City of Bellaire

Technical Memorandum
Cost Estimate Refinement

City of Bellaire

WWTP Cost Estimate Refinement

HDR Project: 10424607

March 14, 2025

HDR Engineering, Inc.
Texas Registered Firm No. F-754

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1 Introduction

As part of Work Order No. 1 from the City of Bellaire (City), HDR performed a condition assessment on the City's wastewater treatment plant (WWTP) and three lift stations. The result of this condition assessment included a set of opinions of probable construction costs (OPCC) for recommended improvements. After feedback from city leadership and citizens in a public workshop, the City issued Work Order No. 2 to further refine the OPCCs and explore two additional options.

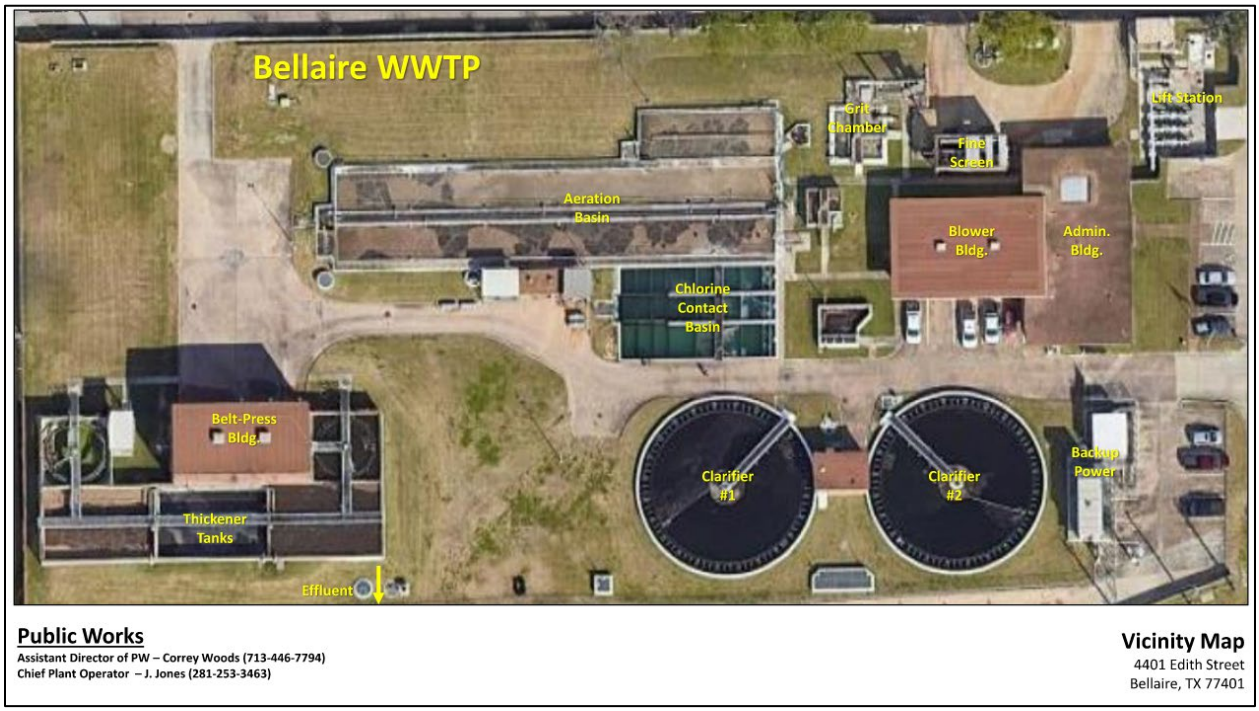
This technical memo provides a record of the results of Work Order No. 2. The alternatives/projects that are being further explored and refined include:

- Alternative 1: Replacement of the Existing WWTP – This includes a mixture of rehabilitation and replacement of all major processes at the existing facility.
- Alternative 2: Replacement of the Existing WWTP with a greenfield WWTP on the adjacent Public Works Site – This includes construction of a greenfield WWTP on the neighboring Public Works site, and decommissioning/demolition of the majority of the existing WWTP.
- Alternative 3: Demolition of the Existing WWWTP and Pump all Wastewater to City of Houston Southwest WWTP – This includes decommissioning/demolition of the existing WWTP, upgrades to the WWTP influent pump station, and construction of a force main to the City of Houston WWTP.
- Replacement of the Bellaire Lift Station – This includes the construction of a new lift station and demolition of the existing lift station.

1.1 Background

The City of Bellaire operates and maintains a wastewater treatment plant (WWTP) located at 4401 Edith Street, Bellaire, Texas. The WWTP has gone through several upgrades and expansions with the last major project occurring in 1974. The existing lift station, grit chamber, Junction Box No. 1, pre-aeration basin (primary clarifier in 1974 converted to pre-aeration basin), clarifiers, chlorine contact basin (final clarifier in 1974 converted to chlorin contact basin) were placed into service in 1974. Several other modifications took place in the year 1994 such as fine screen facility, grit classifier and fine bubble aeration system in the aeration basin. In 2017, disinfection system, lift station piping and blower building piping were replaced. The WWTP is currently permitted for an annual average daily flow (ADF) of 4.5 million gallons per day (mgd) and a peak two-hour (P2H) effluent flow of 11.5 mgd. **Figure 1-1** shows an aerial view of the existing WWTP.

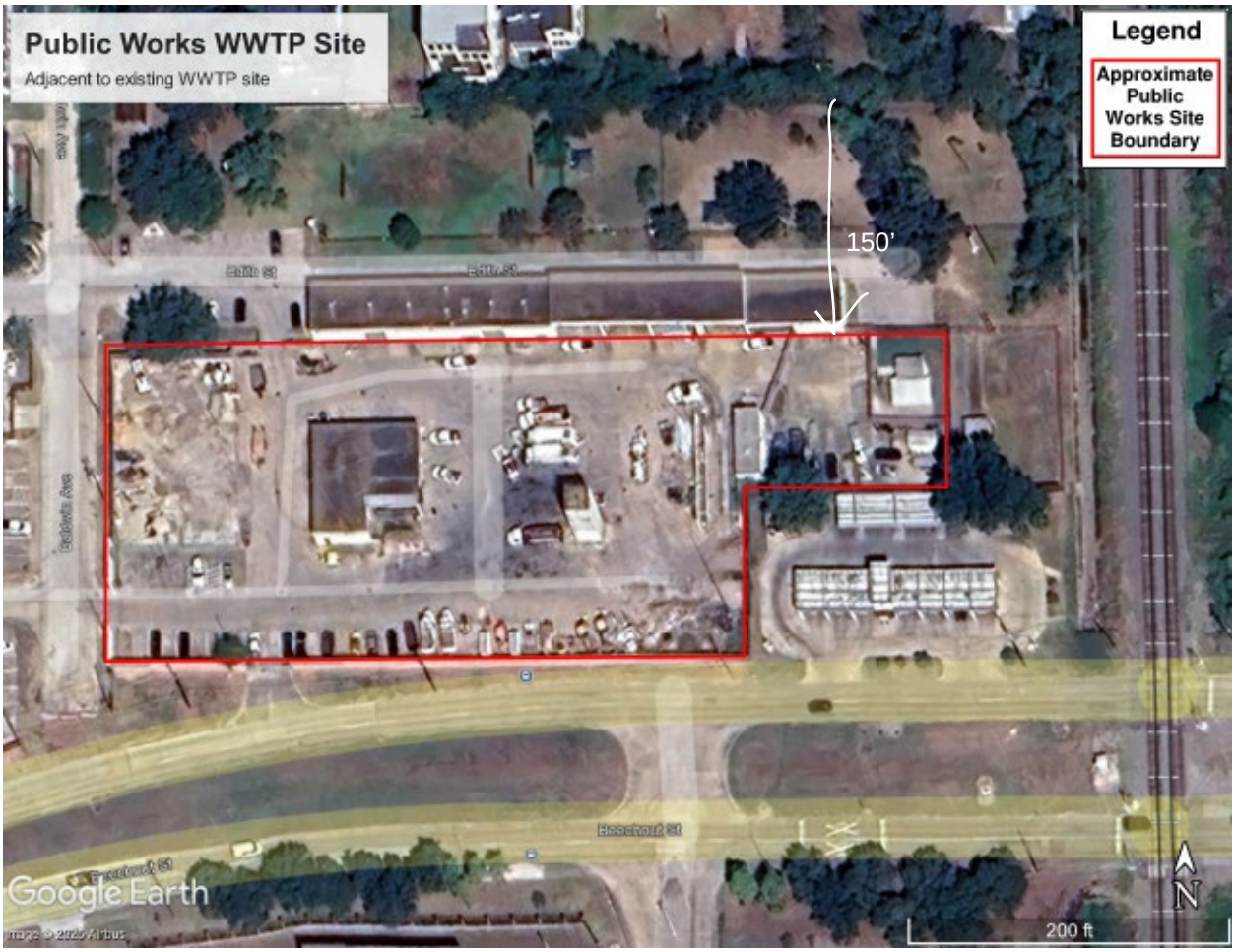
Figure 1-1. Bellaire WWTP Aerial View



HDR conducted a condition assessment on the City's wastewater system infrastructure as a part of the Work Order No. 1 effort. This assessment determined that most of the infrastructure at the existing WWTP needs to be replaced. HDR also provided the City with a Class 5 OPCC for the replacement of the WWTP as a part of the Work Order No. 1 effort. As a part of Work Order No. 2, the City asked HDR to update and refine this estimate.

