analysis of alternatives to mitigate wet weather collection system sanitary sewer overflows (SSOs) is underway;
  - Mitigating wet weather SSOs will substantially increase the wet weather hydraulic loading on the KIWWTP during major storm events – further modeling is needed to

[1]NMC to EWQ analysis for LCA's new 4 MGD discharge (Revised), Namsoo Suk, Ph.D., February 28, 2014

quantify the wet weather peak on the KIWWTP, but preliminary analysis indicates peak flow will be substantially above 120 MGD for currently projected 2050 flows;

- Accordingly, much of the recent planning and analysis has focused on increasing the peak wet weather capacity of the KIWWTP;
- As a first step, increasing the peak capacity from the current 87 MGD to 100 MGD is planned. This will involve replacing the pumps in the main influent pump station with higher capacity pumps. Pump replacement is already in the capital expenditures Master Plan due to their age. Guidance from the Pennsylvania Department of Environmental Protection (DEP) indicated that a Water Quality Management Part II (WQM II) permit submission would be required;
- The first step would be followed by extending the Park Pump Station Force Main to the KIWWTP which would increase the peak influent flow to 120 MGD;
- To increase KIWWTP capacity to match 120 MGD of peak flow, operating the plant's Plastic Media Trickling Filters (PMTFs) and Rock Media Trickling Filters (RMTFs) in parallel during major wet weather events (as opposed to normal sequential operation) has been identified as an attractive option. A flow sheet for this approach was reviewed (see Handout). Historical data demonstrate that parallel operation will still achieve 65% BOD short duration removal during a wet weather event, which is a DEP required minimum; These next steps were also reviewed with DEP, yielding the further guidance that these steps would also require WQM II permit submission. Mr. Kovach commented that the Basin-wide DRBC standard is 85% BOD removal, but this is on a monthly average basis. (Wet weather peak flows associated with storm events in excess of 100 MGD are expected to have durations of 48 hours or less.) All DRBC limits should be incorporated into a revised NPDES permit, but DEP understands this;
- To increase wet weather capacity above 120 MGD, three approaches are under consideration: (a) utilize parallel operation at higher rates – historical data is being reviewed to determine how far parallel operation can be taken while still meeting the DEP 65% criterion; (b) utilize wet weather equalization (EQ) basins to capture the peak flow and release it after storm flows subside; and (c) utilize a high-rate treatment system (BioActiflo™). EQ, as a conventional well-known technology was not discussed further. With respect to high-rate treatment, the key elements of the concept were reviewed using a second handout (attached): The current concept for high-rate treatment involves constructing a Force Main from the PTP and the western Lehigh service area to the KIWWTP that will be diverted from the main plant during storm events. The diverted storm flow will feed into a new parallel wet weather treatment line at the KIWWTP involving use of contact stabilization followed by high-rate separation employing flocculation, ballasting, and lamella separation. The ballast, a microsand, is recovered in cyclones and recycled back to the head of the high-rate separation steps. The treated storm water will be disinfected and discharged through its own outfall (the current plan is to use the already permitted 002 outfall which is normally idle). This high-rate approach is, in effect, PTP wet weather direct discharge. The approach is attractive due to its small footprint compared with EQ and by previous estimate, lower in cost. The wet weather peak flow capability of this concept is envisioned to be on the order of 40 MGD. Since dry weather flow would still be treated through the main KIWWTP, the shorthand direct discharge description is "0/40", meaning no dry weather direct discharge, but 40 MGD of wet weather direct discharge. Piloting of the high-rate approach is planned;

• Mr. Kovach offered the following feedback on this update –

- The projected effluent limits should Substantial Alteration take place would not be expected to change significantly from what was projected in 2014; however, these values are only advisory and future new or modified dockets from other dischargers would impact;
- DRBC would not have any concerns with using Outfall 002, since from a modeling perspective it is in close proximity to 001 and would be treated as one outfall, anyway. DRBC will defer to DEP on evaluating (but will support their position);
- KIWWTP modifications strictly for wet weather management would not trigger Substantial Alteration, but any significant alterations would require DRBC approval as authorized by Section 3.8 of the Delaware River Basin Compact; i.e., a docket is needed. a Flood Hazard Special Permit review would be included the new docket process. A not substantial alteration-driven new Dockets would come with a 5-year expiration and other updated features, but not new permit limits;
- DRBC would prefer one docket that covers the alterations discussed (KIWWTP projects to increase wet weather peak flow capability to 100 and 120 MGD). The first project would trigger a docket which can layout the projects to follow, so only one would be needed, as long as the plan doesn't change. Docket would be detailed, but allow for flexibility in timelines and applicable technology. There would be public notice of a docket and the potential for public involvement.

- Ms. Gross led the discussion on the next agenda item: What would be the DRBC's position regarding DEP having approved a WQM II permit modification (DRBC was copied) to increase the Hydraulic Design Capacity of the KIWWTP to 44.6 MGD if the KIWWTP were to discharge 41-42 MGD on an annual average basis (but not exceed the Design Organic Capacity of 70,000 lbs./day of BOD[2])? Mr. Kovach responded –
  - Exceeding 40 MGD would trigger Substantial Alteration;
  - DRBC usually defers to DEP with respect to assessing treatment capacity. If the annual average design flow specified in future WQM II permit modifications remains unchanged at 40 MGD there would be no impact;
  - With a caveat: DRBC regulations[3] provide that multi-phased capital projects, even if they do not constitute an expansion, would be deemed a Substantial Alteration if, in the aggregate they constitute: "a complete upgrade or modernization of an existing wastewater treatment plant, including substantial replacement or rehabilitation of the existing wastewater treatment process or major physical structures…" As noted above, though: "…modifications made solely to address wet weather flows; and alterations that are limited to changes in the method of disinfection and/or the addition of treatment works for nutrient removal are not deemed to be Substantial Alterations or Additions."
  - And a second caveat: Technically, if effluent loadings increase for whatever reason above levels at the time that SPW was implemented, regardless of permit limits, it could be deemed Substantial Alteration, but DRBC doesn't typically look at it that way.

The meeting was concluded, and Mr. Moore led a KIWWTP tour for Mr. Kovach and Ms. Henson.

[2] Under the DEP regulatory framework, annual average design flow is used to determine the allowable Design Organic Capacity. It was reconfirmed to be 40 MGD in the recent WQM II permit modification.
[3] Administrative Manual –Part III WATER QUALITY REGULATIONS With Amendments through December 4, 2013 (18 CFR PART 410)