AGENDA STATEMENT City of Bellaire

MEETING: City Council - Jul 08 2024
PREPARED BY: Sharon Citino
DEPARTMENT: City Manager's Office

ITEM TITLE:

Presentation and discussion regarding stormwater and wastewater capital projects, need and funding - Submitted by Sharon Citino, City Manager

BACKGROUND/SUMMARY:

Staff will make a presentation on stormwater and wastewater capital projects need and funding for discussion by the City Council. Representatives from Ardurra Group Incorporated and HDR Engineering Inc. will be in attendance to answer questions. The City's financial advisor, James Gilley, of U.S. Capital Advisors LLC, will also be in attendance to answer questions. The presentation and technical memoranda from the consultants are attached.

CITY ATTORNEY REVIEW:

☐ **Yes** ☑ **No**

Stormwater & Wastewater Capital Projects

Need & Funding

JULY 8, 2024

Agenda:

1. Stormwater Projects
   - Need
   - Scope
   - Estimated Cost
2. Wastewater Projects
   - Need
   - Scope
   - Estimated Cost
3. Funding Options
4. Impact of Issuing Debt
5. Path Forward

Stormwater Projects:

Need:

- 95% Bellaire properties are at risk of flooding
- Rain events more frequent, more intense
- Existing stormwater infrastructure built to outdated standards
- Insurance costs rising
- Delays extend risk and costs

Stormwater Projects:

Scope:

- Cypress Ditch widening
- Property acquisition
- Detention construction

Stormwater Projects:

Estimated Cost:

$110M

Engineering/construction/construction management & inspection

- Cypress Ditch widening $90M
- Property acquisition $8M
- Detention construction $12M

Wastewater Projects:

Need:

- WWTP and Bellaire lift station at or past useful life
- Major, costly repairs necessary to keep facilities functioning
- Delays increase costs and risk regulatory compliance

Wastewater Projects:

Scope - Alternative A: Rebuild WWTP

- Rebuild WWTP
- Relocate and rebuild Bellaire lift station
- Rehab/replace collection lines

Wastewater Projects:

Scope - Alternative B: Rehab WWTP

- Rehab WWTP
- Relocate and rebuild Bellaire lift station
- Rehab/replace collection lines

Wastewater Projects:

Scope – Alternative C: Connect to Houston's WWTP

- Pay impact fees
- Build new lift station and force main
- Demolish WWTP
- Relocate and rebuild Bellaire lift station
- Rehab/replace collection lines

Wastewater Projects:

Estimated Cost – Alternative A: Rebuild WWTP

$100M

Projects:

▪ Rebuild WWTP	$85.5M
▪ Relocate and rebuild Bellaire lift station	$3.5M
▪ Rehab/replace collection lines	$11M

Wastewater Projects:

Estimated Cost – Alternative B: Rehab WWTP

$71.5M

Projects:

Rehab WWTP	$57M
Relocate and rebuild Bellaire lift station	$3.5M
Rehab/replace collection lines	$11M

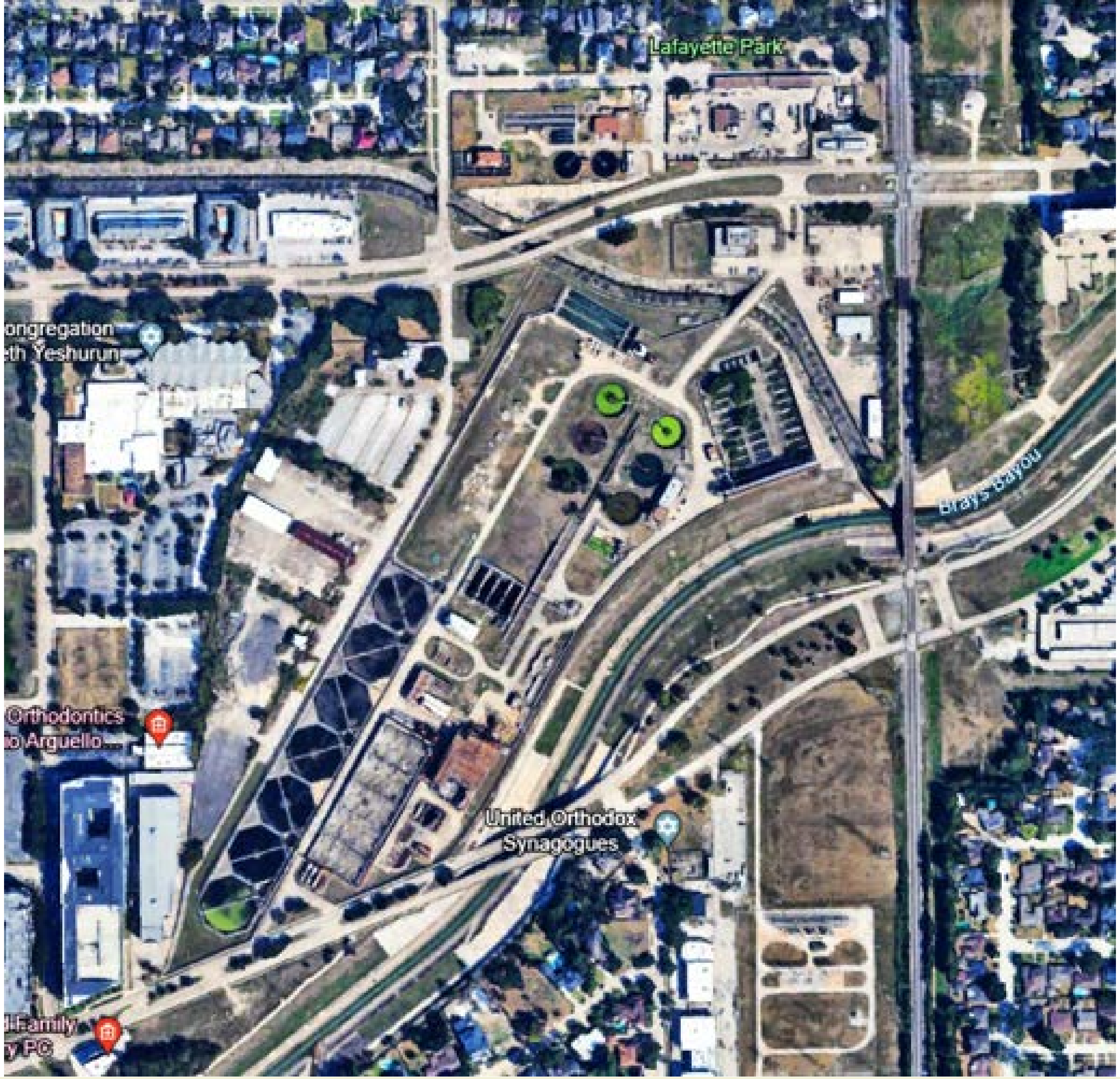
Wastewater Projects:

Estimated Cost – Alternative C: Connect to Houston's WWTP

$29.5M

Projects:

Pay impact fees	$11.5M
Demolish WWTP	$1.25M
Build new lift station and force main	$2.25M
Relocate and rebuild Bellaire lift station	$3.5M
Rehab/replace collection lines	$11M


Lafayette Park
Brays Bayou
Orthodontics
United Orthodox
Synagogues
Family

Water Projects:

Need:

- Continued investment in water facilities
- Resiliency

Potential Scope:

- Water line replacements
- Rehab storage tanks
- Backup generation for Renwick water plant

Cost: TBD

Funding Options:

- Partnerships
- Federal appropriation
- State appropriation
- Grants
- Sell property
- Issue debt

Impact of Issuing Debt:

On Ratepayers/Property Owners:

- Increased utility rates or property taxes (debt service portion; is not subject to property tax cap)

On City:

- De minimis reduction in bonding capacity

Path Forward:

Discussion Items:

- Do we call a bond election for wastewater projects in 2024?
- Do we call a bond election for stormwater projects in 2024?
- Do we request bonding capacity for the total cost, or a portion of those costs?
  - Phasing plan for stormwater projects
  - Alternative C for wastewater projects

ARDURRA

Cypress Ditch Improvements Project

Project Background

Cypress Ditch (HCFCD Unit No. D115-00-00) serves as the primary outfall for the majority of the City's storm drainage systems, including major storm drainage trunklines on S. Rive Avenue, IH-610, and Newcastle Drive, as well as storm drainage systems belonging to the City of Houston. The ditch is approximately 9,500 linear feet, running from Chimney Rock Road to Brays Bayou. The portion of the channel between Chimney Rock Road and S. Rice Avenue, approximately 2,500 linear feet, is natural and unlined, while the remainder is concrete lined. The width of the channel right-of-way (ROW) ranges from 80 feet at the west end to 100 feet between IH-610 and Newcastle Drive.

