FINAL

CLEARWATER WRF MASTER PLAN: FUTURE WRF STRATEGIES

Technical Memorandum

BLACK & VEATCH PROJECT NO. 408831
CITY PROJECT NO. 17-0007-UT

PREPARED FOR

City of Clearwater, Florida

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BLACK & VEATCH

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AACEI	Association for the Advancement of Cost Engineering International
AAD	Annual Average Day
AADF	Annual Average Daily Flow
AD	Average Day
APRICOT	A Prototype Realistic Innovative Community of Today
ASR	Aquifer Storage and Recovery
AWT	Advanced Wastewater Treatment
BEBR	Bureau of Economic and Business Research
BFP	Belt Filter Press
cBOD5	Carbonaceous Biochemical Oxygen Demand
CHP	Combined Heat and Power
CIP	Capital Improvements Plan
City	City of Clearwater
CMOM	Capacity Management, Operation, and Maintenance
CWA	Clean Water Act
d	Day
DMR	Discharge Monitoring Report
DPR	Direct Potable Reuse
dtpd	Dry Ton per Day
DWF	Dry Weather Flow
EPA	Environmental Protection Agency
EQ	Equalization
EWRF	East Water Reclamation Facility
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FOG	Fat, Oil and Grease
GHG	Greenhouse Gas
GPCD	Gallons per Capita per Day
I&C	Instrumentation and Controls
I&I	Infiltration and Inflow
IPR	Indirect Potable Reuse
kWh	Kilowatt-hour
lb/d	Pounds per Day
LCC	Life Cycle Cost
MD	Maximum Day

mg/L	Milligrams per Liter
mgd	Million Gallons per Day
MMAD	Maximum Month Average Day
MSWRF	Marshall Street Water Reclamation Facility
NEWRF	Northeast Water Reclamation Facility
NH3	Ammonia
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
O&M	Operations and Maintenance
OEDR	Office of Economic and Demographic Research
OPCC	Opinion of Probable Construction Costs
PFAS	Per and Polyfluoroalkyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
PHF	Peak Hourly Flow
PRC	Potable Reuse Commission
PS	Pump Station
PSL	Primary Sludge
R&R	Renewal and Replacement
RDT	Rotary Drum Thickener
RMF	Regional Management Facility
SLR	Sea Level Rise
SWFWMD	Southwest Florida Water Management District
TAZ	Transportation Analysis Zone
TKN	Total Kjeldahl Nitrogen
TM	Technical Memorandum
TP	Total Phosphorus
TS	Total Solids
TSS	Total Suspended Solids
TWAS	Thickened Waste Activated Sludge
VS	Volatile Solids
WAS	Waste Activated Sludge
WRF	Water Reclamation Facility
WWCS	Wastewater Collection System
yr	Year

Executive Summary

The City of Clearwater Public Utilities Department (City) has undertaken the completion of a 30-year Master Plan and implementation strategy for the City's three water reclamation facilities (WRF). The Master Plan will be used as an aid in determining current WRF renewal and replacement needs as well as a budgeting and planning roadmap for implementing future facility modifications, upgrades, operational and maintenance improvements and compliance with future regulations, and to ensure the facilities are efficient and economical.

The Master Plan will be completed following five steps as illustrated in the workplan below.

The first step of the Master Planning process is to identify the strategic objectives and goals of the Public Utilities Department for the WRFs. There are many configurations or strategies available to the City including the extremes of maintaining all three WRFs to consolidation all the WRFs into one. So, the second step is to use those goals and objectives to assess possible future WRF strategies and select the best scenario for the City to evaluate further in the next phases of the Master Plan. This will allow for a detailed assessment of the selected strategy and for a clear roadmap of the next steps.

As will be presented in this Technical Memorandum (TM), all of the aspects of managing and operating the facilities were considered and evaluated at a big picture, order of magnitude level, including growth (flow and load projections), changing regulations, operations and maintenance (O&M) impacts (climate variability, coastal hazards), renewal and replacement (R&R) needs (condition assessment), effluent management, biosolids management, and potential consolidation of the facilities. This is a critical step which will direct each of the remaining stages.

Existing System Summary

The City owns and operates three WRFs – the Northeast (NEWRF), Marshall Street (MSWRF), and East (EWRF) WRFs. **Figure ES-1** shows the locations of the three WRFs in the City, their respective service areas, and the City's approximately 75 lift/pump stations. The NEWRF also treats flow from the City of Safety Harbor.

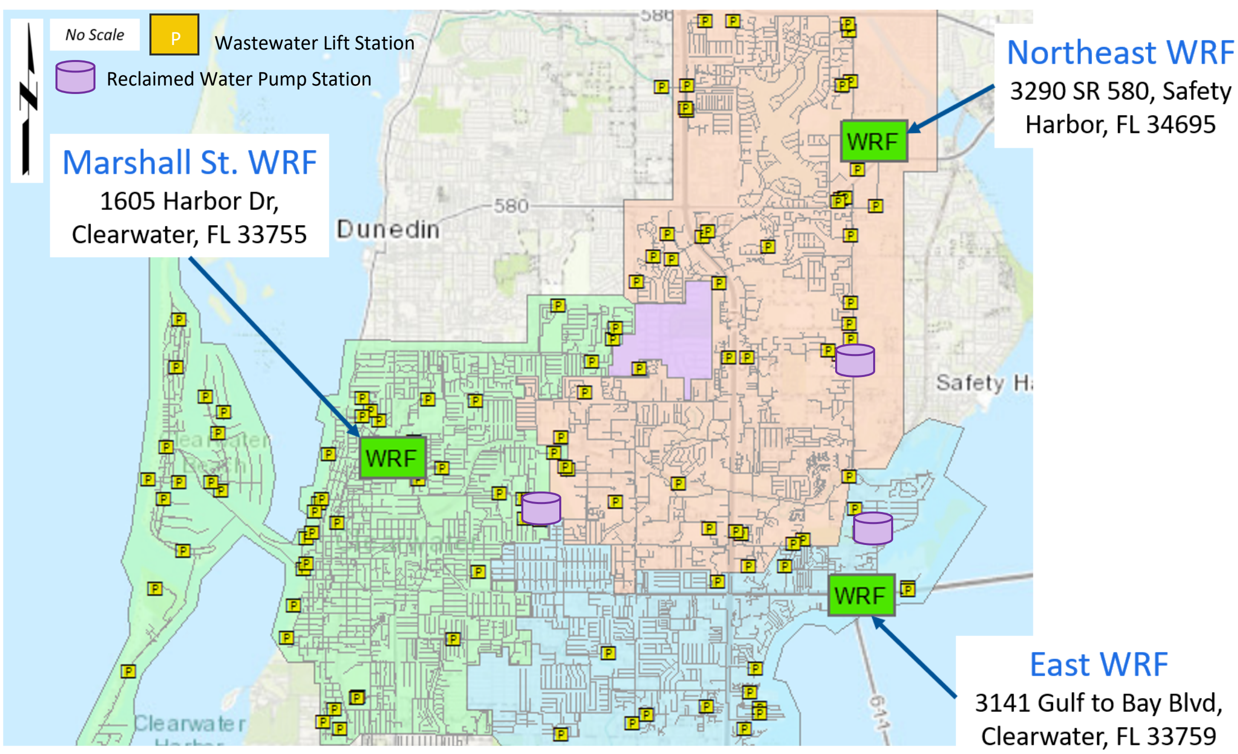


Figure ES-1 City of Clearwater's Three Water Reclamation Facilities, Basin Areas, and Lift Stations

The following is a summary of the existing system analyses and evaluations:

- The City is growing and while the WRFs have sufficient capacity to meet existing and future average daily flows and loadings, maximum and peak flows and loadings will require improvements before the 2050 planning horizon is completed.
- All three WRFs are in relatively good to fair physical condition with some assets in poor and very poor condition. All of the WRFs will require some R&R investments throughout the planning horizon. However, both the EWRF and MSWRF are located at sites vulnerable to coastal hazards and will therefore experience increased degradation and R&R investment needs. Additionally, both locations will require capital investments to protect from coastal hazards such as:
  - Increase height of sea/flood wall.
  - Elevate existing, outdoor equipment (i.e., pumps, control panels, and electrical equipment).
  - Provide tie-downs for chemical storage tanks.
  - Install protective barriers at building entrances/sealing buildings.
  - Appropriate protective coatings.
- There are two new pieces of Florida legislation which will impact rules and regulations for biosolids management (Florida Administrative Code Chapter 62-640 (Biosolids Rule) and effluent disposal (Senate Bill 64). The solutions for the new regulations are not significantly impacted by the system configuration. (*"Biosolids"* refers to the residuals and sludge from wastewater treatment that have been sufficiently processed to comply with regulatory requirements for beneficial use.)
  - The biosolids evaluation indicates the best route for the City to undertake is to continue existing operation with 100 percent of digested biosolids to be hauled to a regional management facility for further processing to Class AA biosolids.
  - The effluent management evaluation indicates the best route for the City to undertake is to expand the public access reuse system and storage to allow for up to 90 percent disposal of the WRF effluent.

Consolidation Analysis

Consolidation Scenarios

The evaluation of the potential configuration scenarios took all the major components of managing a WRF into consideration, including capacity, renewal and replacement, regulations, effluent management, biosolids, and costs, and shortlisted down to six. These were then compared to each other using weighted criteria which were created from the City's WRF objectives and goals. The City's WRF Master Plan objectives and goals are discussed in Section 1.1. Six scenarios were evaluated and are summarized in **Table ES-1** below.

Table ES-1 Shortlisted WRF Consolidation Scenarios

Scenario No.	Scenario Name	Description	Total No. of WRFs
1	Maintain Existing WRFs (Baseline Scenario)	No consolidation. Maintain as three separate WRFs.	3
2	All at NEWRF	Complete consolidation. Consolidate all MSWRF and EWRF flow to NEWRF.	1
3	MSWRF to NEWRF	Partial consolidation. Consolidate by directing all MSWRF flow to NEWRF. Maintain EWRF where it is currently located.	2
4	EWRF to NEWRF	Partial consolidation. Consolidate by directing all EWRF flow to NEWRF. Maintain MSWRF where it is currently located.	2
5	MSWRF+EWRF to New WRF	Partial consolidation. Consolidate by directing all MSWRF and EWRF flow to a new WRF. Maintain NEWRF where it is currently located.	2
6	All at New Regional WRF	Complete consolidation. Divert all flow from all three WRFs to a new facility at a location that is not one of the existing WRFs.	1

Cost Summary

The net present value (NPV) of the capital, land acquisition, annual maintenance O&M and R&R costs were calculated and then combined to calculate the life-cycle costs for each scenario. The total NPV cost for each scenario by category is shown on **Figure ES-2**. The life-cycle costs for the six WRF consolidation scenarios are presented in **Table ES-2**, in 2022 dollars.

Table ES-2 Life-Cycle Costs by Type and Scenario ($M)

Scenario No.	1	2	3	4	5	6
Scenario Name	Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+EWRF to New WRF	All at New Regional WRF
Total No. of WRFs	3	1	2	2	2	1
O&M	$495	$399	$431	$462	$460	$394
Land Acquisition	-	-	-	-	$51	$111
Capital Collection System	$7	$246	$164	$82	$246	$327
Capital WRFs		$115	$81	$10	$105	$151
R&R	$483	$222	$330	$376	$437	$100
Total	**$986**	**$983**	**$1,006**	**$931**	**$1,299**	**$1,083**

1. All costs expressed in June 2022 million dollars.
2. Costs are AACEI Class 5 Classification [-50 percent to +100 percent]

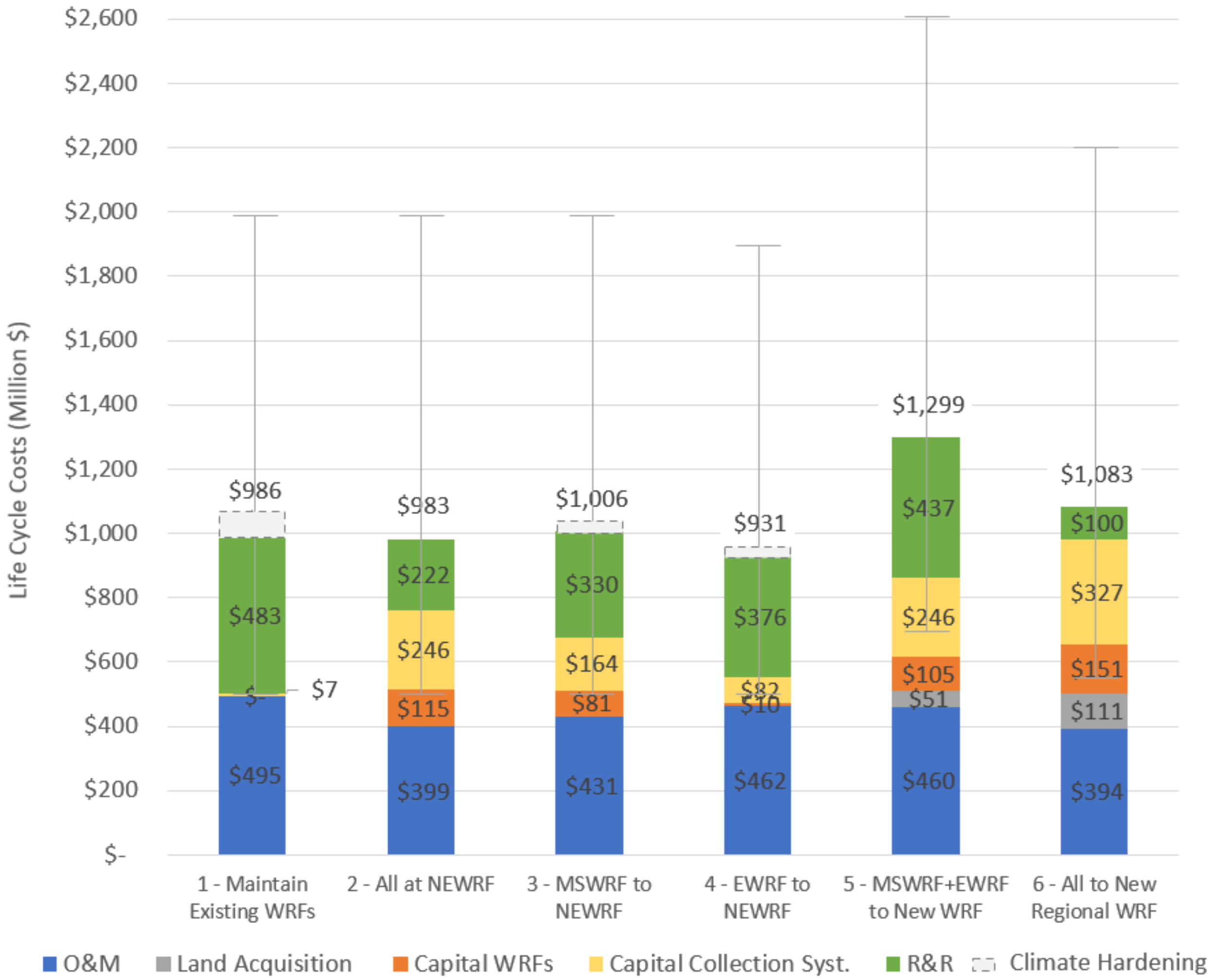


Figure ES-2 Total NPV Life-Cycle Costs for Scenarios 1 through 6

Recommendation

The results summarized in **Table ES-3** below are an average of scores submitted by the Public Utilities Director, Public Utilities and Engineering Stakeholders, and the Black & Veatch team.

After developing and evaluating the six consolidation scenarios, Black & Veatch recommends the City proceed with Scenario 2 – Consolidating both the EWRF and MSWRF to the NEWRF, which scored the highest (most favorable) as a composite of all criteria across all scenarios. This WRF strategy scores the highest for maintenance reliability/resilience, ease of operations, climate and environmental vulnerability, sustainability, and public perception.

Table ES-3 Consolidation Scoring Results

Scoring Criteria	Weight	Recommended Score											
		Scenario 1	Scenario 1	Scenario 2	Scenario 2	Scenario 3	Scenario 3	Scenario 4	Scenario 4	Scenario 5	Scenario 5	Scenario 6	Scenario 6
		Maintain Existing WRFs	Weighted Score	All at NEWRF	Weighted Score	MSWRF to NEWRF	Weighted Score	EWRF to NEWRF	Weighted Score	MSWRF+ EWRF to New WRF	Weighted Score	All to New Regional WRF	Weighted Score
System Reliability and Resilience	22%	2.3	0.51	1.3	0.29	1.7	0.37	2.7	0.59	2.7	0.59	1.5	0.33
Maintenance Reliability and Resilience	21%	1.0	0.21	3.0	0.62	2.0	0.41	2.0	0.41	2.7	0.55	3.0	0.62
Ease of Operations	17%	1.0	0.17	3.0	0.50	2.0	0.33	2.0	0.33	2.5	0.42	3.0	0.50
Climate and Environmental Vulnerability	14%	1.0	0.14	3.0	0.43	2.0	0.29	2.0	0.29	3.0	0.43	3.0	0.43
Sustainability (Greenprint 2.0 is City's Sustainability Plan)	11%	1.0	0.11	2.0	0.23	1.0	0.11	1.0	0.11	2.0	0.23	3.0	0.34
Financial Responsibility	9%	2.0	0.17	2.0	0.17	2.0	0.17	3.0	0.26	1.0	0.09	1.0	0.09
Public Perception	6%	1.5	0.1	3.0	0.19	2.0	0.13	2.3	0.15	1.0	0.06	1.0	0.06
Final Score	**100%**		**1.41**		**2.43**		**1.81**		**2.14**		**2.36**		**2.37**

1.0 Introduction

The City of Clearwater (City) owns and operates three Water Reclamation Facilities (WRFs) – the Northeast (NEWRF), Marshall Street (MSWRF), and East (EWRF) WRFs. **Figure 1** shows the locations of the three WRFs in the City, their respective service areas, and the City's approximately 75 lift/pump stations. The NEWRF also treats flow from the City of Safety Harbor.

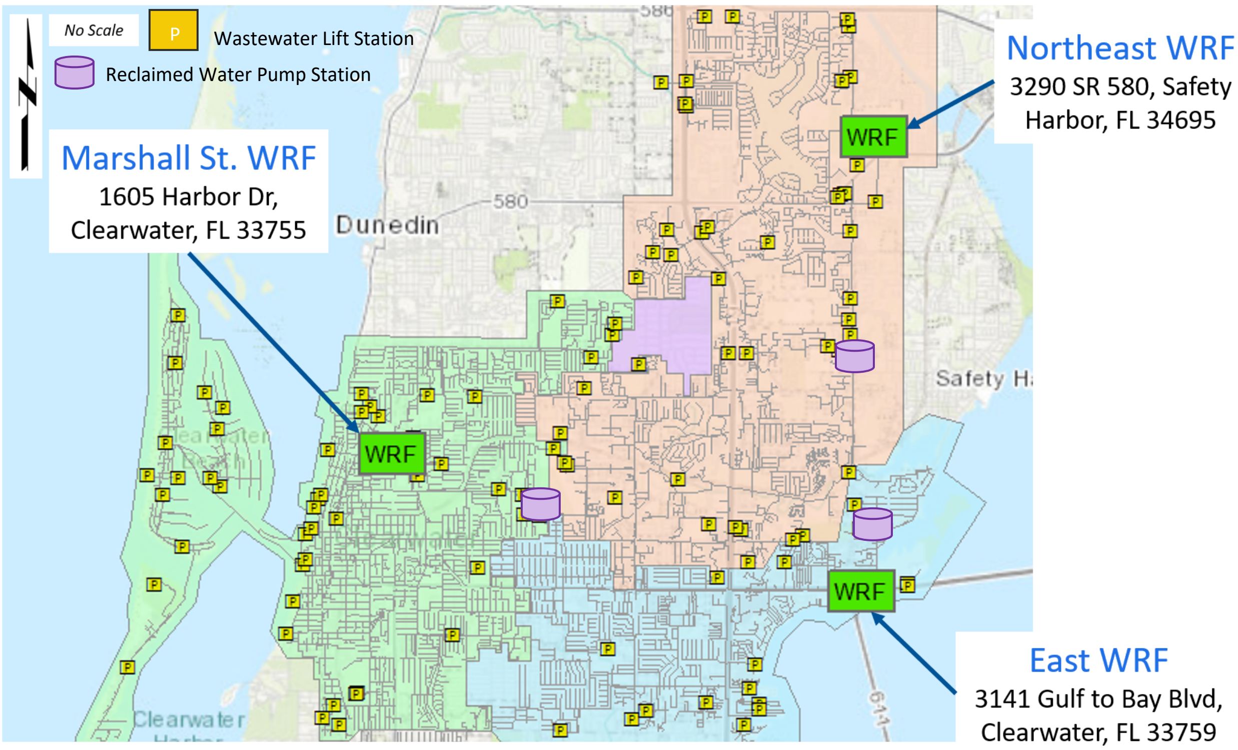


Figure 1 City of Clearwater's Three Water Reclamation Facilities, Basin Areas, and Pump Stations

The City has retained Black & Veatch to develop a 30-year WRF Master Plan, capital improvement plan (CIP) and implementation strategy for the City's WRFs. The Master Plan will be used as an aid in determining current WRF renewal and replacement (R&R) needs as well as a budgeting and planning road map for implementing future facility modifications, upgrades, operational and maintenance improvements, compliance with future regulations, and to provide facilities that are efficient, resilient, sustainable, and economical.

The first step of the Master Planning process is to identify the strategic objectives and goals of the Public Utilities Department for the WRFs. There are many configurations or strategies available to the City including the extremes of maintaining all three WRFs to consolidation all the WRFs into one. So, the second step is to use those goals and objectives to assess possible future WRF strategies and select the best scenario for the City to evaluate further in the next phases of the Master Plan. This will allow for a detailed assessment of the selected strategy and for a clear roadmap of the next steps.

As will be presented in this Technical Memorandum (TM), all of the aspects of managing and operating the facilities were considered and evaluated at a big picture, order of magnitude level, including growth (flow and load projections), changing regulations, operations and maintenance (O&M) impacts (climate variability, coastal hazards), R&R needs (condition assessment), effluent management, biosolids management, and potential consolidation of the facilities.

1.1 Strategic Goals and Objectives

To aid in selecting the best scenario for the City to evaluate further in the next phases of the Master Plan, the City and Black & Veatch worked together through a series of workshops to identify the overall WRF Master Plan project goals and strategic objectives, which are included in **Table 1**. The Goal Setting Workshop was on January 26, 2022 and the Goals and Objectives were finalized during the a WRF Master Plan progress meeting on February 16, 2022.

Table 1 Strategic Goals and Objectives

Goals	Objectives
1. Service Reliability and Resiliency. Operate and maintain infrastructure efficiently to provide a reliable and resilient service to customers.	1.1 Provide high quality, reliable, efficient, and effective water, wastewater, and reclaimed water services in an environmentally sound manner, which will protect the public health and safety. 1.2 Provide, develop, and maintain permanent systems to meet anticipated population growth while providing practical protection to the environment at a cost consistent with the public's ability and willingness to pay. 1.3 Maintain and enhance assets over the long-term at the lowest possible life-cycle cost and acceptable risk. 1.4 Recruit, develop, and retain a competent workforce, and invest in opportunities for professional and leadership development. Support an inclusive and collaborative organization dedicated to continual learning and improvement. 1.5 Implement procedures for institutional knowledge retention. 1.6 Maintain and develop infrastructure to achieve Class I Reliability standards.
2. Sustainability. Manage infrastructure and resources to achieve (or surpass) the Clearwater Greenprint 2.0 sustainability goals and objectives to mitigate climate change impacts and improve resilience.	2.1 Proactively maintain and reinvest in infrastructure. 2.2 Assess climate-related risks, including the impacts of sea level rise (SLR), and develop and implement solutions to mitigate these risks. 2.3 Decrease energy consumption, use more renewable energy, and reduce the impact of the built environmental on the natural environment. Evaluate viability of generating energy from local sources (e.g., biogas, turbine generators). 2.4 Support the City in exceeding greenhouse gas (GHG) emissions targets. Reduce Public Utilities GHG emissions by XX%[1] below 2007 levels by 2035, and XX%[1] below 2007 emissions levels by 2050.
3. Financial Responsibility. Ensure responsible financial management through optimization of expenditures.	3.1 Set priorities and spend money aligned with Strategic Direction. 3.2 Select appropriate solutions to achieve the optimal balance between life-cycle costs, risk, and levels of service and other organizational objectives. 3.3 Optimize use of employees, assets, and resources to minimize O&M costs.

Goals	Objectives
4. Safety. Maintain and operate facilities to ensure employee, community, and public safety.	4.1 Implement practical and effective solutions and controls to continuously improve processes to manage employee and public safety and align with Occupational Safety and Health Administration (OSHA) standards. 4.2 Maintain a safe environment. 4.3 Proactively identify and manage safety risks effectively. 4.4 Maintain and make timely updates to the Continuity of Operations Plan and Emergency Response Plan to ensure effective emergency preparation, response, and recovery.
5. Quality. Produce treated effluent and recycled water that meet or exceed full compliance with regulatory requirements [*current and upcoming*].	5.1 Meet or exceed current and future regulatory requirements. 5.2 Implement improvements for performance data collection and analysis. Continuously measure and improve performance. 5.3 Conduct ongoing performance improvements informed by quality management principles, performance monitoring (metrics), utilizing data, and turning data into actionable knowledge. 5.4 Manage public perception by maintaining high quality services and engaging customers.
[1]Targets to be determined during technical analysis of the Water Reclamation Facility Master Plan.	

1.2 Definitions and Background Information

Reliability: Class I reliability as described in Paragraph 62-600.300(4)(l), F.A.C. which references (l) U.S. Environmental Protection Agency, 1974. Design Criteria for Mechanical, Electric, and Fluid System and Component Reliability – MCD-05. Environmental Quality Instructional Resources Center, The Ohio State University, 1200 Chambers Road, Room 310, Columbus, Ohio 43212.

Resilience: The ability of a piece of infrastructure, system, environment, or community to sustain or recover its essential functions when presented with a disruption.

Sustainability: Meeting current needs without compromising the ability of future generations to meet their own needs.

Capital Improvement Plan (CIP): Short-term is within 5-years and long-term is greater than 5 years from current date.

Existing CIP Prioritization Criterion (listed in no particular order): Regulatory Compliance, Organizational Goals and Objectives, Public Perception/Public Relations, Level of Service, Operating Efficiency, Maintenance Costs, Safety and Security, Risk Management. (The existing CIP Prioritization Criterion listed is for reference only and will be applied during subsequent phases of the WRF Master Plan during the CIP prioritization task. The criterion does not impact the analysis performed during the consolidation evaluation.)

2.0 Growth and Capacity Projections

The first component of the facility management evaluated was growth and capacity by determining the flow and load projections. These items help determine whether the facilities need to be expanded or whether the existing facilities have sufficient capacity for the next 30 years.

2.1 Hydraulic Capacity/Flow Projections

2.1.1 Wastewater Collection System Master Plan Flows Validation

The newest available information was used to validate or update the projected influent flows to each WRF completed in the recent Wastewater Collection System Master Plan (WWCS MP, City Project No. 17-0006-UT/December 2021). The results indicated that the flow projections in the WWCS MP are validated and can be used as the current projection. The WWCS MP flow projections are shown in **Table 2.**

The WWCS MP reported peak hour wet weather flows for a 25-year design storm for existing, 2030, and 2050 planning horizons based on hydraulic model results. However, the reported peak hourly flows represented flows prior to the implementation of improvements within the model that were recommended in the WWCS MP and are lower than peak hour flows after improvements are completed. The flow presented in this TM represent the higher peak flows with improvements and are reported in **Table 2**.

Table 2 Validated WWCS MP Projected Wastewater Influent Flows

WRF	Year	Dry Weather Flow[2] (mgd)	Annual Average Flow[3] (mgd)	Peak Hour Flow[4] (mgd)
MSWRF	Existing[1]	5.03	5.51	30.64
	2030	5.33	5.84	32.30
	2050	5.73	6.28	30.83
EWRF	Existing[1]	2.07	2.27	22.15
	2030	2.33	2.55	22.75
	2050	2.68	2.94	23.41
NEWRF	Existing[1]	4.24	4.65	25.29
	2030	4.51	4.94	25.73
	2050	4.86	5.33	25.73
Total Service Area	Existing[1]	11.34	12.43	78.08
	2030	12.17	13.34	80.78
	2050	13.27	14.55	79.97

1. BV confirmed appropriate use of the period of record used in the WWCS MP (6/2017-3/2019 with consideration of a prolonged 2-week storm event in 2015 and Hurricane Hermine in 2016; City Project No. 17-0006-UT/ December 2021).
2. As reported in Table 4-2 of the WWCS MP.
3. WWCS MP did not report annual average daily flow. This column is WWCS MP dry weather flow (DWF) times the approximate 5-year historical ratio of AADF to DWF (1.1).
4. PHF as calculated by the hydraulic model including improvements developed by the WWCS MP.

2.1.2 Current Flow Projections Validation

The methodology of flow projection validation was to compare independently calculated projections to the projections contained in the WWCS MP. The methods used to complete the independent flow projections can be summarized by the following equation:

- Future Flow = Existing Flow + Historical Gallons per Capita per Day x Future Population
  - **Existing Flow** = Provided by the WWCS MP at approximately the parcel level.
  - **Historical Gallons per Capita per Day (gpcd)** = Calculated using various population data sources and daily discharge monitoring data as 95 gpcd; refer to Subsection 2.1.2.1 for summary.
  - **Future Population** = Chosen based on a comparison of projections that are standard for the region; refer to Subsection 2.1.3 for summary. Traffic Analysis Zone data was chosen as the basis for projections. The analysis shows a service area population of about 157,000 people in 2050.

2.1.2.1 Historical Gallons per Capita per Day

The first step of calculating the gpcd was to benchmark the City's historic service area population. The service area population can be defined as individuals who use the City's wastewater collection system. The City's service area population was calculated as follows:

- All individuals within the City of Clearwater and Safety Harbor reported by the University of Florida's Bureau of Economic and Business Research (BEBR), less users with private wastewater treatment systems (septic users and On Top of the World development).

Total City level estimates from BEBR were used to report the historical total City population for Clearwater and Safety Harbor.

Pinellas County transportation analysis zone (TAZ) data from the City and shapefiles from the WWCS MP were leveraged to estimate the historic population with private wastewater treatment. The unserved population in 2015 was estimated to be approximately 11,200. This population was held constant throughout the historical period. The historical population is reported in **Table 3**.

Table 3 Historical Population Estimated (BEBR and TAZ)

Year	Total City Population[1] (A)	Total Safety Harbor Population[1] (B)	Unserved Population (Septic and On Top of the World Users)[2] (C)	City of Clearwater Service Area Population (A + B - C)
2017	113,723	17,343	11,192	119,874
2018	115,589	17,470	11,192	121,867
2019	116,585	17,608	11,192	123,001
2020	117,292	17,072	11,192	123,172
2021	117,800	17,105	11,192	123,713

1. BEBR Population Estimates
2. Estimated by selecting TAZ population within areas identified as unserved in the WWCS MP

For the next step of the analysis, 5 years of historical data from discharge monitoring reports (DMRs) were analyzed and quality controlled. Quality control included filling in null values for NEWRF November 2017 and confirming that none of the historical flows were outliers on an annual basis because of rain. Note that the type of flow projected for the WWCS MP was DWF. To remain consistent, the DMRs were averaged to report both DWF and annual average flow. The approach used to distinguish DWFs from others was to rank and graph each daily flow for each WRF on a percentile graph (**Figure 2**). Based on this graph, flows less than the 75th percentile were deemed DWF and averaged together to report the historical DWF. The historical dry weather and annual average flows are shown in **Table 4**.

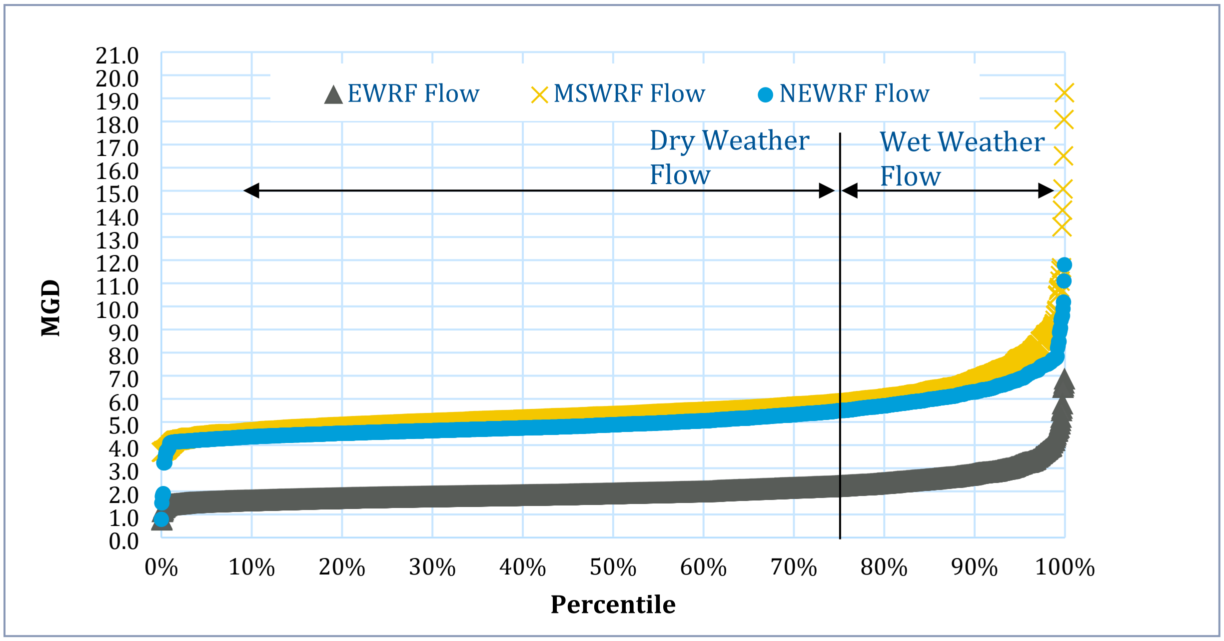


Figure 2 Independent Estimation of Historical Dry Weather Flow

Table 4 Independent Estimation of Historical Dry Weather and Annual Average Flow Results

Year	DWF (mgd)				Annual Average Flow (mgd)			
	EWRF	MSWRF	NEWRF	City Total	EWRF	MSWRF	NEWRF	City Total
2017	1.74	4.93	4.60	11.26	1.93	5.07	4.90	11.90
2018	1.89	5.06	4.69	11.63	2.11	5.32	5.09	12.52
2019	1.93	5.12	4.87	11.92	2.39	5.98	5.44	13.81
2020	1.85	5.14	4.75	11.74	1.97	5.66	5.04	12.66
2021	1.70	5.02	4.77	11.49	1.93	5.61	5.21	12.75
5-Year DWF				**11.61**	**5-Year Annual Average Daily Flow**			**12.73**

The final step of the historical GPCD analysis was to divide the total City DWF by the service area population. The 5-year average GPCD is 95 as summarized in **Table 5**.

Table 5 Independent Estimation of Historical Gallons per Capita per Day

Year	Historical Service Area Population[1]	Total City Flow[2]	Total Flow Per Capita[3] (gpcd)
2017	119,874	11.26	94
2018	121,867	11.63	95
2019	123,001	11.92	97
2020	123,172	11.74	95
2021	123,713	11.49	93
5-Year Average			95

1. Source: BEBR, Census, and TAZ
2. Source: DMRs-DWF
3. Calculated

2.1.3 Future Population Projections

Three regionally accepted population projections were analyzed to determine which source would be used as the future growth basis within the City. The three populations projections were the following:

- 2022 BEBR County Level Projections | Downloaded from Website.
- 2019 Southwest Florida Water Management District (SWFWMD) Parcel Level Projections | Downloaded from Website.
- 2019 Pinellas County TAZ Block Level Projections | Provided by City.

The maximum planning year was 2045 for each source. A linear extrapolation was performed for each source to project until the WRF Master Plan horizon year of 2050. It should be noted that only the permanent residential population was taken from each population source as opposed to the functional population. This was done since the gpcd calculated was based on a permanent residential population basis. Once the permanent population for each source was extracted, it was converted into an annual growth rate as shown on **Figure 3**. Historical percentages ranged from 0.14% to 1.66% as shown in **Figure 3** with the gray values. All the projection method’s annual growth rates fall within the historical range.

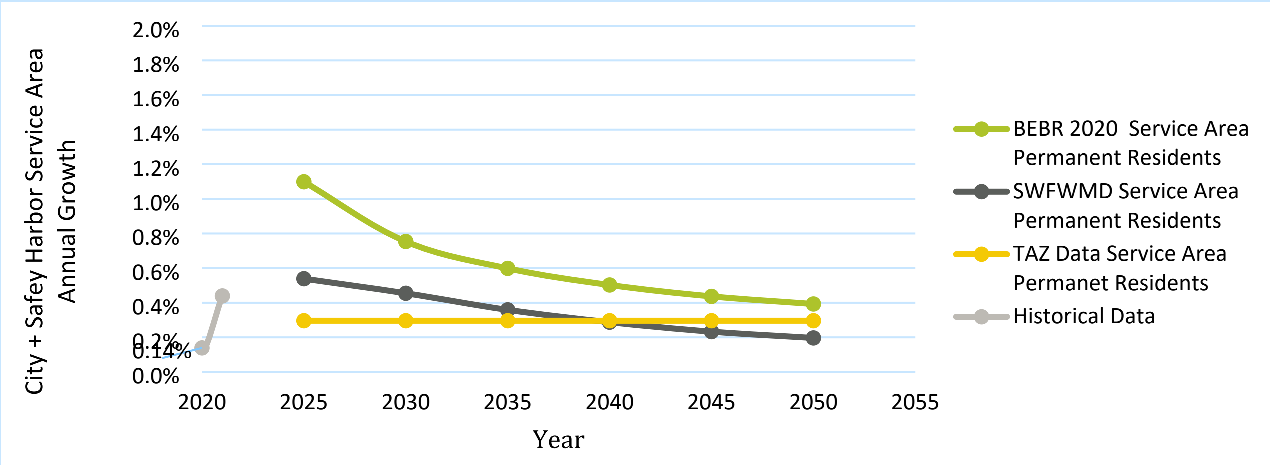


Figure 3 Historical and Projected Annual Growth Rates

After comparing each projection data source, it was concluded that there is a small difference between the growth rate for each population projection. The growth rates are all low and all within the historical range. BEBR cannot be used to complete the independent flow projection because there is not a spatial component to the flow projections, and it is actually at the County level. Also, there is no data indicating why SWFWMD data are a better source of projections than Pinellas County TAZ. Accordingly, Pinellas County TAZ was selected to complete this independent calculation of the flow projections, in alignment with the final WWCS MP (City Project No. 17-0006-UT/December 2021) and final Water Master Plan (City Project No. 18-0022-UT/July 2019), which both used TAZ.