The City of Bellaire also owns an adjacent property east of the existing WWTP site, which they currently utilize as a Public Works site. The City has plans to repurpose the site in the future, and, as part of Work Order No. 2, asked HDR to conduct a cost estimate for building a greenfield WWTP on this site to replace the existing WWTP. An aerial image of this site is shown in **Figure 1-2**.

Figure 1-2. Bellaire Public Works Site Aerial View



Building a greenfield WWTP on this site would allow the existing plant to continue to operate and treat the City's wastewater while the new plant is constructed, eliminating the need for costly construction sequencing practices, such as the utilization of a temporary package plant, that would have been needed with only the original site being available.

The City of Bellaire also owns three lift stations in its wastewater collection system. The Bellaire Lift Station is one of these stations and is located near the intersection of Highway 610 and Bellaire Boulevard. The condition assessment from the Work Order No. 1 effort determined that this lift station should be replaced due to the facility reaching the end of its expected lift and the safety hazards involved with it being in the middle of the busy Bellaire Boulevard. The location of this lift station is shown as an aerial image in **Figure 1-3**.

Figure 1-3. Bellaire Lift Station Aerial View

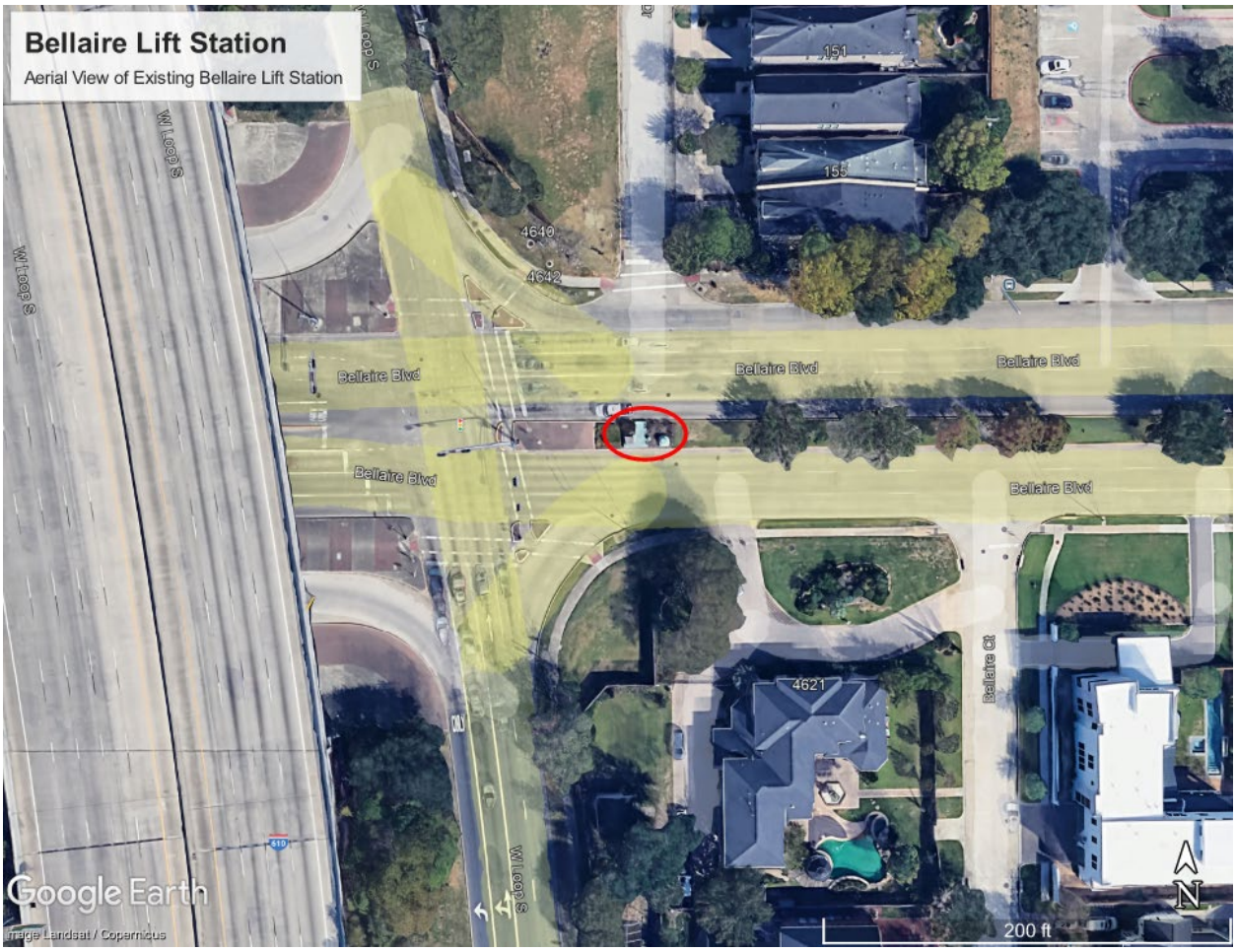


Figure 1-4 shows a street view of the existing Bellaire Lift Station. This image highlights the limited space available to access the station and the dangers present due to the oncoming traffic.

Figure 1-4. Bellaire Lift Station Street View

HDR provided a Class 5 OPCC for the replacement of this lift station with Work Order No. 1. As a part of Work Order No. 2 effort, the City asked HDR to update and refine this estimate.

2 WWTP Alternatives

OPCCs were generated for three alternatives: the replacement of the existing WWTP (Alternative 1), the construction of a greenfield WWTP (Alternative 2), and the construction of a forcemain to the City of Houston's Southwest WWTP (Alternative 3). For the OPCCs, each of these alternatives was sized for an annual average daily flow (AADF) rate capacity of 2.5 mgd and a peak two-hour flow rate of 6.25 mgd, which is less than the rated capacity of the existing WWTP of 4.5 mgd AADF. This capacity assumption is based on an analysis of the plant's flow history, which was performed as part of the condition assessment effort. The City of Bellaire plans to confirm this capacity is adequate through flow monitoring and an evaluation of the plant's flow data for the last 5 years as required by the Texas Commission on Environmental Quality (TAC §217.34(1)).

Additionally, the alternatives presented assume the peaking factor remains consistent with the plant's existing permit, but a flow analysis will be required to confirm what peaking factor is required for the re-rated plant or lift station.

2.1 Conventional Activated Sludge System

Both WWTP alternatives assume the use of the conventional activated sludge (CAS) process. It is a proven and effective treatment technology and is the most common secondary treatment technology used at WWTPs. Due to its conventionality, the City of Bellaire asked HDR to use CAS in this OPCC refinement to provide a base level of cost. The existing Bellaire WWTP currently also uses a conventional activated sludge process with aeration treatment basins.

The CAS treatment process that was selected was the Modified Ludzack-Ettinger (MLE) process which is better suited for removing organic matter, ammonia, and nitrogen from wastewater than the existing setup at the plant.

2.1.1 Treatment Infrastructure

Along with the treatment basins and aeration system, conventional activated sludge processes also typically require a headworks facility, secondary clarifiers, a disinfection system, and a solids handling system.

2.1.1.1 Headworks Facilities

For both alternatives, the OPCC for the headworks facility includes screening, screenings handling, and grit removal and was developed assuming a peak flow capacity of 6.25 mgd (WWTP permitted peak two-hour flow capacity). This matches the assumptions and design criteria used with the original cost estimate.

2.1.1.2 Secondary Clarifiers

Based on the results of the plant condition assessment, HDR assumed that the two existing 80-foot diameter secondary clarifier structures could continue to be used if the clarifier mechanisms were replaced. This matches the assumptions used with the original cost estimate.

For the greenfield WWTP, HDR used TCEQ Rule §217.154(c) and the peak two-hour flow rate (6.25 mgd) to determine the clarification capacity needed. Based on these calculations, two 58-foot diameter secondary clarifiers would be required at the greenfield WWTP located on the Public Works site.