Due to the level of development in both the City of Bellaire and the City of Houston and the change in drainage standards and criteria to accommodate for increased rainfall, the capacity in Cypress Ditch is not adequate to support flows from the City's storm drainage systems. Since the performance of the City's storm drainage systems is dependent on the capacity in the ditch, the limited capacity in the ditch negatively impacts the ability of those systems to minimize flood risk to Bellaire residents.

Engineering
& Disaster
Management

Project Scope

The Cypress Ditch Improvement project will increase the overall capacity in Cypress Ditch by reconstructing the lined portion of the channel between S. Rice Avenue and Brays Bayou and improving the natural channel section between Chimney Rock Road and S. Rice Avenue. The lined project will change the channel sides from a 2H:1V slope to a 1.5H:1V slope and deepen the channel bottom, where feasible, which will increase the channel's cross section volume, thereby increasing the maximum potential flow in the channel and lowering the water surface elevation during storms up to the 100-year (1% Annual Exceedance Probability [AEP]) storm event. Improvements to culverts where the channel crosses beneath roadways, specifically IH-610, will also be included to ensure these crossings do not create bottlenecks in the conveyance of the channel.

The project will also include the construction of surface detention to provide mitigation for the channel improvements. These ponds will be located on parcels currently owned by the City of Houston that are adjacent to Cypress Ditch, south of Beechnut Street and west of Newcastle Drive.

The projects are described in more detail in the attached Technical Memoranda.

Project Schedule

The anticipated schedule for the project is 9 months for final design and 24 months for construction, with construction anticipated to start in the fall of 2025.

Project Cost

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www.ardurra.com

The total cost for the project, inclusive of the construction of the channel improvements and detention basins and associated costs for engineering design and land acquisition, is approximately $110 million.

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TBPE Registration Number: F-3531

TECHNICAL MEMORANDUM 05

TITLE	**REGIONAL DRAINAGE IMPROVEMENT PLAN – REGIONAL DETENTION**		
PROJECT NO.	23001-00	PREPARED BY:	ADAM EATON, PE
TASK NO.	WORK ORDER 1, TASK E	APPROVED BY:	CHRIS CANONICO, PE
DATE	DECEMBER 27, 2023	REVISION	2

1. PROJECT BACKGROUND

The City of Bellaire (the City) commissioned the Master Drainage Concept Plan (MDCP) to provide a detailed analysis of the City's major north-south drainage systems and recommend improvements to those systems to reduce flooding potential within the City limits. The MDCP recommended conveyance and capacity improvements to Cypress Ditch (HCFCD Unit D115-00-00) and Kilmarnoch Ditch (HCFCD Unit D113-00-00), new storm sewer trunk lines along S. Rice Ave. and IH-610, and surface detention facilities to mitigate the proposed improvements. As part of the Regional Drainage Improvement Program (RDIP), the City requested that Ardurra evaluate the recommendations of the MDCP and refine the proposed improvements or recommend alternative improvements accordingly.

Mitigation is required for storm drainage and flood reduction infrastructure improvement projects to ensure that no adverse impacts are created on downstream systems. For such infrastructure improvements in the City, mitigation is required to ensure there are no adverse impacts created in Cypress Ditch or Brays Bayou (HCFCD Unit D100-00-00). Mitigation volume can be provided through surface detention (detention ponds), linear detention (closed conduit systems including oversized storm sewers or box culverts), subsurface detention basins, or stormwater tunnels. In most instances, surface detention is the more cost-effective alternative in terms of dollars per acre-foot of volume achieved.

The MDCP estimated that all of the improvements proposed therein would require approximately 1,850 acre-feet (ac-ft) of mitigation volume. The MDCP identified seven properties that would provide approximately 394 ac-ft of mitigation volume, through the construction of surface detention ponds, at a projected construction cost of $35 million. These properties include the City of Houston's Southwest Wastewater Treatment Plant (SW WWTP) and a CenterPoint Energy easement located on the west side of Kilmarnoch Ditch.

As part of the Regional Drainage Improvement Program (RDIP), the City requested that Ardurra evaluate the recommendations of the MDCP and refine the proposed improvements or recommend alternative improvements accordingly, which included determining the mitigation volume required for the refined or alternative improvements and evaluating potential locations for surface detention, including properties that were identified in the MDCP. The RDIP recommended improvements to Cypress Ditch and the IH-610 storm sewer system be completed first (the First Phase projects), as these systems serve as the outfalls to all other City storm drainage systems and need to be improved to facilitate other potential storm drainage infrastructure improvements throughout the City.

2. Project Location and Description

While the entirety of the City was considered for potential locations for surface detention ponds, ponds located at the southern, or downstream, end of the city, specifically along Cypress Ditch, Brays Bayou, or the major north/south drainage, are preferrable as they provide more efficient use of the volume by the system(s) they are being used to mitigate. Ponds at the southern end of the city right along Cypress Ditch or Brays Bayou, with discharges directly to either of those channels, can be excavated deeper than ponds further upstream or those that discharge into a storm sewer.

Another alternative for surface detention in the City is pocket detention, which comprises utilizing a larger number of smaller parcels for surface detention ponds to achieve the required mitigation volume from the cumulative volume of all the parcels. However, the volume available from each parcel is minimal, given the area of each parcel and the depth to which they can be excavated, accounting for sloped sides and berms, and thus the need to acquire a large number of smaller parcels to provide mitigation benefits for the larger First Phase projects, pocket detention was not explored in detail for this project.

3. Previous Drainage Studies

The City commissioned the MDCP, dated April 2022, to provide a detailed analysis of the flooding conditions resulting from the performance of the major drainage systems within the City limits. The City also authorized a Drainage Study in 2016 to investigate possible alternatives to reduce the occurrence of structural flooding within the city limits. The MDCP was used as the starting point for the current analysis included in the RDIP.

The Harris County Flood Control District (HCFCD) is in the process of updating the Brays Bayou hydraulic models to incorporate both the Project Brays improvements and ATLAS 14 rainfall data for the MAAPnext program. HCFCD provided an interim model for the Regional Drainage Improvement Program.

4. Purpose and Scope of Work

The purpose of this technical memorandum (TM) is to summarize further analysis of potential locations for large surface detention basins to provide mitigation volume for the recommended improvements identified through the RDIP tasks and as analyzed and presented in TMs 03 (Cypress Ditch Improvements) and 04 (IH-610 Storm Sewer System Improvements). The current estimated total mitigation volume required for the proposed improvements is approximately 380 acre-feet; this total volume may change as these projects are further refined and mitigation volume re-calculated through preliminary and final design. And because these projects represent only the First Phase of the RDIP, additional mitigation volume will be required as future projects are identified and developed.

This analysis includes identifying potential properties or parcels, calculating the potential volumes for those parcels individually as well as the total cumulative volume available, and providing rough cost estimates for construction and property acquisition. The viability of all sites presented in the MDCP was not verified through the first phase of the RDIP. As the RDIP progresses and projects are further developed, additional properties will need to be investigated to determine if they can provide detention volume.

For the purpose of this TM, the term "regional detention" is used to indicate detention facilities that would provide mitigation volume for the regional impacts of the RDIP, including First Phase projects and future projects to be developed. Such facilities could also potentially provide additional mitigation volume that could be utilized by the City of Houston (COH), HCFCD, or both, presenting an opportunity for sharing costs for acquisition and/or construction. The potential for sharing costs and mitigation volume with either entity will be further evaluated in the next phase of the RDIP.

While this analysis identified opportunities to construct detention ponds with the volume necessary to mitigate the First Phase projects, the ponds must also contemplate providing volume to facilitate other potential future City drainage infrastructure projects.

5. METHODOLOGY

The analysis was conducted using Google Maps and Google Earth to identify potential parcels to serve as surface detention ponds, and parcel information (including ownership, parcel size, and current value) was obtained from the Harris County Appraisal District (HCAD). In instances where parcel size was not provided in the HCAD data, surface area was estimated using the Google Earth measuring tool.