Once the Pinellas County TAZ data source was selected, the final step of adding the existing flow to the future flow was performed in ESRI ArcGIS Pro and Microsoft Excel. The WWCS MP projection for 2050 was compared to the population projections from the independent projection, and a 5 percent difference was calculated as shown in **Table 6**. Larger differences withing each WRF service area is expected, as a City-wide gpcd was performed whereas the WWCS MP developed a unique gpcd per WRF basin based on gravity flow meters throughout the collection system. All in all, the WWCS MP flows are similar to the independent projections and slightly more conservative and are therefore considered validated. The WWCS MP projections will be used moving forward.

Table 6 Validation Results of WWCS MP Projections with Independent Projections

Water Reclamation Facility	Year	WWCS MP (DWF – mgd) Selected Flow	Independent Review (DWF – mgd)	Difference (%)
MSWRF	2050	5.73	5.47	5
EWRF	2050	2.68	2.67	0
NEWRF	2050	4.86	4.46	8
Total Service Area Flow	**2050**	**13.27**	**12.60**	**5**

2.2 Treatment Capacity/Load Projections

The City provided operating data and DMRs for the City's three WRFs. The following tasks were completed using that information:

- Evaluated the data for the period from January 1, 2019, through December 31, 2021, and developed load projections.
- Analyzed historical daily plant influent data consisting of flow, carbonaceous biochemical oxygen demand ($cBOD_5$), total suspended solids (TSS), ammonia (NH_3), and total phosphorus (TP).
- Developed influent mass loadings and mass loading peaking factors. The influent mass loading peaking factors are applied along with flow peaking factors to develop the following design concentrations for each constituent at each flow condition:
  - Average day (AD) mass loads.
  - 30-day moving mass load averages.
  - Maximum month average day (MMAD) mass load peaking factors.
  - Maximum day (MD) load peaking factors.

2.2.1 Influent Loads Projections

2.2.1.1 East Water Reclamation Facility

Influent Annual Average Daily Flow (AADF), MMAD, and MD flow data from 2019 to 2021 are presented in **Table 7**. The EWRF operated at approximately 38 percent of the permitted AADF of 5 million gallons per day (mgd) in 2021. As presented in **Table 7**, the influent flow rates decreased from 2.4 to 1.9 mgd AADF from 2019 to 2021. Similar trends were observed for TSS, and NH_3. BOD_5 loading went down in 2020 by 20 percent and then back up in 2021 by 16 percent.

Table 7 EWRF Historical Influent Flow and Loads Summary (2019-2021)

Year	Flow (mgd)			TSS (lb/d)			BOD_5 (lb/d)			NH_3 (lb/d)			TP (lb/d)		
	AADF	MMAD	MD	AAD	MMAD	MD	AAD	MMAD	MD	AAD	MMAD	MD	AAD	MMAD	MD
2019	2.4	3.8	6.9	3,188	3,719	5,121	3,141	3,485	4,609	533	662	817	66	80	116
2020	2.0	2.4	5.2	2,632	3,223	4,704	2,515	2,820	4,512	475	536	619	72	81	111
2021	1.9	3.0	4.6	2,330	2,626	4,175	2,990	3,610	4,414	458	517	573	74	84	112
Average	2.1	3.0	5.5	2,717	3,189	4,667	2,882	3,305	4,512	489	572	670	71	82	113
Maximum	2.4	3.8	6.9	3,188	3,719	5,121	3,141	3,610	4,609	533	817	2,100	74	84	117

Influent data, peaking factors, and concentrations developed for the EWRF are presented in **Table 8**. Flows and loads are presented under current conditions and at year 2050, which is the end of the planning period.

The EWRF reports $cBOD_5$ measurements with the addition of a nitrification inhibitor, which is added to the samples by the laboratory to suppress nitrifiers so that the only oxygen demand is carbonaceous. Using a nitrification inhibitor can inhibit heterogenous bacteria resulting in underestimation of the true $cBOD_5$. In the absence of site-specific sampling, a typical $cBOD_5/BOD_5$ ratio of 0.84 is used. Therefore, the inhibited influent $cBOD_5$ measurements were divided by 0.84 to estimate uninhibited influent BOD_5

concentrations as presented in **Table 8**. The same correction factor was applied to the NEWRF and MSWRF historical $cBOD_5$ data.

The EWRF only reports NH_3 measurements. Therefore, the influent TKN peaking factors in **Table 8** were assumed to be equal to the influent NH_3 peaking factors. In the absence of historical influent TKN data, influent TKN was estimated using a NH_3/TKN ratio of 0.7 based on past project experiences in Florida. The same NH_3/TKN = 0.7 was used to estimate TKN at the NEWRF and MSWRF.

Table 8 EWRF Influent Peaking Factors, Flows, and Loads Developed from 2019 to 2021 Data

Flows and Loads Peaking Factors				
Peaking Factors		AADF	MMAD	MD
Flow		1.00	1.59	2.87
BOD_5		1.00	1.21	1.79
TSS		1.00	1.22	1.79
TKN[1]		1.00	1.24	1.53
NH_3		1.00	1.24	1.53
TP		1.00	1.22	1.77
Current Flows and Loads		AADF	MMAD	MD
Flow	mgd	2.10	3.34	6.01
BOD_5[2]	mg/L	165	125	103
	lb/d	2,882	3,480	5,171
TSS	mg/L	155	119	97
	lb/d	2,717	3,327	4,856
TKN[1]	mg/L	39.9	31.1	21.4
	lb/d	698	867	1,071
NH_3	mg/L	27.9	21.8	14.9
	lb/d	489	607	750
TP	mg/L	4.0	3.1	2.5
	lb/d	71	86	125
Projected Flows and Loads (2050)		AADF	MMAD	MD
Flow	mgd	2.94	4.68	8.43
BOD_5[2]	mg/L	165	125	103
	lb/d	4,039	4,878	7,248
TSS	mg/L	155	119	97
	lb/d	3,808	4,663	6,807
TKN[1]	mg/L	39.9	31.1	21.4
	lb/d	979	1,215	1,501
NH_3	mg/L	27.9	21.8	14.9
	lb/d	685	851	1,051
TP	mg/L	4.0	3.1	2.5
	Lb/d	99	121	175

Notes:

1. The facility only reports influent NH_3 concentrations. Therefore, the influent Total Kjeldahl Nitrogen (TKN) peaking factors were assumed to be equal to the influent NH_3 peaking factors. In the absence of historical influent TKN data, influent TKN was estimated using a NH_3/TKN ratio of 0.7 based on past project experiences in Florida.
2. $cBOD_5$ /BOD_5 ratio of 0.84 was applied to historical data to account for nitrification inhibitor.

2.2.1.2 Northeast Water Reclamation Facility

Influent AADF, MMAD, and MD flow data from 2019 to 2021 are presented in **Table 9**. The NEWRF operated at approximately 38 percent of the permitted AADF of 13.5 mgd in 2021. As presented in **Table 9**, the influent flow rates ranged between 5.1 and 5.4 mgd AADF between 2019 and 2021. Influent flow rate, TSS, BOD_5, and NH_3 loadings decreased in 2020 but increased in 2021. The influent TP AADF loading increased from 155 pounds per day (lb/d) in 2019 to 202 lb/d in 2021.

Table 9 NEWRF Historical Influent Flow and Loads Summary (2019-2021)

Year	Flow (mgd)			TSS (lb/d)			BOD_5 (lb/d)			NH_3 (lb/d)			TP (lb/d)		
	AADF	MMAD	MD	AAD	MMAD	MD	AAD	MMAD	MD	AAD	MMAD	MD	AAD	MMAD	MD
2019	5.4	7.0	11.8	9,694	12,246	18,235	11,075	13,910	18,488	1,217	1,639	2,063	155	193	271
2020	5.1	6.3	9.5	6,956	9,348	18,461	8,568	12,184	17,086	1,171	1,245	1,712	167	189	289
2021	5.2	6.5	8.9	8,065	9,180	19,666	8,777	10,565	18,032	1,227	1,377	1,711	202	225	353
Average	5.2	6.6	10.1	8,238	10,258	18,787	9,473	12,220	17,869	1,205	1,420	1,829	175	202	304
Maximum	5.4	7.0	11.8	9,694	12,246	18,235	11,075	13,910	18,488	1,227	1,639	2,063	202	225	353

Influent data, peaking factors, and concentrations developed for the NEWRF are presented in **Table 10**. Flow and loads are presented under current conditions and at year 2050, which is the end of the planning period.

Table 10 NEWRF Influent Peaking Factors, Flows, and Loads Developed from 2019 to 2021 Data

Current and Projected Influent Peaking Factors, Flows, and Loads				
Peaking Factors		**AADF**	**MMAD**	**MD**
Flow		1.00	1.29	2.17
BOD_5		1.00	1.42	2.05
TSS		1.00	1.34	2.65
TKN[1]		1.00	1.35	2.28
NH_3		1.00	1.35	1.69
TP		1.00	1.24	1.75
Current Flows and Loads		**AADF**	**MMAD**	**MD**
Flow	mgd	5.24	6.77	11.35
BOD_5[2]	mg/L	217	239	206
	lb/d	9,473	13,472	19,462
TSS	mg/L	189	196	231
	lb/d	8,238	11,070	21,864
TKN[1]	mg/L	39.4	41.2	41.5
	lb/d	1,721	2,324	3,925
NH_3	mg/L	27.6	28.8	21.6
	lb/d	1,205	1,623	2,042
TP	mg/L	4.0	3.8	3.2
	lb/d	175	216	306
Projected Flows and Loads (2050)		**AADF**	**MMAD**	**MD**
Flow	mgd	5.33	6.89	11.55
BOD_5[2]	mg/L	189	239	206
	lb/d	8,387	11,928	17,232
TSS	mg/L	189	196	231
	lb/d	8,387	11,271	22,260
TKN[1]	mg/L	39.4	41.2	41.5
	lb/d	1,753	2,366	3,996
NH_3	mg/L	27.6	28.8	21.6
	lb/d	1,227	1,652	2,079
TP	mg/L	4.0	3.8	3.2
	lb/d	178	220	311

Notes:
1. The NEWRF only reports influent NH_3 concentrations. Therefore, the influent TKN peaking factors were assumed to be equal to the influent NH_3 peaking factors. In the absence of historical influent TKN data, influent TKN was estimated using a NH_3/TKN ratio of 0.7 based on past project experiences in Florida.
2. $cBOD_5$ /BOD_5 ratio of 0.84 was applied to historical data to account for nitrification inhibitor

2.2.1.3 Marshall Street Water Reclamation Facility

Influent AADF, MMAD, and MD flow data from 2019 to 2021 are presented in **Table 11**. The MSWRF operated at approximately 56 percent of the permitted AADF of 10 mgd in 2021. As presented in **Table** 11, the influent flow rates decreased from 6.0 and 5.6 mgd AADF from 2019 and 2021. Similar trends were observed for TSS loadings. TP loading increased during this 3-year period. BOD_5 and NH_3 loadings decreased in 2020 then increased in 2021.

Table 11 MSWRF Historical Influent Flow and Loads Summary (2019-2021)

Year	Flow (mgd)			TSS (lb/d)			BOD_5 (lb/d)			NH_3 (lb/d)			TP (lb/d)		
	AADF	MMAD	MD	AAD	MMAD	MD	AAD	MMAD	MD	AAD	MMAD	MD	AAD	MMAD	MD
2019	6.0	8.2	19.2	7,561	9,805	13,894	7,759	9,340	12,452	1,312	1,875	2,155	163	220	409
2020	5.7	7.2	11.1	6,506	8,599	13,653	6,899	8,191	11,653	1,282	1,473	1,747	178	187	268
2021	5.6	7.5	16.5	5,102	6,438	13,880	7,435	9,111	12,402	1,342	1,550	1,879	197	226	474
Average	5.7	7.6	15.6	6,390	8,281	13,809	7,364	8,880	12,169	1,312	1,633	1,927	179	211	384
Maximum	6.0	8.2	19.2	7,561	9,805	13,894	7,759	9,340	12,452	1,342	1,875	2,155	197	226	474

Influent data, peaking factors, and concentrations developed for MSWRF are presented in **Table 12**. Flow and loads are presented under current conditions and at year 2050 which is the end of the WRF Master Plan planning period.

Table 12 MSWRF Influent Peaking Factors, Flows, and Loads Developed from 2019 to 2021 Data

Current and Projected Influent Peaking Factors, Flows, and Loads				
Peaking Factors		**AADF**	**MMAD**	**MD**
Flow		1.00	1.37	3.22
BOD_5		1.00	1.23	1.69
TSS		1.00	1.32	2.72
TKN[1]		1.00	1.43	2.35
NH_3		1.00	1.43	1.64
TP		1.00	1.35	2.50
Current Flows and Loads		**AADF**	**MMAD**	**MD**
Flow	mgd	5.75	7.86	18.50
BOD_5[2]	mg/L	154	138	81
	lb/d	7,364	9,024	12,439
TSS	mg/L	133	129	113
	lb/d	6,390	8,445	17,383
TKN[1]	mg/L	39.1	40.9	28.5
	lb/d	1,874	2,680	4,405
NH_3	mg/L	27.4	28.6	14.0
	lb/d	1,312	1,875	2,155
TP	mg/L	3.7	3.7	2.9
	lb/d	179	241	449
Projected Flows and Loads (2050)		**AADF**	**MMAD**	**MD**
Flow	mgd	6.28	8.59	20.22
BOD_5[2]	mg/L	154	138	81
	lb/d	8,046	9,859	13,590
TSS	mg/L	133	129	113
	lb/d	6,981	9,227	18,992
TKN[1]	mg/L	39.1	40.9	28.5
	lb/d	2,048	2,928	4,813
NH_3	mg/L	27.4	28.6	14.0
	lb/d	1,434	2,049	2,355
TP	mg/L	3.7	3.7	2.9
	Lb/d	196	264	491

Notes:

1. The MSWRF only reports influent NH_3 concentrations. Therefore, the influent TKN peaking factors were assumed to be equal to the influent NH_3 peaking factors. In the absence of historical influent TKN data, influent TKN was estimated using a NH_3/TKN ratio of 0.7 based on past project experiences in Florida.
2. $cBOD_5$ /BOD_5 ratio of 0.84 was applied to historical data to account for nitrification inhibitor.

3.0 Renewal and Replacement Planning

A major expense associated with the WRFs that should be planned for is R&R. The facilities were built in the 1970s and 1980s and have aging assets that need to be rehabilitated or replaced, and two of the facilities are located at sites vulnerable to coastal hazards. This section discusses the results and a high-level condition assessment of the facilities and the resulting R&R requirements, as well as the impacts to the facilities from climate changes and coastal hazards.

3.1 Condition Assessment

A high-level condition assessment was conducted to identify immediate R&R needs at each of the City's three WRFs. The physical condition assessment was conducted over 2 days, January 4 and 5, 2022. A summary of observations and initial conclusions are documented below. This high-level condition assessment was intended to provide inputs on R&R costs to aid in the decisions and discussions around consolidating the WRFs, which is further discussed in Section 7.0. A detailed condition assessment will be conducted as part of the next phase of the Master Plan and will be used to prepare detailed and specific R&R CIP projects for the selected scenario.

The specific processes surveyed at the three WRFs are summarized in **Table 13**.

Table 13 Summary of Processes Surveyed

Process	EWRF	NEWRF	MSWRF
Aeration Tanks	■	■	■
Anoxic Tanks	■	■	■
Buildings	■	■	■
Chemical Storage	■	■	■
Chlorination	■	■	■
Fermentation Tanks	■	■	■
Filter Complex	■	■	■
Final Settling Tanks	■	■	■
Grit Removal System	■	■	■
Headworks	■	■	■
Influent Pump Station (PS)	■	N/A	■
Intermediate PS	■	■	■
Plant Drain PS	N/A	■	N/A
Primary Tanks	N/A	*	■
Sludge Dewatering	N/A	■	■
Sludge Digestion	N/A	■	■
Sludge Holding Tank	■	*	N/A
Sludge Thickening	■	■	■
Transfer Pumping	■	N/A	N/A

* Under construction at time of condition assessment.
N/A = Not applicable (e.g., item doesn't exist at WRF)

3.1.1 Water Reclamation Facility Assessment Summary

Each process was scored per discipline (process mechanical, electrical, and structural) using a 1-5 scale based on its visual condition. The 1-5 scale is based off the following scores:

- 1 = Very Good
- 2 = Good
- 3 = Fair
- 4 = Poor
- 5 = Very Poor

Specific definitions per discipline are in the Data Collection Plan included in **Appendix A**.

The overall scoring distribution across all three WRFs was between 2 - Good and 3 - Fair, trending toward 3 – Fair. **Figure 4** and **Figure 5** provide the overall, average condition score per WRF and average condition score per discipline per WRF.

NOTE: the scoring results and asset data is available in MS Excel format for importing into a computer maintenance management system (CMMS) when the City is ready for the data.

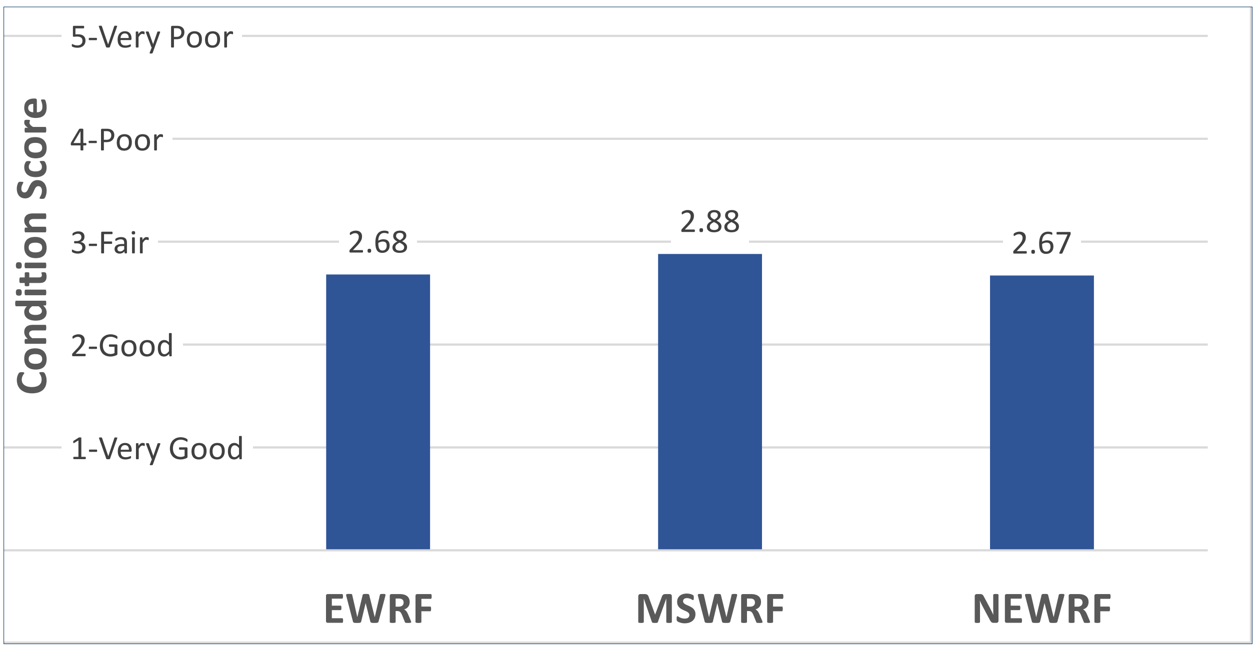


Figure 4 Average Condition Scores per WRF

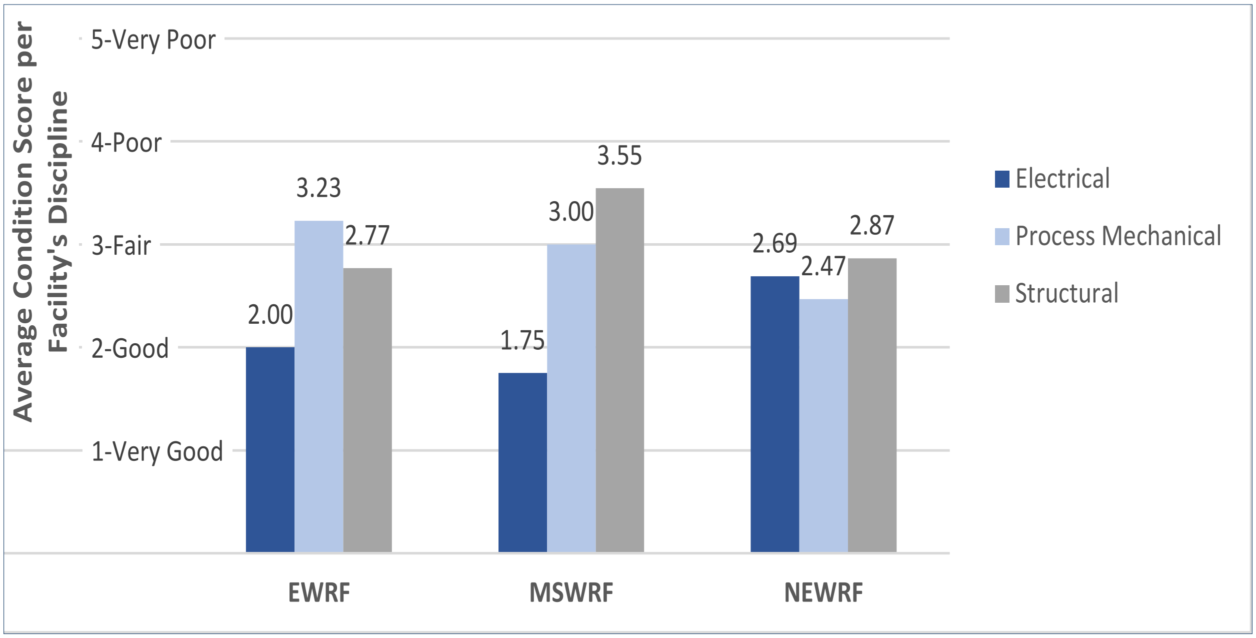


Figure 5 Average Condition Scores per Facility Discipline

The specific breakdown of how processes scored in each discipline at each WRF is shown on **Figure 6**.

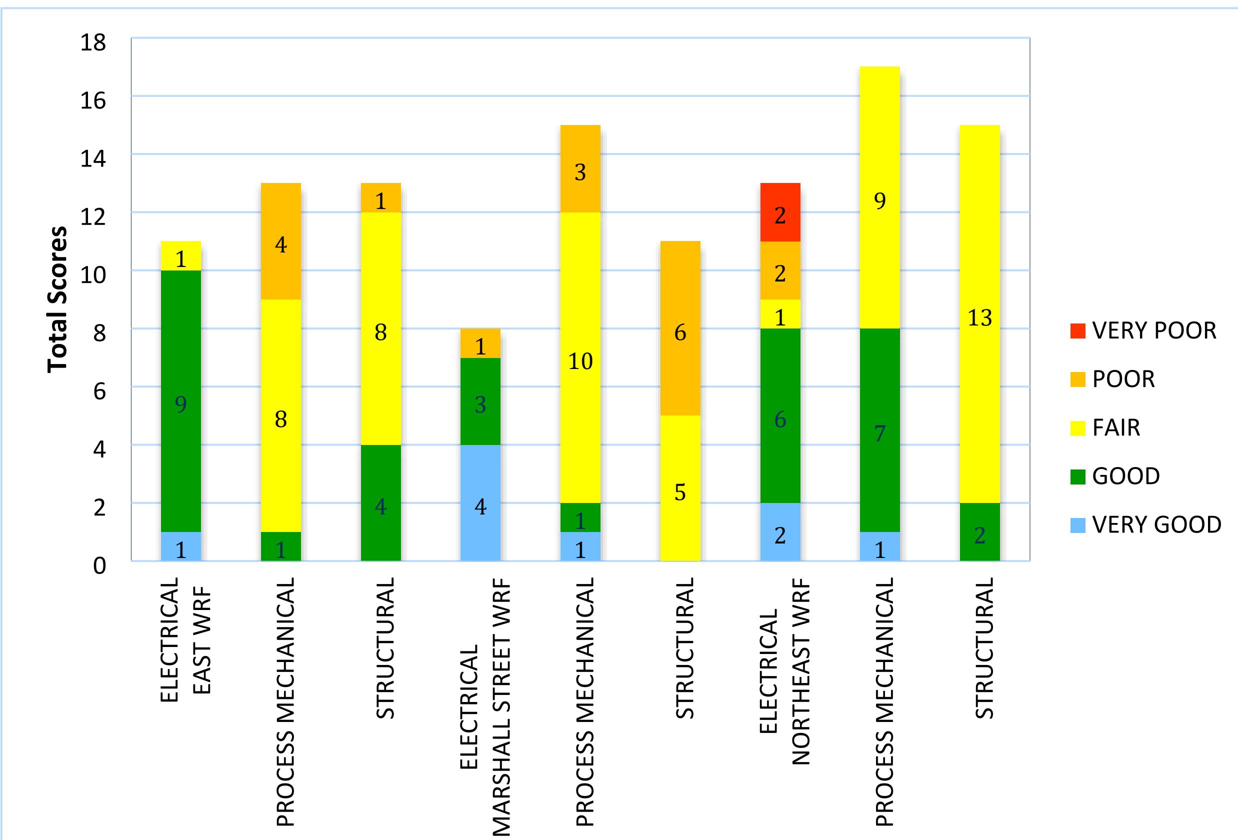


Figure 6 Score by Discipline and Process for Each WRF

3.1.2 Very Poor Scoring Assets

The emphasis of the condition assessment was to identify immediate R&R needs. This correlates with the processes scoring in the 5 – Very Poor category. The two processes scoring in this range were found exclusively at the NEWRF, with both scores originating within the Electrical discipline. The list of processes in need of immediate renewal and replacement and the comments made in the field are as follows:

- Headworks Electrical – Motor control center (MCC) 15 and all other equipment in this electrical room need replacing very soon. Visible rust and structural damage to MCC were observed. There was no room for expansion, and there was corrosion to some chopper pump conduits. The City has an active project for replacement of this equipment in the NE WRF Grit Removal, Salsnes Filter and Equalization System Improvements/ NE WRF Improvements Project (City Project No. 15-0045-UT and 19-0029-UT). (Refer to **Figure 7** and **Figure 8**.)
- Admin Building Electrical – MCC DC1 and MCC DC2 needs replaced. Extremely old and housed in non-air-conditioned space. The City has an active project for replacement of this equipment in the NEWRF MMC-1, DC-1 and DC-2 Replacement Project (City Project No. 17-0028-UT). (Refer to **Figure 9** and **Figure 10**.)

Figure 7 NEWRF Headworks Electrical 1

Figure 8 NEWRF Headworks Electrical 2

Figure 9 NEWRF Admin Electrical 1

Figure 10 NEWRF Admin Electrical 2

3.1.3 City Projects Under Design and Construction

The following list represents City projects which were under design or construction at the time of the high-level condition assessment during January 2022.

- EWRF Influent Pump Station (City Project No. 13-0016-UT)
- NEWRF Blend Tank Improvements (City Project Nos. 14-0036-UT and 19-0029-UT)
- NEWRF Grit Removal, Salsnes Filter and Equalization System Improvements (City Project Nos. 15-0045-UT and 19-0029-UT)
- NEWRF MCC-1, DC-1 and DC-2 Replacement (City Project No. 17-0028-UT)
- EWRF Sand Filter Building – Feed Pump Station and Force Main Improvements (City Project No. 17-0048-UT)
- MSWRF Influent Pump Station and Headworks Replacement (City Project No. 18-0026-UT)
- MSWRF Chlorine Contact Chamber (City Project No. 18-0060-UT)
- EWRF Chemical Storage and Handling (City Project No. 19-0034-UT)
- MSWRF Sand Filter Refurbishment (City Project No. 20-0011-UT)
- EWRF Screw Lift Improvements (City Project No. 20-0013-UT)
- NEWRF Clarifier Gates (City Project No. 21-0017-UT)
- MSWRF and NEWRF Digest Cover Evaluation and Repairs (City Project No. 21-0022-UT)

3.1.4 Renewal and Replacement Impacts from Aging Infrastructure

The overall results of the high-level condition assessment demonstrated that all three WRF are in fair condition. However, specific needs and magnitude of improvement needs varies with respect to each WRF and specific process. The variance in score between the processes will mainly impact the timing of R&R needs at each facility. This information was used in Section 7.5 to prepare the life cycle costs as part of the consolidation analysis.

3.2 Climate Variability/Coastal Hazard Vulnerability Assessment

A Climate and Vulnerability Assessment was performed to assess existing and future flooding considerations, which increases the WRF R&R needs. Both MSWRF and EWRF are located along coastal water bodies, therefore, the potential for flooding was deemed an immediate concern. NEWRF is outside the zone of concern for coastal hazards. Current scientific guidance indicates that future conditions will not only exacerbate flood events like 100-year floods and hurricane surges, but also potentially lead to more frequent tidal flooding events. As part of this assessment, a review of currently available flood data sets was conducted for Federal Emergency Management Agency (FEMA) identified flood scenarios, National Oceanic and Atmospheric Administration (NOAA) storm surge scenarios and expected future scenarios (tidal and 100-year flooding).

The full Climate and Vulnerability Assessment is in **Appendix B**.

3.2.1 FEMA Flood Zones and Pinellas Vulnerability Assessment Flood Events

The EWRF and MSWRF are impacted by localized flooding as identified on the FEMA's Flood Insurance Rate Maps (FIRMs) and the Pinellas County Sea Level Rise and Storm Surge Vulnerability Assessment – February 2022. The NEWRF is not exposed to these hazards. The estimated impacts from localized flooding are shown on **Table 14**.

Table 14 Estimated Impacts from Localized Flooding

	Current FEMA and Pinellas Vulnerability Assessment		
EWRF	**100-yr FEMA (2021)**	**100-yr Pinellas Vulnerability Study (2018 base)**	**500-yr Pinellas Vulnerability Study (2018 base)**
Count of equipment inundated	54	39	68
Percent of all equipment inundated	78%	57%	99%
Average depth of inundation (feet)	3.26	2.43	4.45
MSWRF	**100-yr FEMA (2021)**	**100-yr Pinellas Vulnerability Study (2018 base)**	**500-yr Pinellas Vulnerability Study (2018 base)**
Count of equipment inundated	35	36	97
Percent of all equipment inundated	34%	35%	94%
Average depth of inundation (feet)	1.58	3.44	3.55

3.2.2 Storm Surge Flood Events

The EWRF and MSWRF are impacted by flooding on the Pinellas County's storm surge inundation maps. The NEWRF is not exposed to these hazards. The estimated impacts from storm surge caused by hurricanes are shown on **Table 15**.

Table 15 Estimated Impacts from Storm Surge

	Storm Surge (per the National Hurricane Center)				
EWRF	**Category 1 Storm Surge**	**Category 2 Storm Surge**	**Category 3 Storm Surge**	**Category 4 Storm Surge**	**Category 5 Storm Surge**
Count of equipment inundated	54	68	69	69	69
Percent of all equipment inundated	78%	99%	100%	100%	100%
Average depth of inundation (feet)	3.26	5.45	16.36	16.36	38.36
MSWRF	**Category 1 Storm Surge**	**Category 2 Storm Surge**	**Category 3 Storm Surge**	**Category 4 Storm Surge**	**Category 5 Storm Surge**
Count of equipment inundated	37	99	100	100	100
Percent of all equipment inundated	36%	96%	97%	97%	97%
Average depth of inundation (feet)	4.44	4.48	10.43	15.43	37.43

3.2.3 Future Conditions (Sea Level Rise and 100-year Events)

The MSWRF and EWRF face exposure to increases in tidal conditions, however, the existing projections indicate that daily tidal events will remain at the shoreline or adjacent to the facilities until at least 2070 and therefore do not represent increased hazard within the planning period. Tidal events still increase the potential for flooding during coastal events and impacts to the groundwater.

Pinellas County has modeled a 2070 100-year flood event which indicates a tidal height 2 feet higher than the current 100-year projection for MSWRF and 2.7 feet higher than the current 100-year projection for EWRF. The increase in SLR and resulting impacts on 100-year flood events would lead to 90 percent of all equipment at both MSWRF and EWRF inundated. The NEWRF is not exposed to these hazards.

3.2.4 Infiltration and Inflow

Due to SLR causing high groundwater levels, the City's WRFs may experience increased groundwater infiltration during both dry- and wet-weather. The conveyance and treatment of these extraneous flows leads to increased costs and GHG emissions. Additional measures could be proactively taken to reduce infiltration and inflow (I/I) into the system. These measures include the following:

- Further implementation of the gravity sewer renewal and replacement program.
- Replacement of gravity sewers with pressure system, e.g., vacuum or low-pressure sewer systems.

3.2.5 Renewal and Replacement Impacts from Climate Variability and Coastal Hazards

As mentioned above, both the MSWRF and EWRF have a high risk of exposure to flood events. Although MSWRF is slightly less exposed, a Category 2 storm surge event or higher will likely inundate large portions of both facilities. Because of climate variability, R&R will need to focus on an adaption strategy to keep the facilities fully operational during a high flood event. Protective R&R strategies include the following:

- Elevating skid-mounted equipment indoor where head space allows.
- Elevating outdoor equipment – pumps and control panels.
- Providing tie-downs for chemical storage tanks.
- Installing protective barriers at building entrances/sealing buildings.
- Sandbagging at building entrances.
- Installing sealed/flood proof control panels.

This information was further used to prepare implementation costs for consolidation and assess the scenarios for coastal impacts in Section 7.0.

4.0 Regulatory Review and Emerging Issues

An analysis was conducted to evaluate potential future regulations that may impact the City's WRFs and future capital improvement decisions. This evaluation included contacting state and federal regulatory agencies as well as consulting with technical experts on regulations. The following list includes regulations that were reviewed:

- Clean Water Act – National Pollutant Discharge Elimination System (NPDES).
- Florida State House Bill 53 (2021) – Public Works.
- Florida State Senate Bill 712 (2020) – Environmental Resource Management or "The Clean Waterways Act" - Florida Administrative Code Chapter 62-610, 62-640, 62-625, 62-550, and 62-555, 62-600.
- Florida State Senate Bill 712 (2020) – Environmental Accountability.
- Florida State House Bill 1309 (2021) – Environmental Regulation.
- Florida House of Representatives Senate Bill 64 (2021) – Reclaimed Water.

Two regulations that may impact or support the City's WRF strategy include Florida Administrative Code Chapter 62-640 (Biosolids Rule) and Senate Bill 64. Brief summaries of each are described below:

- Florida Administrative Code Chapter 62-640: The biosolids rule revisions were developed to minimize the migration of nutrients, specifically phosphorus, to prevent impairment to waterbodies. The rule revised the method to determine land application rates set by phosphorous concentration and prohibits application of biosolids to land with a seasonal high-water table within 6-inches of the soil surface or depth of the biosolids placement. Compliance of new rules to take place within 1-year for new permits or permit renewals issued after July 1, 2020, and within 2-year of the of the effective date for all permits (June 21, 2023).
- Florida House of Representatives Senate Bill 64 (2021) – Reclaimed Water: This bill dictates that domestic wastewater utilities that dispose of effluent, reclaimed water, or reuse water by surface water discharge must eliminate non-beneficial surface water discharges by January 1, 2032. The City's "Surface Water Discharge Plan to Comply with Senate Bill 64" was approved by Florida Department of Environmental Protection (FDEP) in May 2022 (City Project No. 21-0016-UT).

Further commentary on these two regulatory updates is included in Sections 5.0 and 6.0, respectively. A full summary of the regulations reviewed is included in **Appendix C**.

5.0 Biosolids Management Strategy Development Summary

Biosolids management programs in Florida are facing significant challenges because of issues related to increasingly stringent regulations. Biosolids refer to the residuals and sludge from wastewater treatment that have been sufficiently processed to comply with regulatory requirements for beneficial use. Recent changes to Chapter 62-640 of the Florida Administrative Code resulted in more limitations being placed on biosolids practices. These changes could include more stringent requirements for biosolids management practices, including more limitations on land application and additional monitoring and inspection requirements. The potential future changes in regulations can have far-reaching implications, especially for facilities that currently land apply Class B biosolids. This section presents discussions and evaluations to develop a biosolids management strategy that aligns with the City's goals and provide a sustainable approach for meeting current and anticipated future regulatory requirements. A complete overview of the Biosolids Management Strategy is provided in **Appendix D**.

5.1 Current Solids Operation

The following subsections provide an overview of the current solids process operations at the City's three WRF facilities.

5.1.1 East WRF

EWRF is a 5 mgd secondary treatment plant that produces waste activated sludge (WAS) only. Rotary drum thickeners (RDTs) are used to thicken WAS from approximately 1 percent total solids (TS) to 4 to 5 percent TS. The thickened WAS (TWAS) is stored in a holding tank until it is hauled to the NEWRF by a third party. A process flow diagram for solids processes at EWRF is presented on **Figure 11**.

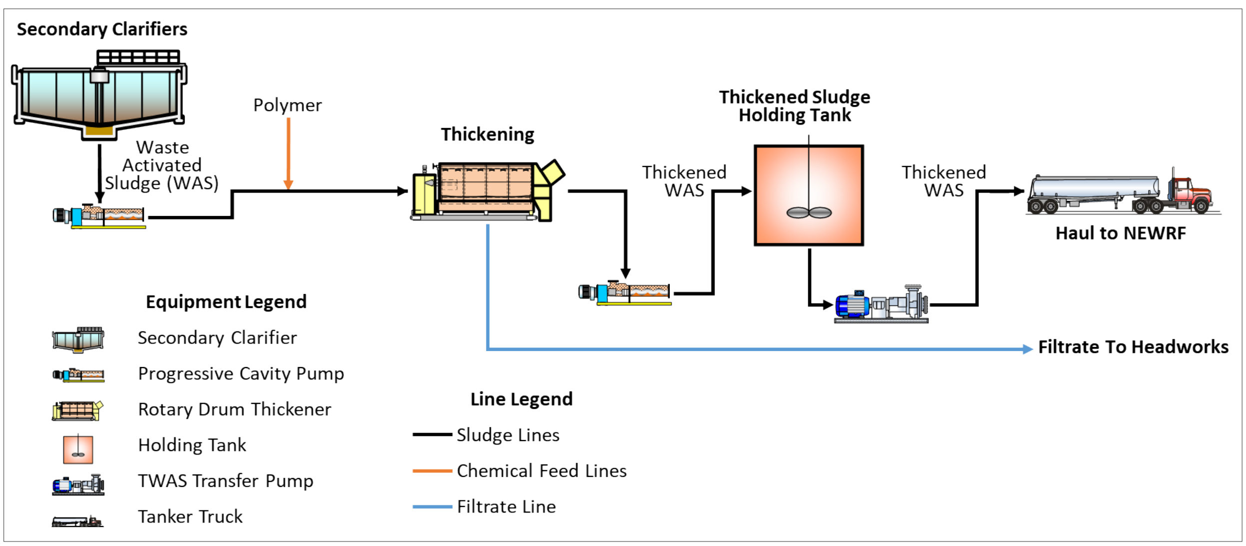


Figure 11 EWRF Solids Process Flow Diagram

5.1.2 Northeast WRF

NEWRF is permitted for 13.5 mgd. It currently utilizes a primary clarifier for removal of primary solids (PSL) from the influent. The City is in the process of installing primary filters to replace the primary clarifier. WAS from the secondary clarifiers is thickened by RDTs. PSL and TWAS from NEWRF are blended with TWAS from EWRF (refer to Subsection 5.1.1) and fed to the anaerobic digester. The digested sludge is transferred to a storage tank prior to dewatering. The City has one centrifuge and two belt filter presses (BFPs) for dewatering operations. The centrifuge is primarily used since it produces a dewatered biosolids cake at approximately 22 percent TS compared to the BFPs producing cake at 16 percent TS when they are used. Dewatered biosolids cake are hauled away by a third party for beneficial use. A process flow diagram for solids processes at NEWRF is presented on **Figure 12**.