2.1.1.3 Chemical Disinfection

HDR developed OPCCs both WWTP alternatives assuming each would require a new chemical disinfection system, with sodium hypochlorite and sodium bisulfite, and new chlorine contact basins. The OPCC for each chemical feed system was based on a maximum required pound per hour feed rate, which were determined based on the plant's peak two-hour flow rate of 6.25 mgd and TCEQ Rules §217.272(b) and §217.280(b). The chlorine contact basins were sized based on the plant's peak two-hour flow rate as well and TCEQ Rule §217.281(b). Based on these calculations, a chlorine contact basin with a total volume of 0.18 million gallons, a sodium hypochlorite system with a maximum feed rate of 13.0 pounds per hour, and a sodium bisulfite system with a maximum feed rate of 19.1 pounds per hour would be required at the replacement

WWTP or the greenfield WWTP located on the Public Works site. This matches the assumptions and design criteria used with the original cost estimate.

2.1.1.4 Solids Handling

Based on the results of the plant condition assessment, HDR assumed that the existing aerobic digesters and thickeners would remain in service, while new belt filter presses would be installed in the existing solids handling building for dewatering. Additionally, HDR determined that the floor elevation of the presses would need to be raised to keep the presses above the floodplain. This matches the assumptions used with the original cost estimate.

For the greenfield WWTP alternative, solids handling will be provided in the form of aerobic digestion followed by dewatering. The capacity of the digesters was determined based on TCEQ Rule §217.249(t)(4)(B). Based on these calculations, two aerobic digesters, each with a volume of at least 1.30 MG will be required at the greenfield WWTP on the Public Works site. This volume is much higher than the volume at the existing WWTP (0.57 MG) since the existing WWTP's solids handling process also includes thickeners. The treatment provided by the thickeners at the existing plant permit a smaller retention time in the digesters while still providing a similar biosolid quality at the end of the process.

2.2 Treatment Basins and Aeration System

The treatment basin volume and aeration system capacity needed for an MLE process at the Bellaire WWTP were determined using the BioWin computer model during the original cost estimate (further details can be found in **Section 3.2.1** in the *Wastewater Facility Improvements Cost Estimate Technical Memorandum*) as part of our Work Order No. 1 task. The models originally used for this task were further updated and refined as a part of this cost estimate. **Table 2-1** lists the treatment basin volumes and aeration system capacities used for the different cost estimates for the Bellaire WWTP.

Table 2-1. Treatment Basin and Aeration System Sizes Across OPCCs

Cost Estimate	Anoxic Volume (MG)	Aerobic Volume (MG)	Total Volume (MG)	Aeration System Capacity (scfm)
Replacement of Existing WWTP – Original (2024)	0.46	1.38	1.84	2,500
Alt. 1: Replacement of Existing WWTP – Updated (2025)	0.32	0.96	1.34	4,000
Alt. 2: Greenfield WWTP on Public Works Site (2025)	0.36	1.10	1.46	3,940

The proportion of anoxic volume to aerobic volume was kept the same across all three cost estimates. Between the two estimates for the replacement of the existing WWTP, the original estimate had more volume compared to this updated estimate. This decrease in volume was due to the refinement of the model and the solids flux analysis. With the updated model, the return activated sludge (RAS) rate was run as 70% of the influent flow rate rather than the original 30%. This higher RAS rate allows the basins to operate at a higher mixed liquor concentration, requiring less basin volume. While the 30% RAS rate is a reasonable return rate, HDR increased the return rate to refine the basin volume and provide a more efficient site layout.

The basin volume required for the greenfield WWTP is slightly higher than the volume required for the replacement of the existing WWTP (2025). This was due a difference in secondary clarifier capacity between the two alternatives. The replacement of the existing WWTP would reuse the structures of the two existing 80-foot diameter clarifiers, which provide more clarifier capacity than what is needed, based on TCEQ regulations, for a plant with a 6.25 mgd peak flow rate. The greenfield WWTP would use two 58-foot diameter clarifiers, since these would need to be fully constructed. Based on the solids flux analysis, the higher secondary clarifier capacity provided with the replacement of the existing WWTP would allow the clarifiers to handle a higher solids load and allow the basins to operate at a higher mixed liquor concentration, resulting in a lower basin volume requirement.

When comparing the aeration system capacities, the differences between the two 2025 alternatives are insignificant and are a result of intricate differences between the two alternatives' models. There is a significant difference (+60%), however, between the original estimate's aeration system capacity and the capacity of the aeration system used in the updated estimate for the replacement of the existing WWTP. HDR sized the aeration system in the original estimate based on the average aeration capacity needed. While updating and refining this cost estimate however, HDR determined that it would be more accurate and conservative to base the cost estimate on the maximum aeration capacity needed. This adjustment to the assumptions used to create these OPCCs led to the differences seen between the aeration system capacities used.

2.3 Alternative 1: Replacement of Existing WWTP

Replacement of the existing WWTP would require a combination of rehabilitation and replacement of treatment components, including the headworks, secondary treatment, the disinfection facility, the solids handling building and equipment, and a new administration building.

For this cost refinement, it was assumed that the City would construct a new, enclosed headworks facility including screening and grit removal, utilize conventional activated sludge for secondary treatment, and utilize liquid chemical disinfection. Based on these assumptions, the following costs were factored into this alternative's estimate:

- Demolish
    - Existing headworks facility, pre-aeration basins, aeration basins, blower building, administration building, and disinfection facility
- Replace
    - New headworks facility
    - New activated sludge basins
    - New blower air supply system for the activated sludge basins
    - New sodium hypochlorite and sodium bisulfite chemical systems
    - New chlorine contact tanks
    - New administration building with a laboratory

    - New belt filter presses
- Rehabilitate
    - Modify the solids dewatering building to move all equipment to second story
    - Replacement in kind of the existing secondary clarifier equipment
    - Raising the exterior walls of the existing secondary clarifiers
- Other
    - Purchasing/leasing a temporary package plant to treat the City's wastewater during construction

An advantage of this alternative is that the aerobic digesters and secondary clarifier structures on the existing site are rehabilitated instead of replaced, which reduces the construction costs. Due to the constraints on the site, existing facilities will need to be demolished before new facilities can be constructed, which interferes with the ability to continue treating their wastewater during construction. To address this issue, the City will need to purchase a temporary package plant through the duration of construction so that the plant remains in service.

2.4 Alternative 2: Greenfield WWTP on Public Works Site

Moving the WWTP across the road to the City's Public Works site would require the construction of a greenfield WWTP, including all the associated infrastructure. For this alternative, to provide an even comparison between the two WWTP alternatives, it was assumed that the City of Bellaire would construct an enclosed headworks facility, utilize conventional activated sludge for secondary treatment, and utilize liquid chemical We use gas disinfection. Based on these assumptions, the following costs were factored into this alternative's estimate:

- Decommission
    - Existing headworks facility, pre-aeration basins, aeration basins, blower building, administration building, and disinfection facility
- Construct
    - New headworks facility
    - New activated sludge basins
    - New blower air supply system for the activated sludge basins
    - New secondary clarifiers
    - New sodium hypochlorite and sodium bisulfite chemical systems
    - New chlorine contact tanks
    - New aerobic digesters
    - New solids dewatering building and installation of new belt filter presses and polymer system within
    - New administration building with a laboratory

An advantage of this alternative is that it mitigates the need to purchase a temporary package plant to treat the City's wastewater during construction. With this alternative, the existing WWTP can remain online until the new WWTP is constructed. The City would have to build more permanent infrastructure with this alternative though, since they would not be able to continue using the secondary clarifier structures and aerobic digesters on the existing site.

2.5 Alternative 3: Send Wastewater to Houston

Alternatively, instead of replacing the existing WWTP or building a greenfield WWTP, the City may negotiate a contract with the City of Houston to send their wastewater to Houston's Southwest WWTP for treatment. The Houston Southwest WWTP is located south of the Bellaire WWTP on Beechnut Street, 2,000-ft from the existing Bellaire WWTP. This alternative would require the lowest amount of capital investment but would leave the City dependent on the City of Houston to set their wastewater rates. At this time, HDR has not been involved in any discussions with the City of Houston regarding this issue, so it is possible that the City of Houston may be unwilling or unable to treat Bellaire's wastewater at their Southwest WWTP. The following costs were factored into this alternative's estimate:

- Demolish
  - Existing headworks facility, pre-aeration basins, aeration basins, blower building, administration building, and disinfection facility
- Replace
  - New pumps within the existing Bellaire WWTP influent lift station
- Construct
  - Forcemain from the existing Bellaire WWTP influent lift station to the influent lift station of Houston's Southwest WWTP