Potential parcels considered for this analysis were subject to the following criteria:

- Larger parcels along Cypress Ditch or Brays Bayou, optimizing the hydraulic efficiency of the potential pond, yielding more potential volume
- Vacant parcels, with minimal development (e.g., parking lots) or those where existing structures are known to be unused
- Parcels immediately adjacent to the City and within a two-mile reach, both upstream and downstream of the City, along Brays Bayou
- Publicly and privately owned parcels

The depth and total volume achievable for each potential detention pond depended on the location and the system to which they discharged. Parcels that were immediately adjacent to either Cypress Ditch or Brays Bayou that discharge to those channels were assumed to have a potential depth of excavation of 20 feet, as this is roughly the depth of each channel near their confluence. Potential volumes for parcels not adjacent to these channels that discharge to storm sewer systems were calculated using excavated depths of 8 feet. The volume for each parcel was calculated at 50-percent and 75-percent of the total maximum volume (total area multiplied by total depth) to account for the required sloped sides, maintenance berms, and potential volume reductions necessary to incorporate mixed-use design considerations, including stepped or shelfed bottoms, varying depth detention cells, etc. Ponds were assumed to have flat bottoms.

The volumes presented in this TM represent conceptual level volumes; the total achievable volume for each parcel will be further refined in the next phase of the RDIP. The total achievable volume for each parcel will depend on whether the ponds are maximized for volume or to accommodate recreational or other amenities, whether the ponds are designed to meet HCFCD standards, maintenance requirements and considerations, and other hydraulic and hydrologic design considerations.

Construction costs, including excavation and demolition unit costs, were obtained from recent Harris County bid documents and are also presented as a range. Costs for demolition were assumed to range between $3 and $10 per square yard and costs for excavation were assumed to range between $15 and $25 per cubic yard. Construction costs are presented as low and high costs for one-half and three-quarters of the total achievable excavation depth.

Acquisition costs were obtained from HCAD, where available.

6. CenterPoint Energy Easement

At the time of this analysis, COH was engaging in discussions with CenterPoint Energy regarding utilizing available space in CenterPoint easements for detention in other areas across Houston. Those discussions have not advanced to the point where CenterPoint has either agreed or disagreed to that potential arrangement, so for the purposes of this analysis the CenterPoint easement on the east side of the City of Bellaire, near Kilmarnoch Ditch, was not considered for detention ponds. The City should continue to coordinate with COH and consider engaging in these discussions to find a mutually beneficial path forward for all three parties.

7. Ruffino Hills Regional Detention Facility

The City and the City of West University Place co-owned the Ruffino Hills landfill, located near the interchange of US-59/I-69 and Beltway 8 in southwest Houston. COH has been seeking to acquire the property with the intent to construct a regional detention facility to provide mitigation volume for projects throughout the Keegans Bayou and Brays Bayou watersheds. COH previously purchased the City of West University Place's rights to the property and has been seeking to purchase the City's rights as well. Detention on the Ruffino Hills property would not be a viable option for mitigating City projects or improvements.

Under the RDIP, the City has been advancing conversations with COH to establish a mutually beneficial agreement whereby COH would acquire the City's rights to the Ruffino Hills property, and in return the City would receive cash with which to construct detention or property that could provide usable detention volume for the City. This agreement will continue to be pursued through the next phase of the RDIP.

8. Results

Using the criteria provided in **Section 5**, twelve (12) parcels were ultimately identified as potential locations for regional detention facilities, as shown in **Figure 1** and summarized in **Table 1**.

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TBPE Registration Number: F-3531

Figure 1: Regional Detention Parcels

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Table 1: Regional Detention Analysis Results

Parcel Number	Address	Owner	HCAD Number	Area (ac)	Depth (ft)	Volume (ac-ft)	Construction Cost	Acquisition Cost
1	SW WWTP	COH	0440360000061 0440860000221	37	20	450 – 675	$10.9M - $27.2M(1)	(2)
2	HPW Service Center	COH	0440360000064	6	20	61 – 92	$1.6M - $4.0M	(2)
3	SW Police Substation	COH	0440360000065	5	20	48 – 72	$1.7M - $3.4M(3)	(2)
4	Bellaire WWTP	COB	0591280410001 0591280410004 0440360000059	7	20	66 – 99	$1.6M - $4.0M(1)	N/A
5	4545 Beechnut	FKM Partnership, LTD	1157220020001	5	8	18 – 28	$445,000 - $1.1M	$2.2M
6	0 W Loop S 8801 W Loop S	Meyerland Crossing LLC	0992420000003 0992420000001	7	8	30 – 45	$829,000 - $2.2M	$8.4M
7	0 Meyer Park Dr	TREP WLS Owner LLC	0992430000001	3	8	11 – 17	$320,000 - $834,000	$2.6M
8	4010 S Braeswood Blvd	BG17 - South Braeswood Property Owner LLC	0440860000259	3	20	30 – 45	$733,000 - $1.8M	$5.3M
9	4035 S Braeswood Blvd	BG12 Braeswood and Stella LLC	1463520010001	6	20	61 – 91	$1.9M - $4.1M(3)	$14.1M
10	8700 Stella Link Rd	Stella Link Holdings LLC	1463520010003	4	20	37 – 56	$951,000 - $2.4M	$7.1M
11	5417 S Braeswood Blvd 9602 Chimney Rock Rd 5401 S Braeswood Blvd	Current Owner	0923470000030 0923470000032 0923470000033	4	20	40 – 59	$1.5M - $2.9M(3)	$11.2M
12	5435 S Braeswood Blvd	Cosmos Foundation Inc dba Harmony Science Academy	0923470000001	1	20	13 – 19	$811,000 - $1.3M(3)	$3.5M
Total				**95**	**-**	**967 - 1,451**	**$23.2M - $55.3M**	**$54.4M**

(1) Construction Costs account for excavation only. Costs for demolition costs requires investigation due to wastewater treatment equipment, buildings that could potentially require asbestos abatement, etc.

(2) Acquisition Cost to be negotiated with COH depending on potential cost-share or parcel swap agreement

(3) Construction Cost assumes $500,000 for demolition of existing structures

Although it could provide significant mitigation volume, Parcel 1 (the SW WWTP) should not be considered as a potential site for detention is COH currently does not intend to abandon the facility. Should that change at any point, the City should engage COH in discussion to convert the site into a detention facility, at which point costs for acquisition, demolition, and excavation would be further refined.

Parcels 2 and 3 are both owned by COH: Parcel 2 serves as storage for HPW maintenance equipment and material, and Parcel 3, the SW Police Substation, is currently abandoned. These parcels could be acquired from COH, through either a land swap or volume-share agreement, and converted to detention. The City could offer to provide space for the HPW maintenance equipment and material as part of the agreement.

Parcel 4 is the City's WWTP. Demolishing the WWTP to construct a detention facility on the site would require diverting wastewater flows to the SW WWTP, for which the City would incur an annual cost, that would need approval from COH. The wastewater diversion and treatment agreement could be pursued in order to allow the City to convert the WWTP to a detention facility.

Parcel 5 is a vacant, undeveloped lot with a direct connection to the storm sewer on Beechnut St. Since it is undeveloped, construction costs would be minimized, but since it is privately owned the City would be required to purchase the property, which currently has an HCAD value of $2.2 million.

Parcels 6 and 7 are parking lots that could facilitate direct connections to the City's storm sewer system as well as the TxDOT system along IH-610. These two parcels are privately owned and are currently being redeveloped, making them unusable for surface detention.

Parcel 8 is an undeveloped property immediately adjacent to Brays Bayou. Most of the property lies in the Brays Bayou floodway, with the rest in the 100-year floodplain, so it is unlikely that the property would be redeveloped. The parcel is less than one mile downstream of the City, making it potentially hydraulically feasible to provide mitigation for the City.

Parcels 9 and 10 are a former shopping center along Stella Link Rd. There are a few businesses still in operation, which are all located on Parcel 9. The City could investigate whether there are any plans to redevelop either parcel. Their location near Brays Bayou and proximity to the City (less than one mile downstream) make them potentially hydraulically feasible to provide mitigation for the City.

Parcel 11 is a shopping center with businesses still in operation, however the owner has indicated they are interested in selling. The parcel is located immediately outside the City limits along Brays Bayou, making it potentially hydraulically feasible to provide mitigation for the City.