There are also aerobic digestion tanks at the NEWRF; however, they are not being operated. Anaerobic digestion converts organic material (defined as volatile solids [VS]) to biogas, which is approximately 50 to 60 percent methane. The remainder of the biogas (40 to 50 percent) is carbon dioxide with some other micro-constituents. Approximately 50 percent of the VS in the blended digester feed is converted by anaerobic digestion, which reduces the volume of total solids leaving the plant as dewatered biosolids cake. Biogas is collected from the digester and flared. The City has a combined heat and power engine at this facility that could utilize biogas to produce electricity and heat as hot water; however, it is currently under construction. (Performance Contract Agreement – Energy Efficiency Study, Siemens, City Project No. 08-0048-UT). Hot water for digester heating is provided by boilers using natural gas.

In addition to one primary anaerobic digester, there is a smaller secondary digester; however, its cover fell into the tank and became wedged. City has plans to remove the cover and perform necessary rehabilitation to bring the secondary digester online.

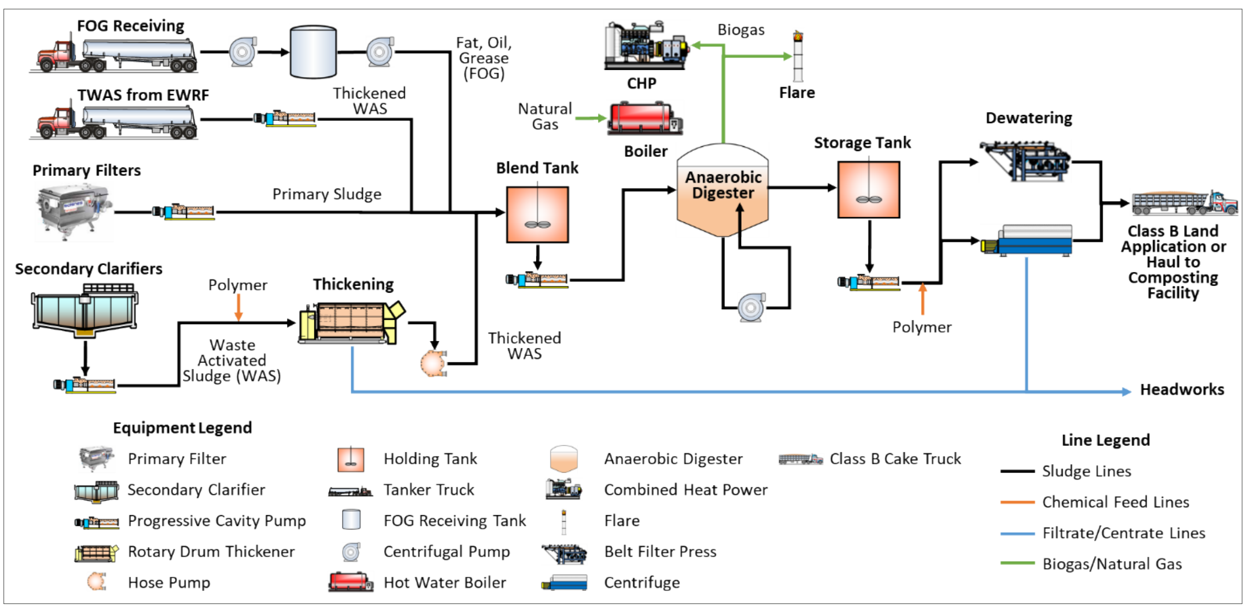


Figure 12 NEWRF Solids Process Flow Diagram

5.1.3 Marshall Street WRF

MSWRF is permitted for 10 mgd. It utilizes primary filters for removal of PSL from the influent and transfer PSL to the anaerobic digester. Only 20 to 25 percent of the influent flow is treated through primary filters. WAS from the secondary clarifiers is thickened by RDTs to approximately 6 percent TS and fed to the anaerobic digester. There is one primary anaerobic digester. At the time of this study, the digester tank was offline for cleaning and rehabilitating the digester cover. A secondary digester had been abandoned in place for a number of years and was recently demolished. Digested sludge is stored in a tank until it is dewatered by a centrifuge or a BFP. Similar to NEWRF, the centrifuge produces a cake at 22 percent TS, whereas the BFP produces 16 percent TS. Dewatered biosolids cake is hauled away by a third party for beneficial use. A process flow diagram for solids processes at MSWRF is presented on **Figure 13**.

A minimal amount of biogas from digestion is used for producing hot water for digester heating. The remainder of the biogas is flared off.

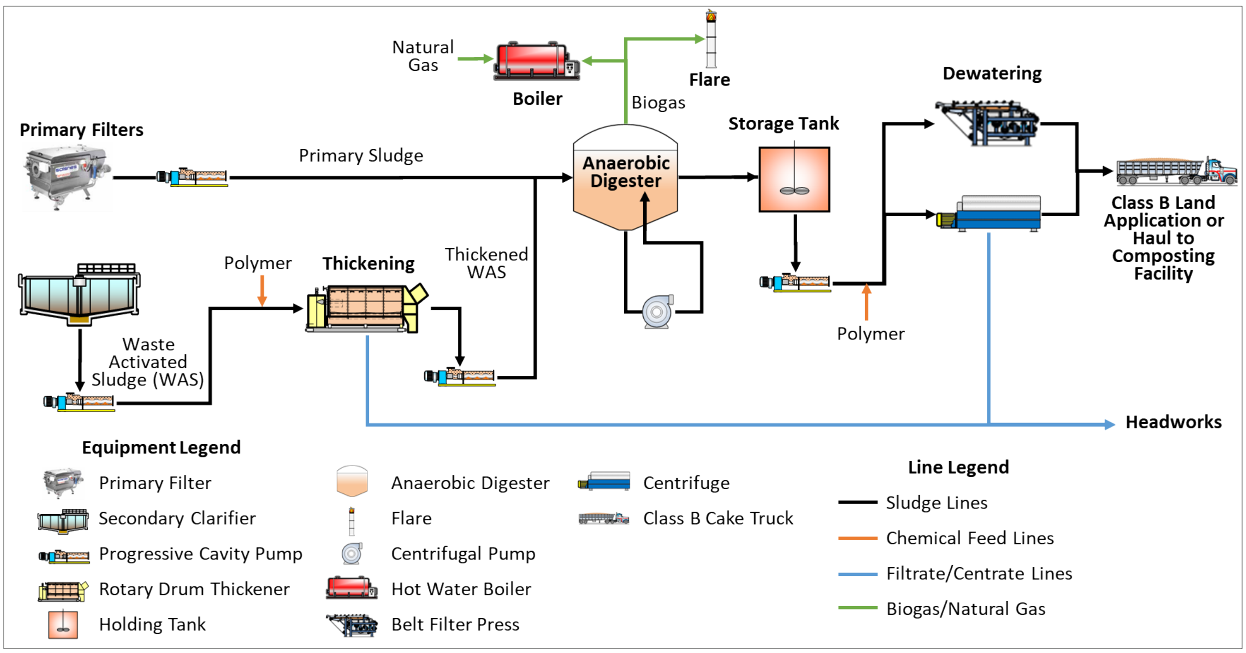


Figure 13 MSWRF Solids Process Flow Diagram

5.1.4 Current Biosolids Management Strategy

The City currently produces biosolids at two of its three WRFs. Both NEWRF and MSWRF utilize anaerobic digestion to meet pathogen reduction and vector attraction reduction requirements of EPA 503 and FDEP 62-640 requirements to produce Class B biosolids. The NEWRF biosolids include the processed sludge from the EWRF. The City contracted with two companies in 2021 to land apply Class B biosolids to sites permitted by these contractors. Class B biosolids from NEWRF are land applied by Merrell Brothers, Inc. and Class B biosolids from MSWRF are land applied by H&H Trucking. These contracts are applicable until 2025.

If there is no available land application site, both contractors have the option to take the City's biosolids to a Regional Management Facility (RMF for further processing to meet Class AA requirements of FDEP 62-640. Under the current program, contractors use composting RMFs to bring Class B biosolids to Class

AA standards. Having two contractors and two alternatives for final outlets provide maximum flexibility for the City. However, the City pays extra for biosolids to be processed at an RMF.

The City has historically relied on Class B land application, but in recent years the contractor had difficulty identifying suitable sites, and as a result, a majority of its biosolids were processed at a RMF (composting) facility in 2020 and 2021. The updated rules of 62-640 for land application, which took effect in June 2021, also limited the available land application area in the region. The contract was rebid in the fall of 2021 with bids based primarily on RMF, land application of landfill was provided as alternative bid items.

5.2 Approach to Biosolids Management Strategy Development

The screening of treatment technologies and the final evaluation of selected treatment and management alternatives followed a two-step approach, as shown on **Figure 14**. The first step was the screening phase. During this phase, a wide range of solids processing technologies were evaluated based on high-level screening criteria, such as current industry experience and how the technology compared to the existing treatment system. Potential screening criteria were reviewed with the City during Task 2.8, Workshop No. 1 (April 22, 2022) and feedback was incorporated to finalize the criteria. The Biosolids Screening Criteria TM in **Appendix D** provides a description of the criteria and their use. Information used as the basis for screening of the technologies was based on engineering experience, literature, and vendor-provided data. During Task 2.8, Workshop No. 2 (May 18, 2022), the City and Black & Veatch reviewed all applicable technologies and screened them down to four alternatives to be evaluated further. Screening eliminated those technologies not deemed suitable for further evaluation. Section 5.3 provides an overview of the results of the screening process.

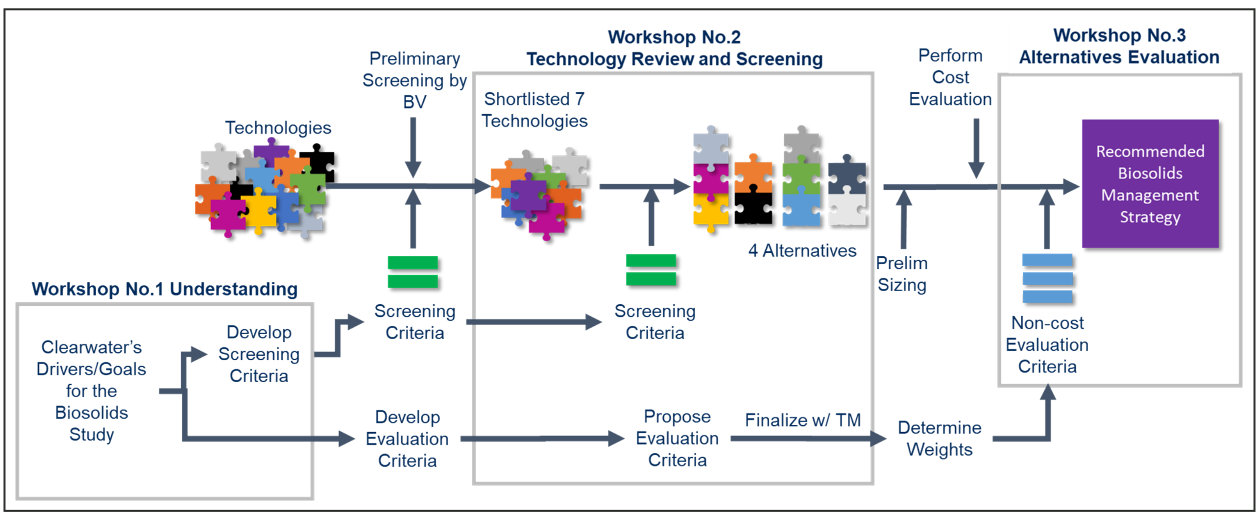


Figure 14 Technology Screening and Alternatives Evaluation Process

The selected technologies from the screening process were then used to develop complete management alternatives for evaluation as the second step. Preliminary sizing for the four shortlisted alternatives, estimated capital costs and annual operating costs were developed. A defined set of non-economic criteria in conjunction with capital costs, annual operating costs, and life-cycle costs were used to identify the best-fit biosolids management approach for the City. The non-economic evaluation criteria were reviewed with the City during Task 2.8, Workshop No. 2 (May 18, 2022). Feedback was used to finalize these evaluation criteria, which are summarized in the Biosolids Screening Criteria TM provided in **Appendix D**. After the evaluation criteria were finalized, the City developed weights for each criterion. The preliminary sizing and capital and annual operations costs were presented during Task 2.8, Workshop No. 3 (July 11, 2022). City staff then assigned a qualitative score to each alternative between 1 and 3 for each criterion. **Section 5.4** provides further details on alternatives evaluation.

5.3 Technology Screening

Screening criteria were established with the City to support evaluation of the wide range of solids processing technologies in the marketplace and ultimate use and disposal practices to eliminate those that are considered unlikely to provide cost effective or reliable solutions for managing the City's biosolids in the future. **Table 16** presents the criteria used to screen technologies. At the end of the screening process, technologies that were deemed to be unsuitable for the City's needs were dropped from further evaluation with concurrence by the City.

Table 16 Screening Criteria

Criterion	Comparative Basis	Description
Final Biosolids Product Quality	Class AA Marketable Product	Class AA marketable product is preferred to open outlets and reduce dependence on third-party management.
	Class AA Cake for Land Application	Class A cake is preferred over Class B because of regulatory restrictions associated with Class B.
	Class B Cake for Land Application	Class B cake is a minimum requirement for this project.
Technology Maturity	Emerging	One or fewer North America operations with less than 2 years of successful track record.
	Early Development	One or more North America operations with 2 to 10 years of successful track record.
	Established	Many facilities and at least 10 years of proven performance history in North America.
Relative Life-Cycle Cost	Low/Moderate/High	Life-cycle cost of the alternative technology was rated against other technologies for similar size facilities based on Black & Veatch experience.
Compatibility with Existing and Planned Liquid and Solids Processes	Yes	Technologies are proven compatible with existing or potential liquid treatment technologies without significant sidestream impacts.
	Sidestream Issues	Potential for impacts on the liquid stream associated with treatment of sidestreams.
	Sludge Type Issues	If a technology is not suitable for all sludge types (PSL and WAS), preferences/restrictions will be noted as applicable.
	Unproven	If a technology is unproven, information is not available to determine potential sidestream impacts.

Criterion	Comparative Basis	Description
Operational Complexity	OK/Moderate/ Complex	An alternative technology was rated against the current operation at City WRFs and compared to other candidate technologies based on Black & Veatch experience.
Size/Footprint	OK/Moderate/ Significant	Ability to locate the new facility on-site or the potential to regionalize treatment elsewhere.

5.3.1 Solids Processing Technologies

A comprehensive list of technologies currently used in the industry for stabilizing wastewater sludge to meet Class AA/A or Class B pathogen removal and vector attraction reduction requirements is provided on **Figure 15**. **Appendix D** provides information slides on all the technologies shown, which were reviewed during Task 2.8, Workshop No. 2 on May 18, 2022.

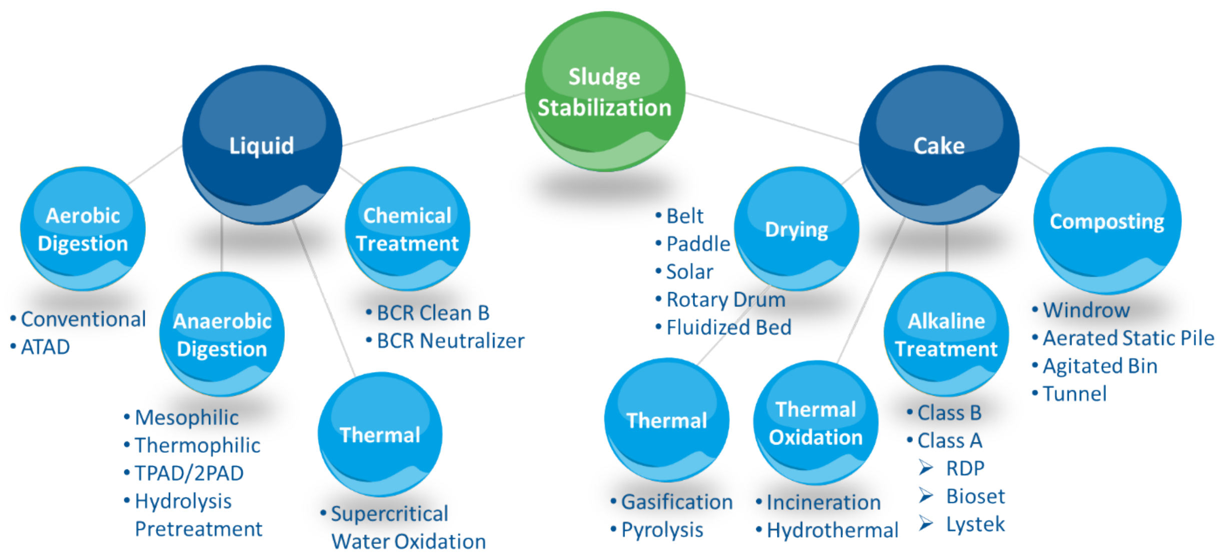


Figure 15 Possible Wastewater Sludge Stabilization Technologies and Enhancement Processes

5.3.2 Summary of Technology Screening

Based on the future biosolids generation from City's WRFs, it was determined that either a composting facility or a solar drying facility could be located at the NEWRF. Either facility would be sized to handle all solids from City facilities. Following Task 2.8, Workshop No. 2 (May 18, 2022) and further evaluations, the technology alternatives were further reviewed at a subsequent workshop on June 2, 2022. The following technologies were then shortlisted for further evaluation based on the input received during this meeting:

- Alternative 1A – Class B Land Application: Existing operation with 100 percent of digested biosolids to be land applied as Class B.
- Alternative 1B – RMF: Existing operation with 100 percent of digested biosolids to be hauled to an RMF for further processing to Class AA.

- Alternative 2: City-wide composting facility at NEWRF to treat digested biosolids from NEWRF and MSWRF to Class AA compost standards.
- Alternative 3: City-wide solar drying facility at NEWRF to treat digested biosolids from NEWRF and MSWRF. As previously noted, the dried biosolids could potentially be classified as Class AA but will require significant testing to demonstrate compliance.
- Alternative 4: Thermal dryer at NEWRF to treat digested biosolids from NEWRF and a thermal dryer at MSWRF to treat digested biosolids from MSWRF. Both of these new facilities would produce Class AA dried biosolids.

5.4 Alternatives Evaluation

Cost is only one of the factors that must be considered in the selection of the City's biosolids management strategy. Equally important are factors such as long-term sustainability of the City's biosolids management program, the number and variety of distribution outlets, ability to react to future changes in environmental regulations, public perception of treatment processes and solids products, and adaptability of the program to growth and other changes in the area.

Nineteen criteria were identified that could be used to assess the relative merits of the alternatives developed during the Task 2.8, Workshop No. 1 on April 22, 2022. These criteria were narrowed down to ten during the Task 2.8, Workshop No. 2 on May 18, 2022. These criteria were summarized in the Biosolids Screening Criteria TM dated July 7, 2022, which is **Appendix D**. The financial criteria were further discussed at Task 2.8, Workshop No. 3 on July 11, 2022, and it was determined that since life-cycle cost also included capital cost, then capital cost would be removed from the evaluation criteria.

The relative importance of each criterion may differ. The City assigned weighting factors to each criterion based on the drivers and goals for its biosolids management strategy. The criteria, scoring definitions, and weighting factors are presented in **Table 17**.

During the Task 2.8, Workshop No. 3 on July 11, 2022, each alternative was reviewed in terms of the criteria and a qualitative rating score between 1 and 3 was assigned to each criterion by the Public Utilities Director, Public Utilities and Engineering stakeholder and Black & Veatch Solids Process Specialists. The averages of all scores are rounded to the nearest integer as presented in **Table 18**.

When the analysis was complete for each alternative, the overall scores for each alternative were calculated using the weighting factors presented in **Table 17**. The overall total scores are provided in **Table 18**. Alternative 1B - Existing operation with 100 percent of digested biosolids to be hauled to an RMF for further processing to Class AA scored the highest for the following reasons:

- It is the lowest cost alternative to achieve Class AA since it does not require installing any new infrastructure.
- Implementation of composting or solar drying at NEWRF may have raised some concerns with the neighboring communities in terms of odor and aesthetics.
- There is lower contract risk than Alternative 1A since the City currently has multiple options for RMF contracts within the region, including a possible facility to be built by Pinellas County in the near future.

Table 17 Scoring Definitions and Weight of Each Evaluation Criterion

Criterion	Weight	Score of 1 Inferior/ Disadvantageous	Score of 2 Neutral/Meets Objective	Score of 3 Superior/ Advantageous
Financial				
Life-Cycle Cost	14%	High life-cycle cost	Intermediate life-cycle cost	Low life-cycle cost
Social				
Public Acceptance	7%	Appreciable risk of noise and odors and low public acceptance of product	Minimal increase in noise and odors and reasonable public acceptance of product	Low risk of noise and odors and good public acceptance of product
Safety	14%	Increased safety risk from new equipment and/or higher truck traffic as compared to existing program to haul finished product	Minimal increase in safety risk from new equipment and/or moderate truck traffic as compared to existing program to haul finished product	Low safety risk from new equipment and low truck traffic as compared to existing program to haul finished product
Product Quality and Program Diversification	11%	Product difficult to store and transport and does not allow for diversification	Product moderately easy to store and transport and allows for some diversification	Product easy to store and transport and allows for good diversification
Environmental				
Regulatory Risk	13%	Requires significant system changes to accommodate potential regulatory changes	Requires moderate system changes to accommodate potential regulatory changes	Requires minimal system changes to accommodate potential regulatory changes
Contract Risk	9%	Totally dependent on third-party contract management and or limited potential contractors	Dependent on third-party contractors but multiple contractors for competition and improved reliability	No requirement for third-party contractor
Functional				
Process Reliability	12%	Appreciable risk of system component failure	Moderate risk of system component failure	Low risk of system component failure
Operational Complexity and Maintainability	12%	Complex system requiring high degree of specialized expertise and complex maintenance requirements over life of system	Moderately complex system requiring moderate degree of specialized expertise and moderately complex maintenance requirements over life of system	Simpler system requiring minimal degree of specialized expertise and simpler maintenance requirements over life of system
Site Constraints	8%	Larger footprint – difficult to accommodate on-site	Minimal increase in footprint	Smaller footprint – easier to accommodate on-site

Table 18 Summary of Alternatives Evaluation Scores

Evaluation Criterion	Alternative 1A Class B Land App		Alternative 1B RMF		Alternative 2 Composting		Alternative 3 Solar Dryer		Alternative 4 Thermal Dryer	
	Average Score	Weighted Score	Average Score	Weighted Score	Average Score	Weighted Score	Average Score	Weighted Score	Average Score	Weighted Score
Financial										
Life Cycle Cost	3.0	0.4	3.0	0.4	2.0	0.3	2.0	0.3	1.0	0.1
Social										
Public Acceptance	1.0	0.1	2.0	0.1	2.0	0.1	2.0	0.1	3.0	0.2
Safety	2.0	0.3	2.0	0.3	2.0	0.3	2.0	0.3	2.0	0.3
Product Quality and Program Diversification	1.0	0.1	2.0	0.2	3.0	0.3	2.0	0.2	3.0	0.3
Environmental										
Regulatory Risk	1.0	0.1	3.0	0.4	2.0	0.3	2.0	0.3	3.0	0.4
Contract Risk	1.0	0.1	3.0	0.3	3.0	0.3	3.0	0.3	3.0	0.3
Functional										
Process Reliability	2.0	0.2	3.0	0.4	3.0	0.4	2.0	0.2	2.0	0.2
Operational Complexity and Maintainability	3.0	0.4	3.0	0.4	2.0	0.2	2.0	0.2	2.0	0.2
Site Constraints	3.0	0.2	3.0	0.2	1.0	0.1	1.0	0.1	2.0	0.2
Weighted Total		**1.9**		**2.7**		**2.2**		**2.0**		**2.3**

5.5 Biosolids Summary and Next Steps

The results of the evaluations completed as part of this biosolids study effort indicate that the most appropriate biosolids management strategy for the City is to continue with the current operation while considering contractual and budgetary requirements to contract with a RMF for a long-term basis. This may also include working with Pinellas County as they develop their approach to implement a RMF within the County limits.

During the next phase of this project, a more detailed condition assessment of the infrastructure at each WRF will be performed, including solids processes. Further, process models for each facility will be updated to evaluate treatment capacity and optimize processes. The findings from these and other tasks that are related to the solids processes will be combined with the biosolids management strategy identified herein to develop a Biosolids Strategic Plan. This plan will also include budgetary requirements and schedule for the planning period.

6.0 Effluent Management Strategy Development

Effluent management is a major component of managing the WRFs, and future effluent options have become more limited because of recent changes in regulations by the Florida Legislature through Senate Bill 64, which nearly eliminates surface water discharges from the WRFs.

Florida's Senate Bill 64 – Reclaimed Water (SB64) requires domestic wastewater utilities that dispose of effluent, reclaimed water, or reuse water by surface water discharge to eliminate non-beneficial surface water discharge by January 1, 2032. According to SB64, municipalities propose a plan that may eliminate non-beneficial surface water discharge utilizing the following methods:

- The plan eliminates the discharge.
- The plan meets section 403.086(10), F.S.
- The plan does not eliminate the discharge – The discharge is a wet weather discharge that occurs in accordance with an applicable department permit.
- The plan does not eliminate the discharge – The discharge is into a stormwater management system and is subsequently withdrawn by a user for irrigation purposes.
- The plan does not eliminate the discharge – The utility operates the domestic wastewater treatment facilities with reuse system that reuse a minimum of 90 percent of a facility's annual average flow, as determined by the FDEP using monitoring data for the prior 5 consecutive years, for reuse purpose authorized by FDEP.
- The plan does not eliminate the discharge – The discharge provides direct ecological or public water supply benefits, such as rehydrating wetlands or implementing the requirements of minimum flows and minimum water levels or recovery or prevention strategies for a waterbody.

Prior to the January 1, 2032, deadline, FDEP requires municipalities to provide annual reports on the status of improvements proposed in the SB64 plan. Through coordination with FDEP, they indicated the first annual report will be due in November 2023.

On May 3, 2022, FDEP approved the City's plan for compliance with SB64 (City Project No. 21-0016-UT). The City's SB64 plan focused on two strategies for the two points of surface water discharge (MSWRF and NEWRF + EWRF combined). The plan, as submitted to the FDEP, is included as **Appendix E**. Decision trees, which summarize the two strategies, are presented on **Figure 16** and **Figure 17**. The City may choose to amend the approved plan as appropriate.

In summary:

- Through the City's Master Reuse System permit, the City will continue to discharge reclaimed water into two stormwater management systems where the water is subsequently withdrawn by users for irrigation purposes. (D-002, Countryside Country Club Pond to Possum Creek to Old Tampa Bay and D-003, Belleair Country Club Pond to Corbet Street Stormwater to Intracoastal Waterway).
- According to the A Prototype Realistic Innovation Community of Today (APRICOT) Act [s. 403.086(8)] allowances, the City will increase the public access reclaimed water utilization at the MSWRF to a minimum of 70 percent with 30 percent backup discharges to Stevenson Creek, a Class III Marine water body.

- The City will increase public access reclaimed water utilization at the EWRF and NEWRF to 90 percent, thus reducing the surface water discharge to 10 percent or less, in compliance with SB64 requirements.
- Increasing public access reclaimed water utilization will be accomplished by adding potential public access reuse customers identified to be located within the City existing Master Reuse System, expanding capacity outside the existing service area, increasing flow to Pinellas County and/or providing reclaimed water service to Safety Harbor. The City is actively conducting a Reuse Master Plan (City Project No. 21-0018-UT).
- Accomplishing 90 percent public access reuse may require implementing the use of another source of water to augment the reclaimed water supply during peak season demands or implementing an aquifer storage and recovery (ASR) system, if feasible, to balance the seasonal variability in reclaimed water demands.
- The City is also evaluating groundwater replenishment and direct potable reuse at the NEWRF that could help achieve 90 percent reuse if implemented.

Much of this summary is applicable regardless of the potential to consolidate any of the WRFs, which will be described in more detail in Section 7.0.

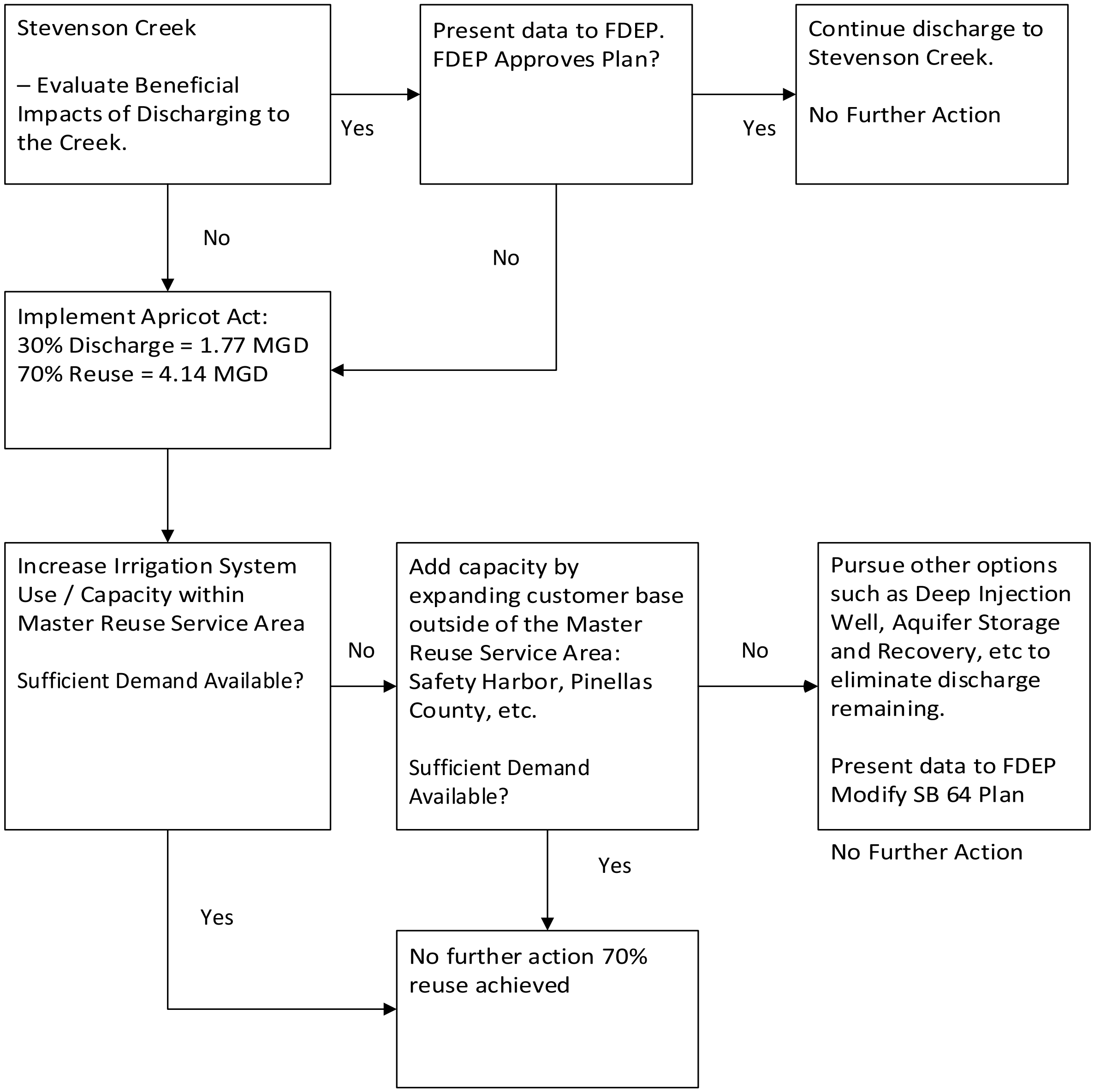


Figure 16 MSWRF Effluent Management Decision Tree

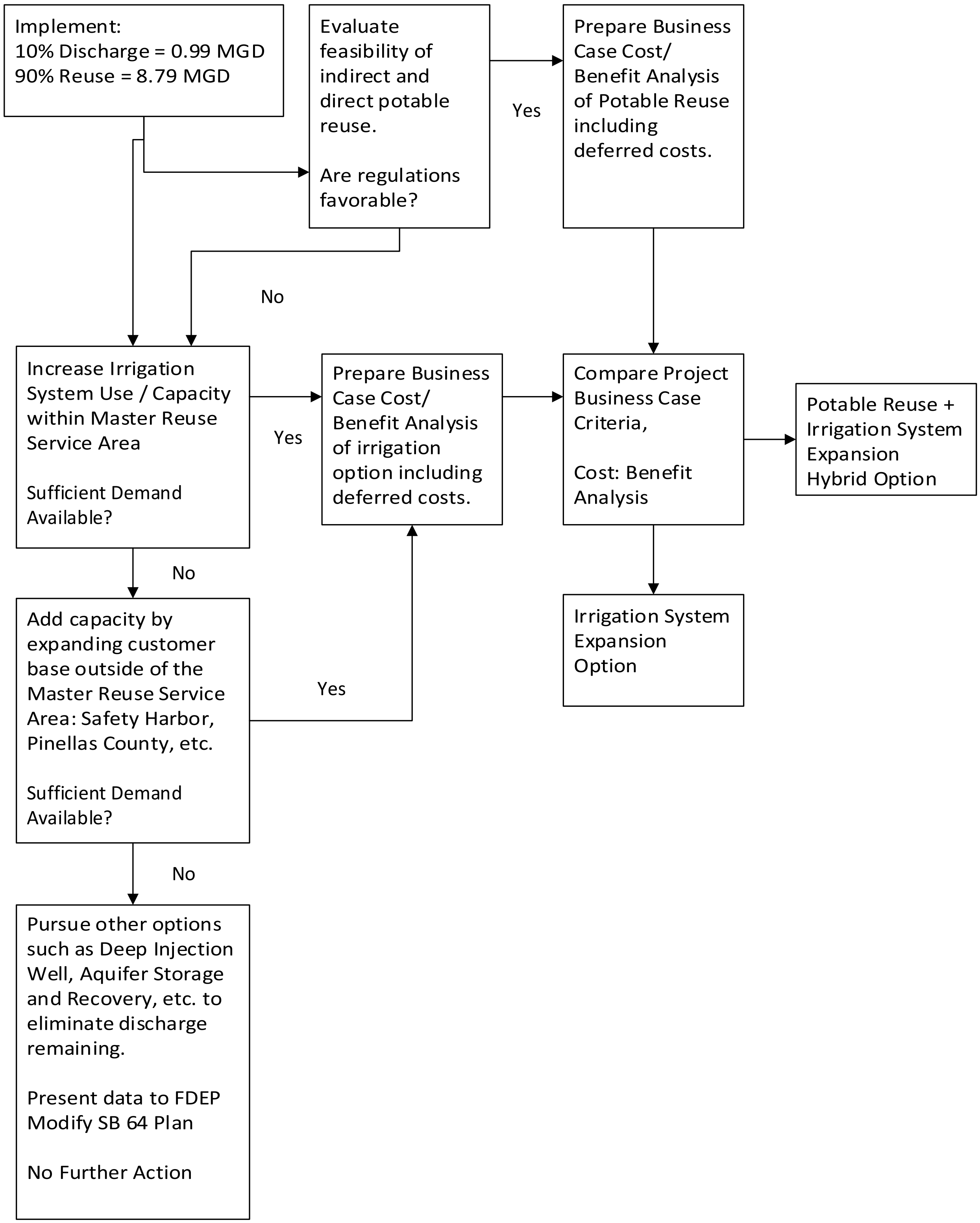


Figure 17 EWRF+NEWRF Effluent Management Decision Tree

7.0 WRF Consolidation Evaluation

A key task of determining the Future WRF Strategies for further evaluation within the WRF Master Plan was to evaluate scenarios for potentially consolidating three WRFs. The evaluation of the scenarios took all the major components of managing a WRF into consideration, including: Capacity, Renewal and Replacement, Regulations, Effluent Management, Biosolids, and Costs. This section details the impacts of consolidation on each category and combines information in a format to facilitate comparison.

The consolidation evaluation followed six steps to compare the various options:

1. **Goal Setting**: Based on goals of Project, City, and Public Utilities Department.
2. **Scenario Development**: 30 scenarios were initially identified, then shortlisted to six that cover the envelope range of possibilities and were reasonable to evaluate further (e.g., it is not feasible to consolidate all facilities to the EWRF, so it was removed).
3. **Evaluation Criteria Development**: Based on City and Public Utilities' goals and refined through a series of workshops.
4. **Criteria Weighting Development**: Determined through a series of surveys and input from the City.
5. **Scenario Analyses and Scoring**: Group consensus on scoring through a series of workshops. Evaluation Criteria Analysis: Sustainability (energy consumption and greenhouse emissions) and financial responsibility (life-cycle costs) were based on calculations.
6. **Recommendation**: The scores and weights were applied and totaled to determine the highest scored scenario.

7.1 Scenario Development

The scenario development began by creating a broad list of options that included approximately 30 consolidation scenarios. The broad list was initially developed through brainstorming sessions with and without the City and focused on ideas for consolidation regardless of constraints such as available space or capacity. (The full list of consolidation scenarios can be found in **Appendix F**.) Further evaluation of the full list was conducted, and scenarios were eliminated based on the following considerations:

- Expansion Availability (e.g., it is unrealistic to consider MSWRF and EWRF expanding because of tight site conditions and proximity to coastal hazards [i.e., the scenario where MSWRF was decommissioned and consolidated to the EWRF site would be unrealistic because of lack of space availability for improvements at EWRF]).
- New facility consideration (e.g., it is unrealistic to consider decommissioning EWRF and converting flow to a new facility. It would be more feasible to decommission EWRF and consolidate flow to an existing facility.)
- Only full flow consolidation between WRFs was considered. No split flow was considered due to expansion availability and coastal hazards vulnerability of the MSWRF and EWRF. (e.g., if EWRF was decommissioned, all of its flow would go to a single receiving plant [i.e., MSWRF, NEWRF, or a new WRF]. If NEWRF were the recipient of the decommissioned/re-routed flow, NEWRF would thus accommodate all future flow projected for the EWRF basin.)