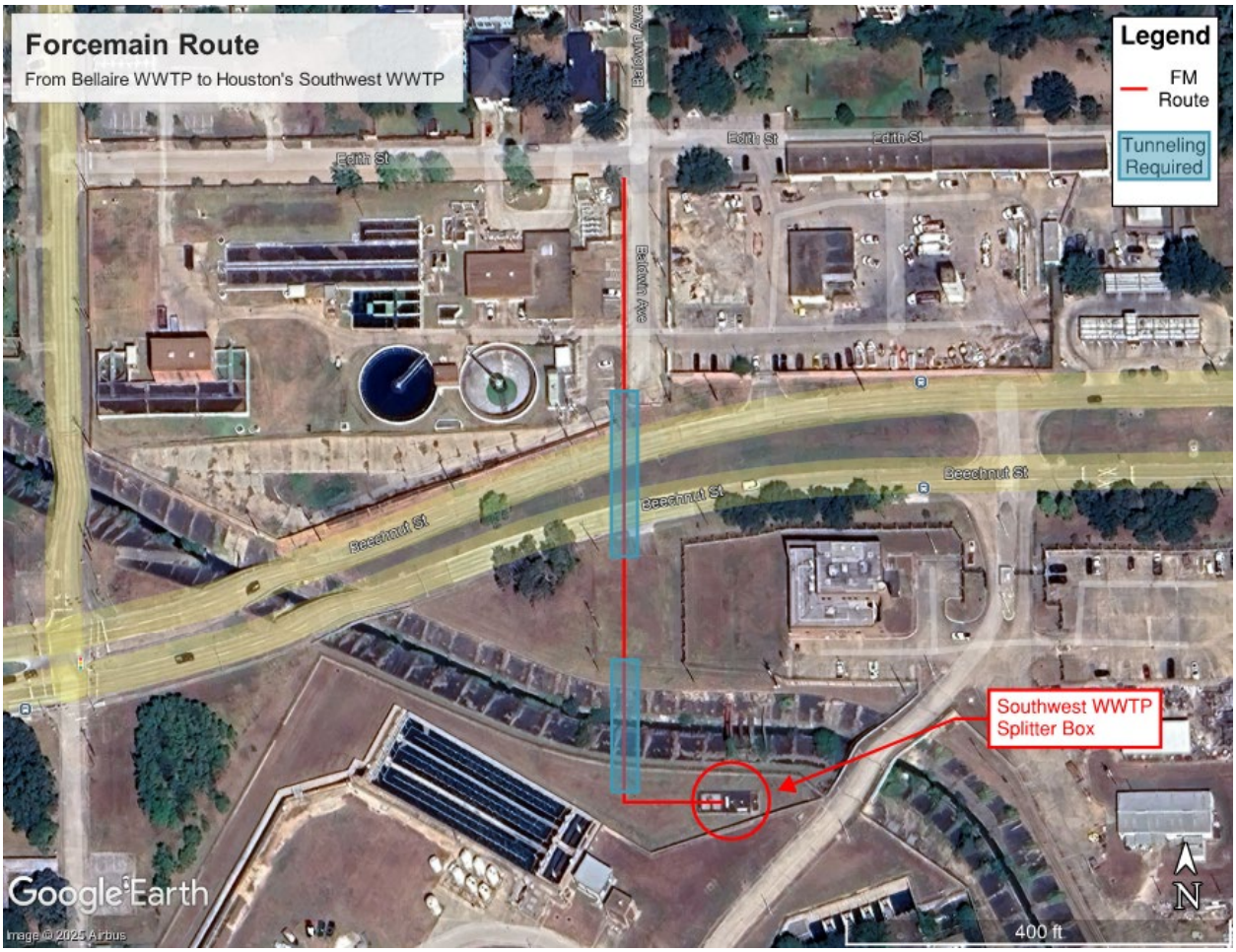
The proposed forcemain that would convey Bellaire's wastewater to the City of Houston's Southwest WWTP was sized based on the criteria listed in **Table 2-2**.

Table 2-2. Forcemain Sizing

Parameter	Value	Notes
Peak Flow Rate Through Forcemain (Q), mgd	6.25	
Maximum Wastewater Velocity Allowed (v), fps	8	Common industry standard
Required Pipe Area (A), sf	1.2	A=Q/v
Required Pipe Diameter (D), in	14.9	D=(2)((A/(π))^(1/2))
Selected Nominal Pipe Diameter, in	16	Rounded up to nearest nominal pipe diameter

Based on these calculations, the forcemain diameter selected for this OPCC was 16 inches. The proposed route and length of the forcemain were selected and determined using available aerial mapping. The proposed route and the measured length of the route are shown in **Figure 2-1**.

Figure 2-1. Proposed Forcemain Route



This route was selected and determined based on the shortest available route to the Southwest WWTP and the assumption that the City of Bellaire will need to convey their wastewater to the splitter box located on the Southwest WWTP site (circled in **Figure 4-6**). This route requires a total forcemain length of 800 ft, with an estimated 350 ft of that total length requiring trenchless installation due to the required crossings at Beechnut Street and the nearby canal.

Alongside the forcemain, it was assumed that the pumps in the existing Bellaire WWTP influent lift station would need to be replaced with pumps designed to convey flow from the existing Bellaire WWTP to Houston's Southwest WWTP. The OPCC for this pump replacement was developed assuming that the firm pumping capacity would match the proposed rerated peak flow capacity of the Bellaire WWTP at 6.25 mgd.

3 Replacement of Bellaire Lift Station

The Bellaire Lift Station, which currently sends flow to the Bellaire WWTP, is in the middle of a busy street and should be replaced. This station will need to be replaced for any of the alternatives, since it will be needed to convey wastewater to the Bellaire WWTP or the Houston WWTP. The OPCC to replace this dry pit lift station was developed assuming that the firm pumping capacity would remain at 3.5 mgd.

- Demolition
  - Existing Bellaire Lift Station
- Replacement
  - New Bellaire Lift Station relocated out of the street

The replacement of this lift station will be required no matter which of the three alternatives listed in **Section 2** are implemented, since it will be needed to convey wastewater either directly to the Bellaire WWTP or to the lift station that will collect and convey all of Bellaire's wastewater to Houston's Southwest WWTP.

4 Site Planning

The following section presents the TCEQ regulations applicable to developing the proposed site plans for both WWTP alternatives.

4.1 Applicable TCEQ Regulations

In order to mitigate the effects of WWTP odors on the public, TCEQ Rule §309.13(e) states that all WWTP units must be located over 150-ft from the nearest property line (500-ft for lagoons with anaerobic activity). If this requirement cannot be met, the owner of the WWTP must either submit a nuisance odor prevention request or sufficient evidence of legal restrictions preventing the construction of residential structures within 150-ft of their WWTP units with their permit application. The nuisance odor prevention request will need to be approved by the executive director of TCEQ and must be in the form of an engineering report that addresses potential odor issues at the plant and provides a plan to address and mitigate them. Sufficient evidence of legal restriction may include restrictive easements, rights-of-way, covenants, deed restrictions, deed records, or private agreements. The following sections present the site limitations imposed by the TCEQ buffer zone requirements.

4.1.1 Bellaire WWTP Site Limitations

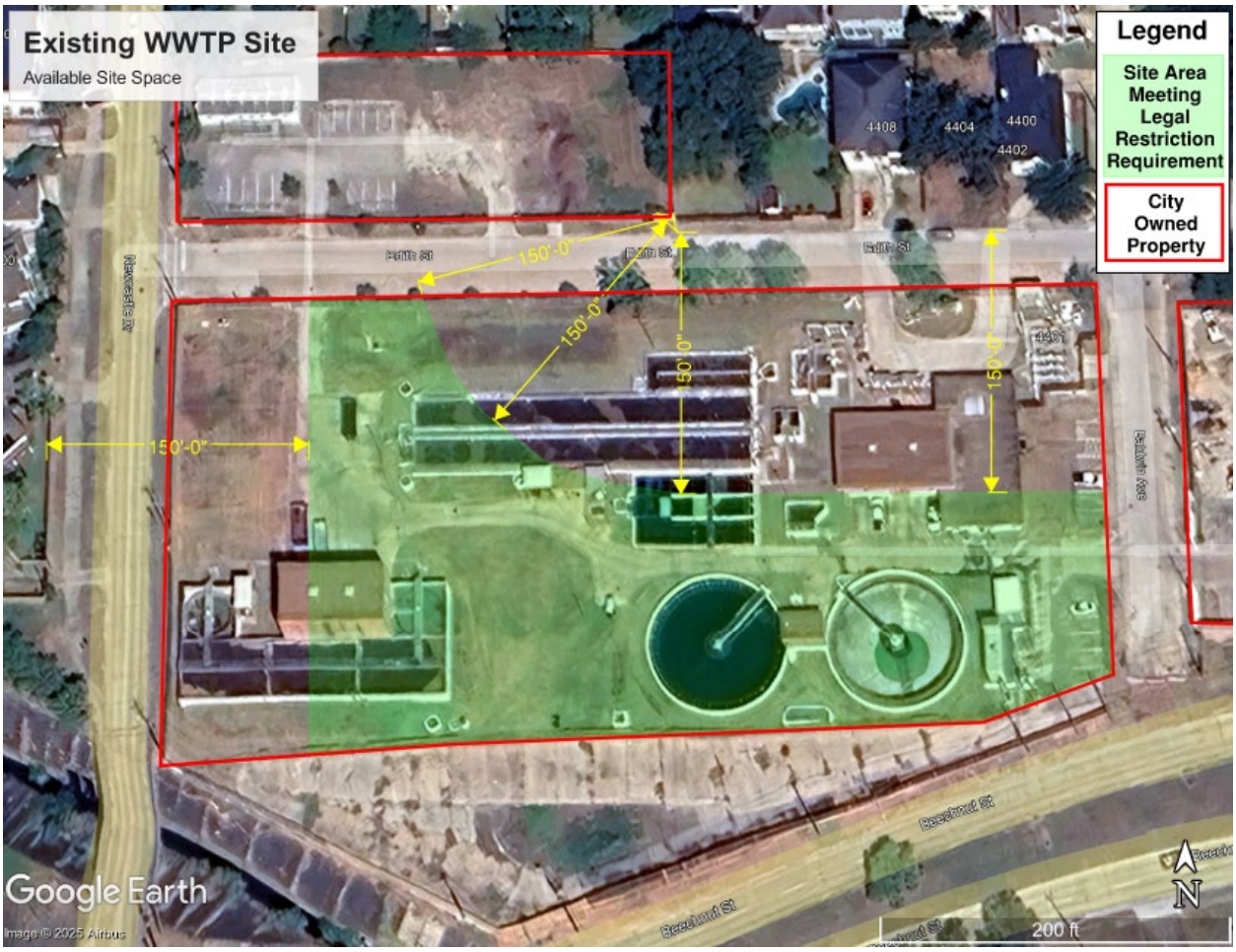
While the existing Bellaire WWTP site does not meet the 150-ft buffer requirement, the existing plant is exempted from this requirement due to TCEQ Rule §309.13(f), which states that a plant that was designed prior to March 1, 1990, is not subjected to the buffer zone requirements, as long as there is no change to the design of the plant.