Parcel 12 is a shopping center with businesses still in operation, but the property is for sale. The parcel is located immediately outside the City limits along Brays Bayou, making it potentially hydraulically feasible to provide mitigation for the City.

The parcels recommended for further analysis to support the development of regional detention are summarized in **Table 2**.

Table 2: Regional Detention Parcel Recommendations

Parcel Number	Volume (ac-ft)	Construction Cost	Acquisition Cost
2	61 – 92	$1.6M - $4.0M	(2)
3	48 – 72	$1.7M - $3.4M(3)	(2)
4	66 – 99	$1.6M - $4.0M(1)	N/A
5	18 – 28	$445,000 - $1.1M	$2.2M
8	30 – 45	$733,000 - $1.8M	$5.3M
9	61 – 91	$1.9M - $4.1M(3)	$14.1M
10	37 – 56	$951,000 - $2.4M	$7.1M
11	40 – 59	$1.5M - $2.9M(3)	$11.2M
12	13 – 19	$811,000 - $1.3M(3)	$3.5M
TOTAL	**373 - 560**	**$11.2M - $25.1M**	**$43.4M**

(1) Construction Costs account for excavation only. Costs for demolition costs requires investigation due to wastewater treatment equipment, buildings that could potentially require asbestos abatement, etc.

(2) Acquisition Cost to be negotiated with COH depending on potential cost-share or parcel swap agreement

(3) Construction Cost assumes $500,000 for demolition of existing structures

All of the recommended parcels could potentially yield between 373 and 560 acre-feet of volume for mitigation. The three publicly owned parcels (Parcels 2, 3, and 4) could potentially yield between 175 and 263 acre-feet of volume at a cost for construction between $4.8 million and $11.4 million for construction, but with no cost for acquisition as these would ideally be included in the land swap with COH. The remaining parcels, all privately owned, could potentially yield 198 and 297 acre-feet of volume at a cost for construction between $6.3 million and $13.7 million, but with a total cost of $43.4 million to acquire the properties.

9. RECOMMENDATIONS

The current estimated mitigation volume required to construct the improvements to Cypress Ditch and the IH-610 storm sewer system, as documented in TMs 03 and 04 (the First Phase projects), is approximately 380 acre-feet. Based on this analysis, the City must utilize a combination of the identified parcels shown in **Table 2** as surface detention ponds to achieve this volume. Additionally, the City will need volume beyond this estimated amount in order to support full implementation of the RDIP and facilitate other future storm drainage infrastructure improvement projects to identified under future phases.

The City's strategy for implementing regional detention solutions should include the following. All costs and volumes presented below are conceptual-level and will need to be further refined through additional analyses and design.

- **Pursue a land swap agreement with COH:** The City and COH should continue to pursue an agreement whereby COH receives the Ruffino Hills property (see **Section 7**), and the City receives Parcels 2 and 3, either through direct ownership or long-term lease from COH, on which detention ponds could be constructed. This would allow both entities to fulfill their mitigation needs and facilitate flood risk reduction across a significant portion of the region. The agreement would ideally not require any cash, so the only costs the City would incur would be for the construction of the detention ponds on Parcels 2 and 3. These parcels could yield between 100 and 170 acre-feet of detention volume at a cost of construction ranging from approximately $3.2 million to $7.4 million.

- **Convert the City's WWTP to detention:** The location of the City's WWTP (Parcel 4) along Cypress Ditch makes it an attractive site for detention. The City has previously investigated opportunities to abandon the WWTP; such an investigation should be re-initiated concurrent with the next phase of the RDIP. The City should coordinate with COH to determine the feasibility and conditions of transferring City wastewater to the SW WWTP, which would require constructing a lift station and force main from the existing City WWTP site south to the SW WWTP and paying COH an annual fee for treatment. This transfer could be included as part of the land swap agreement described above. Once the wastewater transfer infrastructure is in place, the City could demolish the WWTP and construct surface detention on the site. The cost to construct detention on the WWTP site includes approximately $6 million to $10 million to construct the wastewater transfer infrastructure, $1.6 million to $4.0 million for excavation, and $1.0 million to $2.0 million for demolition. The site could potentially yield between 60 and 100 acre-feet of volume.

- **Acquire private properties for detention:** Since the availability of publicly owned properties to serve as detention facilities to provide mitigation volumes necessary to support implementation of the RDIP is limited, the City should consider acquiring private properties to achieve the required mitigation volumes. Parcels 5, 8, 9, 10, 11, and 12 are potentially hydraulically feasible to provide mitigation. Since Parcel 8 is located mostly in the floodway, it is unlikely that it can be redeveloped; the other parcels, however, could be redeveloped. The City should investigate which parcels are planned for redevelopment and determine if those not already being redeveloped could be purchased. The six privately owned parcels identified could potentially yield 200 to 300 acre-feet of detention volume at an estimated cost to demolish and excavate the parcels ranging from $6.3 million to $$13.7 million. The costs to acquire all six parcels is $43.4 million.

- **Advance regional detention to preliminary design:** The next phase of the RDIP should include preliminary design for regional detention. Preliminary design should be completed for Parcels 2, 3, and 4 and should consider Parcels 5, 8, 9, 10, 11, and 12 per the City's direction.

Given the high costs to acquire private properties, especially larger parcels to facilitate more volume, surface detention may not be able to provide the total volume necessary to mitigate all storm drainage infrastructure improvements developed under the RDIP. The City would then need to consider other options for mitigation, including the following. These options could include the following, which would be implemented on a case-by-case basis to support specific projects.

- **Pumped detention:** Traditional surface detention ponds discharge by gravity to a receiving system, either a storm sewer network or a channel, where the depth of the receiving system dictates the total depth of the pond. As an alternative, surface detention ponds can be discharged using a pump system, which would allow the pond to be dug deeper as it would not rely on gravity to fully empty the pond. This would require the City to both construct and maintain the pump systems, increasing the construction costs and creating a new operations and maintenance (O&M) cost.

- **Inline detention:** Because of the extent of existing development in and around the City, large, vacant or developed properties are not readily available, and any such parcels are likely privately owned and would need to be acquired, if not already planned for redevelopment, which constrains the ability of the City to construct surface detention ponds. As an alternative, inline detention, which creates detention within the limits of existing rights-of-way, can be implemented where surface detention ponds are not viable.

Inline detention can be achieved in one of two ways: oversizing the storm sewer or lowering the street to create additional volume. The viability of both options is dependent on the extents of the existing right-of-way, the location and depth of other utilities, and the ability to meet drainage design criteria for both street ponding and structural flood risk reduction. The volume achievable using inline detention not as substantial as surface detention, making it more applicable for local drainage improvement projects where the scope is limited to one or two local streets.

- **Underground detention:** Underground detention, comprising large concrete basins or vaults constructed below grade, is a potential alternative to surface detention in highly developed or urbanized areas like the City. Underground detention basins or vaults can be constructed beneath surface improvements, like parking lots or buildings. Because the detention is built below grade, the basins or vaults cannot discharge by gravity, requiring a pump system for discharge. Underground detention basins are much more costly than other mitigation alternatives on a unit cost (dollars per acre-foot of volume) basis, especially when structures are built on the surface directly above them which necessitates more concrete and structural support to carry the structure's weight.

- **Detention credits from other entities:** Some detention ponds are constructed with excess volume (credits) to provide mitigation for future projects. Both COH and HCFCD have constructed detention ponds along Brays Bayou that may be feasible to provide mitigation for RDIP projects. The City should engage with both COH and HCFCD to determine if either entity has credits available in existing surface detention ponds along Brays Bayou that the City could purchase or otherwise acquire.

- **Public private partnerships (PPPs) for detention:** Publicly owned properties, especially those large enough to support detention ponds with substantial volume and those in a location hydraulically feasible to mitigate City projects, are limited. Because all private development requires mitigation, the City could engage with private property owners and developers to identify where partnership opportunities may exist for the City and the property owner to jointly construct detention on the private property, as opposed to the City trying to acquire the property outright. Such partnerships could focus on either surface detention ponds or underground detention, and the costs for construction and the available volume could be shared between the City and property owner or developer. Such partnerships could be pursued for any of the private properties presented in **Tables 1** and **2**, specifically Parcels 6 and 7.