- Overall reasonableness of the breadth of scenarios: the broad list was filtered to a reasonable number of scenarios (which turned out to be 6). These 6 scenarios represented the "envelope of possibilities", covering aspects such as little and much flow transmission needed, new treatment plants needed or not (and associated land acquisition), much and little capital infrastructure needed, lower and higher relative life cycle costs, etc. The intent was not to complete a full design of the selected scenario, but to narrow the list to reasonable approaches that would lead to the City's strategy for the WRFs over the 30-year planning horizon.
- City Input: Ability of the scenario to meet the City's goals and the WRF Master Plan project goals. Black & Veatch met with the City on May 18, 2022 to discuss consolidation scenarios and some were eliminated from further consideration.

Figure 18 to **Figure 20** show each WRF's space available, and City owned, for any future improvements that may be needed for the various consolidation scenarios. This information was used for shortlisting the scenarios and during the capital cost evaluations.

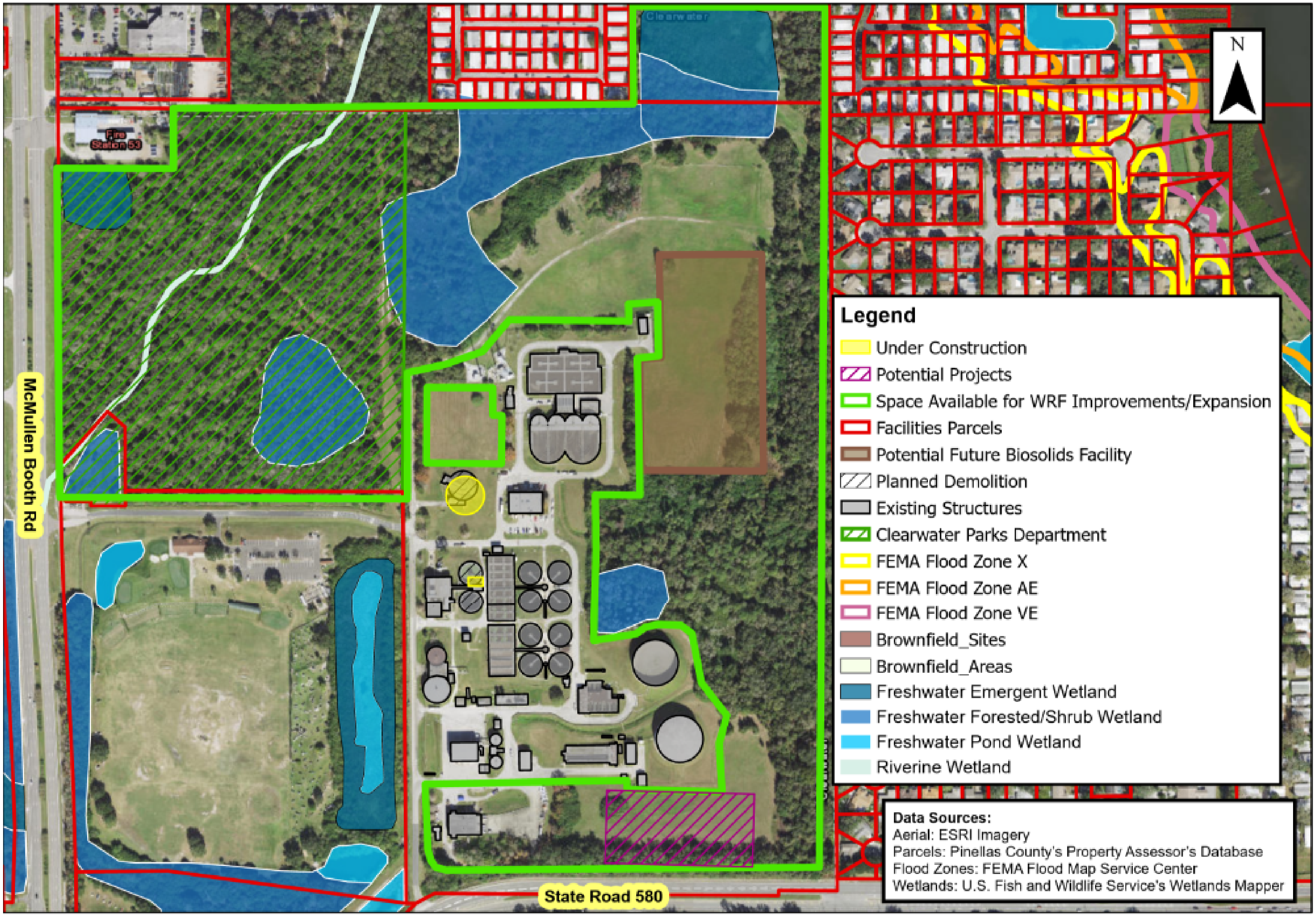


Figure 18 Site Map of NEWRF

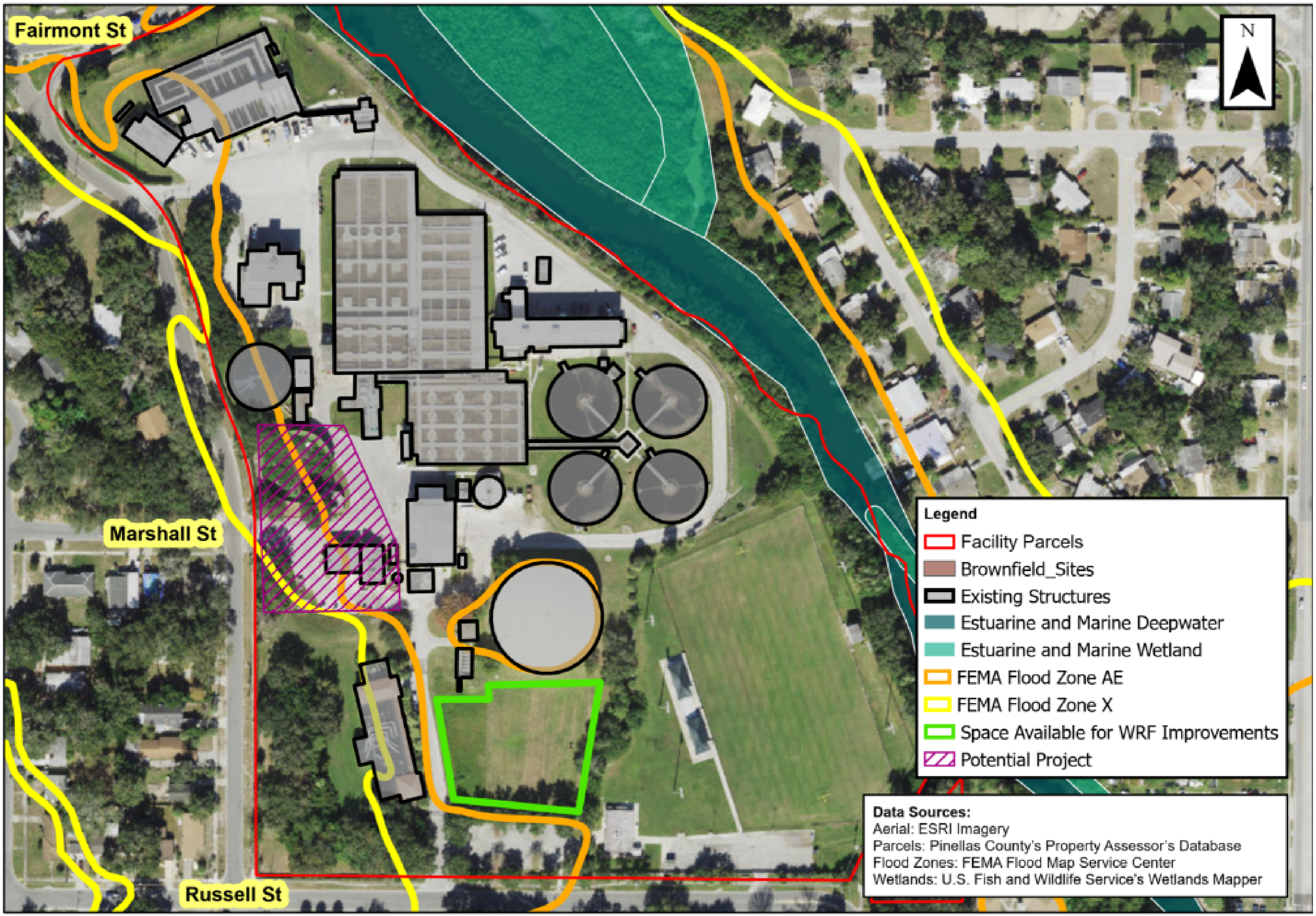


Figure 19 Site Map of MSWRF

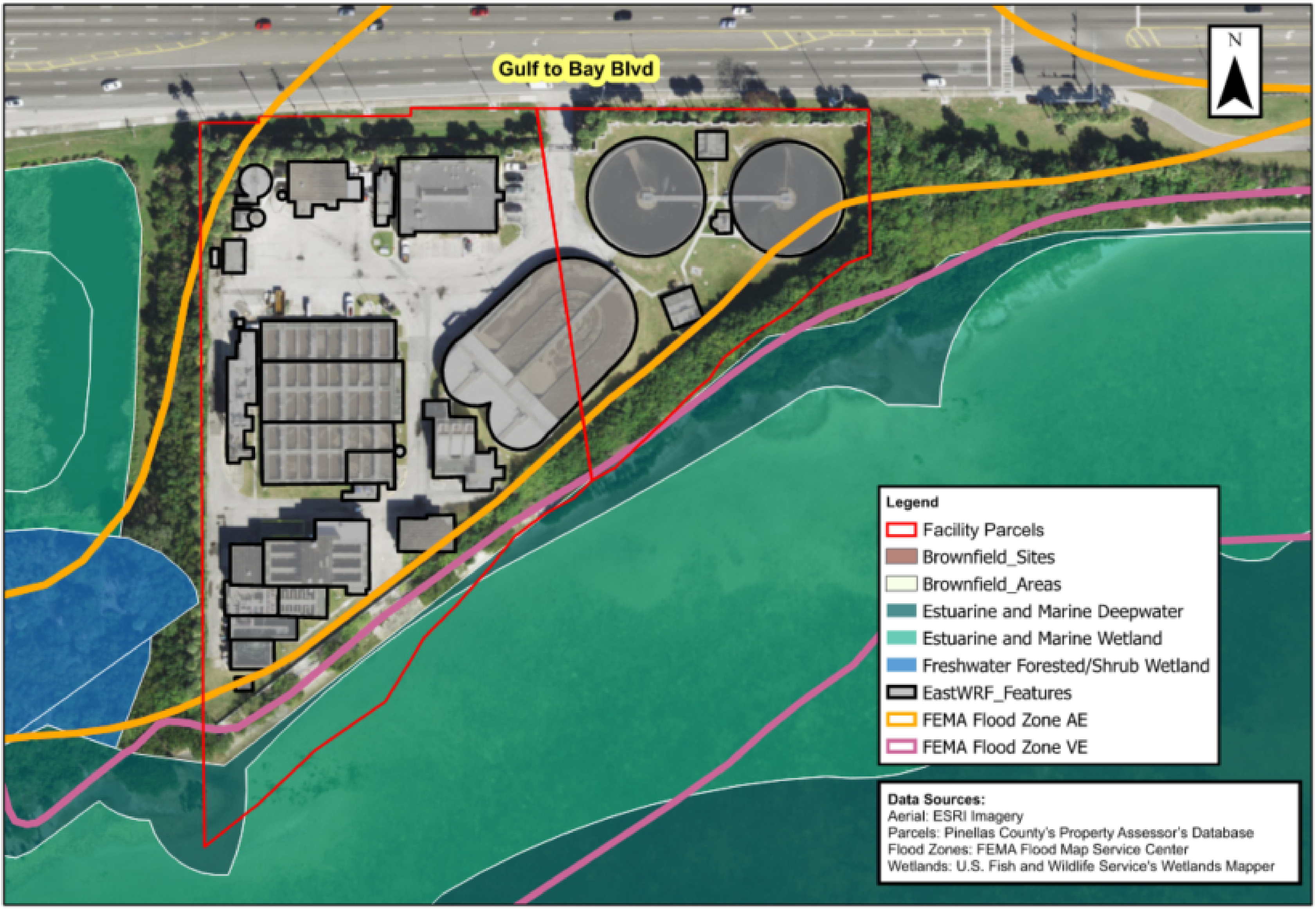


Figure 20 Site Map of EWRF

After applying the above screening criteria, the shortlisted consolidation scenarios were established and are listed in **Table 19**.

Table 19 Shortlisted WRF Consolidation Scenarios

Scenario No.	Scenario Name	Description	Total No. of WRFs
1	Maintain Existing WRFs (Baseline Scenario)	No consolidation. Maintain as three separate WRFs.	3
2	All at NEWRF	Complete consolidation. Consolidate all MSWRF and EWRF flow to NEWRF.	1
3	MSWRF to NEWRF	Partial consolidation. Consolidate by directing all MSWRF flow to NEWRF. Maintain EWRF where it is currently located.	2
4	EWRF to NEWRF	Partial consolidation. Consolidate by directing all EWRF flow to NEWRF. Maintain MSWRF where it is currently located.	2
5	MSWRF+EWRF to New WRF	Partial consolidation. Consolidate by directing all MSWRF and EWRF flow to a new WRF. Maintain NEWRF where it is currently located.	2
6	All at New Regional WRF	Complete consolidation. Divert all flow from all three WRFs to a new facility at a location that is not one of the existing WRFs.	1

Available information was reviewed and coordinated with City staff for additional data. The data review consisted of information such as reports, City Budget/CIP, permits, data, and record drawings. In addition to the data collection and review process, Black & Veatch met with City staff for input on the short-listed scenarios as they were being developed and obtained concurrence before proceeding with evaluating the six scenarios in further detail. The scenarios were developed further by performing critical yet high-level foundational analyses on plant flows, population projections, and wastewater generation rates, which became the basis of assumptions for proceeding further in the evaluation of scenarios (sizing force mains, determining capacity limitations, cost estimating, etc.).

7.2 Evaluation Criteria Development

To evaluate the scenarios (particularly for non-economic factors), evaluation criteria was developed from the City's goals for the WRF Master Plan (refer to Section 1.0). Black & Veatch met with the City on May 23, 2022, and June 1, 2022, to thoroughly review and finalize the proposed weighting criteria. The finalized evaluation criteria and range of available scores are shown in **Table 20**.

Table 20 Evaluation Criteria

Criteria	Score 1 (Least Favorable)	Score 2	Score 3 (Most Favorable)
System Reliability and Resilience	Low reliability or resilience of the collection and treatment systems. Consider items such as the following: • Single point of failure • SSO elimination • SWFWMD environmental resource and groundwater replenishment permitting • Minimum design standards	Medium reliability and resilience of treatment system. Consider items such as the following: • Single point of failure • SSO elimination • SWFWMD environmental resource and groundwater replenishment permitting • Minimum design standards	High reliability and resilience of the treatment system. Consider items such as the following: • Single point of failure • SSO elimination • SWFWMD environmental resource and groundwater replenishment permitting • Minimum design standards
Maintenance Reliability and Resilience	Low maintenance reliability or resilience of the treatment systems. Consider items such as the following: • Useful life and condition of equipment • Spare part requirements/costs • Ability to secure skilled labor/staffing • Size of equipment and safety • Automation - requires a lot of maintenance skill and attention.	Medium maintenance reliability or resilience of the treatment systems. Consider items such as the following: • Useful life and condition of equipment • Spare part requirements/costs • Ability to secure skilled labor/staffing • Size of equipment and safety • Automation - requires intermediate maintenance skill and attention.	High maintenance reliability or resilience of the treatment systems. Consider items such as the following: • Useful life and condition of equipment • Spare part requirements/costs • Ability to secure skilled labor/staffing • Size of equipment and safety • Automation - requires minimal maintenance skill and attention.
Ease of Operations	Highly complex system configuration. Consider the following: • Low capacity to manage resources • Increased risk of safety and quality incidents • Number and locations of WRFs and lift stations • Number of pieces of equipment • Automation - requires a lot of training and human input.	Intermediate system configuration. Consider the following: • Medium capacity to manage resources • Risk of safety and quality incidents remains the same • Number and locations of WRFs and lift stations • Number of pieces of equipment • Automation - intermediate training and input.	Simple system configuration. Consider the following: • High capacity to manage resources • Reduced risk of safety and quality incidents • Number and locations of WRFs and lift stations • Number of pieces of equipment • Automation – user friendly. Requires minimal training and human input.
Climate and Environmental Vulnerability	Potential for significant impacts by climate hazards: flood events, sea level rise, storm surge	Potential for some impacts by climate hazards: flood events, sea level rise, storm surge	Low potential for impacts by climate hazards: flood events, sea level rise, storm surge

Criteria	Score 1 (Least Favorable)	Score 2	Score 3 (Most Favorable)
Sustainability (Greenprint 2.0 is City's Sustainability Plan)	High energy consumption and greenhouse emissions; Does not meet Greenprint 2.0 goals. Consider the following: • WW processes and general quantities produced • Ability to reuse byproducts • End product disposal (e.g., Senate Bill 64, biosolids)	Medium energy consumption and greenhouse emissions; meets Greenprint 2.0 goals. Consider the following: • WW processes and general quantities produced • Ability to reuse byproducts • End product disposal (e.g., Senate Bill 64, biosolids)	Low energy consumption and greenhouse emissions; exceeds Greenprint 2.0 goals. Consider the following: • WW processes and general quantities produced • Ability to reuse byproducts • End product disposal (e.g., Senate Bill 64, biosolids)
Financial Responsibility	Highest life cycle costs [Capital + O&M costs over 30 years]	Average life cycle costs [Capital + O&M costs over 30 years]	Lowest life cycle costs [Capital + O&M costs over 30 years]
Public Perception	Community concerns and lengthy planning and zoning approval process	Minor community concerns or minor planning and zoning approval requirements and/or positive community response	No community or planning and zoning challenges and/or highly positive community response

7.3 Criteria Weighting Development

The evaluation criteria weighting was developed through multiple workshops and surveys with City staff (May to June 2022). The input was used to determine and finalize the weighting criteria. The resulting weights are summarized in **Table 21**.

Table 21 Evaluation Criteria Weights

Evaluation Criteria	Weight
System Reliability and Resilience	22%
Maintenance Reliability and Resilience	21%
Ease of Operations	17%
Climate and Environmental Vulnerability	14%
Sustainability (Greenprint 2.0 is City's Sustainability Plan)	11%
Financial Responsibility	9%
Public Perception	6%
Total	**100%**

7.4 Scenario Analyses

In order to fully evaluate the six scenarios a few more detailed assessments were required: Collection system impacts, treatment process impacts and effluent disposal impacts. Further details on these topics are provided in Subsection 7.4.1, Collection System Consolidation Analysis, and Subsection 7.4.2, Treatment Consolidation Capacity Analysis.

7.4.1 Collection System Consolidation Analysis

A preliminary assessment was performed of the collection system improvements needed to transfer flow and to reconfigure the existing collection system in support of the consolidation scenarios. The resulting required improvements are identified on **Figure 23**.

- Step 1: Locate master lift stations and force mains. (**Figure 21)**
  - Each WRF becomes a new master lift station. (Figure ID Nos. LS11 and LS12)
  - New force mains are proposed to connect the new master lift stations and transfer flow to the NEWRF. The force mains are located along Sunset Point Boulevard (Figure ID Nos. FM13 and FM14) and McMullen Booth Road (Figure ID Nos. FM15 and FM17). Then the two force mains manifold and continue along McMullen Booth Road (Figure ID No. FM18) until it terminates at the NEWRF.
- Step 2: Flow Shedding of Existing System. (**Figure 22)**
  - Storm Surge Categories (1 through 5) and the 100-year flood elevation were uses as surrogates for high-risk areas.
  - Create improvements to redirect flow from lift stations which are in low-risk areas and pump to high-risk areas.
  - Existing flows were rerouted by upgrading existing lift stations and force mains to divert flow to new master lift stations.
  - Existing large gravity interceptors were also routed to the new master lift stations.
  - For example: Figure ID No. LS2 intercepts flow from existing areas that are at low risk (flow from existing gravity, including existing Lift Stations 06 and 49 and rerouted flow from existing Lift Station 07) and pumps to a low-risk path to NEWRF, instead of the current high-risk path to MSWRF.

Once all force mains, proposed master lift stations, and lift station upgrades were identified they were then sized to convey peak hour flow (PHF) using a skeletonized hydraulic model in PCSWMM. (NOTE: A skeletonize model is a reduced version of a larger model that has the correct modeling inputs to analyze a smaller section of a system.) Force mains were sized in the consolidation configuration scenarios to maintain peak hours velocities less than 8 feet per second or maintain discharge pressure at pumping facilities less than 85 pounds per square inch (psi), whichever came first. A summary of results is provided in **Table 22** and are illustrated on **Figure 23**.

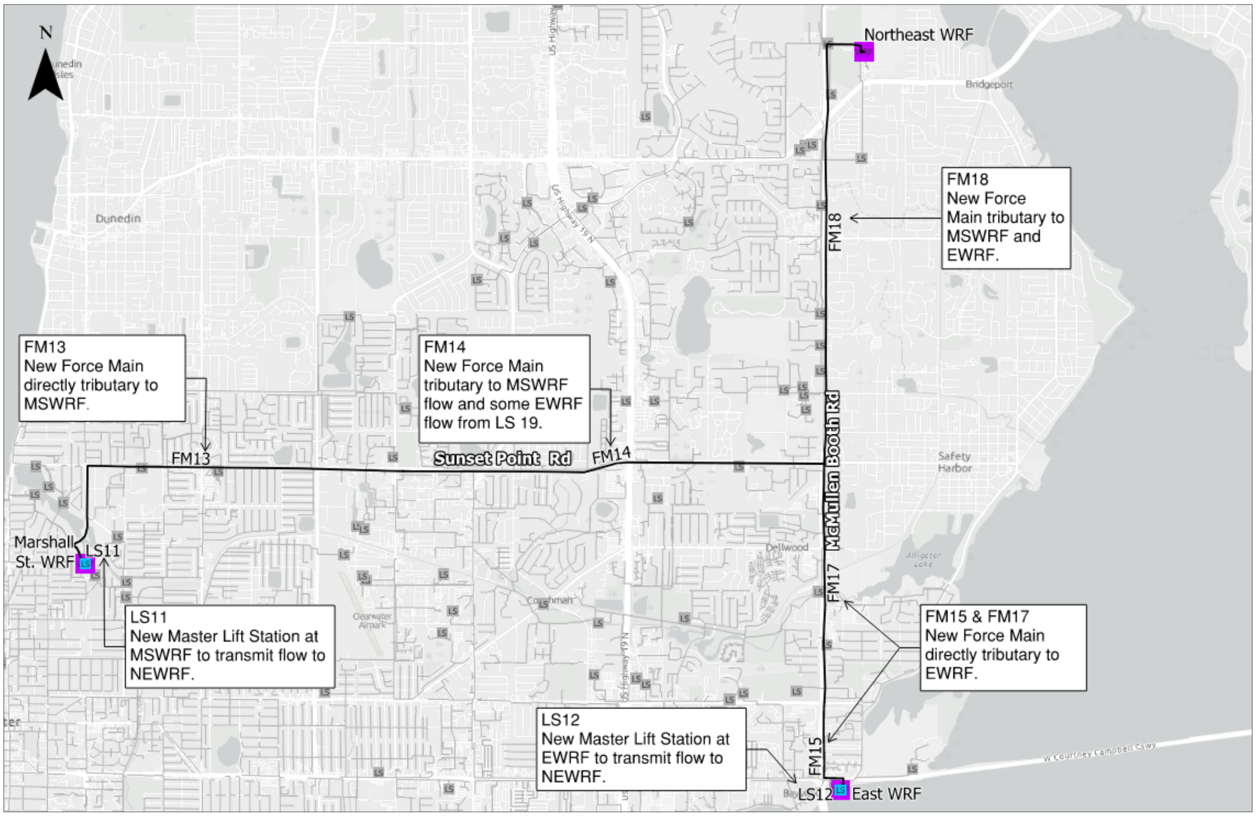


Figure 21 Lift Stations and Force Main Required to Consolidate Flow (Step 1)

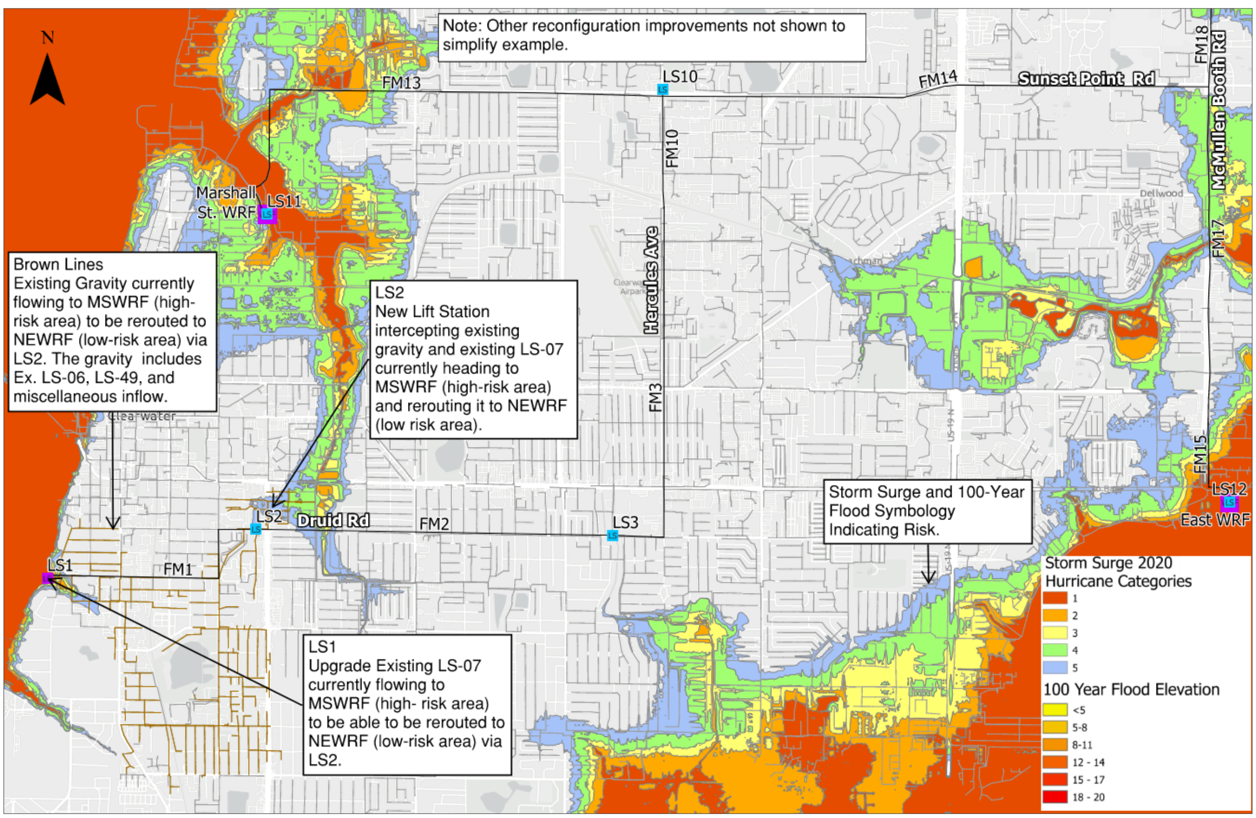


Figure 22 Example of Reconfiguring Existing Infrastructure based on Risk (Step 2)

Table 22 Clearwater Wastewater Collection System Improvements

Improvement Summary	Quantity	Unit
Force Mains		
Install Force Main - 4''	3,050	Linear Feet
Install Force Main - 6''	14,800	Linear Feet
Install Force Main - 8''	7,500	Linear Feet
Install Force Main - 12''	6,900	Linear Feet
Install Force Main - 16''	9,700	Linear Feet
Install Force Main - 18''	14,100	Linear Feet
Install Force Main - 20''	3,650	Linear Feet
Install Force Main - 24''	1,600	Linear Feet
Install Force Main - 30''	8,300	Linear Feet
Install Force Main - 36''	14,500	Linear Feet
Install Force Main - 42''	15,000	Linear Feet
Install Force Main - 48''	16,000	Linear Feet
Existing Lift Station Upgrades		
Upgrade Existing Lift Stations	7	No. of
Upgrade Existing Lift Stations	5	Flow, mgd
Install New Lift Stations		
Install New Lift Stations	6	No. of
Install New Lift Stations	69	Flow, mgd

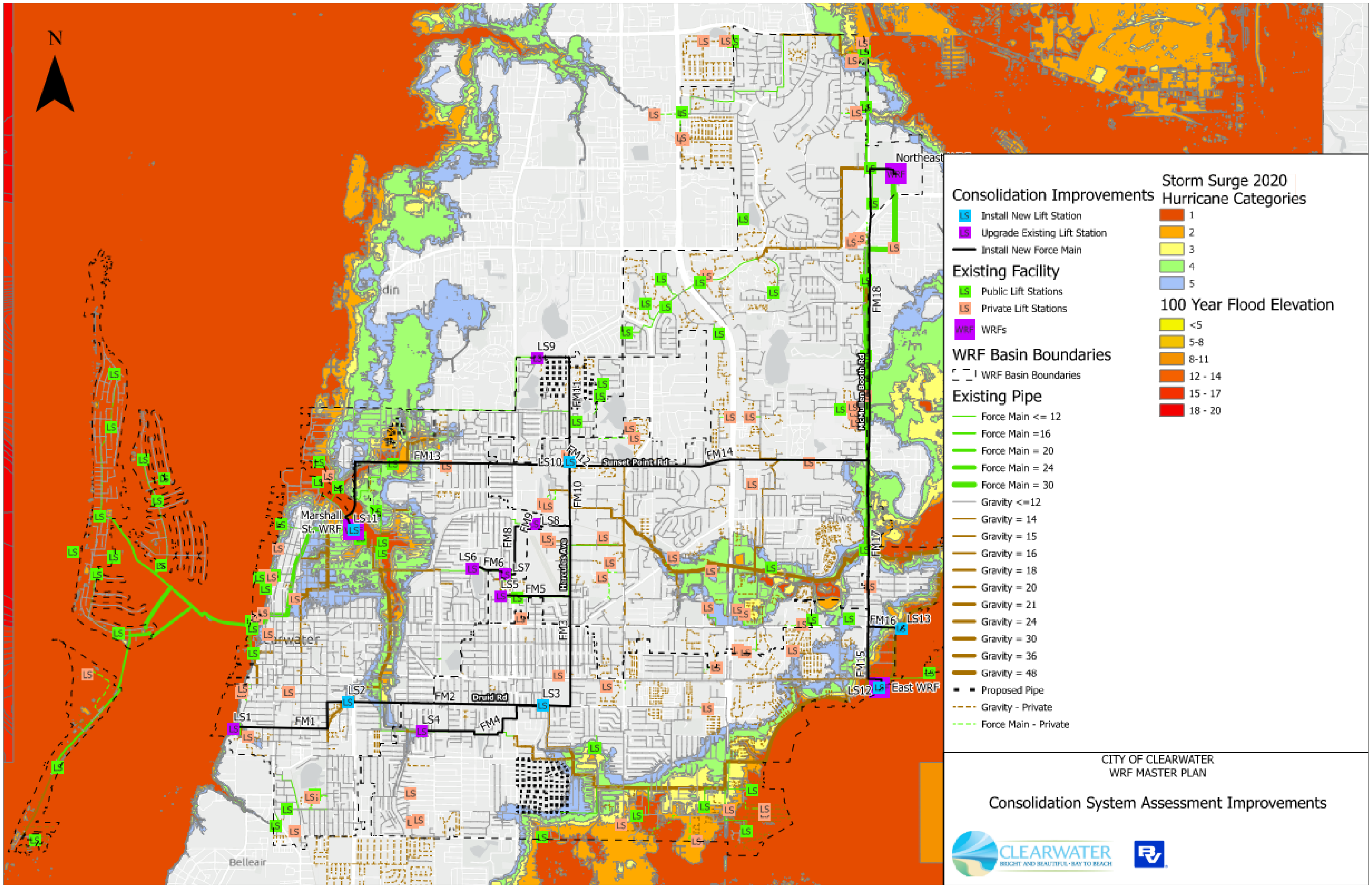


Figure 23 Clearwater Wastewater Collection System Improvements

7.4.2 Treatment Consolidation Capacity Analysis

A capacity assessment was performed for the six shortlisted WRF consolidation scenarios. Flows projected for the year 2050 for each of the WRFs were assessed in this study. More details of the projected flows are provided in the flow projections section of this TM (Section 2.0). The permitted treatment capacity for each existing WRF is summarized in **Table 23** and the projected 2050 AADFs and PHFs at each WRF were estimated for each scenario, as shown in **Table 24**.

Table 23 Permitted Treatment Capacity

WRF	Permitted AADF (mgd)
EWRF	5.0
MSWRF	10.0
NEWRF	13.5

Table 24 Required Flow Capacity for the Six Scenarios

Scenario No.		1	2	3	4	5	6
Scenario Name		Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+EWRF to New WRF	All at New Regional WRF
Total No. of WRFs (mgd)		3	1	2	2	2	1
MSWRF	Existing AADF	5.7			5.7		
	Existing PHF	30.64			30.64		
	2050 Projected AADF	6.28			6.28		
	2050 Projected PHF	30.83			30.83		
	Design AADF	10			10		
	Design PHF	25			25		
NEWRF	Existing AADF	5.2	13.0	10.9	7.3	5.2	
	Existing PHF	22.15	78.08	52.79	47.44	22.15	
	2050 Projected AADF	5.33	14.55	11.61	8.27	5.33	
	2050 Projected PHF	25.73	79.97	56.56	49.14	25.73	
	Design AADF	13.5	13.5	13.5	13.5	13.5	
	Design PHF	27	27	27	27	27	
EWRF	Existing AADF	2.1		2.1			
	Existing PHF	25.29		25.29			
	2050 Projected AADF	2.94		2.94			
	2050 Projected PHF	23.41		23.41			
	Design AADF	5		5			
	Design PHF	12.5		12.5			
New Facility	Existing AADF					10.9	13
	Existing PHF					52.79	78.08
	2050 Projected AADF					11.61	14.55
	2050 Projected PHF					56.56	79.97

The flow comparison included comparing the 2050 projected AADF and PHF to the existing design capacity of the WRFs in each scenario. **Table 25** summarizes the expansion assessment and design capacity needs of each scenario.

- Scenarios 1, 3, and 4: In general, it was assumed that all existing plants can meet their permitted treatment capacity requirements. The 2050 projected AADF was below design capacity at all WRFs, which means capacity expansion is not needed. The WRFs would only have R&R needs. However, the addition of equalization tanks would be necessary because the 2050 projected PHF exceeded the design PHF.
- Scenario 2: 2050 projected AADF and PHF flows for the three WRFs were added together, and the combined flows were compared to design AADF and PHF of the NEWRF. For this scenario, the consolidated flow exceeded design capacity; therefore, 50 percent capacity expansion at NEWRF is needed to handle projected flow (an additional treatment train). The City of Safety Harbor owns 4 mgd of NEWRF's 13.5 mgd capacity. Safety Harbor's future expansion is being considered in the improvements at NEWRF.
- Scenario 5: Considers the consolidation and direction of the MSWRF and EWRF flows to a new facility while the NEWRF operates as is. For this scenario, the AADF design capacity needed for the new facility is between 12 to 15 mgd and no expansion is required for the NEWRF.
- Scenario 6: All current WRFs are consolidated, and flow is directed to a new facility, an AADF design capacity of 14 to 20 mgd would be needed.

Table 25 Capacity Evaluation and Assessment for the Six Shortlisted Scenarios

Scenario No.	1	2	3	4	5	6
Scenario Name	Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+EWRF to New WRF	All at New Regional WRF
Total No. of WRFs	3	1	2	2	2	1
Ability to Handle Current AADF	Yes	Expansion required [A]	Yes	Yes	NEWRF = Yes. New WRF Required [B]	New WRF Required [C]
Ability to Handle Current PHF	EQ basin needed at each WRF	Expansion required [A]	EQ basin needed at EWRF & NEWRF	EQ basin needed at MSWRF & NEWRF	EQ Basin needed at NEWRF. New WRF Required [B]	New WRF Required [C]
Ability to Handle 2050 AADF	Yes	Expansion required [A]	Yes	Yes	NEWRF = Yes. New WRF Required [B]	New WRF Required [C]
Ability to Handle 2050 PHF	EQ basin needed at each WRF	Expansion required [A]	EQ basin needed at EWRF & NEWRF	EQ basin needed at MSWRF & NEWRF	EQ Basin needed at NEWRF. New WRF Required [B]	New WRF Required [C]
Need for Capacity Expansion	No	Yes [A]	No	No	Yes [B]	Yes [C]

A. NEWRF has to be expanded by 50 percent. (one additional treatment train)
B. New 2 to 15 mgd AADF facility required
C. New 20 mgd facility required

7.4.3 Consolidation Impacts to Approved SB64 Plan

Consolidation of the WRFs will impact the SB64 plan. If a WRF is decommissioned, measures will need to be in place to ensure the SB64 requirements are maintained. **Table 26** highlights the impact each consolidation scenario (discussed in Section 7.1) will have on the approved SB64 plan. Consolidation is assumed to take place in 2028/2029; therefore, all surface water discharge elimination will occur in parallel to consolidation and take place prior to the FDEP deadline of 2032.