If the WWTP on the existing site is rerated (initiating changes in the process design) or a new plant is constructed on the Public Works site, both scenarios would be subject to

TCEQ Rule §309.13(e). Neither the existing site or greenfield site is large enough to accommodate the buffer zone requirements and construction of necessary treatment units to provide treatment capacity. The City will either need to submit a nuisance odor prevention request or provide sufficient evidence of legal restrictions preventing the construction of residential structures within 150-ft of the treatment units.

If the City continues to own the property to the east and north of the existing WWTP site, then a significant portion of the existing WWTP site could meet the legal restriction requirements assuming the appropriate deed restrictions could be implemented on City owned property. The City, however, would not be able to sell that land or allow any residential structures to be built on it in the future. The portion of site available for use, if these assumptions are met, is shown in **Figure 4-1**.

Figure 4-1. Available Space on Existing WWTP Site with Assumed Legal Restrictions

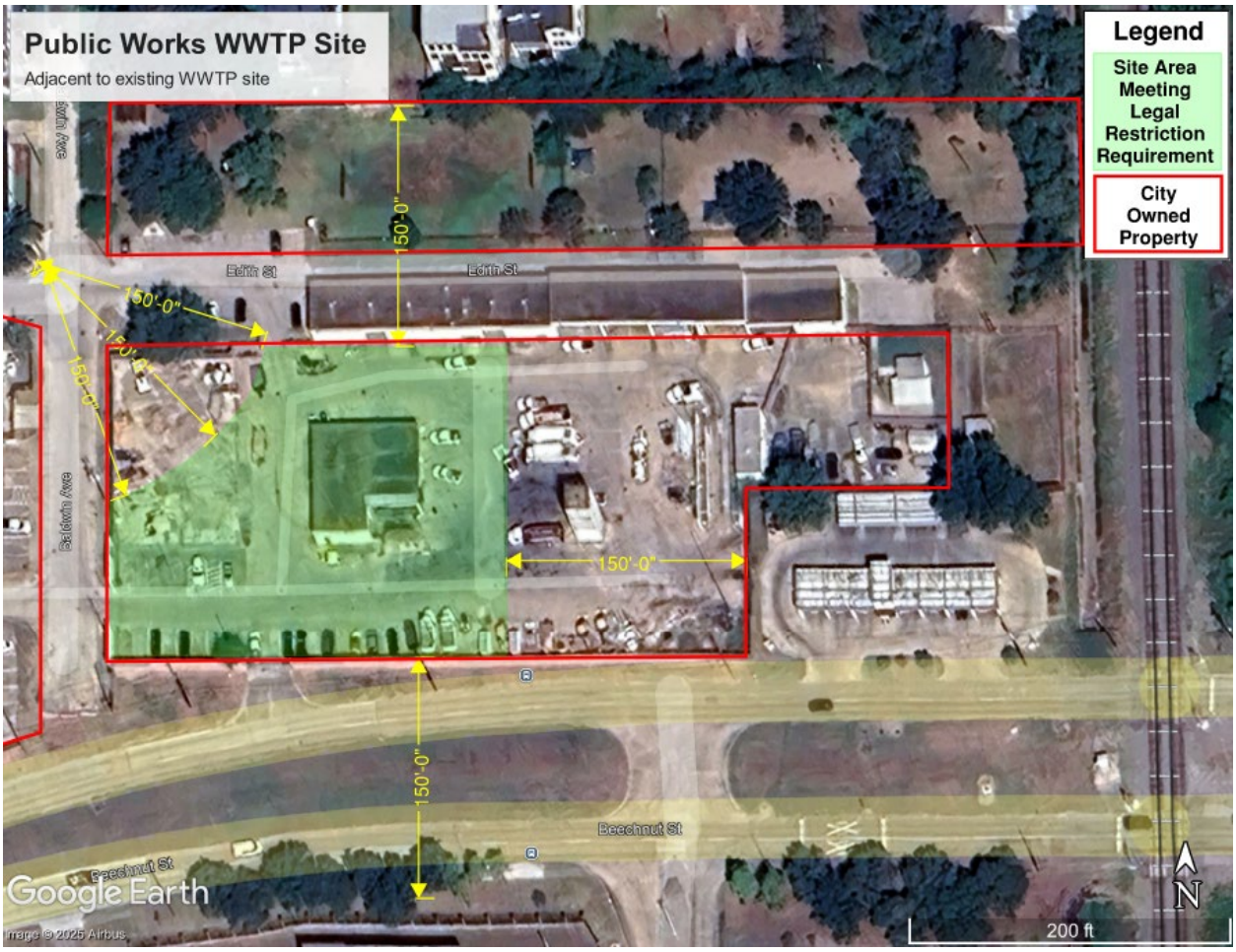


While this makes a significant portion of the site available for use, the adjacent properties on the west side of the site are privately owned residences and severely limit the site space available for treatment units.

4.1.2 Public Works /Greenfield WWTP Site Limitations

If the City continues to own the existing WWTP site and the dog park to the north of the Public Works site, then a significant portion of the Public Works site could meet the legal restriction requirements due to the City owning the land around the site. The City, however, would not be able to sell that land or allow any residential structures to be built on it in the future. The portion of site available for use, if these assumptions are met, is shown in **Figure 4-2**.