Surface detention ponds provide the most technically feasible form of mitigation needed to support the First Phase projects of the RDIP, as well as subsequent projects to be developed. This requires that the City acquire properties, either through a land swap agreement with COH or by purchasing privately or other publicly owned properties. If the City does not acquire such properties, the volume that can be achieved through other mitigation alternatives limits the ability to implement the RDIP. We will continue to evaluate opportunities to implement mitigation alternatives as the RDIP progresses, but it is important that the City seek to acquire the properties identified in **Table 2** to support construction of surface detention ponds.

If you have any questions regarding our analyses or the results or recommendations, or if we can be of further service, please contact us.

Ardurra

Adam Eaton, P.E., ENV SP, CFM
Project Manager

HDR

Technical Memorandum

Executive Summary

Date:	**July 3, 2024**
Project:	**Condition Assessment – Bellaire WWTP and Lift Stations**
Prepared By:	**Chris Malinowski, HDR Engineering**

The City of Bellaire engaged HDR Engineering to perform a condition assessment of the City's wastewater treatment plant ("WWTP") and three lift stations. Whereas the final step of the Condition Assessment project was to provide capital cost estimates for several improvement scenarios, there were many steps used to arrive at that point. The steps included the following efforts.

Hydraulic Assessment

The WWTP has a permitted average daily flow capacity of 4.5 million gallons per day (mgd) and a two hour peak flow capacity of 11.5 mgd. HDR used a surveying company to collect elevations at key points in the WWTP, and then modelled the plant using Visual Hydraulics software. Three scenarios were modelled based on water elevations in the receiving stream: 1) normal water elevation, 2) 100 year floodplain elevation, and 3) 500 year floodplain elevation. The model results showed the following:

- At normal water elevations, the hydraulic capacity of the WWTP is 7mgd with all units in service. The capacity is only 6 mgd with one clarifier out of service, or 6.5 mgd with one aeration basin out of service.
- At 100 year floodplain water level, many processes at the WWTP are inundated when treating 4.5 mgd. This is due to the high level of the receiving stream.
- At 500 year floodplain water level, more than half of the WWTP treatment processes are inundated when treating 4.5 mgd.

Process Assessment

HDR used BioWin software to model the treatment process at the WWTP, as well as comparing existing assets to current TCEQ design criteria. HDR also analyzed data on influent flows and quality. Average daily flows were determined to be approximately 1.2 mgd, well below the permit limit of 4.5 mgd.

All process areas meet requirements for average daily flow of 4.5 mgd. The limiting process are the aeration basins, as shown in the table below.

Process Capacities per BioWin Model

Unit Process	Annual Average Flow Capacity (mgd)	Peak Flow Capacity (mgd)
Aerated Grit Chamber	-	14.5
Aeration Basins	5.16	-
Secondary Clarifiers	-	12.1
Chlorine Contact Tanks	-	13.2

Odor Assessment

HDR set up hydrogen sulfide monitors at key points throughout the plant and used this data to perform a dispersion model to estimate odor levels at the fence lines around the WWTP. The model was used to determine if there was potential for non-compliance with existing Texas Administrative Code regulations that prohibit hydrogen sulfide readings over 80 parts per billion over a 30 minute period on residential, business, or commercial properties.

The highest readings were obtained at the fine screens and headworks areas of the WWTP. When placed in the dispersion model, the results show the potential for readings above 80 ppb on the properties on the north side of Edith Avenue, facing the northern fence of the WWTP.

Resiliency Evaluation

HDR hired a surveying company to measure the elevations of key locations around the WWTP and lift station sites. When comparing current elevations to those from engineering plans from past projects dating back to 1974, it became evident that the WWTP site has subsided approximately 6.3 feet over the last 50 years. Subsidence is common throughout the Houston area, and it is not limited to only the WWTP site.

HDR also compared these new elevations to Harris County Flood Control District floodplain elevations, which are currently under revision. Currently the design value is the 500 year floodplain elevation of 53.62 feet at the WWTP site. At this water elevation, many parts of the WWTP will be under water, including the disinfection system, clarifiers, belt presses, and access to the site. In addition, there would be over a foot of water in the control room where the primary electrical gear is located.

Operations Evaluation

At the time of the evaluation, the City only had two operators to cover the WWTP, lift stations, and water treatment facilities. Based on our experience, the City would normally have 4 operations/maintenance personnel. The operators are doing a good job keeping the facilities in compliance. The WWTP has had some issues keeping up with maintenance over the long term, but progress is being made on certain issues. Key outstanding issues noted include:

- Repair automatic controls to reduce operator time requirements. This includes aeration adjustments, wasting of solids, and lift station starting/stopping.
- Maintain sufficient blowers in service for redundancy purposes.
- Convert disinfection from gas back to liquid chemicals.

Condition Assessment

The influent lift station and blower systems have received much investment in recent years and are in good condition. Other areas are either past their useful lives and/or in need of replacement. These include:

- Aeration Basins: Parts of the concrete tanks are approximately 80 years old and potentially leak. The air diffusers are near the end of their useful life and should be inspected and/or replaced.
- Clarifiers: The weirs and rotating arms are approximately 50 years old and need replacing. One arm is currently damaged and being repaired.
- Electrical: The primary switchgear and motor control center is approximately 50 years old, well past its normal useful life of 30 years. It also needs to be raised above the 500 year floodplain.
- Headworks: Parts of the grit removal system are out of service. Key equipment should be replaced and placed in an enclosed structure to reduce odor emissions.
- SCADA Controls: This system needs to be upgraded and expanded to industry standards. This is currently under procurement by the City.

Alternatives Analysis and Cost Estimates

After analyzing available WWTP flow data and holding discussions with the City, all alternatives were developed for a smaller treatment plant capable of treating an average daily flow of 2.5 mgd, but still able to treat peak flows due to inflow and infiltration throughout the City. Existing average daily flows have been less than 1.2 mgd over the last 5 years, and the City does not anticipate much opportunity for additional flows in future. When the design of WWTP improvements begins, it will be important to identify the peak flows that must be treated. This will be aided by the City's current project of measuring wastewater flows at key locations throughout the wastewater collection system.

The cost estimates for the 4.5 MGD option are also provided for information purposes.

HDR evaluated the following alternatives and developed cost estimates for each:

- Headworks:
  - New grit removal system, improvements to screens, new building
  - New grit removal system and screens
- Secondary Treatment System
  - Conventional Activated Sludge System with aeration basins and clarifiers
  - Aerobic Granular Sludge System with aeration basins and clarifiers combined into the same tank.
- Disinfection System
  - Chemical Disinfection System,
  - Ultraviolet Disinfection System.

Construction cost and annual operating cost estimates were developed for each combination of alternatives. This was done with HDR's WaterCost model. This is shown in the tables below. Total Construction Cost can also be referred to as Opinion of Probable Construction Cost (OPCC).

2.5 MGD Option
Opinion of Probable Construction Cost and Annual Operating Cost Estimates

Alternative	Total Construction Costs	Annual Operating Cost[1]
New HW, CAS, Chemical Disinfection	$29,000,000	$626,000
New HW, AGS, Chemical Disinfection	$38,800,000	$624,000
New HW, CAS, UV Disinfection	$26,700,000	$1,034,000
New HW, AGS, UV Disinfection	$36,400,000	$1,032,000
Rehab HW, CAS, Chemical Disinfection	$26,800,000	$626,000
Rehab HW, AGS, Chemical Disinfection	$36,500,000	$624,000
Rehab HW, CAS, UV Disinfection	$24,400,000	$1,034,000
Rehab HW, AGS, UV Disinfection	$34,100,000	$1,032,000

4.5 MGD Option
Opinion of Probable Construction Cost and Annual Operating Cost Estimates

Alternative	Total Construction Costs	Annual Operating Cost[1]
New HW, CAS, Chemical Disinfection	$41,000,000	$977,000
New HW, AGS, Chemical Disinfection	$51,100,000	$968,000
New HW, CAS, UV Disinfection	$38,700,000	$1,670,000
New HW, AGS, UV Disinfection	$48,800,000	$1,661,000
Rehab HW, CAS, Chemical Disinfection	$38,000,000	$977,000
Rehab HW, AGS, Chemical Disinfection	$48,100,000	$968,000
Rehab HW, CAS, UV Disinfection	$35,700,000	$1,670,000
Rehab HW, AGS, UV Disinfection	$45,800,000	$1,661,000

To convert the OPCC to budget estimates, contingencies and factors must be added. The industry standard at this conceptual stage is to use a Class 5 AACE (American Association of Cost Engineering) estimate. It includes a factor for Undefined Work, as well as a factor for the accuracy of the estimate. For this project we have used 40% and a -35% to +60% factor.