Table 26 Consolidation Impacts to Approved SB64 Plan

Scenario No.	Scenario Name	Impact to Approved SB64 Plan
1	Maintain Existing WRFs (Baseline Scenario)	No impact.
2	All at NEWRF	Because of the decommissioning of MSWRF, the City can no longer utilize the APRICOT Act. Ninety (90) percent of the surface water discharge from NEWRF will need to be eliminated. Further evaluation of the Master Reuse System is required to confirm NEWRF can provide reclaim water to the MSWRF and EWRF service areas and future expansion areas. If expansion of service in unavailable, additional options will be considered..
3	MSWRF to NEWRF	Because of the decommissioning of MSWRF, the City can no longer utilize the APRICOT Act. Ninety (90) percent of the surface water discharge from NEWRF will need to be eliminated. Further evaluation of the Master Reuse System is required to confirm NEWRF can provide reclaim water to the MSWRF service area and future expansion areas. If expansion of service in unavailable, additional options will be considered.
4	EWRF to NEWRF	By keeping MSWRF, the City may utilize the APRICOT Act in eliminating only 70 percent of surface water discharge into Stevenson Creek. Ninety (90) percent of the surface water discharge from NEWRF will need to be eliminated. Further evaluation of the Master Reuse System is required to determine how MSWRF and NEWRF will provide reclaim water to the EWRF service area and future expansion areas. If expansion of service in unavailable, additional options will be considered.
5	MSWRF+ EWRF to New WRF	Although MSWRF will be decommissioned, the City can still utilize the APRICOT Act if all the requirements of the Act are met. The City may face difficulties during the permitting of new discharges during surface waters. Ninety (90) percent of surface water discharge from NEWRF will need to be eliminated. Further evaluation of the Master Reuse System is required to determine how NEWRF and the New WRF will provide reclaim water to the MSWRF and EWRF service areas and future expansion areas. If expansion of service in unavailable, additional options will be considered.
6	All at New Regional WRF	Although MSWRF will be decommissioned, the City can still utilize the APRICOT Act if all the requirements of the Act are met. The City may face difficulties during permitting new discharges to surface waters. Seventy (70) percent to 90 percent of surface water discharge from the new WRF will need to be eliminated. Further evaluation of the Master Reuse System is required to determine how the New WRF will provide reclaim water to the overall Clearwater reclaim service areas and future expansion areas. If expansion of service in unavailable, additional options will be considered.

7.4.4 Sustainability and Greenhouse Gas Emissions

Historical energy use data provided by the City was used to evaluated greenhouse gas (GHG) emissions from each WRF. The historical data is presented in **Table 27**.

Table 27 Historical Energy Use per WRF

FY	MSWRF Total kWh	NEWRF Total kWh	EWRF Total kWh
2019	8,484,100	9,577,591	3,274,440
2020	8,417,000	8,858,782	3,111,240
2021	8,593,400	8,569,625	3,073,080
Average	8,498,167	8,995,333	3,152,920

To estimate GHG per WRF, the EPA's Greenhouse Gas Equivalencies Calculator (Greenhouse Gases Equivalencies Calculator - Calculations and References | US EPA) was used. The EPA's Equivalencies Calculator estimates GHG's by converting kilowatt-hours of energy use into units of carbon dioxide (CO_2) emissions. The results of the GHG calculator are presented in **Table 28**.

Table 28 Tons of CO_2 Produced per WRF

FY	MSWRF Tons of CO_2	NWRF Tons of CO_2	EWRF Tons of CO_2
2019	4,049	4,562	1,563
2020	4,017	4,228	1,485
2021	4,102	4,090	1,467
Average	4,056	4,293	1,505

The average tons of CO_2 per plant were utilized to compare the estimated tons of CO_2 per consolidation scenario per year. The results of the comparison are shown on **Table 29**. The comparison assumes the following:

- If EWRF and MSWRF are decommissioned and flow is diverted to NEWRF, 90% of the GHG emission associated with the decommissioned WRFs will be added to NEWRF GHG emissions. The reduction accounts for update efficiencies of new equipment.
- If a EWRF or MSWRF are decommissioned and flow is diverted to NEWRF, 100% of the GHG emission associated with the decommissioned WRF will be added to NEWRF's GHG emissions.
- If a WRF is decommissioned and flow is diverted to a New WRF, 85% of the GHG emissions associated with the decommissioned WRF will be added to the New WRF's GHG emissions.
- The GHG emission amounts do not account for digestor gas, respiration, or conversion of biogas to CO2.

Table 29 Tons of CO_2 Produced per Scenario per Year

Scenario No.	1	2	3	4	5	6
Scenario Name	Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+EWRF to New WRF	All at New Regional WRF
Tons of CO_2 per Year	9,855	9,298	9,855	9,855	9,020	8,376
CO_2 Production / Average Production per Scenario	1.05	0.99	1.05	1.05	0.96	0.89

7.5 Cost Estimates

A net present value (NPV) life cycle cost analysis for each consolidation scenario was performed. The life-cycle cost includes capital costs, R&R costs, and the annual costs, as described in this section. **Appendix G** contains additional detailed cost tables for reference. Key inputs to the cost calculations include:

- Clearwater WRF historic operating cost data
- Clearwater CIP Budgets including R&R expenditures

7.5.1 General Assumptions

Table 30 is a list of parameters and assumptions followed in developing the capital costs for this evaluation. Detailed capital cost tables are in **Appendix G**.

Table 30 Capital Costs Parameters and Assumptions

Parameter	Value	Notes
Planning Horizon	Through 2050	
Cost Estimate Level	Class 5	Association for the Advancement of Cost Engineering International (AACEI) Class 5 estimate classification is used for conceptual, basis of design, and preliminary design phases with opinion of probable construction costs (OPCC) accuracy ranges of -50 percent to +100 percent.
Cost Estimates Basis	2022 U.S. Dollars	Net Present Value
Escalation Rate	8.0 percent	Escalation Rate = The rate of change in price
Discount Rate	4.75 percent	Discount rate = the interest rate used to determine the present value of future cash flows
Contingencies	17 percent	Engineering Services, Design Services and Construction Management Services
Consolidation Construction End Year	2028	It was assumed that consolidation would take place in six years, which is Planning Year 2028. 2029 would be the first year of the fully implemented scenario

Parameter	Value	Notes
Funding mechanism structures or loan payment schedules	Not included	Costs were applied at the approximate year they are expected to occur. The analysis does not include funding mechanism structures or loan payment schedules.
Treatment technologies	Status Quo	The WRF improvements were evaluated based on conventional treatment technologies that are replacement "in-kind." Technology and process alternatives will be evaluated during Phase 2 of this WRF Master Plan, after the WRF consolidation scenario is selected.
Land Acquisition	Only required for new WRFs	Sufficient space is available at the NEWRF site to expand the facility to accommodate additional flows from MSWRF and/or EWRF including future projected flows.
Biosolids Cost	Excluded	Biosolids costs will be included in the next phase.

7.5.2 Capital Costs and Land Acquisition Costs

The methodology followed to develop the capital costs for each scenario was as follows:

- Information regarding capital improvements required for the collection and treatment systems was gathered from the wastewater process and collection system's specialists, excluding biosolids.
- This information was used by cost estimators to estimate the Class 5 estimates.
- The capital cost estimates were included in the life-cycle costs analysis and spread over the 6-year planning and capital improvements timeline window from 2022 until 2028 and applying yearly escalation factors to the costs spread.
- Capital cost estimates for the improvements associated with each scenario were developed using a combination of several of the following estimating sources:
  - Costs from past projects; professional judgment and experience.
  - Cost estimates provided from equipment manufacturers and vendor cost proposals.
  - Current market values using Timberline software and library of standard components (e.g., linear feet of pipe of certain material).

Table 31 summarizes the capital cost components included in each of the six consolidation scenarios. Details of the cost of each component are included in **Appendix G**.

Table 31 Capital Cost Components

Scenario No.	1	2	3	4	5	6
Scenario Name	Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+EWRF to New WRF	All at New Regional WRF
Total No. of WRFs	3	1	2	2	2	1
WRF Expansion / New WRF	-	X	-	-	X	X
Decommissioning WRF	-	X	X	X	X	X
Collection System Conveyance Improvements	-	X	X	X	**X**	X
Land Acquisition	-	-	-	-	X	X

The following assumptions were made for the capital cost estimates (also summarized in **Table 30**):

- There are limited opportunities to salvage equipment from decommissioned WRFs and a salvage value of $0 was assumed.
- A detailed land analysis was not performed, the new WRF in Scenario 6 was assumed to be on a site similar to the existing NEWRF (least vulnerable to climate hazards) and was assumed to be a similar size to Scenario 2's NEWRF with MSWRF and EWRF's flows consolidated there.

7.5.3 Annual O&M Costs

The methodology followed to develop the annual O&M costs for each scenario was as follows:

- Assessed historic annual costs from the City for personnel, energy, chemicals, maintenance, and professional services for the years of 2019, 2020, and 2021 for the three existing WRFs.
- Calculated the 3-year average annual expenditures (excluding years with zero costs) based on historic and budgeted data, then used this average as the basis for all future annual operating costs. All annual operating costs were assumed to remain the same until the end of 2028 for all scenarios. In 2029, these costs were reduced according to expected savings due to consolidation.

Table 32 summarizes the parameters and assumptions used to develop the annual O&M costs for this evaluation. Detailed annual O&M cost tables are in **Appendix G**.

Table 32 Annual Costs Parameters and Assumptions

Parameter	Notes/Basis
Personnel Service	The baseline cost for personnel service remained the same regardless of consolidation scenario.
WRF Energy Cost	If EWRF and MSWRF are decommissioned and flow is diverted to NEWRF, 90% of the energy usage will be transferred to NEWRF. If EWRF or MSWRF are decommissioned and flow is diverted to NEWRF, the energy usage will remain the same. If EWRF and MSWRF are decommissioned and flow is diverted to a New WRF, 85% of the energy usage will be transferred to the New WRF.
Collection System Pumping Energy Cost	Energy costs ($0.07/kWh) because of additional pumping for the flow transfers that would take place (only applies to Scenarios 2 through 6).
Process Chemical	The baseline cost for Process Chemical the same regardless of consolidation scenario. This cost is considered flow dependent.
Professional Services	Future professional Services costs associated with a WRF being decommissioned were reduced to 5 percent of the original cost. Reduction accounts for engineering services related to compliance and studies previously required for the facility(ies) to be decommissioned and remaining cost are for items related to the pump station and/or EQ tank required at the decommissioned site. No increases are anticipated at the WRF receiving the flow (NEWRF in Scenarios 2, 3, and 4). For Scenarios 5 and 6, assumed same baseline costs for new WRF as the existing costs for largest of the WRFs being decommissioned.
Miscellaneous/ Other	Miscellaneous/other operating service costs from the WRF being decommissioned were reduced by -90 percent and remaining costs are for the pump station and/or EQ tank required at decommissioned site. No increases were anticipated at the WRF receiving the flow (NEWRF in Scenarios 2, 3, and 4). For Scenarios 5 and 6, assume same baseline costs for new WRF as the existing costs for largest of the WRFs being decommissioned.
Maintenance/ Internal Service	Maintenance/internal service costs from the WRF being decommissioned are reduced by -90 percent and remaining costs are for the pump station and/or EQ tank required at decommissioned site. A 30 percent increase is required at the WRF receiving the flow if the WRF will require new treatment trains/units (NEWRF Scenario 2). For WRFs at new location (Scenarios 5 and 6), assume 100 percent of baseline costs for new WRF as the existing costs for largest of the WRFs being decommissioned.

7.5.4 Renewal and Replacement Costs

Conceptual level costs of short-term and long-term R&R improvements required at all of the WRFs were developed for the six scenarios. The methodology followed to develop the R&R costs for each scenario is described below:

- A timeline for renewal and replacement of assets was created for each scenario based on the high-level condition assessment discussed in Section 3.1. **Figure 24** shows the percent of the total R&R costs applied to each planning year based on the R&R timeline summarized below.
  - Very Good (Score = 1) → Rehabilitated or replaced between 2045 and 2050
  - Good (Score = 2) → Rehabilitated or replaced between 2040 and 2045
  - Fair (Score = 3) → Rehabilitated or replaced between 2035 and 2040
  - Poor (Score = 4) → Rehabilitated or replaced between 2025 and 2035
  - Very Poor (Score = 5) → Rehabilitated or replaced between 2022 and 2025
- R&R costs were estimated for the entire planning period for existing infrastructure using 4 percent of original installed cost before annual inflation.
  - EWRF Total R&R Costs = $101,415,624
  - MSWRF Total R&R Costs = $66,140,624
  - NEWRF Total R&R Costs = $132,281,248
- For facilities identified for decommissioning, the R&R costs were reduced by 90 percent through 2028 and by 100 percent after 2029.
- For new WRFs, the R&R costs were calculated to be 50 percent of the baseline R&R costs of the existing WRFs and would begin in 2029.

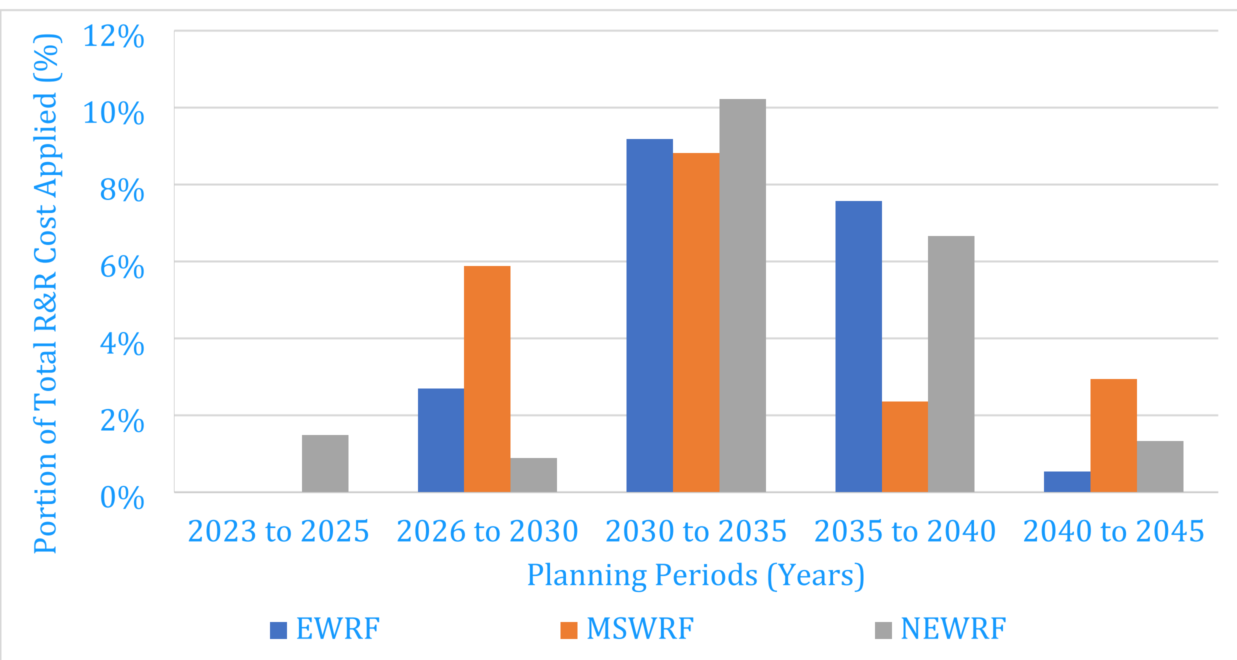


Figure 24 Percent of Total R&R Cost per Planning Year

7.5.5 Life-Cycle Costs

The net present value (NPV) of the capital, land acquisition, annual O&M and R&R costs were calculated and then combined to calculate the life-cycle costs for each scenario. The total NPV cost for each scenario by category is shown on **Figure 25**. The life-cycle costs for the six WRF consolidation scenarios are presented in **Table 33**, in 2022 dollars.

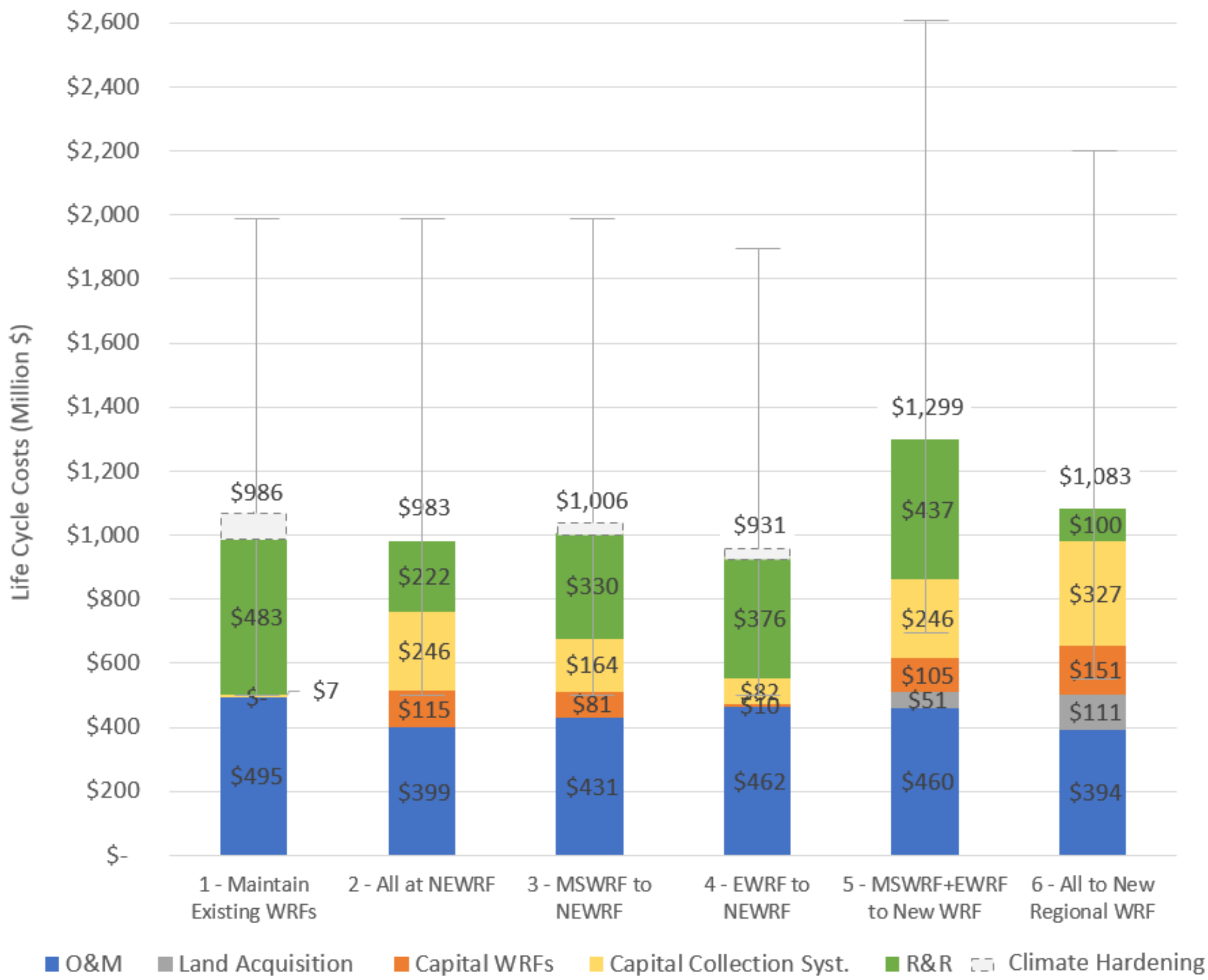


Figure 25 Total NPV Life-Cycle Costs for Scenarios 1 through 6

Table 33 Life-Cycle Costs by Type and Scenario ($M)

Scenario No.	1	2	3	4	5	6
Scenario Name	Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+EWRF to New WRF	All at New Regional WRF
Total No. of WRFs	3	1	2	2	2	1
O&M	$495	$399	$431	$462	$460	$394
Land Acquisition	-	-	-	-	$51	$111
Capital Collection System	$7	$246	$164	$82	$246	$327
Capital WRFs		$115	$81	$10	$105	$151
R&R	$483	$222	$330	$376	$437	$100
Total	**$986**	**$983**	**$1,006**	**$931**	**$1,299**	**$1,083**

1. All costs expressed in June 2022 million dollars.
2. Costs are AACEI Class 5 Classification [-50 percent to +100 percent]
3. Biosolids costs are excluded and will be included in the next phase of the master plan. They would be the same for each scenario and does not affect the results.

Figure 26 displays the relative life-cycle cost across the six scenarios, normalizing to the average cost of all scenarios. As illustrated, Scenario 4 has the lowest costs and is over 10 percent less than the average costs, Scenarios 1, 2, 3 and 6 are all within 6 percent of the average costs, and Scenario 5 is over 20 percent greater than the average costs.

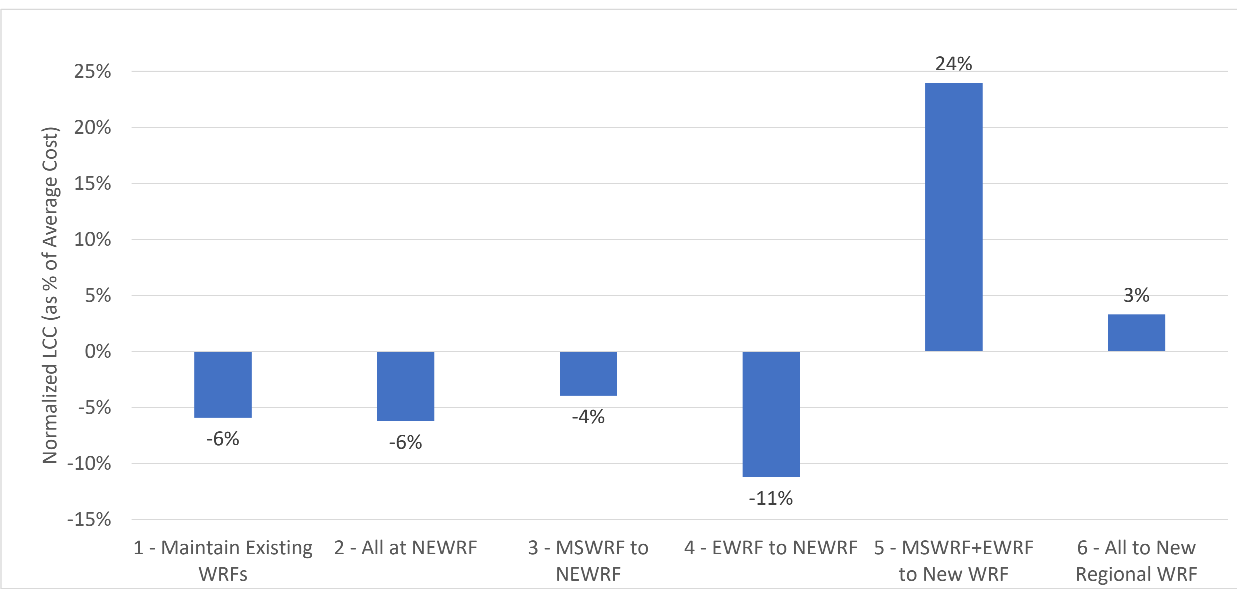


Figure 26 Total Life-Cycle Costs for Scenarios 1 through 6 (Normalized to Average Cost)

7.6 Evaluation Results

The objective of the WRF consolidation evaluation was to arrive at a single Future WRF Strategy to further analyze in Phase 2 of the WRF Master Plan project. This strategy/scenario is a result of the evaluation process describe above and is highlighted in the results below in **Table 34**. Additional justification and discussion supporting the scoring results are summarized in **Table 35**.

The results summarized below are an average of scores submitted by the Public Utilities Director, Public Utilities and Engineering Stakeholder and the Black & Veatch team. The highest ranked scenario was the same for each submitted set of score and Scenario 2 – Consolidating both the EWRF and MSWRF to the NEWRF. Complete weighting and scoring Poll Anywhere results are contained in **Appendix H**.

Table 34 Consolidation Scoring Results

Scoring Criteria	Weight	Recommended Score					
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
		Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+ EWRF to New WRF	All to New Regional WRF
System Reliability and Resilience	22%	2.3	1.3	1.7	2.7	2.7	1.5
Maintenance Reliability and Resilience	21%	1.0	3.0	2.0	2.0	2.7	3.0
Ease of Operations	17%	1.0	3.0	2.0	2.0	2.5	3.0
Climate and Environmental Vulnerability	14%	1.0	3.0	2.0	2.0	3.0	3.0
Sustainability (Greenprint 2.0 is City's Sustainability Plan)	11%	1.0	2.0	1.0	1.0	2.0	3.0
Financial Responsibility	9%	2.0	2.0	2.0	3.0	1.0	1.0
Public Perception	6%	1.5	3.0	2.0	2.3	1.0	1.0
Final Score		**1.41**	**2.43**	**1.81**	**2.14**	**2.36**	**2.37**

Table 35 Consolidation Scoring Results Justification

Scoring Criteria	Recommended Score					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+ EWRF to New WRF	All to New Regional WRF
System Reliability and Resilience	EWRF remains: - Located at the least-resilient area of the 3 WRFs. - Higher susceptibility of SSOs. - No room for an equalization (EQ) basin at EWRF.	One WRF: - Minimizes the chances of SSOs. - Maximizes risk of single POF[1].	EWRF remains: - Located at the least-resilient area of the 3 WRFs. - Higher susceptibility of SSOs. - No room for an EQ basin at EWRF.	Two WRFs: - Lower chances of SSOs. - Decreases risk of single POF.	Two WRFs: - Lower chances of SSOs. - Decreases risk of single POF.	One WRF: - Minimizes the chances of SSOs - Maximizes risk of single POF[1].
Maintenance Reliability and Resilience	Three WRFs: - Highest amount of equipment to be maintained, and most spare parts to be stored. - Requires the highest amount of skilled labor/staffing. - EWRF and MSWRF remain: The condition assessment indicated structural condition is more severe than NEWRF. - Utilizes the existing systems which minimizes useful life and condition of equipment.	One WRF: - Improvements made to NEWRF will lead to newer treatment system that is all integrated at one plant. - Requires the lowest amount of skilled labor/staffing. - Minimizes the amount of equipment to be maintained and spare parts to be stored. - Size of equipment will not greatly increase due to the existing capacity available at NEWRF.	Two WRFs: - Moderate amount of equipment to maintain and store (less than Scenario 1) - Moderate amount of skilled labor/staffing (less than Scenario 1)	Two WRFs: - Moderate amount of equipment to maintain and store (less than Scenario 1) - Moderate amount of skilled labor/staffing (less than Scenario 1)	Two WRFs: - Moderate amount of equipment to maintain and store (less than Scenario 1). - Equipment at New WRF will have the highest useful life and be in the best condition. - Moderate amount of skilled labor/staffing (less than Scenario 1)	One New WRF: - Least amount of equipment to maintain and spare parts to be stored. - All equipment will be new, have the longest remaining life, and be in the best condition. - Requires the lowest amount of skilled labor/staffing.

Scoring Criteria	Recommended Score					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+ EWRF to New WRF	All to New Regional WRF
Ease of Operations	Three WRFs: - Maximizes operational complexity. - Most difficult to manage during emergency operations. - Maximizes pieces of equipment. - If resources are limited, could be challenging and inconvenient to operate at 3 WRF locations but lift stations will still remain throughout entire service area.	One WRF: - Minimizes operational complexity. - Most manageable during emergency operations. - Minimizes pieces of equipment. - More convenient to manage staff (which may be limited) at 1 WRF instead of 2 or 3.	Two WRFs: - Medium degree of operational complexity. - With EWRF remaining, it may be difficult to manage resources and operate the plant there during storm surge. - More convenient to manage staff (which may be limited) at 2 WRFs instead of 3.	Two WRFs: - Medium degree of operational complexity. - MSWRF difficult to manage during storm surge. - More convenient to manage staff (which may be limited) at 2 WRFs instead of 3.	Two WRFs: - Medium degree of operational complexity. - New system may be designed to minimize complexity. - New WRF location would minimize the difficulty to manage during emergency operations. - More convenient to manage staff (which may be limited) at 2 WRFs instead of 3.	One WRF: - Minimizes operational complexity. - Most manageable during emergency operations. - Minimizes pieces of equipment. - Safety concerns reduced due to New WRF. - More convenient to manage staff (which may be limited) at 1 WRF instead of 2 or 3.
Climate and Environmental Vulnerability	- EWRF remains and is most vulnerable to climate hazards. - MSWRF remains and is moderately vulnerable to climate hazards.	- NEWRF is the least vulnerable to climate hazards. - Eliminates the major flood concerns at both EWRF and MSWRF.	- NEWRF is the least vulnerable to climate hazards. EWRF vulnerable to climate hazards. Vulnerability is balanced. - Mitigates some of the overall vulnerability.	- NEWRF is the least vulnerable to climate hazards. MSWRF vulnerable to climate hazards. Vulnerability is balanced. - Mitigates some of the overall vulnerability.	- NEWRF is the least vulnerable to climate hazards. New WRF location would be selected at non-vulnerable location. - Eliminates the major flood concerns at both EWRF and MSWRF.	- New WRF location would be selected at non-vulnerable location. - Eliminates the major flood concerns at both EWRF and MSWRF.

Scoring Criteria	Recommended Score					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	Maintain Existing WRFs	All at NEWRF	MSWRF to NEWRF	EWRF to NEWRF	MSWRF+ EWRF to New WRF	All to New Regional WRF
Sustainability (Greenprint 2.0 is City's Sustainability Plan)	See Section 7.4.4	See Section 7.4.4	See Section 7.4.4	See Section 7.4.4	See Section 7.4.4	See Section 7.4.4
Financial Responsibility	See Section 7.5.5	See Section 7.5.5	See Section 7.5.5	See Section 7.5.5	See Section 7.5.5	See Section 7.5.5
Public Perception	- City has received some complaints regarding the location of EWRF. - Most of the public though may be ok with how things are and would not want to change where the plants are. - No traffic impacts; status quo.	- Reduced complaints about the EWRF location. - Allows land at MSWRF to be utilized in new way to benefit the public. - Large collection system improvements required with temporary impacts to traffic in the City.	- City has received some complaints regarding the location of EWRF. - Allows land at MSWRF to utilized in new way to benefit the public. - Medium collection system improvements required which may impact traffic in the City.	- Expected to receive minimal complaints about the EWRF location if it's not operating at a WRF, but still may be a major pumping station. - Medium collection system improvements required with temporary impacts to traffic in the City.	New WRF: - Limited availability of sites for new WRF outside residential areas. - "NIMBY" (not in my backyard) mindset by residents; resistant to changes. - Large collection system improvements with temporary impacts to traffic in the City.	New WRF: - Limited availability of sites for new WRF outside residential areas. - "NIMBY" (not in my backyard) mindset by residents; resistant to changes. - Large collection system improvements with temporary impacts to traffic in the City.

[1] Risk of single point of failure (POF) can be reduced with redundancy and resolved during design.

8.0 Conclusions and Recommended Next Steps

After developing and evaluating the six consolidation scenarios, Black & Veatch recommends the City proceed with Scenario 2, which scored the highest (most favorable) as a composite of all criteria across all scenarios.

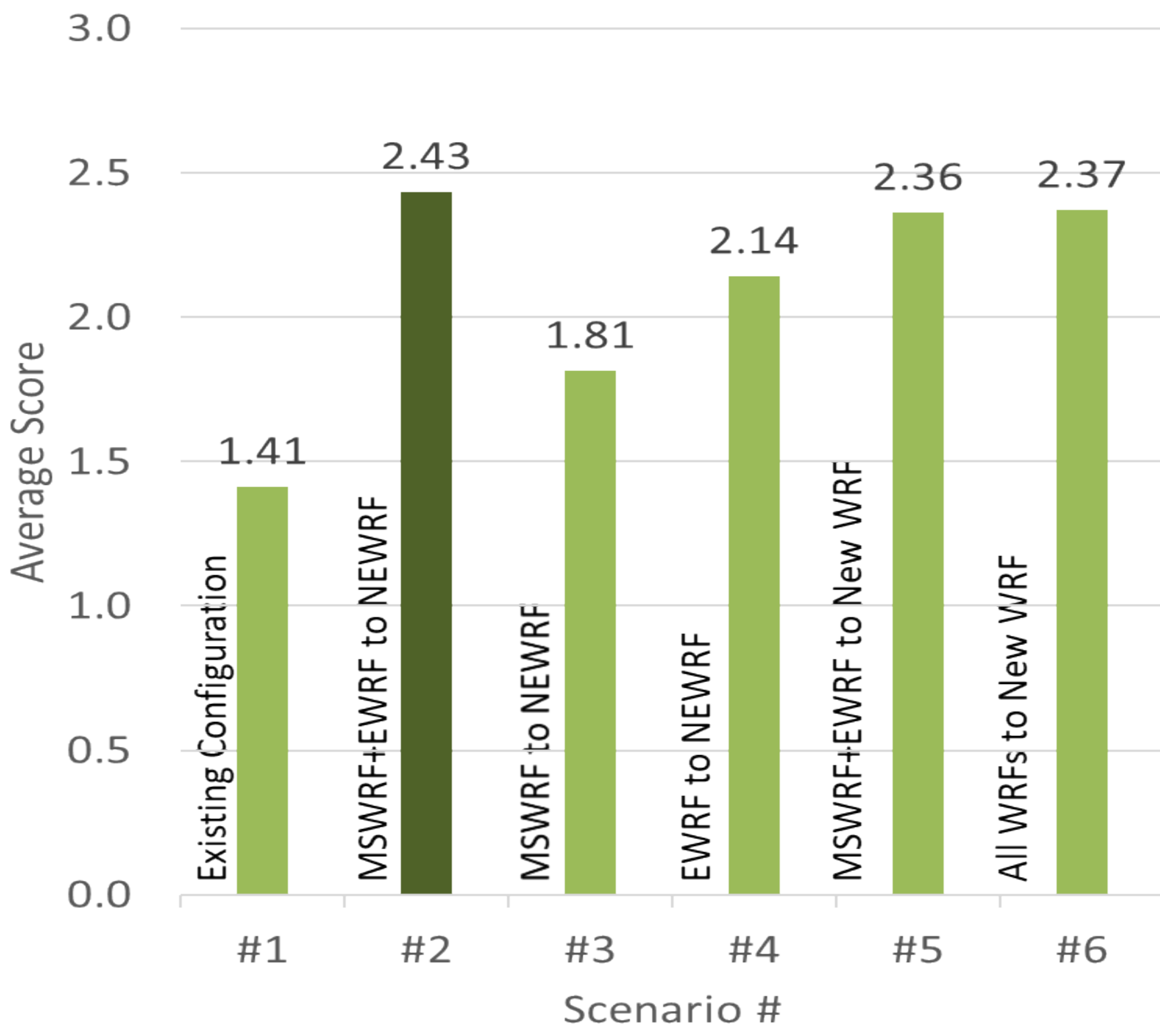


Figure 27 Final Evaluation Results

- Climate and Environmental Vulnerability: NEWRF is least likely to be impacted by climate variability. SLR and storm surge may result in significant inundation at EWRF and MSWRF.
- Capacity and Expansion Capabilities: The existing capacity of NEWRF allows for only one additional treatment train required to treat the flow from EWRF and MSWRF. The NEWRF property contains adequate room for expansion.
- Public Perception: The property owned by Public Utilities that contains NEWRF provides adequate room for expansion while maximizing the space between the plant and private property. The land at MSWRF and EWRF can be utilized in a new way to benefit the public.

- Biosolids Treatment: NEWRF currently treats thickened sludge from EWRF. Consolidating EWRF to NEWRF reduces hauling of biosolids (saving energy and cost).

Recommended next steps to support decision-making and to be included with Phase 2 of the WRF Master Plan include the following:

- Present this TM and a high-level presentation to the City Manager to finalize the recommended scenario before proceeding with Phase 2 of the WRF Master Plan project.
- Through a detailed condition assessment, identify plant components with salvage values and factor that into a more accurate cost estimate. A calculated depreciated value and life remaining on recently installed, newer equipment assets such as pumps would also present opportunities for potential savings.
- Conducting a more detailed evaluation of selected WRF strategy for treatment process optimization, sizing, and cost estimates to increase the accuracy of the recommendations for planning purposes.
- Because of the age of the existing NEWRF, it is recommended that new treatment processes be constructed, in parallel to rehabilitation of the existing infrastructure, equipment, and structures at NEWRF. This will provide the City with a reliable WRF that will be built to the current standards and to best serve the needs of the O&M staff.

Black & Veatch stands ready to further assist the City in this decision to provide the best solution to address the current challenges and plan for the City’s Water Reclamation Facilities through 2050.

Appendix A. High-Level Condition Assessment Data Collection Plan

This Appendix is part of the Water Reclamation Facilities (WRF) Master Plan – Final WRF Strategies Technical Memorandum (City Project No. 17-0007-UT, December 2023).

FINAL

DATA COLLECTION PLAN

WRF Master Plan

B&V PROJECT NO. 408831

PREPARED FOR

City of Clearwater

26 DECEMBER 2023

BLACK & VEATCH

Table of Contents

LIST OF TABLES

1 Field Procedures

1.1 DATA COLLECTION

Data will be collected in the field using a paper data collection form. The form will incorporate existing plant data from the provided record drawings and will include the following sections.

1.1.1 Process Identification

Data will be verified or captures for the following fields:

- Facility
- Process
- Discipline
  - Process Mechanical
  - Electrical
  - Instrumentation and Control
  - Structural

1.1.2 Physical Condition Information

Each process will be scored per discipline using a 1-5 scale based on its visual condition, using the definitions in section **1.2 Condition Assessment**.

- 1 – Very Good
- 2 – Good
- 3 – Fair
- 4 – Poor
- 5 – Very Poor

A photograph may be taken of individual components in the process to assist in scoring justification.

1.2 CONDITION ASSESSMENT GUIDANCE

This guidance describes the approach to the assessment of the physical condition for facility processes. The guidance is intended to enable consistency when evaluating the condition of the processes by providing a standardized set of condition grades.

1.2.1 Structural Condition Descriptions

Table 1 Structural Condition Grading

CONDITION GRADE	PHYSICAL DESCRIPTION
1 - Very Good	No visible defects or erosion. Protective coatings in place.
2 – Good	Few visible defects. Localized surface erosion with slight loss of thickness. No physical deformation. Protective coatings worm or delaminate in small patches only greater than 98% coverage.
3 – Fair	Moderate defects. Moderate surface erosion or corrosion. Some physical deformation or impact damage. Minor movement. Protective coatings significantly degraded 90-98% coverage.
4 - Poor	Significant defects. Loss of thickness, erosion, or corrosion threatening structural integrity. Severe physical deformation or impact damage. Extensive movement. Potential safety hazard. Protective coatings significantly degraded 75-90% coverage. Evidence of minor leakage.
5 – Very Poor	Derelict, or structural failure beyond repair. Safety hazard. Protective coatings failure, coverage less than 75%.

Note that the physical description terms listed are intended as a guide, and evaluators must exercise judgement based on how many terms offered may present themselves at any one site.

1.2.2 Electrical Condition Descriptions

Table 2 Electrical Condition Grading

CONDITION GRADE	PHYSICAL DESCRIPTION
1 - Very Good	New condition, minimal signs of wear.
2 – Good	Superficial surface wear, no interior corrosion. Major components with >10 years of remaining service. Minor components with >3 years of service.
3 – Fair	Deteriorating surface wear, some interior corrosion. Major components with 5-10 years of remaining service. Minor components with <3 years of remaining service, with intermittent failures. Low risk safety hazard.
4 - Poor	Significant surface wear, interior corrosion. Evidence of some arcing. Major components with <5 years of remaining service, recurrent failures. Minor components with <1 year of remaining service, frequent failures. High risk safety hazard.
5 – Very Poor	Failing service, beyond repair. Evidence of arcing. Very high-risk safety hazard.