Figure 4-2. Available Space on Public Works Site with Assumed Legal Restrictions



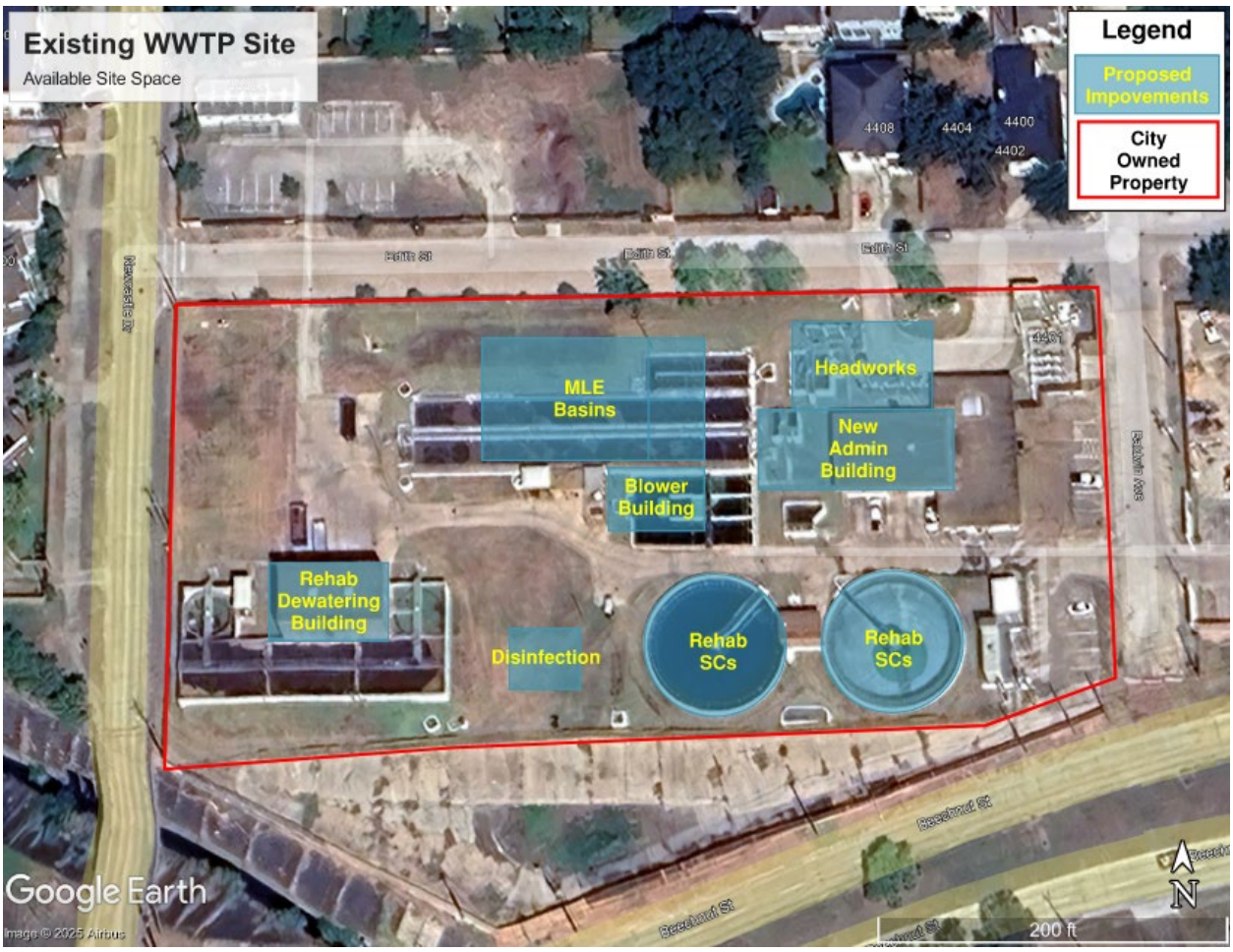
While this makes a significant portion of the site available for use, the adjacent property on the southeast corner of the site is privately owned and severely limits the site space available for treatment units.

If the City decides to either rehabilitate their existing WWTP or build a greenfield WWTP on the Public Works site, HDR would recommend that the City plan to submit a nuisance odor prevention request to TCEQ and work to provide evidence of legal restrictions preventing the construction of residential structures within 150-ft of the WWTP. This approach will require the construction of more odor control units and facilities at the plant with either scenario and allow the City to use more of the site for the wastewater treatment process units.

4.2 Existing WWTP Site Plan

A proposed site plan for the existing WWTP site was prepared by HDR. This site plan assumes that the City would submit a nuisance odor prevention request to TCEQ to comply with TCEQ Rule §309.13(e) and receive variance to buffer zone requirements. The proposed site plan is shown in **Figure 4-3**.

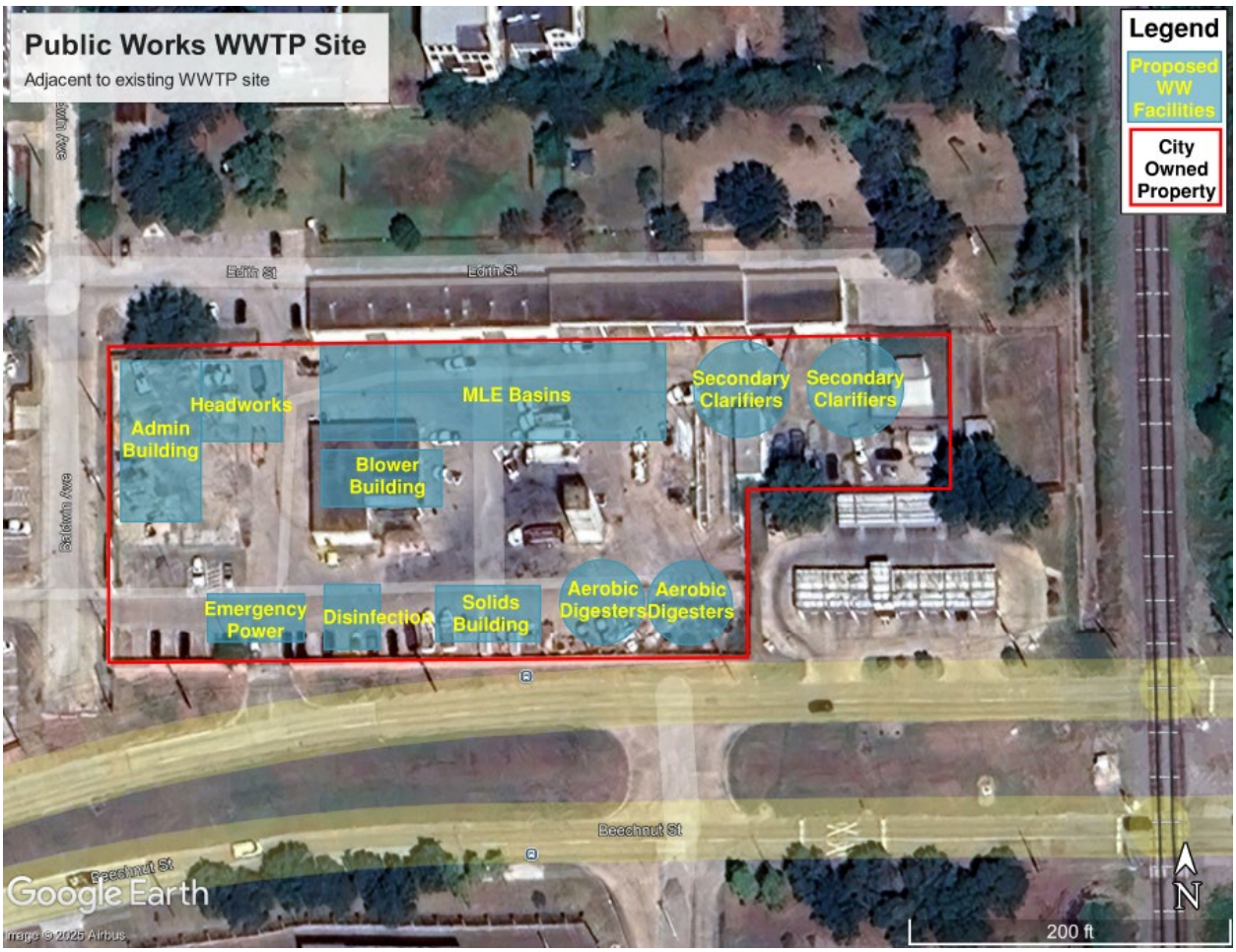
Figure 4-3. Proposed Site Plan for Existing WWTP Site Alternative



4.3 Public Works / Greenfield WWTP Site Plan

A proposed site plan for the Public Works site was prepared by HDR. This site plan was developed assuming that the City would submit a nuisance odor prevention request to TCEQ to comply with TCEQ Rule §309.13(e), allowing more of the site to be utilized. The proposed site plan is shown in **Figure 4-4**.

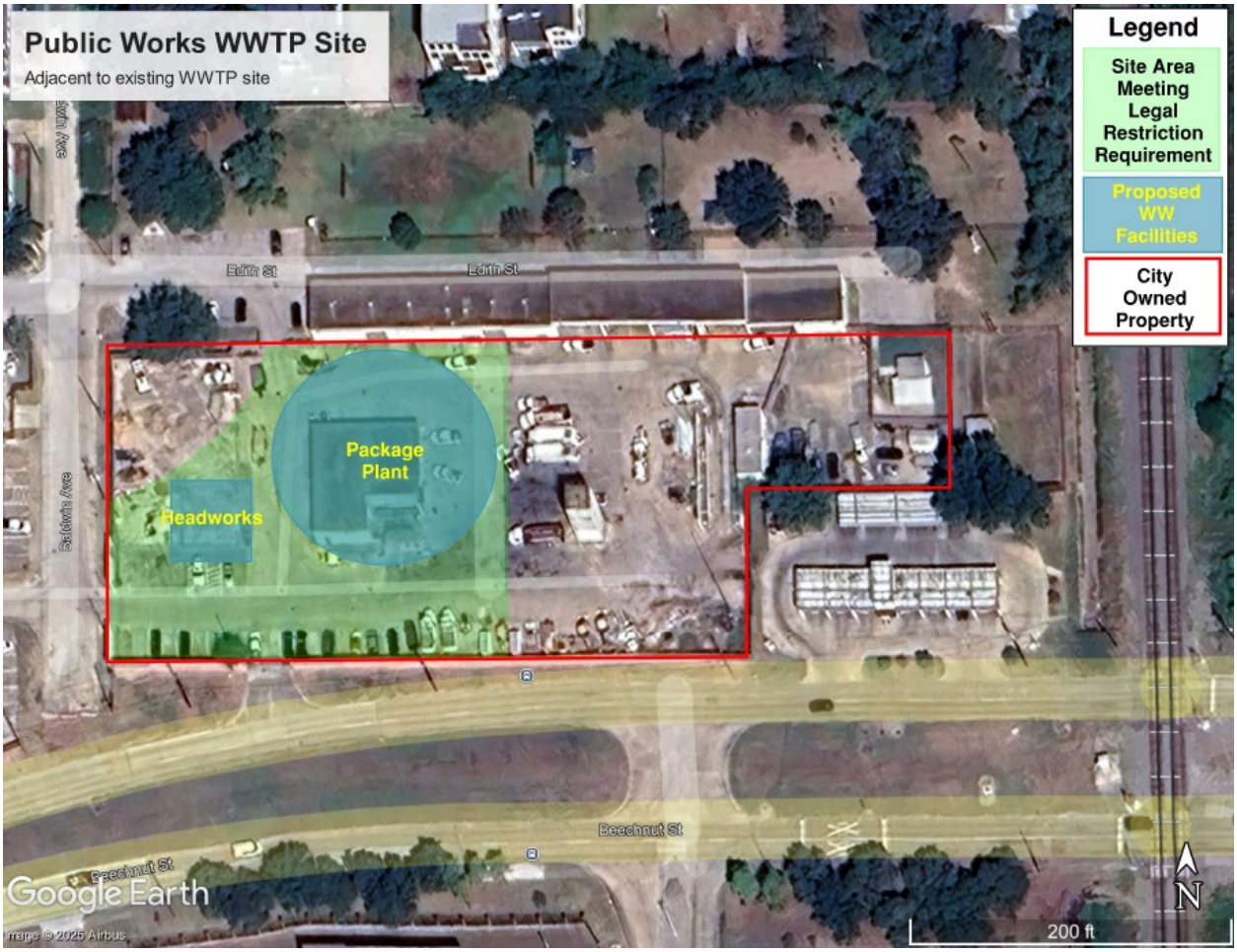
Figure 4-4. Proposed Site Plan for Public Works Site Alternative