AACE Cost Estimating

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%

Adding these factors to the OPCC generates budget estimates as shown in the tables below.

These Class 5 estimates do not include engineering costs nor construction management costs. Typical values for these items are 10% and 3% of construction cost, respectively.

HDR

2.5 MGD Option
Class 5 Budget Estimates for Construction Alternatives

Alternative	Total Construction Cost	Total Project Cost	Total Project Cost -35%	Total Project Cost +60%
CAS with New HW & Chem Disinfection	$29,100,000	$45,400,000	$29,500,000	$72,600,000
AGS with New HW & Chem Disinfection	$38,800,000	$55,100,000	$35,800,000	$88,200,000
CAS with New HW & UV Disinfection	$26,700,000	$43,000,000	$28,000,000	$68,800,000
AGS with New HW & UV Disinfection	$36,400,000	$52,700,000	$34,300,000	$84,300,000
CAS with Rehab HW & Chem Disinfection	$26,800,000	$43,100,000	$28,000,000	$69,000,000
AGS with Rehab HW & Chem Disinfection	$36,500,000	$52,800,000	$34,300,000	$84,500,000
CAS with Rehab HW & UV Disinfection	$24,400,000	$40,700,000	$26,500,000	$65,100,000
AGS with Rehab HW & UV Disinfection	$34,100,000	$50,400,000	$32,800,000	$80,600,000

4.5 MGD Option
Class 5 Budget Estimates for Construction Alternatives

Alternative	Total Construction Costs	Total Project Cost	Total Project Cost -35%	Total Project Cost +60%
CAS with New HW & Chem Disinfection	$41,000,000	$65,400,000	$42,500,000	$104,600,000
AGS with New HW & Chem Disinfection	$51,100,000	$75,500,000	$49,100,000	$120,800,000
CAS with New HW & UV Disinfection	$38,700,000	$63,100,000	$41,000,000	$101,000,000
AGS with New HW & UV Disinfection	$48,800,000	$73,200,000	$47,600,000	$117,100,000
CAS with Rehab HW & Chem Disinfection	$38,000,000	$62,400,000	$40,600,000	$99,800,000
AGS with Rehab HW & Chem Disinfection	$48,100,000	$72,500,000	$47,100,000	$116,000,000
CAS with Rehab HW & UV Disinfection	$35,700,000	$60,100,000	$39,100,000	$96,200,000
AGS with Rehab HW & UV Disinfection	$45,800,000	$70,200,000	$45,600,000	$112,300,000

Technical Memorandum Wastewater Facility Improvements Cost Estimate

City of Bellaire

Wastewater Facilities Engineering and Support

HDR Project: 10387209

May 29, 2024

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

Contents

Tables

Figures

1 Introduction

As part of HDR's Task 3 for the Condition Assessment of City of Bellaire's wastewater treatment plant (WWTP), the City asked HDR to develop opinion of probable construction costs (OPCC) for several WWTP improvements alternatives. Improvements alternatives and OPCCs were developed for the WWTP's preliminary treatment unit processes (screening and grit removal), secondary treatment process, and disinfection.

1.1 Background

The City of Bellaire operates and maintains a WWTP located at 4401 Edith Street, Bellaire, Texas. The WWTP has gone through several upgrades and expansions with the last major expansion 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 chlorine contact basin) were placed into service in 1974. Several other modifications took place in 1994 including the addition of a fine screen facility, grit classifier, and a fine bubble diffused aeration system in the aeration basin. In 2017, the disinfection system, lift station piping, and blower building air piping were replaced. Many of the structures at the plant are nearing the end of their expected life and need to be replaced. These structures include the headworks, pre-aeration basins, aeration basins, secondary clarifier equipment, and chlorine contact basins. The existing plant has a permitted annual average daily flow (ADF) rate of 4.50 mgd and a permitted peak 2-hour flow rate of 11.0 mgd. **Figure 1-1** shows an aerial view of the existing WWTP.

Figure 1-1. Bellaire WWTP Aerial View

2 General OPCC Assumptions

HDR prepared AACE Class 5 (accuracy range of -35% to +66%) planning level OPCCs for these evaluations. **Table 2-1** shows the different AACE planning cost estimate levels and provides further information on each of them.

Table 2-1. 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 2-2**.

Table 2-2. 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 2-3.**

Table 2-3. Assumptions Made for Additional Construction Costs

Category	Assumed Percentage	Category	Assumed Percentage
Misc./Unidentified Site Structures	20%	Field Conditions	7%
Sitework	15%	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%

It is important to note that these estimates do not include the engineering fees associated with these projects.

3 Alternative Evaluation

OPCCs were developed for improvement alternatives at the WWTP's headworks, the secondary treatment process, and the disinfection system. The OPCCs were developed for two ADF scenarios - 2.5 and 4.5 mgd – and peak two-hour flow rates of 6.25 and 11 mgd. Alternatives presented for an average day capacity of 2.5 mgd will require flow monitoring and flow data analysis to confirm and substantiate the need to rerate the plant from 4.5 mgd to 2.5 mgd, ADF. Additionally, the alternatives presented below assume the peaking factor remains the same between to two scenarios. Flow analysis to confirm peaking factor is required if the plant is re-rated.

It was assumed that all alternatives will require the installation and operation of a temporary treatment package plant. This cost is required due to the limited site space and the inability to construct operational facilities while keeping the existing facilities in service.]

3.1 Headworks Facilities

Based on the results of the condition assessment, the grit removal facility at the WWTP is nearing the end of its useful life. The screening facility is in fair condition and improvements can be made to provide continued use. Based on these findings, OPCCs were developed for two alternatives:

- Construction of a new grit removal facility with improvements to the screening area including construction of a building around the screens and channels.

- Construction of a new grit removal facility and screening facility.

OPCCs were developed assuming a peak flow capacities of 6.25 and 11 mgd (WWTP permitted peak two hour flow capacity).

3.2 Secondary Treatment Process

The two secondary treatment processes that were evaluated were a conventional activated sludge process and an aerobic granular sludge process.

3.2.1 Conventional Activated Sludge

The conventional activated sludge (CAS) processes is a proven and effective treatment technology. Conventional activated sludge processes biologically treat wastewater by creating set environmental conditions within a treatment basin. The set environmental conditions then allow certain types of bacteria to grow within the basin, which then remove contaminants from the wastewater through a series of chemical reactions. Conventional activated sludge processes typically require a headworks facility, treatment basins, an aeration system, secondary clarifiers, a disinfection system, and a solids processing system. The existing plant currently uses a conventional activated sludge process with aeration treatment basins.

Based on effluent permit requirements given to the City's WWTP by TCEQ, HDR determined that a MLE process would serve as a cost-effective form of treatment. A MLE process requires that there be two separate zones in the treatment basins, one with anoxic (no oxygen) conditions followed by the other with aerobic conditions. The MLE process also requires the use of an internal or nitrate recycle stream that takes effluent from the aerobic zone to the head of the anoxic zone. MLE processes are very effective at reliably removing BOD and ammonia (NH_4) from wastewater, while also providing full nitrogen removal as well.

The required basin volume and air supply system capacity for the Bellaire WWTP were determined using steady-state BioWin models for a 2.5 mgd ADF scenario and a 4.5 mgd ADF scenario. These systems were sized based on maximum month influent conditions with winter wastewater temperatures. The influent flow rates used for these models were determined by taking the assumed ADF flow rate and extrapolating that to a maximum month flow based on the ratio determined in the probability analysis on the plant's historical influent data from Section 2.2.1 in the *Process Capacity Analysis Technical Memorandum*. The influent concentrations determined from that probability analysis were also used for the models. The other assumptions used to set up the BioWin model are listed in **Table 3-1**.

Table 3-1. BioWin Model Assumptions

Parameter	Value	Notes
Grit Tank Volume, gal	60,000	From City asset list
Grit Tank Underflow, %	0.01	Percent of plant influent flow rate
MLSS in Basins, mg/L	2,950	Based on secondary clarifier steady-state point analysis
Anoxic Basin Volume, %	25	Percent of total basin volume based on common industry standard

Table 3-1. BioWin Model Assumptions (cont.)