Note that the physical description terms listed are intended as a guide, and evaluators must exercise judgement based on how many terms offered may present themselves at any one site.

1.2.3 Instrumentation and Control Condition Descriptions

Table 3 Instrumentation and Control Condition Grading

CONDITION GRADE	PHYSICAL DESCRIPTION
1 - Very Good	New condition.
2 – Good	Minimal cosmetic surface defects. Normal calibration schedule, minimal adjustment required.
3 – Fair	Average physical wear and tear based on process' age. Normal calibration schedule, normal frequency of adjustment required.
4 - Poor	Above average wear based on age, multiple replacements in 2 years. Frequent calibration schedule, high frequency of maintenance or calibration required.
5 – Very Poor	Significant cosmetic wear or evidence of impact. Unreliable performance after maintenance or calibration. Immediate replacement.

Note that the physical description terms listed are intended as a guide, and evaluators must exercise judgement based on how many terms offered may present themselves at any one site.

1.2.4 Process Mechanical Condition Descriptions

Table 4 Process Mechanical Condition Grading

CONDITION GRADE	PHYSICAL DESCRIPTION
1 - Very Good	New condition, minimal signs of wear.
2 – Good	Some wear or surface corrosion, or not designed to current standards. Minor oil or gland leakage evident.
3 – Fair	Functionally sound process and components, moderate wear or surface corrosion. Moderate oil or gland leakage evident, evidence of historic leakage. Evidence of internal wear (sound, smell, temperature, etc.) Roughness when starting / stopping.
4 - Poor	Aging process components, significant wear or surface corrosion. Significant oil or gland leakage evident, evidence of historic leakage. Evidence of moderate internal wear (sound, smell, temperature, etc.) Intermittent failure when starting / stopping. Potential safety hazard.
5 – Very Poor	Failing service, beyond repair. Evidence of arcing. Very high-risk safety hazard.

Note that the physical description terms listed are intended as a guide, and evaluators must exercise judgement based on how many terms offered may present themselves at any one site.

1.3 PROCESSES TO BE SURVEYED

The Processes to be surveyed consist of:

- Aeration Tanks
- Anoxic Tanks
- Buildings
- Chemical Storage
- Chlorination
- Electrical Room
- Equalization Tanks
- Fermentation Tanks
- Filter Complex
- Final Settling Tanks
- Grit Removal System
- Headworks
- Moving Belt Filter System
- Odor Control System
- Power Delivery
- Pump Stations
- Primary Tanks
- Return Activated Sludge
- Sludge Digestion
- Sludge Dewatering

2 Quality Control Plan

2.1 FIELD QUALITY CONTROL

At the end of each day, the forms should be reviewed to ensure information has been recorded correctly. This should include:

- Verifying that all processes have been surveyed within the location surveyed that day.
- Verifying that any comments recorded are understandable and relevant
- Reviewing physical condition scores for outliers. If outliers are found, the reviewer should compare any photos and comments of the process taken during the assessment.
- Meet with plant staff at the end of the data collection period to review scores.

3 Safety Plan

3.1 PERSONAL PROTECTIVE EQUIPMENT

The survey team will use the following PPE:

- Hard hat
- Safety vest
- Steel-toed boots in construction zones
- Hearing protection where required
- Eye protection where required

3.2 SAFETY PROTOCOLS

The survey team will observe the following safety protocols:

- Do not operate any equipment
- Be aware of trip hazards and fall hazards
- Be careful around rotating equipment as equipment that will start without notice
- Do not enter any confined spaces
- Do not open any electrical control panels

3.3 HAZARDOUS AREAS

City staff will provide a briefing to the survey team before entering any chemical containment areas.

Appendix B. Climate and Vulnerability Assessment

ATKINS
Member of the SNC-Lavalin Group

Clearwater WRF Master Plan

Climate Variability and Coastal Hazards Vulnerability Assessment

Black & Veatch

03 October 2022

Technical Memorandum

Notice

This document and its contents have been prepared and are intended solely as information for Black & Veatch and use in relation to developing a technical memo that assesses the three WRFs' vulnerabilities to climate variability and coastal hazards (such as flooding from a severe hurricane, storm surge event, and extreme cold weather) in order to define the threats and associated risks, and then develop potential mitigation or adaptation strategies to enhance the WRFs' resilience to climate variability and coastal hazards.

Atkins North America, Inc. assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

This document has 72 pages including the cover.

Document history

Document title: Climate Variability and Coastal Hazards Vulnerability Assessment

Document reference: Technical Memorandum

Revision	Purpose description	Originated	Checked	Reviewed	Authorized	Date
1.0	Draft Technical Memo	CZ	DP	<initials>	<initials>	06/21/22
1.1	Internally Revised Draft Technically Memo	CZ				07/05/22
1.2	Final Technical Memo	CZ	JP			07/25/22
1.3	Revised Final Technical Memo	CZ				09/07/22
1.4	Final Tech Memo – Post City Review	CZ				10/03/22

Client signoff

Client	Black & Veatch
Project	Clearwater WRF Master Plan
Job number	City PN 17-0007-UT; BV PN 408831
Client signature/date	

Contents

Tables

Figures

Acronym Listing

Acronym	Definition
AD	Above Datum
AE	FEMA flood zone AE. Areas subject to inundation by the 1 percent annual chance flood event where base flood elevations are shown.
CREAT	Climate Resilience Evaluation and Awareness Tool
CSAP	Climate Science Advisory Panel
EPA	Environmental Protection Agency.
EWRF	East Water Reclamation Facility
FDEM	Florida Division of Emergency Management
FDEP	Florida Department of Environmental Protection
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FSG	Florida Sea Grant
GHG	Greenhouse Gas
GIS	Geographic Information System
GWI	Groundwater Infiltration
HPY	Hours Per Year
LiDAR	Light Detection And Ranging.
LiMWA	Limit of Moderate Wave Action
LMSL	Local Mean Sea Level
MCC	Motor Control Center
MGD	Million Gallons per Day
MHHW	Mean Higher High Water
MHW	Mean High Water
MSWRF	Marshall Street Water Reclamation Facility
NAVD	North Atlantic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
RSLC	Relative Sea Level Change
SLOSH	Sea, Lake and Overland Surges from Hurricanes
SLR	Sea Level Rise
SWFWMD	Southwest Florida Water Management District
SWMM-CAT	Storm Water Management Model - Climate Adjustment Tool
TBEP	Tampa Bay Estuary Program
TBRPC	Tampa Bay Regional Planning Council
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VE	FEMA flood zone VE (Velocity). Coastal areas are subject to additional flooding from storm-induced waves
WRF	Water Reclamation Facility

Introduction

The City of Clearwater (City) owns and operates three Water Reclamation Facilities (WRFs) – the Northeast, Marshall Street, and East WRFs. This WRF Master Plan project entails developing a 30-year Master Plan (2021-2050) a budgeting and planning road map for implementing future facility modifications, upgrades, operational and maintenance improvements, compliance with future regulations, and to provide facilities that are efficient, resilient, sustainable, and economical. This technical memorandum provides a climate vulnerability assessment as well as recommendations for mitigating the identified vulnerabilities.

Executive Summary

The City of Clearwater is in the process of evaluating future scenarios for its water reclamation facilities (WRFs). As part of this, it was determined that a climate vulnerability assessment that identifies existing and future flooding considerations would be part of the evaluation process. With two of the three plants located along water bodies in a coastal city, the potential for flooding is of immediate concern. Current scientific guidance indicates that future conditions will not only exacerbate flood events like 100-year floods (also known as 1% annual exceedance probability floods) and hurricane surges, but also potentially lead to more frequent tidal flooding events. To help with this assessment, a review of currently available flood data sets was assessed for FEMA identified flood scenarios, NOAA storm surge scenarios, and expected future scenarios (tidal and 100-year flooding) as identified in the Pinellas Sea Level Rise and Storm Surge Vulnerability Assessment. The City's project team determined that a 30-year planning horizon (2050) should be utilized for assessments due to the expected lifecycle of the existing sites and any of its replacement equipment. Following the assessment, the foundation for potential flood resilience activities to the site was also established. Depending on how the City chooses to move forward (multiple consolidation scenarios are being considered), a detailed set of recommendations will be developed as part of a future task order.

Comparison of Site Vulnerabilities

The table below provides a comparison of each site's existing and future flood vulnerability as well as additional information that may be useful with future assessments of the site. As the sites represent a collection of facilities and equipment within a single parcel, the analyses focused on impacts to the buildings but also identify impacts on each WRF's parcel as future plans may require expansion or relocation within the footprint of the land owned by the City. The count of equipment identified in the table is based on information collected from record drawings and site visits. Information collected was intersected with geospatial hazard layers. The table is meant to provide a relative order of magnitude for each site's vulnerability. The "Average depth of inundation" statistic is identifying the potential depth (average) of flooding for all the pieces of equipment expected to be impacted by flood waters per the specific flood scenario.

FEMA Flood Zones and Pinellas Vulnerability Assessment Flood Events

The two facilities that are impacted by localized flooding as identified on FEMA's Flood Insurance Rate Maps (FEMA FIRMs) and the Pinellas Vulnerability Study are the East WRF and the Marshall Street WRF. The Northeast WRF is not currently exposed to these hazards.

Table ES-1 - Estimated Impacts from Localized Flooding

	Current FEMA and Pinellas Vulnerability Assessment		
East WRF	**100yr FEMA 2021**	**100yr Pinellas Vulnerability Study (2018 base)**	**500yr Pinellas Vulnerability Study (2018 base)**
Count of equipment potentially flooded	54	39	68
Percent of all equipment flooded	78%	57%	99%
Average depth that flooded equipment is inundated (feet) per each scenario	3.26	2.43	4.45
Marshall WRF	**100yr FEMA 2021**	**100yr Pinellas Vulnerability Study (2018 base)**	**500yr Pinellas Vulnerability Study (2018 base)**
Count of equipment potentially flooded	35	36	97
Percent of all equipment flooded	34%	35%	94%
Average depth that flooded equipment is inundated (feet) per each scenario	1.58	3.44	3.55

Storm Surge Flood Events

Similar to the localized flood events information listed above, the two facilities that are impacted by flooding as identified on the County's storm surge inundation maps are the East WRF and the Marshall Street WRF. The Northeast WRF is not currently exposed to these hazards. Storm surge data was provided by the Tampa Bay Regional Planning Council in coordination with Pinellas County's Emergency Management. The storm surge values provided were only available as specified ranges of potential inundation as follows:

- 0 to 1 foot
- 1 to 1.5 feet
- 1.5 to 3 feet
- 3 to 6 feet
- 6 to 9 feet
- 9 to 12 feet
- 12 to 15 feet
- 15 to 20 feet
- 20 to 42 feet

Each WRF site was intersected with storm surge polygons for each category of storm and the higher value of the range was utilized to assess worst case scenarios. It should be noted that the only major hurricane (Category 3 or higher) to directly impact the Greater Tampa Bay area was in 1921 as a category 3 storm.

Table ES-2 - Estimated Impacts from Storm Surge

	Storm Surge (per the National Hurricane Center)				
East WRF	**Category 1 Storm Surge**	**Category 2 Storm Surge**	**Category 3 Storm Surge**	**Category 4 Storm Surge**	**Category 5 Storm Surge**
Count of equipment potentially flooded	54	68	69	69	69
Percent of all equipment flooded	78%	99%	100%	100%	100%
Average depth that flooded equipment is inundated (feet) per each scenario	3.26	5.45	16.36	16.36	38.36
Marshall Street WRF	**Category 1 Storm Surge**	**Category 2 Storm Surge**	**Category 3 Storm Surge**	**Category 4 Storm Surge**	**Category 5 Storm Surge**
Count of equipment potentially flooded	37	99	100	100	100
Percent of all equipment flooded	36%	96%	97%	97%	97%
Average depth that flooded equipment is inundated (feet) per each scenario	4.44	4.48	10.43	15.43	37.43

Future Conditions (Sea Level Rise and 100-Yr Events)

Again, the Northeast WRF's higher elevation and distance from the coast eliminate the exposure to tidal events and tidally influenced flood scenarios. Pinellas County's Vulnerability Study utilizes a 528 hours per day (approximately equivalent to Mean Higher High Water [MHHW]) value to illustrate future tidal conditions. The two facilities with exposure to increases in tidal conditions are the East WRF and the Marshall Street WRF. However, the existing projections indicate that daily tidal events will remain at the shoreline or adjacent to the facilities until at least the 2070 timeframe. These factors will still increase the potential for flooding during coastal events as well as impacts to the groundwater. Pinellas County has also modeled a 2070 100-year event which indicates a height 2 feet higher than the current 100-year event for the Marshall Street WRF, and 2.7 feet higher than current 100-year event at the East WRF.

Table ES-3 - Expected Impacts from Future Tide and 100-Year Flood Events

	Future Conditions		
East WRF	**SLR 2040 High (MHHW/528HPY Depth)**	**SLR 2070 Intermediate (MHHW/528HPY Depth)**	**100yr Pinellas Vulnerability Study (2070)**
Count of equipment potentially flooded	0	0	62
Percent of all equipment flooded	0%	0%	90%
Average depth that flooded equipment is inundated (feet) per each scenario	0.00	0.00	3.81
Marshall Street WRF	**SLR 2040 High (MHHW/528HPY Depth)**	**SLR 2070 Intermediate (MHHW/528HPY Depth)**	**100yr Pinellas Vulnerability Study (2070)**
Count of equipment potentially flooded	0	0	93
Percent of all equipment flooded	0%	0%	90%
Average depth that flooded equipment is inundated (feet) per each scenario	0.00	0.00	2.67

Infiltration and Inflow

Due to sea level rise (SLR), the City's three WRFs potentially could experience increased flows during both dry- and wet-weather. These extraneous flows enter the gravity sewer system through both public and private lines. The conveyance and treatment of extraneous flows leads to increased costs and greenhouse gas (GHG) emissions. However, measures could be proactively taken to reduce or essentially eliminate infiltration and inflow (I/I) into the system. These measures include:

- Implementation of a gravity sewer renewal and replacement program,
- Replacement of gravity sewers with pressure systems, e.g., vacuum or low-pressure sewer systems.

Replacing gravity sewers with pressure systems in low-lying areas, such as Clearwater Beach, would not only reduce sewer flows, but would also increase resilience against climate events. Further study and investigation would be needed to develop an optimized plan for future wastewater system resilience.

Resilience Recommendations

The brief summaries above indicate that there is high exposure to flood events for the East and Marshall Street WRF's. Although Marshall Street is slightly less exposed, a Category 2 surge event or higher is likely to inundate large portions of both facilities.

Most of the damage anticipated to be experienced at the facilities during flooding events, if no adaptation is provided, is to electrical equipment that supplies power throughout the plants and control panels, with consequent loss of power and control capability for critical operations and safety systems. At the two most low-lying facilities, where a large percentage of existing equipment is vulnerable to flood damage, the most vulnerable equipment is considered to be the electrical and control equipment at the facilities. The most critical equipment is the main influent sewage pumps, which keep the incoming wastewater flows from the collection system moving through the facilities and ensure during a flood event that they receive at a minimum a reduced degree of treatment before being discharged.

Main sewage pump motors, whether integral with the pumps or not, are at particular risk from flooding. Loss of function of the motors would result in the inability to pump incoming wastewater flows through the facilities. Equally, electrical equipment supplying power to main sewage pumps and control panels for controlling the pumps are at high risk for loss of function and are therefore considered critical equipment. For these assets, adaptation strategies with high resiliency and low failure potential are recommended. For other auxiliary assets and assets which do not directly impact the plant's ability to provide a minimum level of treatment, strategies recommended would be those that provide a balance between resiliency and good return on investment.

Some adaptation strategies may not keep a facility fully operational during a high flood event, temporary sandbagging for example, but can protect equipment from flood damage and reduce the time required to return to full operation after a flood event.

To help inform the assessments above, as well as support resilience recommendations, the East and Marshall Street sites had a detailed itemization of their critical equipment, existing heights, and potential inundation from each of the flood scenarios. Some of the key recommendations are identified below. As noted in the introduction, the consolidation scenario chosen by the City at a future meeting will be utilized for a more detailed set of recommendations. Protective actions would likely include the following:

- Elevating skid mounted equipment indoor where head space allows
- Elevating outdoor equipment – pumps and control panels
- Providing tie-downs for chemical storage tanks
- Installing protective barriers at building entrances/sealing building
- Sandbagging at building entrances
- Installing sealed/submersible control panels
- Installing submersible pumps
- Installing watertight floor hatches
- Installing/extending flood walls

Climate Vulnerability Assessment

1. Background

The intent of this document is to provide an assessment of the three WRFs' vulnerabilities to climate variability and coastal hazards (such as flooding from a severe hurricane, storm surge event, and extreme temperature). By identifying the threats and associated risks, potential mitigation, or adaptation strategies to enhance the WRFs' resilience to climate variability and coastal hazards can be developed. The assessment integrates and refines information from the City's vulnerability related documents to support the identification of the appropriate levels of resiliency to climate variability/coastal hazards for each WRF. The approach used to assess the sites is visualized in the figure below.

Figure 1-1 - WRF Vulnerability Assessment Process

The following documents (and associated data) were considered to support this task:

- Pinellas County's Vulnerability Assessment (2021)
  - The County is calling this project the Vulnerability Assessment in their online tools and viewers. However, the technical document that describes the methodologies and data created from the project is titled "Pinellas County Sea Level Rise and Storm Surge Vulnerability Assessment – February 2022"
- Clearwater's Greenprint Sustainability Plan (2021)
- FEMA Flood Insurance Rate Maps (updated August 2021)
- Local studies from Tampa Bay Regional Planning Council [TBRPC] (including work from the Climate Science Advisory Panel [CSAP]), Tampa Bay Estuary Program [TBEP], and Pinellas County
- State and federal studies from NOAA, USACE, EPA, FEMA, FDEM, FDEP, and SWFWMD
- Groundwater gage data from SWFWMD
- After-Action Reports or other records from previous flood events at the WRFs
- Field visits to each water reclamation facility to review site and collect feedback from operators
- Record drawings of each water reclamation facility

The document mostly combines the results of geospatial datasets and onsite visits to the WRFs to determine each site's exposure to flood hazards that the city, county, and regional entities are utilizing for planning and policy making. Maps and tables are used to convey the exposure, including an asset-level (significant equipment) identification of flood vulnerability for the Marshall Street and East WRFs as they are the two with significant flood exposure. The last section of the document begins to layout potential resilience options for the City to consider along with the potential consolidation scenarios.

2. Identify Future WRF Strategies – Defining Planning Scenarios

This flood hazard assessment is intended to analyze each of the three WRF sites' exposures to flood hazards and help inform future scenarios for potentially consolidating and/or relocating WRF's. This section will provide maps and data points to consider when reviewing alternatives. Below is a map of the three facilities within the city boundary and showing their approximate heights above sea level per a digital elevation model derived from 2017 LiDAR from Pinellas County. It also shows half-mile buffers around the sites as many of the maps that follow provide insight to vulnerabilities within the footprint of the site as well as the areas adjacent to them. Following the map is a summary comparing the exposure of each site to different flood hazards. The remainder of this report will further expound upon information (tabular and spatial) available and its implication at each WRF.

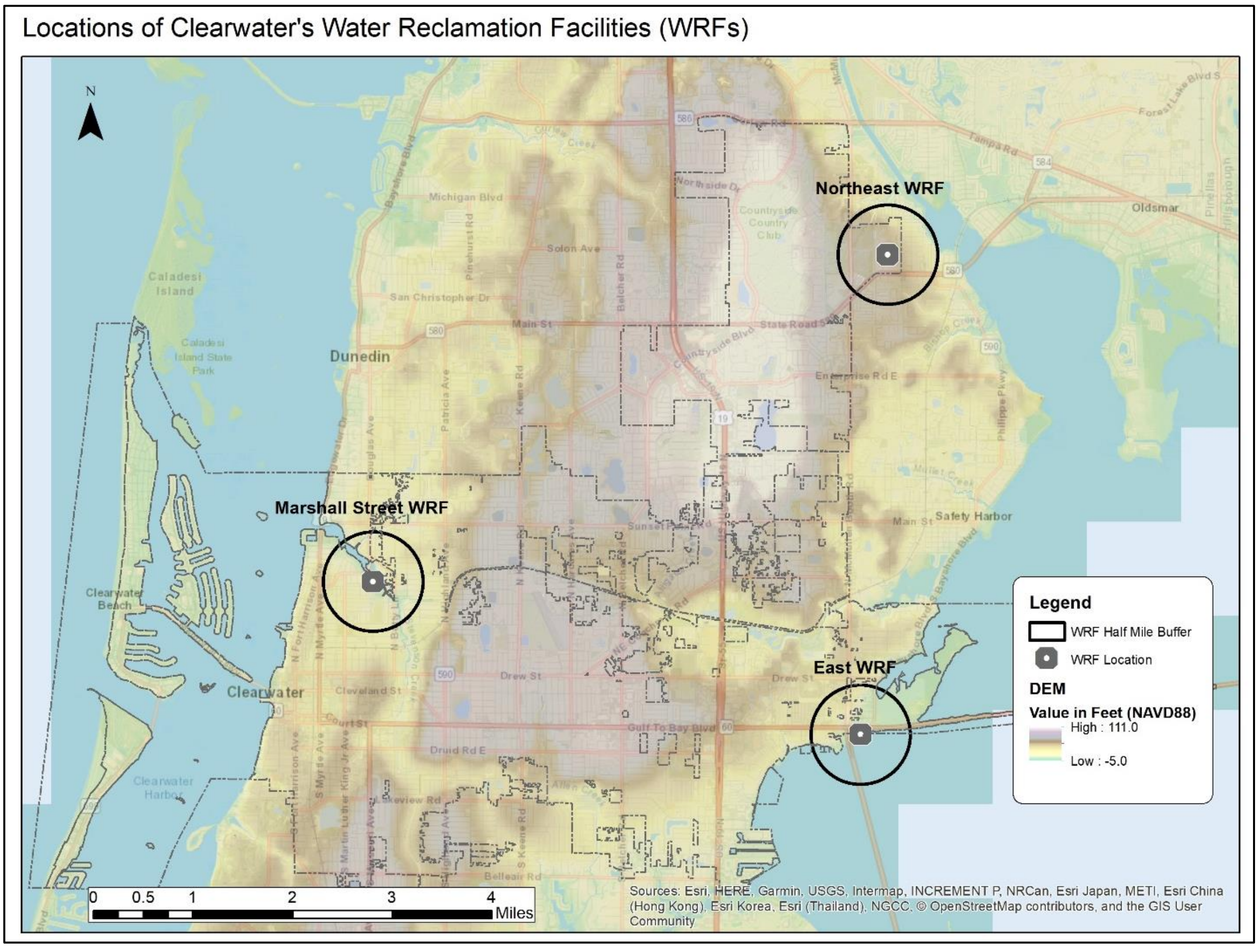


Figure 2-1 - Location of the WRFs within the City

Data Available through the Pinellas County "All-inOne" FloodApp (Ordered as Listed in the Layers within the App)
https://pinellas-egis.maps.arcgis.com/apps/webappviewer/index.html?id=a2e94afd62dd47ee87b8971ec72ff7d3

Data Layer	East Plant	Marshall St	Northeast
Parcels	PIN: 162916831060000207	PIN: 152910000001200200	PIN: 162821000003100000
Elevation Certificates (County, City, and State Uploads)	N/A	EC for announcer booth (not part of the plant's facilities)	N/A
FEMA Revalidated Letters	N/A	N/A	N/A
Pinellas County Watersheds	Coastal Zone 3 SWMP	Stevenson Creek	Possum Branch
Pinellas County Floodplain (nonTidal Regulated - Data as of 2016)	N/A; Coastal watershed	Yes; Stevenson Creek WMP	Only flood area is the narrow creek running through the undeveloped area on northwest corner of the parcel; Possum Branch WMP
Storm Surge Category	Category 1	Category 1	Very small portion of the parcel (vacant area on northeast corner that is not near the facilities) touches the inland extent of the Category 5 area.
Pinellas County Evacuation Zones	Evacuation Zone A	Evacuation Zone A	Outside of evacuation zones
Pinellas County Floodplain - Coastal 100 Year (Vulnerability Assessment, 2021)	BFE 10.3' NAVD 88; Northeast corner of parcel is BFE 10.2 NAVD 88	BFE 10.9' NAVD 88	Outside of 100-year flood area
Pinellas County Floodplain - Coastal 500 Year (Vulnerability Assessment, 2021)	BFE 14' NAVD 88	BFE 14' NAVD 88	Outside of 500-year flood area
Pinellas County Future (2070) Floodplain - Coastal 100 Year (Vulnerability Assessment, 2021)	BFE 13' NAVD 88	BFE 13' NAVD 88	Outside of future flood area
National Wetlands Inventory	Estuarine at shoreline; Uplands at rest of parcel where facilities are located	Upland	Lacustrine in facilities area; Uplands for other areas of parcel; Small areas of Palustrine within uplands
Coastal Barrier Resource Systems - CBRS Prohibitions	Outside CBRA	Outside CBRA	Outside CBRA
Erosion Control Line	Outside Erosion Control Area	Outside Erosion Control Area	Outside Erosion Control Area
Coastal Construction Control Line	Outside CCCL	Outside CCCL	Outside CCCL
FEMA FIRM 2009 vs FEMA FIRM 2018 Preliminary	AE areas changing from 9' (2009) to 12' (2018) VE areas changing from 9" (2009) to 13' and 14' (2018)	Changing from 10.0 (2009) to 9.0 (2018 Prelim)	No Change
NFHL - FIRM Panels - Effective	12103C0129H (8/24/21)	12103C0106J (8/24/21)	12103C0089H (8/24/21) & 12103C0087H (8/24/21)
NFHL - FEMA FIRM - Effective - Flood Zones *[Only shows zones]*	Zone AE; BFE 12' NAVD 88 Zone VE; BFE 13' NAVD 88 Zone VE; BFE 14' NAVD 88	Zone AE; BFE 9' NAVD 88	Zone X (Minimal Flood Hazard)
FEMA - FIRM - Effective (NFHL) *[Includes additional layers from the FEMA geoDB, like transects, water lines, etc]*	Zones AE (12') Within LiMWA area (1.5' - 3' wave action) and VE (13' and 14')	Zone AE; BFE 9' NAVD 88	Zone X (Minimal Flood Hazard)
FEMA 2009 (Historic)	Zone AE; BFE 9' NAVD 88; Zone VE (at shoreline); BFE 9' NAVD 88	Zone AE; BFE 10' NAVD 88	Zone X (Minimal Flood Hazard)
Sea Level Rise	See Below	See Below	See Below
SLR Year 2030	No impacts; only at shoreline	No impacts; only at shoreline	No Impacts
SLR Year 2050	No impacts; only at shoreline and western boundary	No impacts; only at shoreline	No Impacts
SLR Year 2070	Areas adjacent to facilities inundated with 2.33 to 4.56 feet of water with "high" scenario	Areas adjacent to facilities inundated with 2.33 to 4.56 feet of water with "high" scenario	No Impacts
SLR Year 2100	Most facilities inundated w/ SLR elevations of 3.9' to 8.5'	Most facilities inundated w/ SLR elevations of 3.9' to 8.5'	No Impacts
Pinellas County Data *[Address Labels, Evac Routes, Boundaries, etc.]*	N/A	N/A	N/A

Figure 2-2 - Overview of Each Site's Flood Exposure per Information Available through the Pinellas County All-in-One Flood Application

2.4.1. Prepare for and Conduct Climate Variability/Vulnerability Workshop

An introductory meeting was held with staff from the City of Clearwater, Black & Veatch, and Atkins to help provide an overview of the proposed approach to climate vulnerability for the three locations. The meeting was held virtually on January 25, 2022 and informed the City staff on new FEMA flood elevations, data from the Pinellas County Vulnerability Study, as well as national storm surge information. Additionally, information on sea level rise (SLR) projections and a methodology for assessing impacts to each site from SLR was conveyed to the team for approval. Furthermore, a brief discussion was held on how different local, state, and federal agencies have approached mitigation and adaptation planning for these types of facilities. The meeting concluded with an introduction to the ENV SP sustainability framework and how the team's approach to the project would align to that framework and could potentially earn credits under that system if the City chooses to apply for certification. Full meeting materials (minutes, agenda, and slides) have been provided to the City.

2.4.2. Precipitation and Localized Flooding Hazard Analysis

To assess the exposure to known flood hazards, existing elevations have been identified (at least the 100-year flood event) for known flood hazards using FEMA FIRM Maps (2021) as well as local watershed models for each of the three facilities. Future conditions are available as estimates from NOAA and the Pinellas County Vulnerability Study. The Pinellas County FIRM maps went effective in August of 2021, with most of the updates related to coastal modelling. Many inland areas of the County did not have a change to risk levels. As some of these sites sit at or near open water, it's helpful to understand the FEMA FIRM mapping nomenclature. The graphic below describes the coastal mapping terms.

2.4.2.1. Marshall Street WRF

The Marshall Street facility is located along Stevenson Creek and at risk from potential flooding. The August 2021 FEMA FIRM maps indicate a 100-yr base flood (1% annual chance of exceedance) elevation of 9-feet in the North Atlantic Vertical Datum of 1988 (NAVD 88). Most of the site's facilities are located on land with an elevation of 6 to 8 feet (NAVD 88).

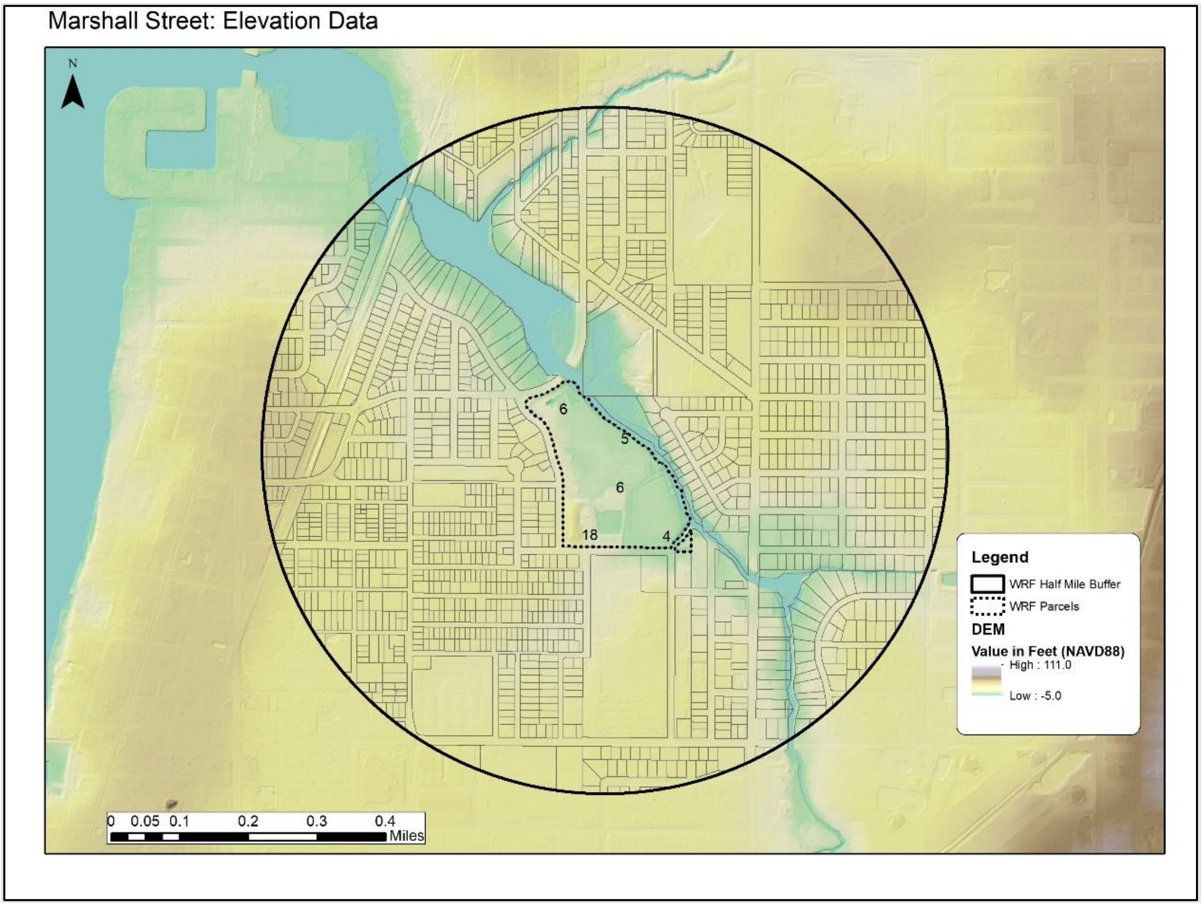


Figure 2-3 - Elevation Data for Marshall Street (includes parcel boundaries within 1/2 mile of the WRF)

Marshall Street: Special Flood Hazard Areas

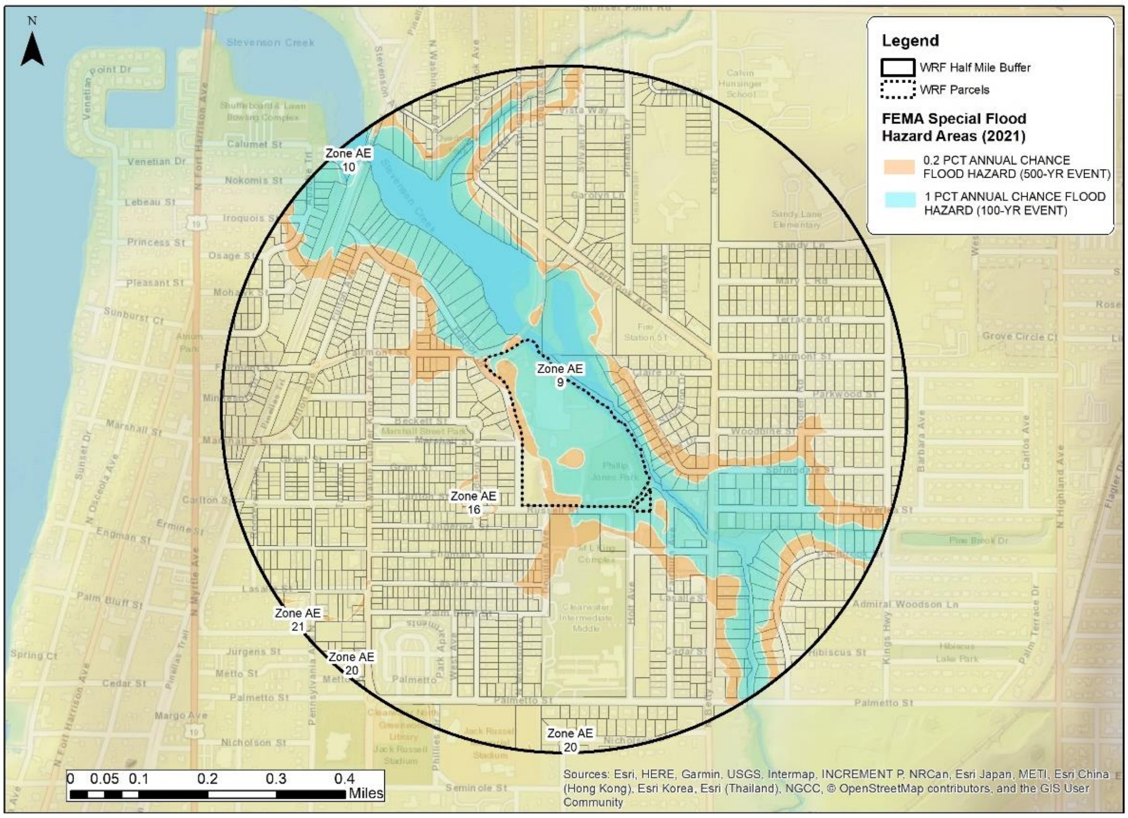


Figure 2-4 - Special Flood Hazard Areas within 1/2 Mile of the Marshall Street WRF (FEMA 2021)

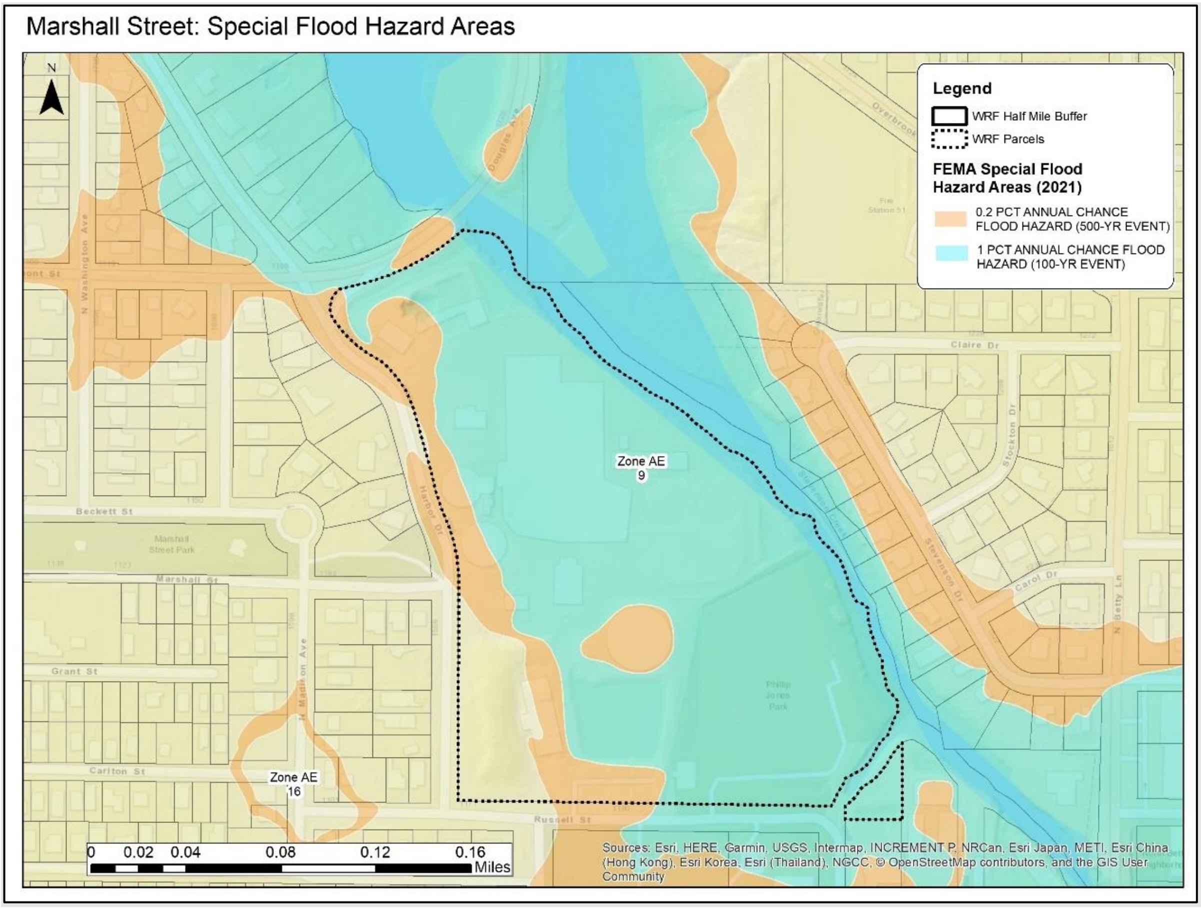


Figure 2-5 - FEMA Special Flood Hazard Areas in the Immediate Vicinity of Marshall Street WRF Parcel (FEMA 2021)

2.4.2.2. East WRF

The East Plant, with its location along the coast, is exposed to coastal flooding. Ground elevations are generally at sea level along the coast and slope up to 5 and 6 feet near Gulf to Bay Blvd. Moving inland from the water, the FEMA FIRM maps indicate that the site transitions from a velocity zone (VE 13) to a coastal AE (AE 12 with expected waves of 1.5 to 3 feet). The property borders the velocity zone and is located within an area known as the LiMWA (Limit of Moderate Wave Action). This means waves of 1.5 to 3 feet are likely to occur in a 100-year event.