4.4 Package Plant on Public Works Site

The adjacent Public Works site could also be considered for use as a location for a temporary package plant while the required improvements for the existing WWTP are constructed on the current WWTP site. This would allow construction sequencing to run more smoothly and help mitigate delays during construction. This package plant and its required supporting facilities could be set up on the Public Works site to meet the 150-ft TCEQ boundary requirement with residential legal restrictions applied, as shown in **Figure 4-5**. This assumes that the existing influent pump station on the existing WWTP site are utilized and kept in operation with this package plant while it is used.

Figure 4-5. Proposed Site Plan for Temporary Package Plant on Public Works Site



The footprint shown for the temporary package plant in **Figure 4-5** includes aeration basins, blowers, secondary clarifiers, a disinfection system, and aerobic digesters.

5 General OPCC Assumptions

HDR prepared AACE **Class 5** (accuracy range of -35% to +60%) planning level OPCCs for these evaluations. **Table 5-1** shows the different AACE planning cost estimate levels and provides further information on each of them.

Table 5-1. AACE Classification of Construction Cost Estimates

Estimate Class	Class 5	Class 4	Class 3	Class 2	Class 1
Project Phase Description[1]	Master Plan or Concept Design	Predesign Report and Drawings	50% to 60% Design Complete	90% to 95% Design Complete	Bid Documents
Level of Project Definition[2]	0% to 2%	1% to 15% PDR (up to 30% design)	10% to 40%	30% to 70%	70% to 100%
Accuracy of Estimate[2,3]	-35% to +60%	-20% to +40%	-15% to +30%	-10% to +20%	-5% to +10%
Undefined Work (Contingency)[2]	25% to 40%	20% to 30%	15% to 25%	10% to 20%	5% to 15%

Note: General – When transmitting an OPCC, include a reference to the AACE Class, the associated accuracy, and the assumptions. It should also indicate that the estimate does not represent extreme market fluctuations due to events which cannot be predicted.

1. Based on typical project deliverables.
2. Based on OPCC definition
3. Accuracy represents the variance from the estimate. For example, a Class 4 estimate isi -20% to +40% and will be between 0.8 and 1.4 times the estimate prepared by the engineer or professional estimator.

HDR's WaterCost tool – a planning level parametric cost estimating tool - was used to generate the OPCCs for the WWTP improvements. The tool derives costs from cost curves and typical conditions. The costs from these curves are simple to determine, easily modified, and are completed by the project engineering team. These curves are developed using default input values for a range of WWTP sizes.

The WaterCost tool requires several market assumptions to reliably generate accurate cost estimates for a project. These include ENR indexes, which are commonly used in several different markets and serve as a reflection of the local economy's effect on construction costs. The ENR indexes used for this analysis are listed in **Table 5-2**.

Table 5-2. ENR Index Assumptions

ENR Index	Value Used	ENR Index	Value Used
ENR CCI (20-City Average)	10,430	BLS Concrete	276.8
ENR Building Index	5,563	BLS Steel	158.7
ENR Skilled Labor Index	9,696	BLS Pipe and Valves	303.3
Producer Price Index for Finished Goods	193.4	BLS Electrical and Instrumentation	113.2
BLS General Purpose Machinery	227.2	Housing	150

Additional categorical costs involved with construction are also factored into the estimate by the tool through assumed percentages. These percentages are applied and added to the costs determined from the cost curves for each WWTP unit process in the estimate. These categories, and the percentages used for them in these estimates, are listed in **Table 5-3.**

Table 5-3. Assumptions Made for Additional Construction Costs

Category	Assumed Percentage	Category	Assumed Percentage
Misc./Unidentified Site Structures	15%	Field Conditions	7%
Sitework	30%	Mobilization & Demobilization	5%
Demolition	1%	Contingency	25%
I&C (SCADA)	8%	General Contractor OH & Profit	8%
Site Electrical	2%	Bonds & Insurance	1.5%
Yard Piping	5%	Construction Contingency	5%
Soil Conditions	7%	Legal & Fiscal	2%

When accounted for together, the costs added for miscellaneous/unidentified site structures (15%) and the contingency (25%) are in alignment with the upper limit of contingency (40%) needed for a Class 5 estimate based on **Table 5-1**.

The estimated engineering fees associated with these projects will be added as a separate line item in the final cost estimate results. These fees are assumed to be 10% of the total project cost.

6 Cost Estimate Results

The results from the OPCCs for the three different alternatives are listed and broken down in **Table 6-1**. This table lists the estimated construction cost estimate, which includes our contingency factor from the OPCC class level, the engineering fees associated with construction and design for the alternative, and the total project cost, which is the construction cost and the engineering cost added together.

Table 6-1. Cost Estimate Results

Alternative/Project	Construction Cost	Engineering Fees	Total Project Cost	
Replacement of Existing WWTP – Original (2024) excludes Bellaire Lift Station[1]	*$69.4M*	*$6.94M*	*$76.4M*	
Alt. 1: Replacement of Existing WWTP – Updated (2025)	$95.8M	$9.58M	$105.4M	$42/gal
Alt. 2: Greenfield WWTP on Public Works Site (2025)	$118.2M	$11.8M	$130.1M	$52/gal
Alt. 3: Forcemain to Houston WWTP	$4.34M	$0.43M	$4.77M	
Replacement of the Bellaire Lift Station	$1.88M	$0.19M	$2.07M	

Notes:

1. The original cost estimate presented in the Cost Estimate TM from 2024 listed a total project cost for the replacement of the existing WWTP that included the cost of replacing the Bellaire Lift Station. That price was modified and re-presented here to exclude the cost of replacing the Bellaire Lift Station.

There are several factors which result in the updated total project cost estimate being higher than the original total project cost estimate by $29 million. They include:

- Temporary Package Plant: The updated cost estimate includes $33.7 million for a temporary package plant, whereas the original cost estimate only included $17.8 million for the package plant. The primary reason for the difference in these two prices, is that the package plant manufacturer HDR has been communicating with stopped offering short term package plant leases after the original cost estimate. While they do offer long term leases still, it would be cheaper for the City to just purchase a package plant rather than lease one long term. HDR is not aware of any other manufacturers who offer package plant leases currently.

$10.5 million

- Odor Control – Based on the site plan analysis done for this project, the City will need to submit a nuisance odor prevention request to TCEQ to comply with TCEQ Rule §309.13(e). It is highly likely that, in response to the City's request, TCEQ will require the installation of an odor control systems at the headworks and dewatering facilities on the existing site. While the cost of odor control at the headworks was included in the original estimate, the estimated cost for the system was raised by $4.2 million due to this analysis. The addition of the dewatering odor control system increased the total project cost by $3.6 million as well.
- Administrative Building & Laboratory – The original cost estimate did not include costs for improvements to the existing Administrative Building and the addition of an on-site laboratory within the building. In the updated estimate, this added $2.6 million to the total project cost.
- Rising Equipment Costs – The estimated costs for the replacement mechanisms within the existing secondary clarifiers and the belt filter presses for dewatering were based on feedback from equipment manufacturers in both the original and updated cost estimates. When comparing the updated prices to the prices used in the original estimate, the rise in cost of these pieces of equipment led to a rise in the total project cost by $2.7 million.
- Downsizing of the Aeration Basin – As explained in this document, our revised design approach resulted in a smaller aeration basin. This resulted in a lower total project cost estimate by approximately $1.2 million when compared to the original cost estimate.