Parameter	Value	Notes
Aerobic Basin Volume, %	75	Percent of total basin volume based on common industry standard
DO Setpoint in Aerobic Zones, mg/L	2.0	Common industry standard
NRCY/IMLR Flow, %	300	Percent of plant's influent flow rate
Secondary Clarifier Surface Area, sf	10,050	From record drawings
Secondary Clarifier Underflow, %	30	Percent of plant's influent flow rate
Aerobic SRT, days	6	Common industry standard
Aerobic Digester Volume, gal	12,600	From record drawings

The model was then run through several steady-state simulations to determine the basin volume and aeration system capacity required for the two different capacity scenarios. These results are listed in **Table 3-2** and were used to estimate the cost of this secondary treatment process alternative.

Table 3-2. BioWin Model Results

ADF Capacity, mgd	Anoxic Basin Volume, MG	Aerobic Basin Volume, MG	Total Basin Volume, MG	Air System Capacity Required, scfm
2.5	0.46	1.38	1.84	2,500
4.5	0.93	2.40	3.7	4,500

HDR prepared preliminary site plans for these alternatives based on these results. **Figure 3-1** shows a preliminary site plan for a conventional activated sludge MLE process for the 2.5 mgd ADF capacity scenario. The site plan presented below does not meet the buffer zone requirements set by TCEQ which requires greater than 150-ft from property line to the nearest treatment unit (30 TAC § 309.13(e)) and will require review and approval prior to proceeding with this alternative.

Figure 3-1. Preliminary Site Plan for 2.5 / 6.25 mgd CAS System

Figure 3-2 shows a preliminary site plan for a conventional activated sludge MLE process for the 4.5 mgd ADF capacity scenario. The site plan presented below does not meet the buffer zone requirements set by TCEQ which requires greater than 150-ft from property line to the nearest treatment unit (30 TAC § 309.13(e)) and will require review and approval prior to proceeding with this alternative.

Figure 3-2. Preliminary Site Plan for 4.5 / 11.0 mgd CAS System

The area shown for the CAS basins in these site plans assumes a basin side water depth of 20 feet. As noted above, a temporary package plant would be required to maintain plant operations while the existing basins are demolished and the new BNR basins are constructed due to the limited space on site.

3.2.2 Aerobic Granular Sludge

Aerobic granular sludge (AGS) is a type of activated sludge process that requires the establishment of environmental conditions that favor the development of granular sludge. Granular sludge is activated sludge that forms in larger granules that can measure 0.5-3.0 mm in diameter. Being larger and having more surface area than a typical activated sludge, granular sludge can settle much faster and can also provide anaerobic, anoxic, and aerobic environments within a single tank, which allows phosphorus and total nitrogen removal to occur within the same tank. Since the granular sludge settles much faster than conventional sludge, many manufacturers, including AquaNereda, have developed technologies utilizing granular sludge within a sequencing batch reactor. The combination of a sequencing batch reactor with granular sludge provides an effective and efficient wastewater treatment process within a compact footprint.

Typical AGS sequencing batch processes operate on a 3-stage cycle. The first stage is the simultaneous fill and draw time where treated wastewater is drawn out of the basin and replaced with influent wastewater. This is then followed by the second stage, when the granular sludge within the basin is given time to conduct the reactions involved with treating the wastewater in the basin. Once enough time has been given for the reactions to occur, the third stage occurs, when the granular sludge settles to the bottom of the basin before the process is repeated. Sludge will also be regularly removed from the basin to maintain a desired solids retention time (SRT) for granular sludge.

The required AGS basin volume and AGS equipment cost were determined for both scenarios using HDR's AquaNereda AGS Sizing tool. This tool was created through HDR's experience with designing AquaNereda AGS systems and a collection of budgetary costs for previous AGS projects that HDR has worked on. The basin volumes were determined based on the assumed influent characteristics, common biological parameters, hydraulic constraints, a targeted MLSS concentration, set batch reactor sequence cycle times, and a targeted effluent quality. The systems were also sized to allow for the basins to continuously receive influent and eliminate the need for wet weather storage. The costs were estimated by applying a cost curve to the collection of historical budgetary costs of AquaNereda systems. The tool provided two costs for the AGS equipment, one based on basin size and one on the maximum month influent flow rate at the plant. The higher of these two costs was used in this estimate. The design results for both capacity scenarios are listed in **Table 3-3** and were used to estimate the cost of this secondary treatment process alternative**.**

Table 3-3. HDR AquaNereda AGS Sizing Tool Results

Plant Capacity Scenario, mgd	Basin Volume (Each), MG	Number of Basins	Total Basin Volume, MG	AGS Equipment Cost
2.5 / 6.25	0.64	3	1.93	$7,000,000
4.5 / 11.0	0.94	3	2.82	$9,600,000

HDR also prepared preliminary site plans for these alternatives based on these results. **Figure 3-3** shows a preliminary site plan for an AquaNereda AGS process for the 2.5 mgd ADF capacity scenario. As noted above, the site plan presented below does not meet the buffer zone requirements set by TCEQ which requires greater than 150-ft from property line to the nearest treatment unit (30 TAC § 309.13(e)) and will require review and approval prior to proceeding with this alternative.

Figure 3-3. Preliminary Site Plan for 2.5 / 6.25 mgd AGS System

Figure 3-4 shows a preliminary site plan for an AquaNereda AGS process for the 4.5 mgd ADF capacity scenario. As noted above, the site plan presented below does not meet the buffer zone requirements set by TCEQ which requires greater than 150-ft from property line to the nearest treatment unit (30 TAC § 309.13(e)) and will require review and approval prior to proceeding with this alternative.

Figure 3-4. Preliminary Site Plan for 4.5 / 11.0 mgd AGS System

As with the CAS alternatives, a temporary package plant would be required to maintain plant operations while the existing basins are demolished and the new BNR basins are constructed due to the limited space on site.

3.3 Disinfection System

HDR developed OPCCS for two disinfection system alternatives – chemical disinfection with sodium hypochlorite and sodium bisulfite and ultraviolet (UV) light disinfection. The OPCC for each system was based on peak two-hour flow rates of 6.25 and 11 mgd.

Chemical disinfection involves the addition of chemicals to wastewater to kill or inactivate bacteria, viruses, and other microorganisms. The most common chemicals used for wastewater disinfection are chlorine gas and sodium hypochlorite. For this evaluation, it was assumed that a sodium hypochlorite chemical system would be used, due to the heavier maintenance requirements and safety concerns associated with chlorine gas. In addition to the disinfectant, sodium bisulfite would also have to be added to the wastewater for dichlorination.

UV disinfection involves the exposure of wastewater to ultraviolet light that will kill or inactivate bacteria, viruses, and other microorganisms. Various UV technologies are available in today's market including horizontal and inclined bulb systems.

4 Cost Estimate Results

The results of the cost estimate conducted by HDR are presented in the following sections. Annual operating costs for the secondary treatment and disinfection alternatives were also estimated. The OPCCs do not include costs for a temporary package treatment plant to treat flows during the construction of the proposed improvements. These costs are described and presented in Section 4.2.

4.1 Headworks, Secondary Treatment, and Disinfection Improvements

4.1.1 2.5 / 6.25 mgd WWTP

The OPCCs for the 2.5 mgd ADF and 6.25 mgd peak two hour WWTP improvements are presented by unit process alternative in **Table 4-1**.

Table 4-1. 2.5 / 6.25 mgd WWTP Unit Process Alternative Costs

Unit Process	Alternative	Total Construction Costs	Annual Operating Cost
Headworks	New grit and screenings facility	$6,500,000	N/A
	New grit and screenings facility rehab.	$4,200,000	N/A
Secondary Treatment	CAS	$17,800,000	$479,000
	AGS	$27,600,000	$476,000
Disinfection	Chemical	$4,721,000	$147,000
	UV	$2,331,000	$555,000

Table 4-2 presents the OPCCs for the combined alternatives.