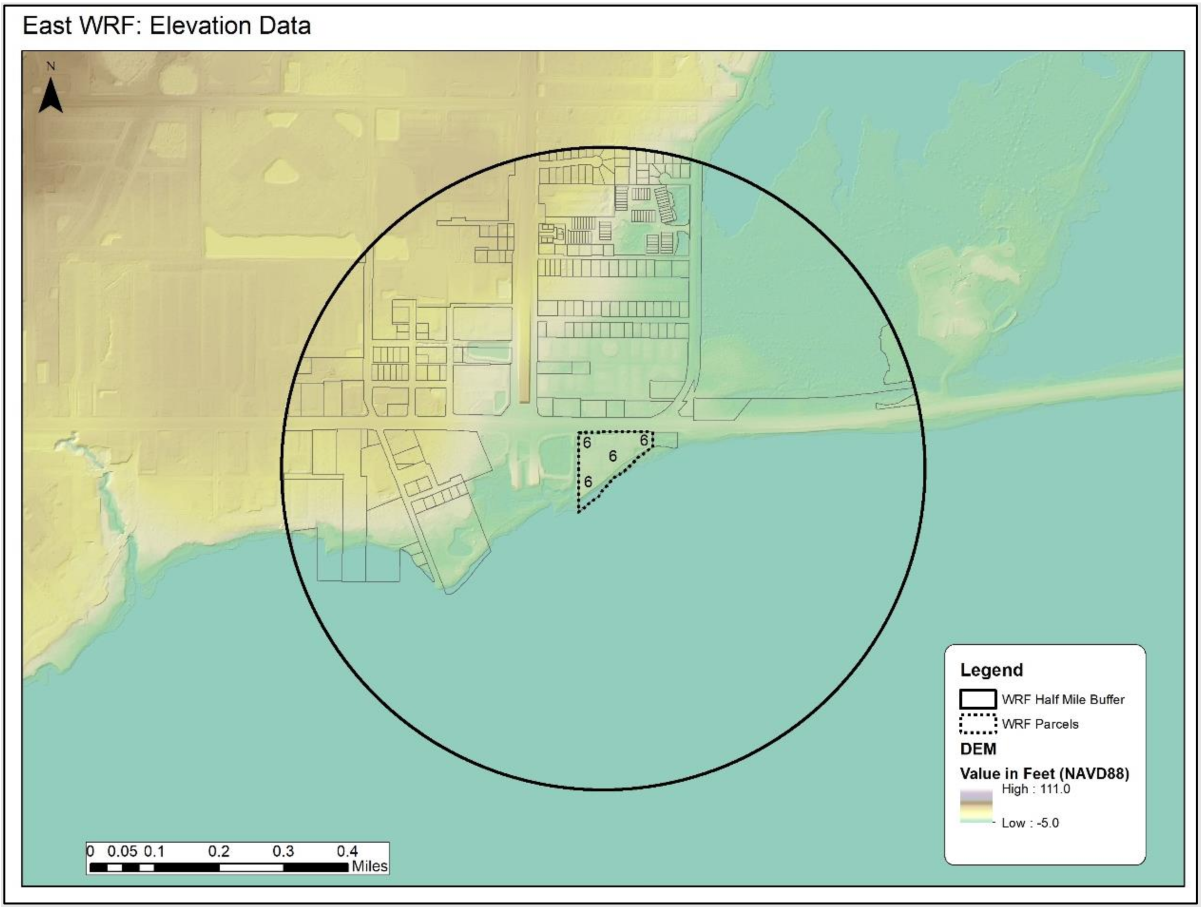


Figure 2-6 - Elevation Data for the East WRF (includes parcel boundaries within 1/2 mile of the WRF)

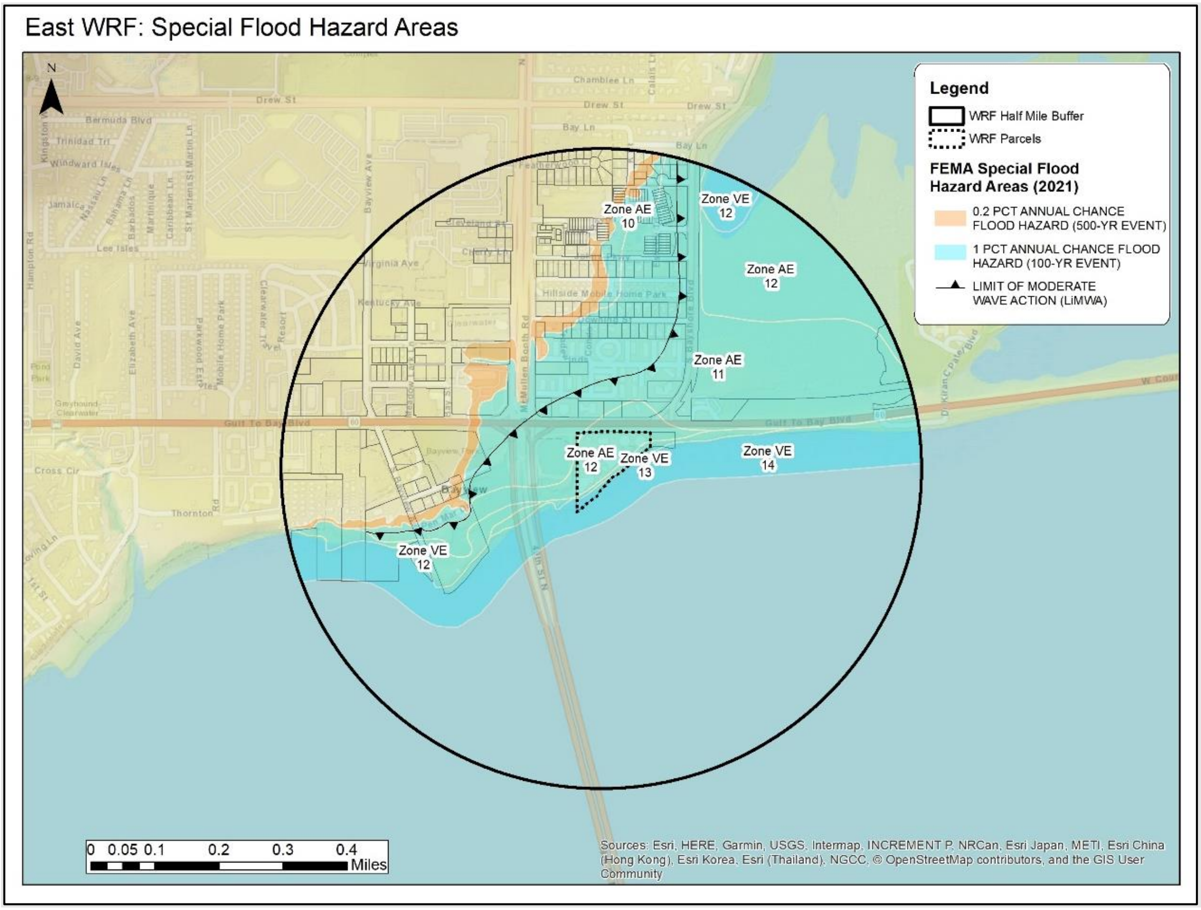


Figure 2-7 - Special Flood Hazard Areas within 1/2 Mile of the East WRF (FEMA 2021)

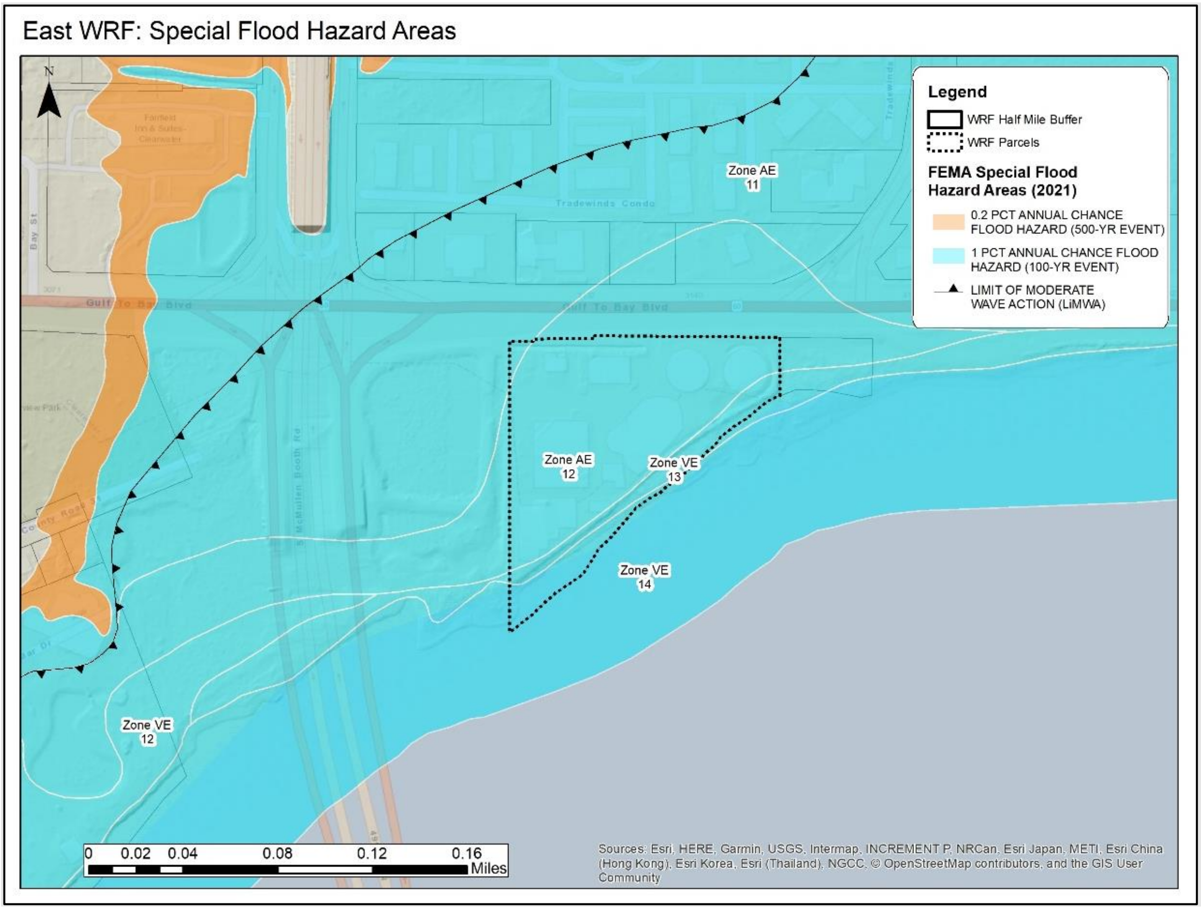


Figure 2-8 - FEMA Special Flood Hazard Areas in the Immediate Vicinity of the East WRF Parcel (FEMA 2021)

2.4.2.3. Northeast WRF

The Northeast WRF is located in an area outside of the FEMA special flood hazard areas. Wetlands adjacent to the facility provide retention and attenuation for localized flooding events. City of Clearwater staff noted that they were not aware of any significant flooding in the past. One storage area located below the maintenance building has had some water intrusion in the past. That area is now vacant storage and all equipment has been relocated on site. As a note the northwest portion of the parcel boundary illustrated below is the North Clearwater Nature Park and not part of the WRF.

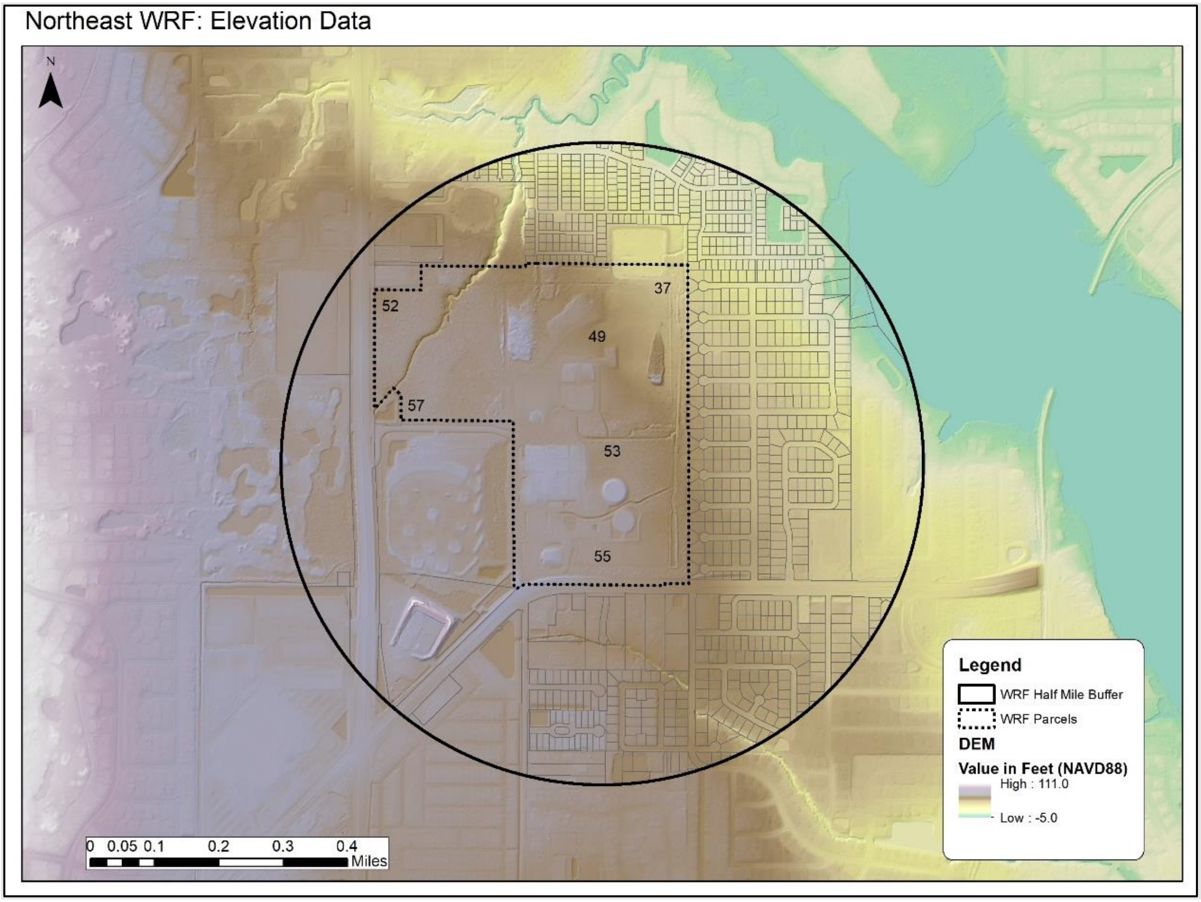


Figure 2-9 - Elevation Data for the Northeast WRF (includes parcel boundaries within 1/2 mile of the WRF)

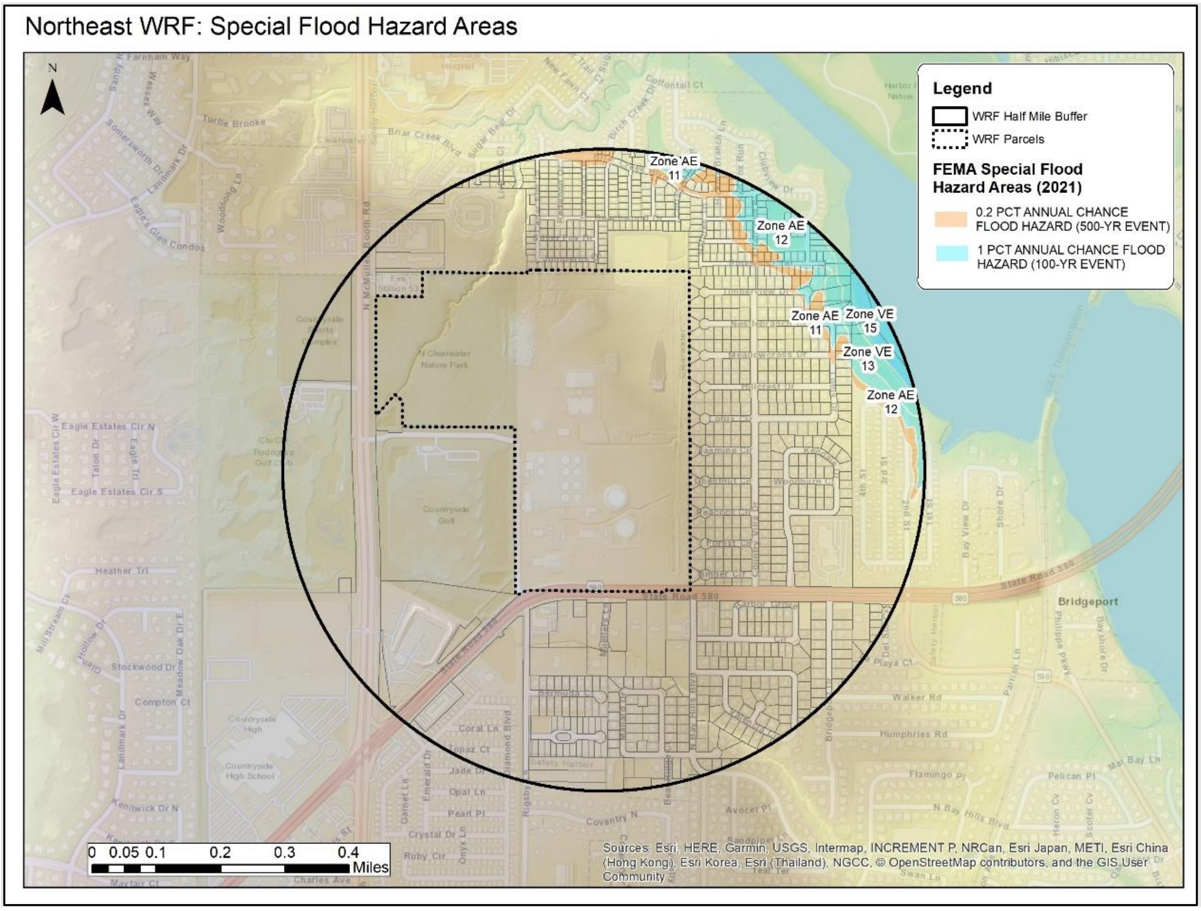


Figure 2-10 - Special Flood Hazard Areas within 1/2 Mile of the Northeast WRF (FEMA 2021)

2.4.3. Sea Level Rise Assessment

Sea level rise (SLR) is expected to directly impact two of the three facilities at some point in the future. For the purposes of this project, it was noted that the City would like to utilize a 30-year planning horizon for analysis. During the Climate Vulnerability Workshop in January 2022, it was also identified that many of the system components will have lifespans longer than 30 years and thus a longer planning horizon may also be considered in certain analyses. A key factor that the City asked to be evaluated was not just the potential for daily or frequent inundation of system components, but also impacts to inflow and infiltration (I/I). The section below will identify the results of a focused assessment on the WRF-specific resilience to SLR while considering the I/I impact on flows to the plants with the assumption that the wastewater collection system can deliver it there. Lastly, the SLR assessment also provides groundwater monitoring information and catalogues it accordingly.

In reviewing the potential extents of sea level rise inundation, the latest Pinellas County data was utilized. Their online geospatial viewer is available at: https://floodmaps.pinellascounty.org/pages/sea-level-rise. The viewer utilizes projections from NOAA and the local Climate Science Advisory Panel to provide expected heights and extents of sea level rise at planning horizons (2030, 2050, 2070, 2100). The background page for the viewer notes:

> "Coastal communities surrounding Tampa Bay are low-lying and densely-populated and therefore vulnerable to sea-level rise. In response to requests from local governments in the Tampa Bay region, Florida Sea Grant (FSG) and the Tampa Bay Regional Planning Council (TBRPC) are working together to guide sea-level rise adaptation planning in the region. Discover how sea level rise might affect your property by clicking the map.
>
> Based upon a thorough assessment of scientific data and literature on SLR, the Tampa Bay Climate Science Advisory Panel (CSAP) concludes that the Tampa Bay region may experience SLR somewhere between 11 inches to 2.5 feet in 2050 and between 1.9 to 8.5 feet in 2100."

In 2019, The CSAP provided a set of recommendations[1] that were formalized for use by local practitioners:

Table 2-1 - Sea Level Change Relative to the Year 2000 for St. Petersburg, FL in Feet above Local Mean Sea Level (LMSL)

Year	NOAA Intermediate-Low (Feet)	NOAA Intermediate (Feet)	NOAA High (Feet)
2000	0	0	0
2030	0.56	0.79	1.25
2040	0.72	1.08	1.77
2050	0.95	1.44	2.56
2060	1.15	1.87	3.48
2070	1.35	2.33	4.56
2080	1.54	2.82	5.71
2090	1.71	3.38	7.05
2100	1.90	3.90	8.50

[1] For more information, visit https://www.tbrpc.org/wp-content/uploads/2019/07/CSAP_SLR_Recommendation_2019_Final.pdf

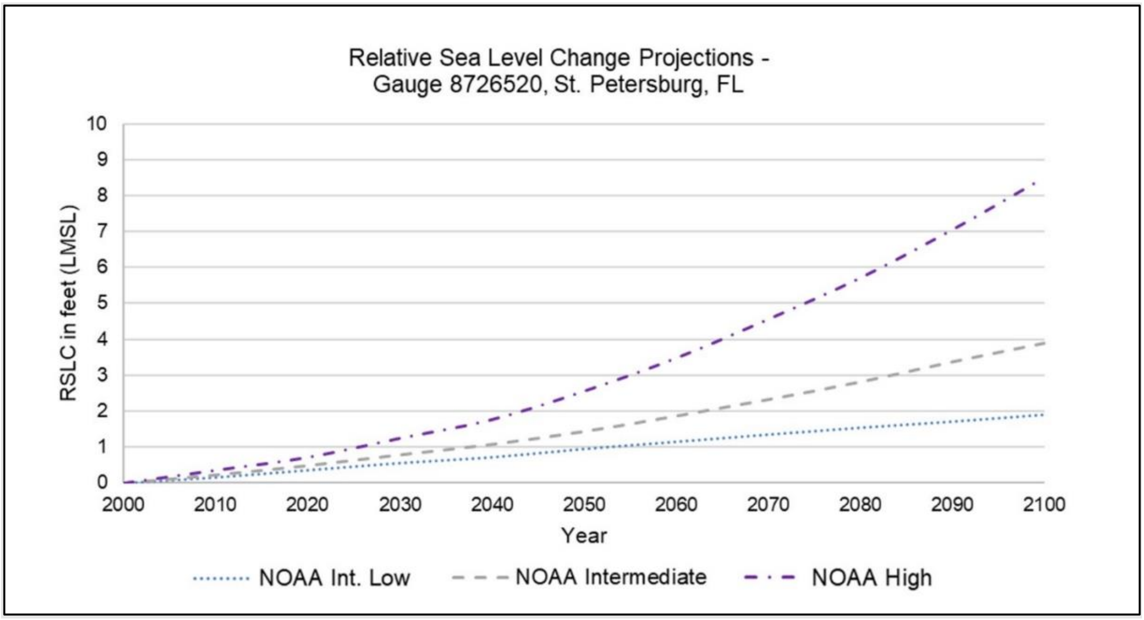


Figure 2-11 - Graphic Relative Sea Level Change (RSLC) Scenarios for St. Petersburg, Florida, as calculated using the regionally corrected NOAA 2017 curves. (USACE 2019)

The corresponding geospatial data was made available from Pinellas County's staff and utilized for mapping purposes in this document. As noted above, the planning horizon chosen for this project was 30-years with the acknowledgement that some considerations should be made for longer horizons as parts of the plant and/or equipment will have longer life cycles. The geospatial data indicates that there are no direct impacts expected from SLR tidal inundation at any of the plants through the 2070 planning horizon. Inundation at the shoreline will move inland and be adjacent to some of the equipment. The higher water levels will also result in higher elevations for other future flood events (100-year storm and storm surge). Groundwater will also be impacted but is not part of the viewer tools available. To help illustrate the extents, maps are provided for expected SLR inundation from 2040 (Intermediate Low) and 2070 (Intermediate High) provided by the Tampa Bay Regional Planning Council.

Additionally, Pinellas County performed their own vulnerability assessment for flood events which has similar results. Data from the Pinellas Study looked at planning horizons of 2040, 2070, and 2100.

The methodology utilized to determine these areas in the Pinellas Study is identified below from the Final Report (Pinellas County Sea Level Rise and Storm Surge Vulnerability Assessment; February 2022; WSP):

> WSP adapted the NOAA method to map the variability of tidal flooding and sea level rise corresponding to the five flood frequency increments, three sea level rise projections, and three horizon years (along with current 2018 conditions). For reasons previously discussed, the water levels associated with these astronomical high tides are, for most flood frequency increments, higher than the present tidal epoch MHHW baseline water level (the value typically used by NOAA when mapping sea level rise inundation). In general, the WSP adaptation of the NOAA process attempts to account for the local and regional variability of both (1) the current and future water elevations associated with the suite of astronomical high tide flooding frequencies chosen by this project (most of which are higher than the MHHW tide elevations used by NOAA as a baseline), and (2) the amount of sea level rise (which, as previously noted, varies a small amount by location in the county).

The report goes on to discuss the specific tidal flooding scenarios that were mapped:

> Regular tidal flooding will become an increasingly common occurrence in low-lying portions of the County as the twenty-first century progresses. To better understand this hazard, the project team mapped the frequency of tidal flooding by days of flooding per year. Five increments of tidal flood frequency were determined in coordination with the County after an initial investigation of the local tidal cycle. Information on water depths and elevations are included with each inundation layer.

The five tidal flooding frequency increments evaluated include:

- 1 hour per year (King Tide)
- 50 hours per year
- 250 hours per year
- 528 hours per year (mean higher high water [MHHW])
- 1,185 hours per year (mean high water [MHW])

The report's graphic further illustrates these scenarios:

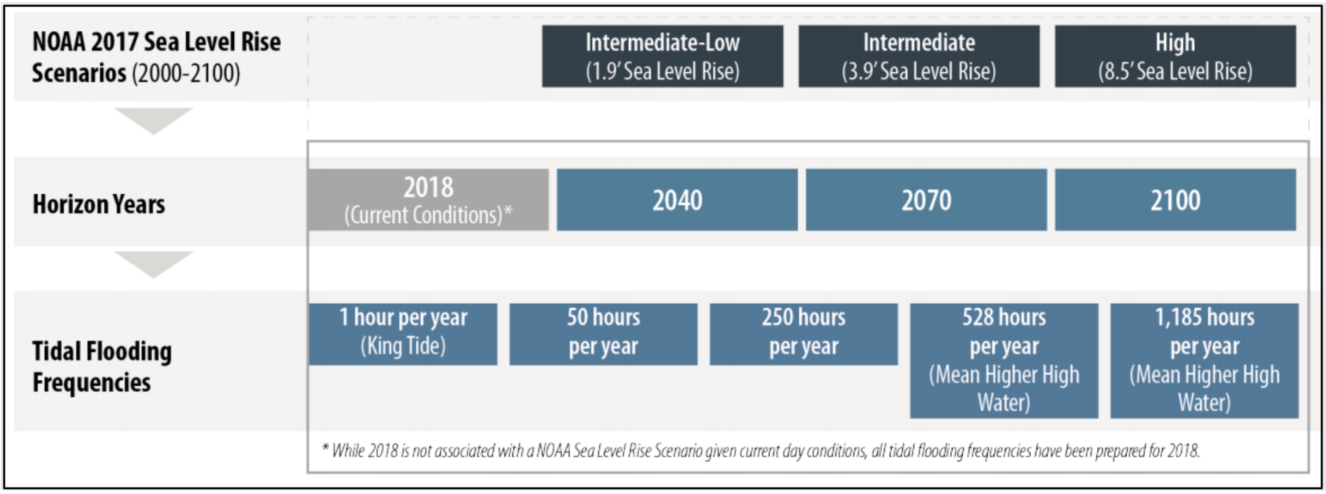


Figure 2-12 - Sea level rise scenarios modeled for the Pinellas County Sea Level Rise and Storm Surge Vulnerability Assessment

The TBRPC sea level rise inundation areas and the Pinellas Sea Level Rise and Storm Surge Vulnerability Assessment's inundation areas were utilized to review proximity and potential flooding at each site. Only the Marshall Street and East WRFs have exposure to these events as identified within the maps that follow.

2.4.3.1. Marshall Street WRF

SLR Inundation from NOAA/TBRPC

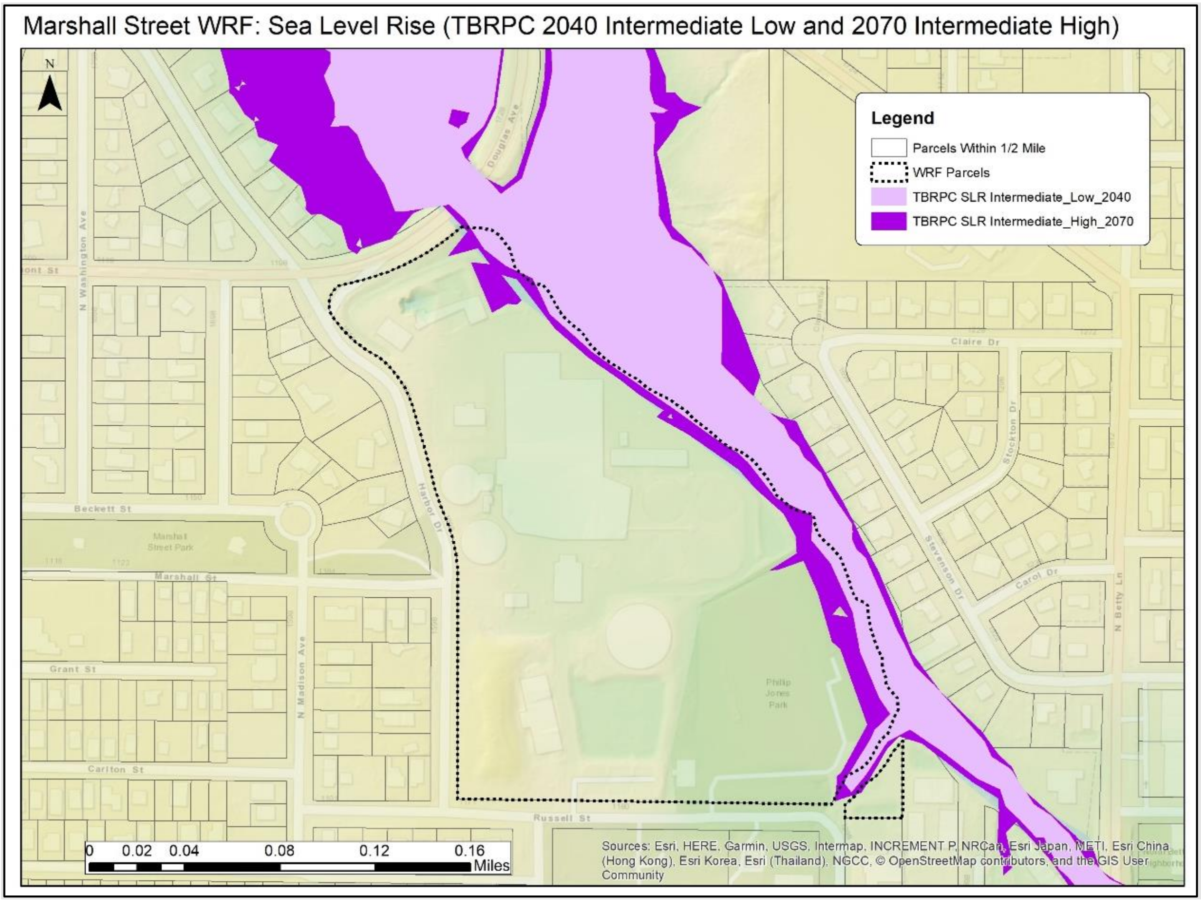


Figure 2-13 - Projected 2040 and 2070 SLR Inundation Areas Near the Marshall Street WRF (Tampa Bay Regional Planning Council)

SLR Inundation from Pinellas County Vulnerability Study

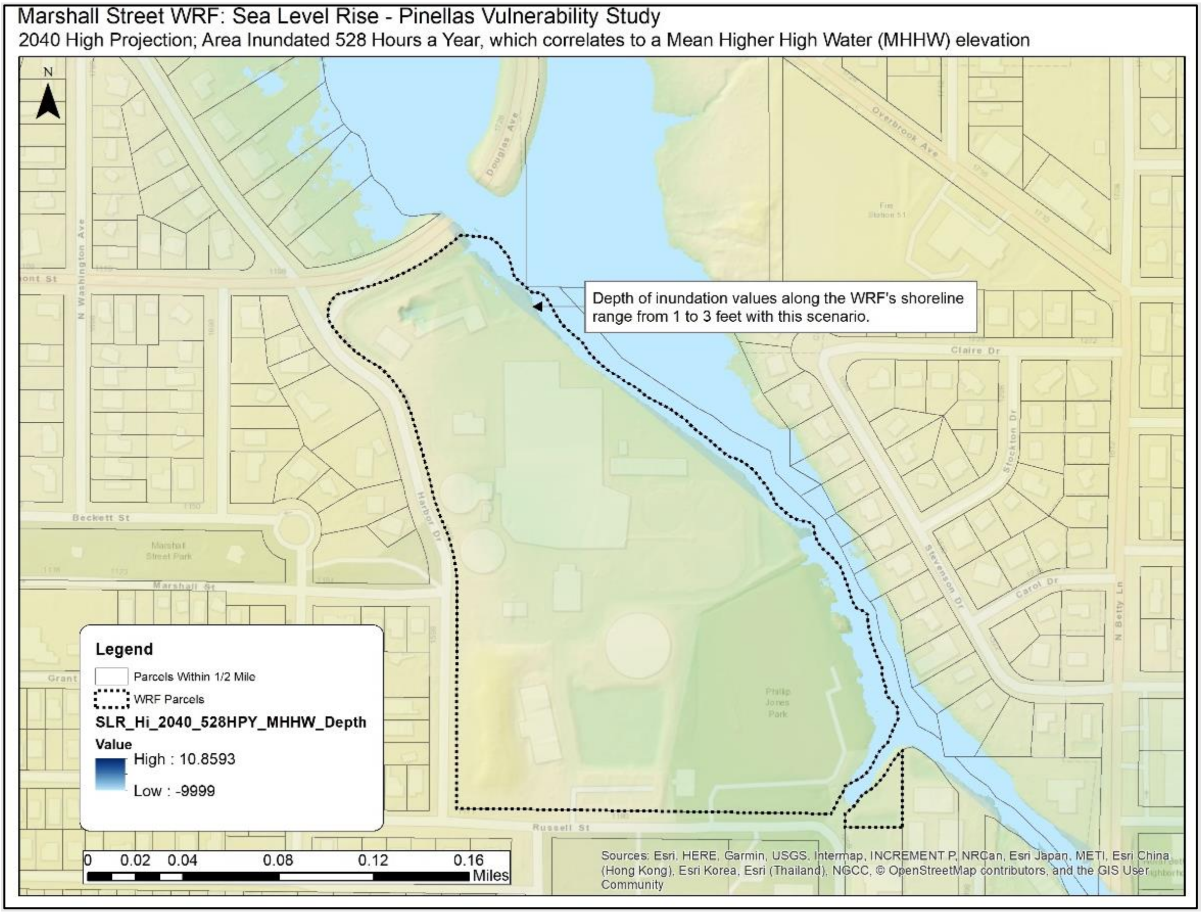


Figure 2-14 - Projected 2040 Depths of SLR Inundation Areas Near the Marshall Street WRF (Pinellas County Vulnerability Assessment)

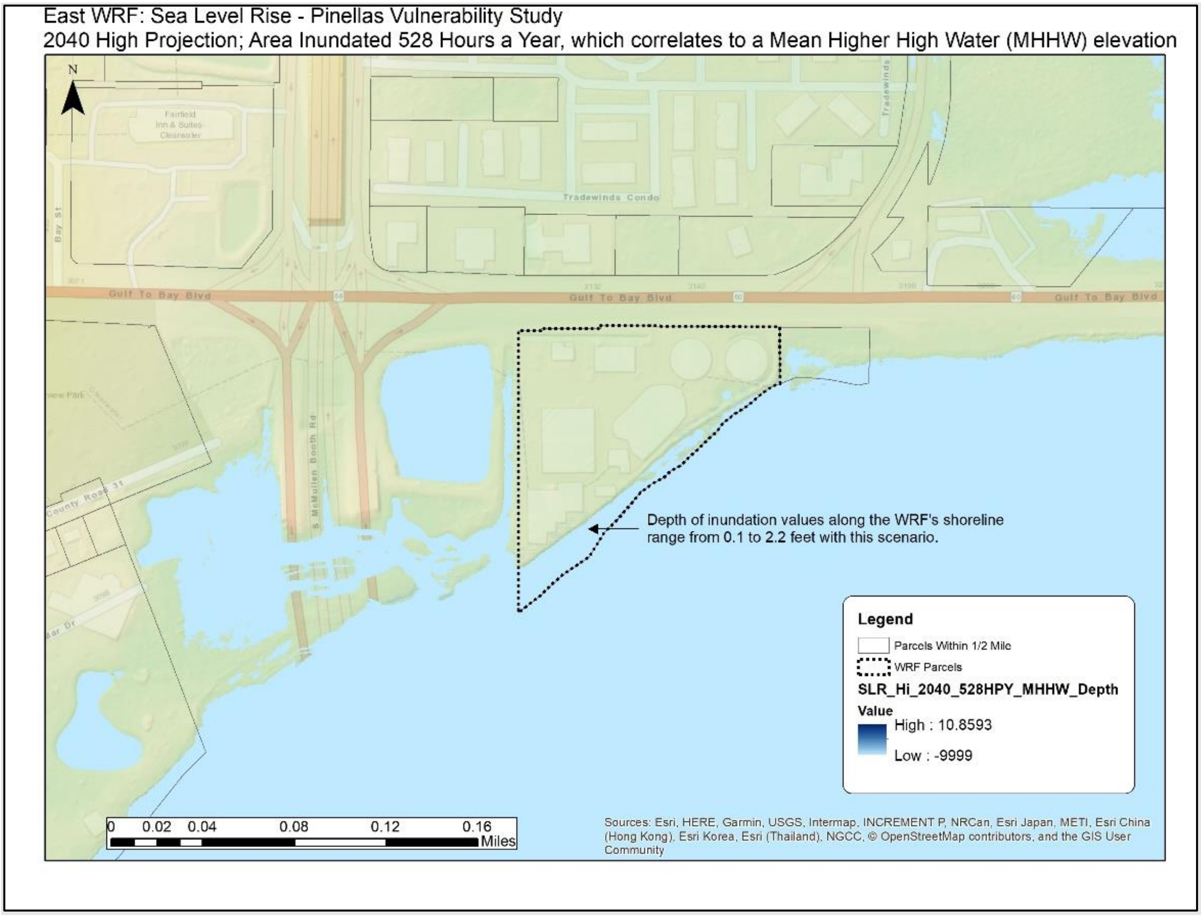


Figure 2-15 - Projected 2070 Depths of SLR Inundation Areas Near the Marshall Street WRF (Pinellas County Vulnerability Assessment)