Additionally, a portion of the noted increase in the total project cost between the original and updated cost estimates can be attributed to inflation.

The cost to replace the Bellaire Lift Station was excluded from the total project cost presented for both options (as well as the options for Public Work Site and Forcemain to Houston). This cost estimate remained essentially the same as our Original Cost Estimate, at $2.07M.

The OPCCs for the three main alternatives (replace existing WWTP, construction a greenfield WWTP, and construct forcemain to Houston's WWTP) are further broken down in **Appendix A**.

When comparing the total project costs across these three alternatives, the forcemain alternative has the lowest project cost by a significant margin. Between the two WWTP

alternatives, constructing a greenfield plant on the Public Works site would be significantly more expensive than replacing the existing plant. When comparing the estimated project cost of the forcemain construction compared to the project costs of the two WWTP alternatives, the cost to construct the forcemain and the associated lift station is significantly lower.

6.1 Cost Comparison with Other Recent Projects

After generating costs for the three alternatives and the Bellaire Lift Station, HDR compared the estimated construction costs for the two WWTP alternatives to the cost of other WWTP construction projects around the country. These prices were broken down by capacity (dollars per gallon of wastewater treated per day) and then adjusted for inflation to account for changes in market conditions year over year. **Table 6-2** provides a summary of the costs for these other WWTP construction projects.

Table 6-2. Other WWTP Construction Project Costs

Name of Project/Plant	Total Project Cost	Constructed Average Flow Capacity (MGD)	Unit Capacity Price ($/gal)	Year of Bid	Adjusted Unit Capacity Price ($/gal)
Stowe WRRF in Charlotte, NC	$495.3M	15	$33.02	2023	$35.12
Sam's Branch WWTP in Clayton, NC	$230.0M	6	$38.33	2023	$40.77
Rocky River WWTP in Concord, NC	$140.5M	4	$35.10	2024	$36.14
Siler City WWTP in Siler City, NC	$75.0M	2	$37.50	2024	$38.59
Lower Dorchester WWTP in Dorchester County, SC	$201.5M	8	$25.20	2024	$25.92
Nansemond WWTP Upgrade and Expansion in Suffolk, VA	$317.6M	13	$24.40	2022	$27.66
Nelson WWTF Improvements in Johnson County, KS	$504.3M	15	$33.60	2023	$35.75
Rolling Hills WWTP in Houston, TX	$14.6M	0.35	$41.71	2024	$42.92
				Average Unit Capacity Cost:	**$35.36**

For the two WWTP alternatives for the City of Bellaire, HDR estimated a capacity cost of $42.17 per gallon per day (gpd) treated for the rehabilitation of the existing WWTP and $52.02 per gpd treated for the construction of the greenfield WWTP. These costs per gallon are higher than the average adjusted unit capacity cost of $35.36 per gallon treated but are considered reasonable e due to several factors.

Many of the projects listed in **Table 6-2** are expansion projects, meaning that these projects did not have to include construction for many WWTP components that are needed to replace the existing Bellaire WWTP or construct a greenfield Bellaire WWTP. Many of these missing components include an administrative building, plant lab, and solids handling improvements. Additionally, the site constraints present at both the existing WWTP site, and the Public Works site will increase construction costs due to the effort required to coordinate and work around a constrained site. Many of the projects listed also involved the construction of wastewater treatment capacity much higher than that what is needed at the Bellaire WWTP. Typically, the more capacity that is built within

a single WWTP construction project, the lower the unit price tends to be. If we look at the two projects with constructed capacities most similar to that of the two alternative Bellaire WWTP projects (Siler City and Rolling Hills), we see unit prices around $40-$42 per gallon treated, which is much closer to our estimated costs compared to the overall average unit cost.

7 Summary and Recommendation

Several components of the City of Bellaire's existing WWTP need to be replaced or rehabilitated in the upcoming years to keep the plant operational. HDR developed AACE Class 5 construction cost estimates for three alternatives that could be used to address the issues at the City's WWTP. The alternatives considered included:

1. Alternative 1: Rehabilitate the existing WWTP on the existing WWTP site.
2. Alternative 2: Construct a greenfield WWTP on the adjacent Public Works site.
3. Alternative 3: Construct a forcemain to the City of Houston's Southwest WWTP and convey the City's wastewater there for treatment.

Additionally, the cost estimates for all three of these alternatives also included the estimated costs needed for the replacement of the Bellaire Lift Station, which would need to be replaced no matter which alternative was selected.

The total project costs estimated for these three alternatives are summarized in **Table 7-1**.

Table 7-1. Cost Estimate Results

Alternative Number	Alternative/Project Name	Total Project Cost
1	Replacement of Existing WWTP – Updated (2025)	$105.4M
2	Greenfield WWTP on Public Works Site (2025)	$130.1M
3	Forcemain to Houston WWTP	$4.77M
N/A	Replacement of the Bellaire Lift Station	$2.07M

Finding Number 1 – Updated Cost Estimate versus Original Cost Estimate

When comparing the updated cost estimate for the replacement of the existing WWTP to the original cost estimate that was conducted in 2024, the updated estimated cost was around $29.0M higher. This difference between the original and updated estimates can primarily be attributed to the increase in the temporary package plant costs and the inclusion of additional cost for odor control facilities, although inflation also increased the updated cost estimate to a degree.

Finding Number 2 – Replacement on Existing Site versus Public Works Site

Based on the results of this cost estimate, constructing a greenfield plant on the Public Works site would be significantly more expensive than replacing the existing plant, even though the constructing a greenfield WWTP would not require the use of a temporary package plant during construction. The greenfield WWTP is more expensive due to the need for new secondary clarifiers, digesters, and a dewatering building there. Those

same facilities already exist at the existing WWTP and are in a condition which would allow for their continued use. The total cost to construct those facilities for the greenfield WWTP is significantly higher than the cost associated with the temporary package plant that would be needed to replace the existing WWTP.

Finding Number 3 – Cost Comparison to other Projects

For the two WWTP alternatives, the unit treatment capacity cost came out to $42.17 per gpd treated for the replacement of the existing WWTP and $52.02 per gpd treated for the construction of the greenfield WWTP. While these unit costs are significantly higher than other recent WWTP construction projects, several factors led HDR to remain confident in these estimates, including differences in the facilities constructed within these projects, the constrained sites available for the Bellaire WWTP, and the relatively low treatment capacity required at the Bellaire WWTP.

Finding Number 4 – Forcemain to Houston WWTP Still the Least Expensive Alternative

Construction of a forcemain to the City of Houston WWTP remains the least expensive option in terms of capital costs. The cost estimate for this option (including Bellaire Lift Station) is $4.77 million, versus replacement at the existing plant site (with Bellaire Lift Station) at $105.4 million, new WWTP at the Public Works Site (with Bellaire Lift Station) at $130.1 million.

Appendix A. OPCC Breakdown

Table 1. Breakdown of Construction Costs for Alternative 1 – Replacing Existing WWTP

Unit Process	Construction Costs
Screening Facility	$5,403,000
Grit Removal Facility	$4,423,000
MLE Basins	$19,198,000
Aeration System	$3,471,000
Secondary Clarifiers	$5,079,000
Chlorine Contact Tank	$5,806,000
Sodium Hypochlorite System	$1,412,000
Sodium Bisulfite System	$746,000
Belt Filter Presses	$8,929,000
Administrative Building	$2,442,000
Odor Control for Headworks	$4,901,000
Odor Control for Dewatering	$3,342,000
Temporary Package Plant	$30,689,000
Total	**$95,840,000**

Table 2. Breakdown of Construction Costs for Alternative 2 – Constructing a Greenfield WWTP on the Public Works Site

Unit Process	Construction Costs
Screening Facility	$5,403,000
Grit Removal Facility	$4,423,000
MLE Basins	$19,198,000
Aeration System	$3,471,000
Secondary Clarifiers	$13,259,000
Chlorine Contact Tank	$5,806,000
Sodium Hypochlorite System	$1,412,000
Sodium Bisulfite System	$746,000
Aerobic Digesters	$38,209,000
Belt Filter Presses	$14,505,000
Polymer System	$1,119,000
Administrative Building	$2,442,000
Odor Control for Headworks	$4,901,000
Odor Control for Dewatering	$3,342,000
Total	**$118,234,000**

Table 3. Breakdown of Construction Costs for Alternative 3 – Constructing a Forcemain to Houston's Southwest WWTP

Unit Process	Construction Costs
Forcemain	$2,028,000
Replace Influent Lift Station Pumps	$892,000
Demolition of Existing WWTP	$1,418,000
Total	**$4,337,000**