Table 4-2. 2.5 / 6.25 mgd WWTP Combined Alternative Costs

Alternative	Total Construction Costs	Annual Operating Cost[1]
New HW, CAS, Chemical Disinfection	$29,000,000	$626,000
New HW, AGS, Chemical Disinfection	$38,800,000	$624,000
New HW, CAS, UV Disinfection	$26,700,000	$1,034,000
New HW, AGS, UV Disinfection	$36,400,000	$1,032,000
Rehab HW, CAS, Chemical Disinfection	$26,800,000	$626,000
Rehab HW, AGS, Chemical Disinfection	$36,500,000	$624,000
Rehab HW, CAS, UV Disinfection	$24,400,000	$1,034,000
Rehab HW, AGS, UV Disinfection	$34,100,000	$1,032,000

1. Includes the estimated operating costs for the secondary treatment process and disinfection process.

4.1.2 4.5 / 11.0 mgd WWTP

The OPCCs for the 4.5 mgd ADF and 11.0 mgd peak two hour WWTP improvements are presented by unit process alternative in **Table 4-3.**

Table 4-3. 4.5 / 11.0 mgd WWTP Unit Process Alternative Costs

Type of Unit Process	Alternative	Total Construction Costs	Annual Operating Cost
Headworks	New grit and screenings facility	$7,600,000	N/A
	New grit and screenings facility rehab.	$4,600,000	N/A
Secondary Treatment	CAS	$27,900,000	$729,000
	AGS	$38,000,000	$719,000
Disinfection	Chemical	$5,500,000	$248,000
	UV	$3,200,000	$942,000

Table 4-4 presents the results by combined alternatives.

Table 4-4. 4.5 / 11.0 mgd WWTP Combined Alternative Costs

Alternative	Total Construction Costs	Annual Operating Cost[1]
New HW, CAS, Chemical Disinfection	$41,000,000	$977,000
New HW, AGS, Chemical Disinfection	$51,100,000	$968,000
New HW, CAS, UV Disinfection	$38,700,000	$1,670,000
New HW, AGS, UV Disinfection	$48,800,000	$1,661,000
Rehab HW, CAS, Chemical Disinfection	$38,000,000	$977,000
Rehab HW, AGS, Chemical Disinfection	$48,100,000	$968,000
Rehab HW, CAS, UV Disinfection	$35,700,000	$1,670,000
Rehab HW, AGS, UV Disinfection	$45,800,000	$1,661,000

1. Only includes the estimated operating costs for the secondary treatment process and disinfection process.

4.2 Miscellaneous Plant Improvements

In addition to the headworks, secondary treatment, and disinfection system improvements described above, several other plant processes require upgrades to provide continued use. Costs for a temporary treatment plant package are also discussed below.

4.2.1 Bellaire Lift Station Replacement

Based on the plant condition assessment, the Bellaire Lift Station, which sends flow directly to the WWTP, should be replaced. The station has a firm capacity of 3.5 mgd and is a dry pit type station. The OPCC to replace this station is $2.00M.

4.2.2 Solids Dewatering Improvements

Solids dewatering improvements are also recommended for the WWTP. These improvements include two belt filter presses (one to replace the existing press and another for redundancy) and providing an elevated space within the existing dewatering buidling for those presses, to keep them above the 100-year floodplain elevation. The OPCC for these improvements is $4.20M.

4.2.3 Package Treatment Plant Costs

A temporary package plant will be required to treat the plant influent while proposed improvements are under construction. Assuming a construction duration of 36 months, the estimated costs for a package plant for the two different capacity scenarios are listed in **Table 4-5**. The assumed monthly rental costs for the package plants are from an estimate provided by a package plant manufacturer for a recent HDR project (adjusted for inflation).

Table 4-5. Construction Sequencing Estimated Costs

Plant Capacity Scenario, mgd	Monthly Rental Cost	Total Rental Cost for Project
2.5 / 6.25	$281,000	$10,100,000
4.5 / 11.0	$505,000	$18,200,000

The proposed location for the package plant would be on the southern side of the site, between the existing solids handling facility and secondary clarifiers.

5 Summary

Several pieces of infrastructure and equipment at the City of Bellaire's existing WWTP are nearing the end of their expected useful life and need to be replaced or rehabilitated in the upcoming years. HDR developed an AACE Class 5 construction cost estimate for the construction projects that will be needed to rehabilitate the existing WWTP. Cost estimates were conducted and provided for alternatives for multiple different unit processes at two different WWTP capacity scenarios. These two scenarios were:

1. 2.5 mgd ADF / 6.25 mgd peak flow capacity
2. 4.5 mgd ADF / 11.0 mgd peak flow capacity

The alternatives considered included:

1. Rehabilitate vs replace headworks screening facility
2. Conventional activated sludge vs AGS secondary treatment system
3. Chemical disinfection vs UV disinfection

Additionally, cost estimates were also conducted for required dewatering improvements at the WWTP and the replacement of the Bellaire Lift Station. It was also determined, through preliminary site plans, that a package plant would likely need to be rented and used to treat the WWTP's influent while the secondary treatment basins are under construction, so a cost estimate was provided for that as well.

The cost estimate results indicate that rehabilitating the headworks screens, conventional activated sludge, and UV disinfection would cost less compared to their counter-alternative. It is also important to note, however, that the cost of operating the AGS system would be slightly lower than that of a conventional system, and the cost of operating a chemical disinfection system would be significantly lower than a UV disinfection system. Other factors should also be considered when selecting an alternative though, including operator preference, availability, and proven effectiveness.

Additionally, since this is a Class 5 AACE construction cost estimate, an additional accuracy range of -35% and +60% should be considered with these cost estimate results.

For the 2.5/6.25 mgd capacity scenario, the total project cost was estimated to be within a range of $30.6M to $45.0M. If the package plant is required during construction, an additional $10.1M would be required for the rental cost. The total project costs for the 2.5/6.5 mgd capacity scenario alternatives, combined with the package plant costs, are presented in **Table 5-1**, along with the range of costs associated with this Class 5 AACE construction cost estimate.

Table 5-1. Summary of 2.5/6.25 mgd Capacity Alternative Total Costs

Alternative	Total Construction Cost	Total Project Cost	Total Project Cost -35%	Total Project Cost +60%
CAS with New HW & Chem Disinfection	$29,100,000	$45,400,000	$29,500,000	$72,600,000
AGS with New HW & Chem Disinfection	$38,800,000	$55,100,000	$35,800,000	$88,200,000
CAS with New HW & UV Disinfection	$26,700,000	$43,000,000	$28,000,000	$68,800,000
AGS with New HW & UV Disinfection	$36,400,000	$52,700,000	$34,300,000	$84,300,000
CAS with Rehab HW & Chem Disinfection	$26,800,000	$43,100,000	$28,000,000	$69,000,000
AGS with Rehab HW & Chem Disinfection	$36,500,000	$52,800,000	$34,300,000	$84,500,000
CAS with Rehab HW & UV Disinfection	$24,400,000	$40,700,000	$26,500,000	$65,100,000
AGS with Rehab HW & UV Disinfection	$34,100,000	$50,400,000	$32,800,000	$80,600,000

For the 4.5/11.0 mgd capacity scenario, the total project cost was estimated to be within a range of $41.9M to $57.3M. If the package plant is required during construction, an additional $18.2M would be required for the rental cost. The total project costs for the 4.5/11.0 mgd capacity scenario alternatives, combined with the package plant costs, are presented in **Table 5-2**, along with the range of costs associated with this Class 5 AACE construction cost estimate.

Table 5-2. Summary of 4.5/11.0 mgd Capacity Alternative Total Costs

Alternative	Total Construction Costs	Total Project Cost	Total Project Cost -35%	Total Project Cost +60%
CAS with New HW & Chem Disinfection	$41,000,000	$65,400,000	$42,500,000	$104,600,000
AGS with New HW & Chem Disinfection	$51,100,000	$75,500,000	$49,100,000	$120,800,000
CAS with New HW & UV Disinfection	$38,700,000	$63,100,000	$41,000,000	$101,000,000
AGS with New HW & UV Disinfection	$48,800,000	$73,200,000	$47,600,000	$117,100,000
CAS with Rehab HW & Chem Disinfection	$38,000,000	$62,400,000	$40,600,000	$99,800,000
AGS with Rehab HW & Chem Disinfection	$48,100,000	$72,500,000	$47,100,000	$116,000,000
CAS with Rehab HW & UV Disinfection	$35,700,000	$60,100,000	$39,100,000	$96,200,000
AGS with Rehab HW & UV Disinfection	$45,800,000	$70,200,000	$45,600,000	$112,300,000