2.4.3.2. East WRF

SLR Inundation from NOAA/TBRPC

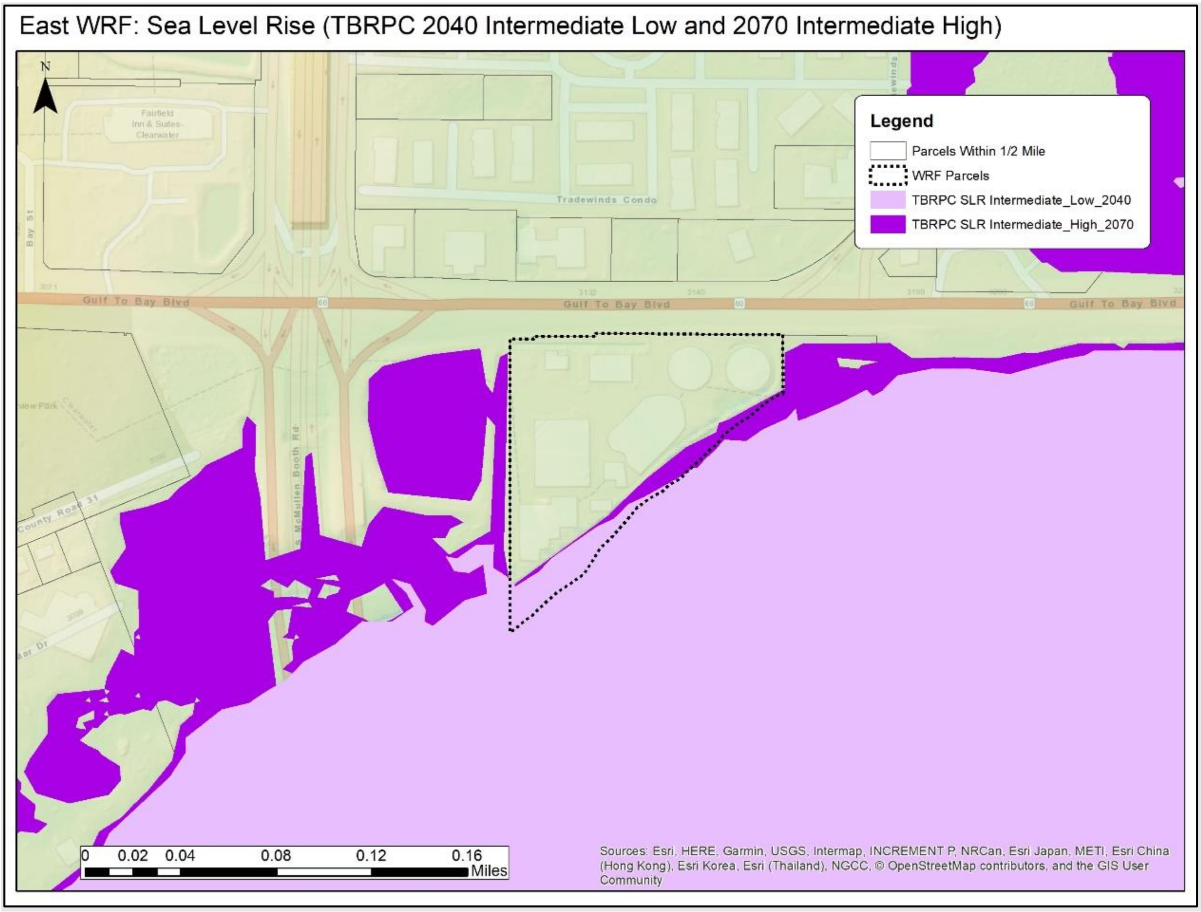


Figure 2-16 - Projected 2040 and 2070 SLR Inundation Areas Near the East WRF (Tampa Bay Regional Planning Council)

SLR Projections from Pinellas County Vulnerability Study

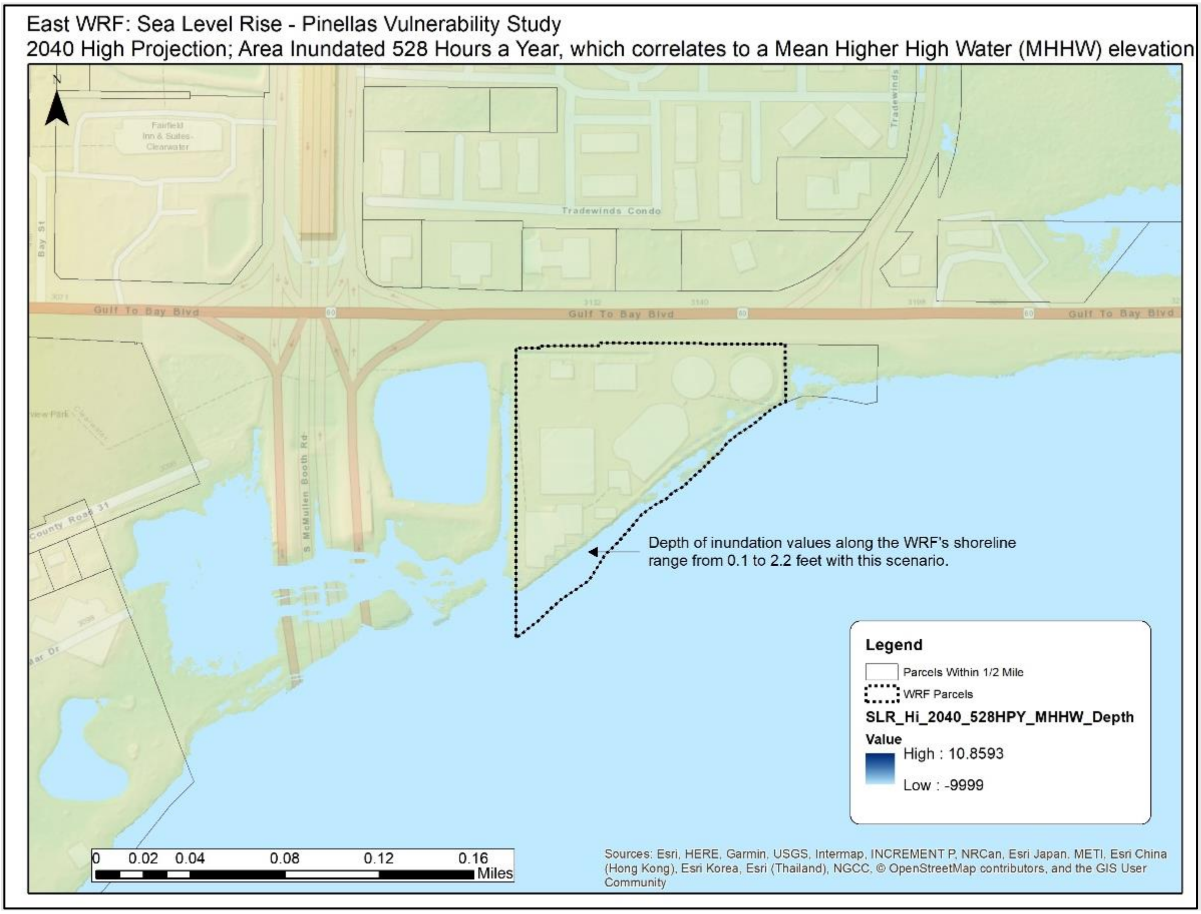


Figure 2-17 - Projected 2040 Depths of SLR Inundation Areas Near the East WRF (Pinellas County Vulnerability Assessment)

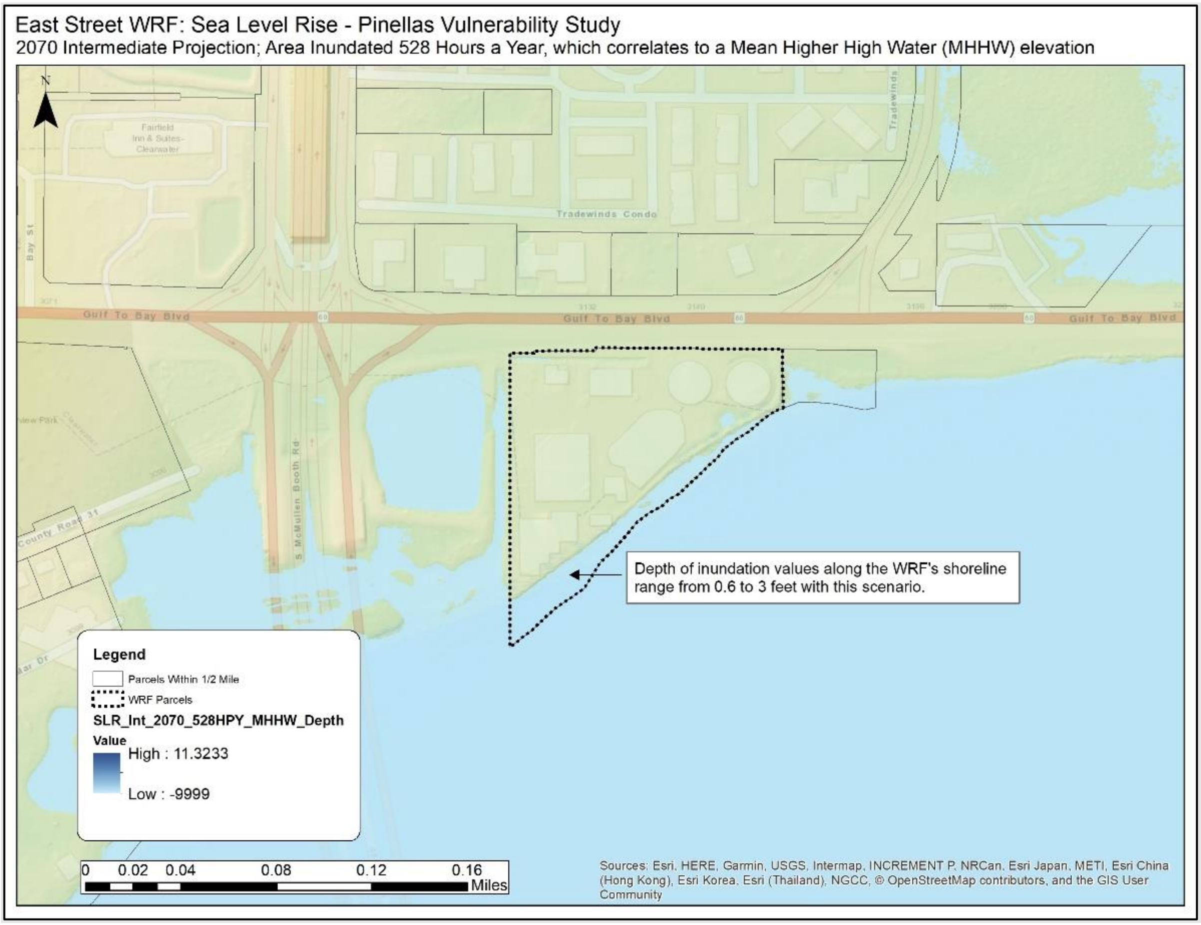


Figure 2-18 - Projected 2070 Depths of SLR Inundation Areas Near the East WRF (Pinellas County Vulnerability Assessment)

2.4.3.3. Northeast WRF

There are no expected tidal impacts from SLR at the Northeast WRF. The site is located away from the coast at heights well above sea level (most facilities located at approximately 50 feet NAVD 88).

2.4.3.4. Rough Cost Estimation for Addressing SLR at Marshall Street and East WRF's Compared to Pumping to the Northeast WRF

After reviewing the projected estimates of SLR at Marshall Street and East WRFs, there is no expected direct threats to the two facilities within this project's planning horizon (2050). There will be increased tidal events at the shoreline and exacerbated impacts to other flood scenarios as well as potential for further intrusion into the groundwater. If SLR progresses at a level higher/and or faster than expected, shoreline protection or armoring may be needed to protect the vulnerable portions of the sites.

2.4.3.5. Impact of Sea Level Rise on Groundwater Infiltration into the Sanitary Sewer System

A proposed methodology for quantifying the increase in groundwater infiltration into the sanitary sewer system was presented to the City of Clearwater (City) on January 25, 2022 during the Climate Variability and Vulnerability Workshop. The general steps to the methodology are as follows:

- Gather data needed for the analysis, including:
  - NOAA Tidal Gauges,
  - USGS groundwater gauges,
  - Southwest Florida Water Management District (SWFWMD) groundwater gauges
  - Sewer flow and corresponding rainfall data
  - City's calibrated SWMM model and future model scenarios and/or City's sanitary sewer system GIS
- Develop flow-calibrated model to project increases in groundwater infiltration into the sanitary sewer system
- Establish correlation between tidal levels and surficial groundwater levels and identify zone of influence
- Project future surficial groundwater levels based on SLR
- Project future climate-adjusted rainfall
- Develop new future SWMM model scenario using projections from steps 4 and 5 to quantify peak flows into each WRF as outlined in the Scope of Services Task 2.4.3.

The following is a brief discussion of the status and findings of this effort.

2.4.3.5.1. Gather Existing Data

The hourly tidal data at the Clearwater Beach and St. Petersburg Stations were downloaded from the NOAA website. Hourly groundwater data were obtained from USGS for the Garden Street Triangle Well and the Pinellas Well 665. The SWFWMD maintains a network of groundwater gauges within and around the City of Clearwater. Daily data from these gauges are available from the SWFWMD website and were obtained for further analysis.

The City provided historical sewer flow and rainfall data during the 2017-2019 period, which could be used to develop a flow-calibrated model to predict increases in groundwater infiltration within the zone of influence. The SWMM collection system model and/or the City's sanitary sewer system could be utilized to perform additional analyses as identified below when the appropriate datasets are available.

2.4.3.5.2. Develop Flow-Calibrated Model to Project Increases in Groundwater Infiltration

The flow-calibrated model to project groundwater infiltration into the sanitary sewer system is based on the following technical publication:

Fung, A., Babcok, R., "A Flow-Calibrated Method to Project Groundwater Infiltration into Coastal Sewers Affected by Sea Level Rise," Water 2020, 12, 1934; doi10.3390/w12071934.

This model could be developed using a MS Excel spreadsheet and outputs from the next two subsections of the document (correlation between tide and groundwater as well as the projection of future surficial groundwater levels) would be used as model inputs, along with the outputs from the analysis of the sewer flow and rainfall data. The sewer flow and rainfall data will be used to estimate the dry-weather groundwater infiltration to the sewer system in each metering basin.

2.4.3.5.3. Establish Correlation Between Tidal Levels and Surficial Groundwater Levels

The daily NOAA tidal levels and the hourly USGS groundwater levels were analyzed in the MS Excel spreadsheet titled “Preliminary Groundwater Elevation Correlation.xlsx.” These data were averaged seasonally for dry and wet seasons during the period 2017-2020, which overlapped with the City’s sewer flow and rainfall monitoring period. The dry season was defined as the period from October through May and the wet season as the period from June through September. The NOAA annual average tidal levels and USGS average annual groundwater elevations during both the dry and wet seasons are presented in Figure 2-19 - Average Dry Season Groundwater and Tidal Elevation Comparison and Figure 2-20 - Average Wet Season Groundwater and Tidal Elevation Comparison, respectively.

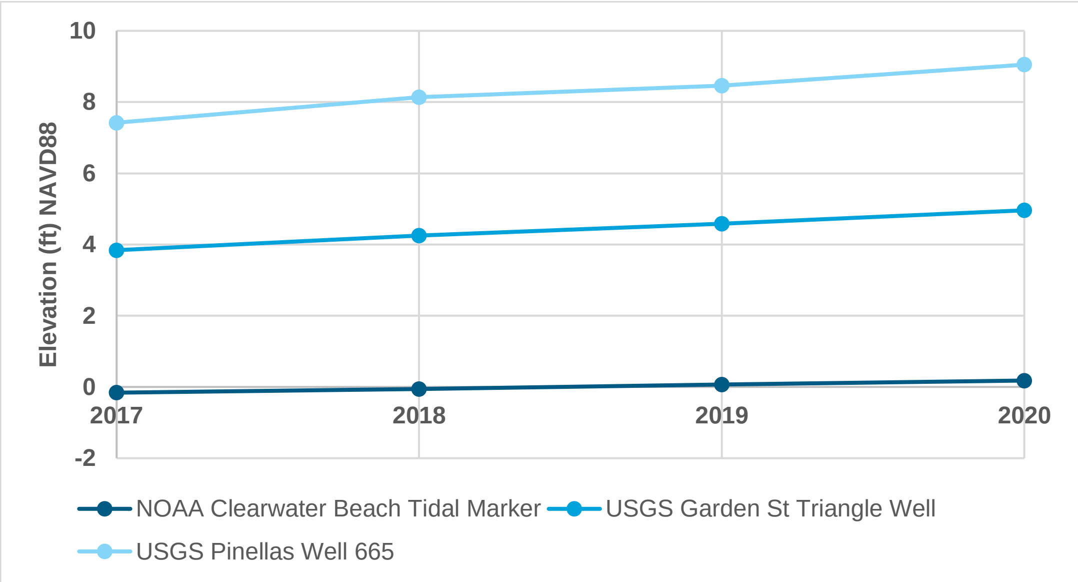


Figure 2-19 - Average Dry Season Groundwater and Tidal Elevation Comparison

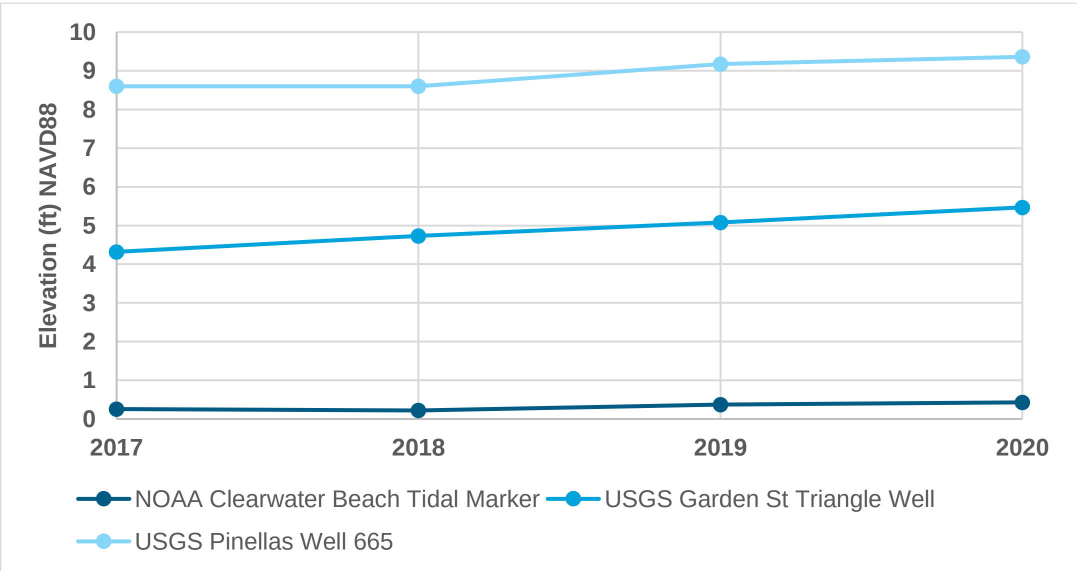


Figure 2-20 - Average Wet Season Groundwater and Tidal Elevation Comparison

The two USGS groundwater wells are located at lower ground elevations (less than 30 feet above datum (AD)). Upon inspection of the topography of the City, there are areas at elevations greater than 95 feet AD. At higher elevations, it is expected that tidal levels will not significantly impact groundwater levels in the surficial aquifer. The SWFWMD maintains a network of groundwater gauges across the City, several of which are located at higher elevations. However, the resolution of data available through the SWFWMD website is daily, which is not adequate to establish a correlation with the hourly tidal data. An email request was sent to the SWFWMD on June 1, 2022 to inquire whether hourly groundwater level data are available. A response was received on June 16, 2022 and hourly data were provided for eight well locations. At the time of this writing, the hourly groundwater data at these additional locations had not yet been analyzed. Subsequent analyses could be focused on delineating a “zone of influence” within which the groundwater table can be expected to be significantly impacted by tidal levels. This process would identify the sewers that are prone to increased GWI due to SLR. It is not anticipated that the increase in GWI will significantly impact peak wet weather flows. However, the average daily dry weather flows could be impacted more noticeably. A zone of influence map could be produced once the final consolidation scenario is selected.

As seen in Figure 2-19 and Figure 2-20, the average sea levels and groundwaters levels illustrate an upward trend from 2017 to 2020 during both the dry and wet seasons. These average dry and wet season groundwater elevations, along with similar averages from the SWFWMD groundwater gauges, would then be used during calibration of the groundwater infiltration model (aka flow-calibrated spreadsheet model). If the City wants to understand quantitatively the impact on future dry weather flows, a flow-calibrated spreadsheet model would need to be developed. This could be done for an additional fee once the final consolidation scenario is selected and the zone of influence map has been prepared.

2.4.3.5.4. Project Future Surficial Groundwater Levels

Based on the projection of future SLR, the groundwater contour map will be adjusted proportionally, but not higher than the ground surface. Using the flow-calibrated GWI model, the length of submerged gravity sewers within the zone of influence will be quantified, as will the average depth of submergence over the gravity system. This information will be used as inputs to the flow-calibrated GWI model to quantify future groundwater infiltration into the sewer system.

2.4.3.5.5. Project Future Climate-Adjusted Rainfall

To determine future precipitation, the EPA SWMM Climate Adjustment Tool (SWMM-CAT) could be used to project the future 25-year, 24-hour duration design storm as presented during the Climate Variability and Vulnerability Workshop and present in Figure 2-21.

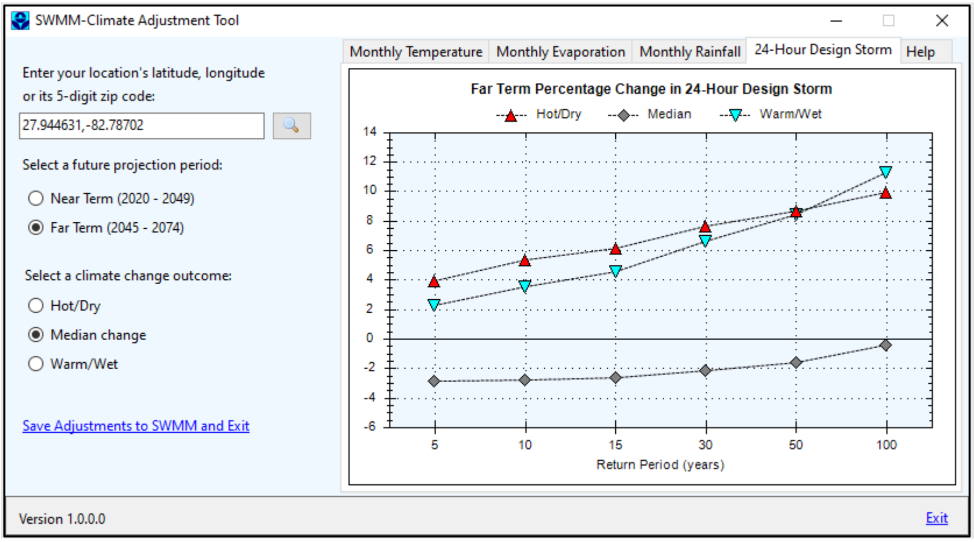


Figure 2-21 - EPA SWMM Climate Adjustment Tool

The 25-year, 24-hour duration design storm hyetograph will be adjusted based on output from the SWMM-CAT.

2.4.3.5.6. Use SWMM Model to Quantify Peak Flows into each WRF

Using the future predicted groundwater infiltration from the flow-calibrated GWI model, the climate-adjusted 25-year, 24-hour duration storm and projected future base sanitary flow, the City’s EPA SWMM model could be used to project the future dry- and wet-weather flows into each WRF for use in the master planning effort or be considered separately at the discretion of the City.

2.4.3.5.7. Future Work

The following progression of future work activities could be performed at the discretion of Black & Veatch and/or the City:

1. Using the recently obtained hourly data from the SWFWMD, determine the zone of influence in terms of the groundwater table with respect to tidal levels. This would be depicted on a map and can be performed within the existing budget.
2. Quantify the length of gravity sewers tributary to each WRF that lie within the zone of influence. The gravity sewers would be added to the map in item 1. Either the City's SWMM model or the sanitary sewer system GIS would be needed.
3. Develop the flow-calibrated model and quantify the increase in groundwater infiltration to each WRF. This work would done for an additional fee.

Using the output from the flow-calibrated GWI model in item 3, the climate-adjusted 25-year, 24-hour design storm and the projected future base sanitary flow, the City's EPA SWMM model could be used to project future dry- and wet-weather flows into each WRF.

2.4.4. Storm Surge Assessment

Two of the three facilities are extremely exposed to potential storm surge impacts. Storm surge models are updated every four to five years using new data and computing technologies. The most recent National Hurricane Center surge model (released in 2020) uses a modeling that's more focused to the Tampa Bay region and new, higher-resolution elevation data. The updates in 2022 were made based on new storm surge predictions from the National Hurricane Center's Sea Lake Overland Surge in Hurricanes (SLOSH) model that identify where storm surge may do the most damage. The data available from Pinellas County Emergency Management and the Tampa Bay Regional Planning Council provides expected above ground flood depths from different categories of storms.

Pinellas County's Emergency Management Office notes that "the greatest killer of people during hurricanes is storm surge – the dome of water pushed ashore by powerful hurricane winds. Storm surge isn't a gradual rising of water. It rushes in and out sweeping anything not secured back out to sea, people included. During Hurricane Katrina, residents of coastal Mississippi were caught off guard by storm surge flood waters. Entire buildings were moved and the loss of life was staggering. Pinellas County is extremely vulnerable to surge flooding because of its coastal and low-lying geography. In fact, a Category 3 storm could flood 42 percent of the county's households."

Categories of Storms

The Saffir-Simpson scale is traditionally utilized to differentiate storm types and is primarily based on wind speeds. As noted in Pinellas County's 2020 Local Mitigation Strategy: "Hurricanes are further ranked by wind speed from Category 1 to 5, with 5 being catastrophic. The Saffir-Simpson Hurricane Wind Scale[2] is shown in the table below.

Table 2-2 - Saffir-Simpson Hurricane Wind Scale

Category	Sustained Winds	Types of Damage Due to Hurricane Winds
1	74–95 mph	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96–110 mph	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111–129 mph	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes
4 (major)	130–156 mph	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	157 mph or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

[2] For more information, visit http://www.nhc.noaa.gov/aboutsshws.php

2.4.4.1. Marshall Street WRF

Category 1

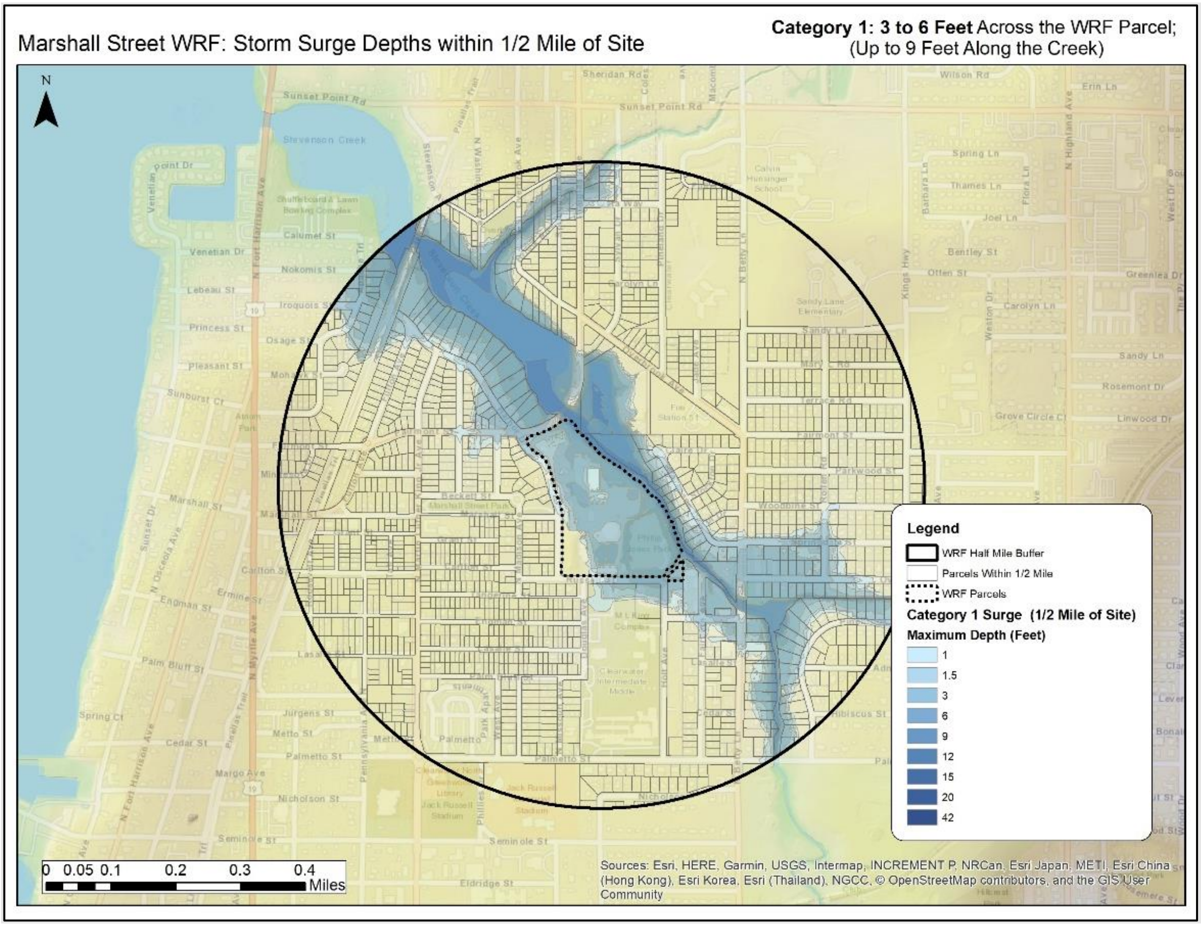


Figure 2-22 - Estimated Maximum Depths of Inundation from a Category 1 Hurricane Storm Surge to Marshall Street WRF (1/2 Mile Radius of Site)

Category 2

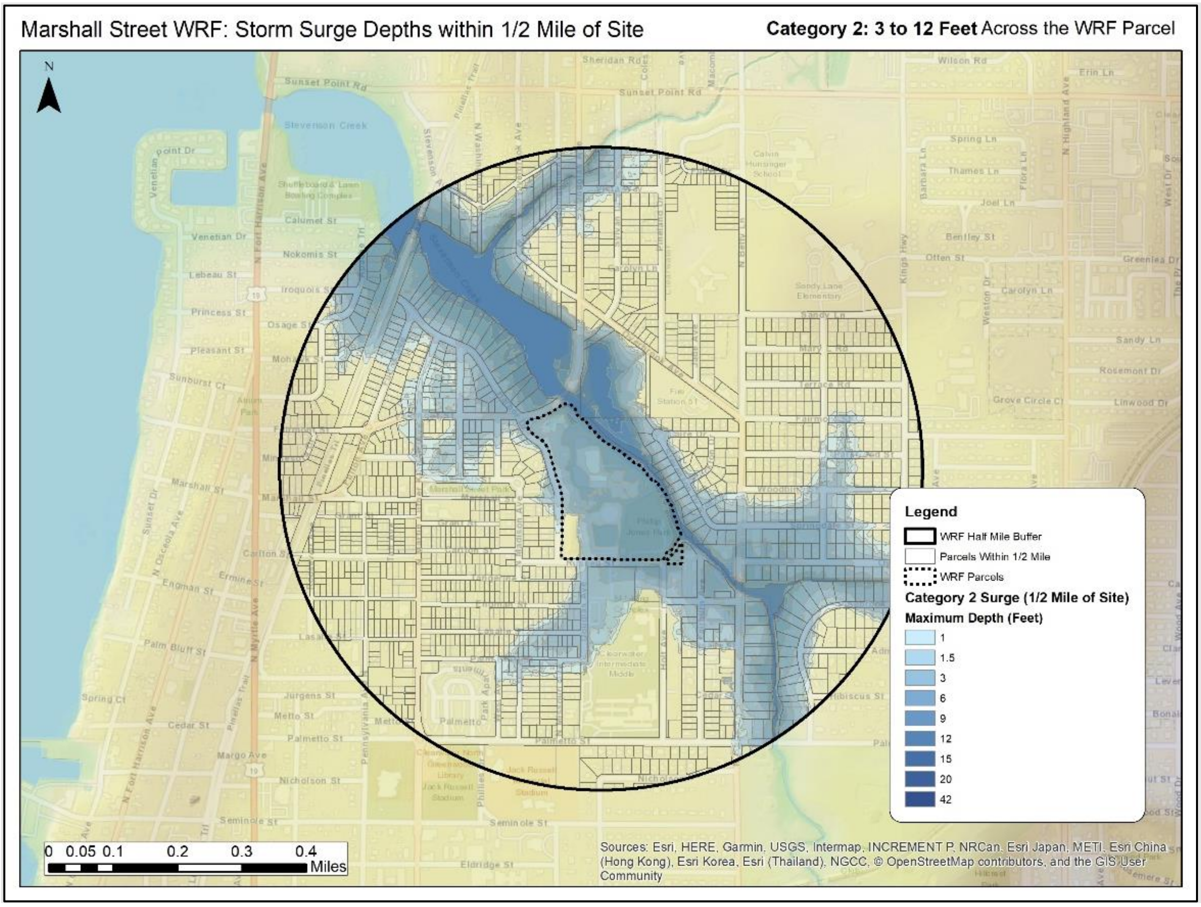


Figure 2-23 - Estimated Maximum Depths of Inundation from a Category 2 Hurricane Storm Surge to Marshall Street WRF (1/2 Mile Radius of Site)

Category 3

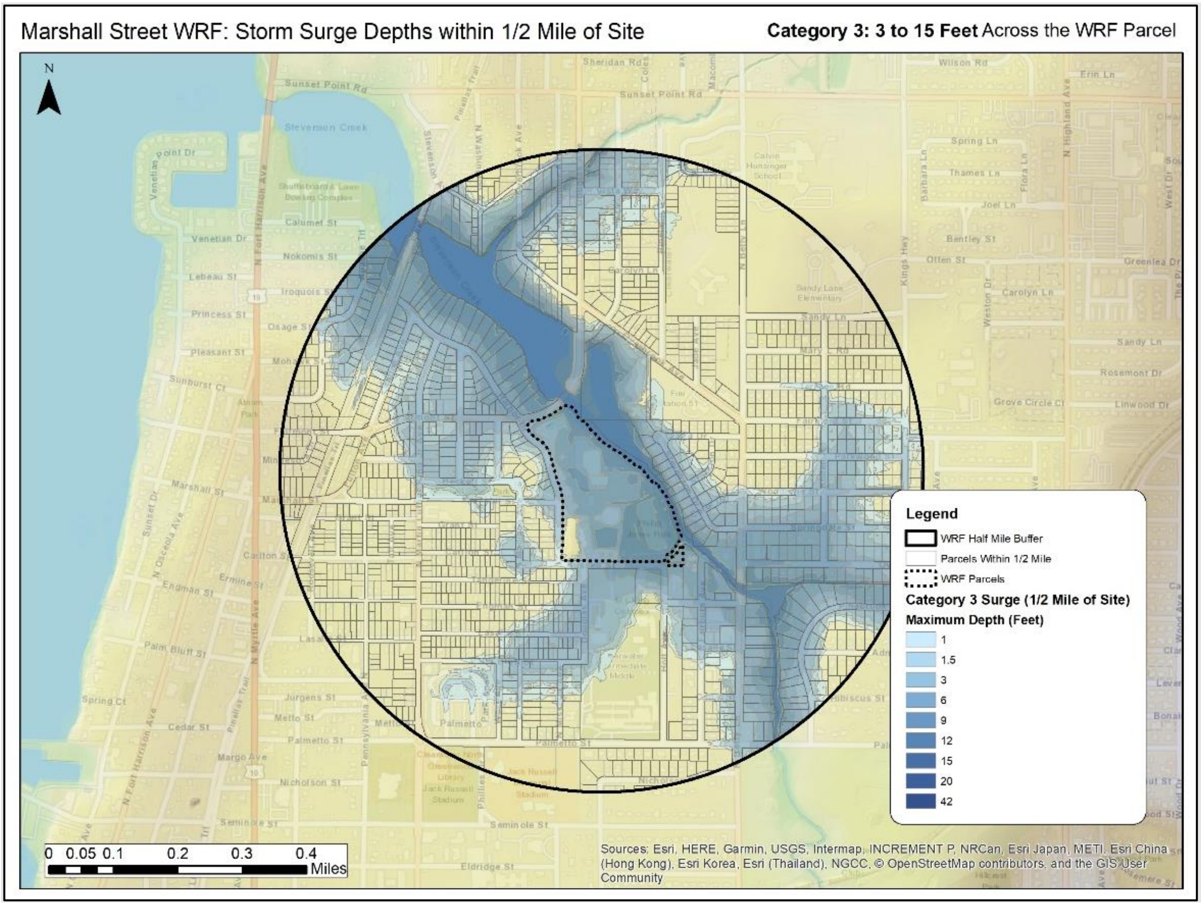


Figure 2-24 - Estimated Maximum Depths of Inundation from a Category 3 Hurricane Storm Surge to Marshall Street WRF (1/2 Mile Radius of Site)

Category 4

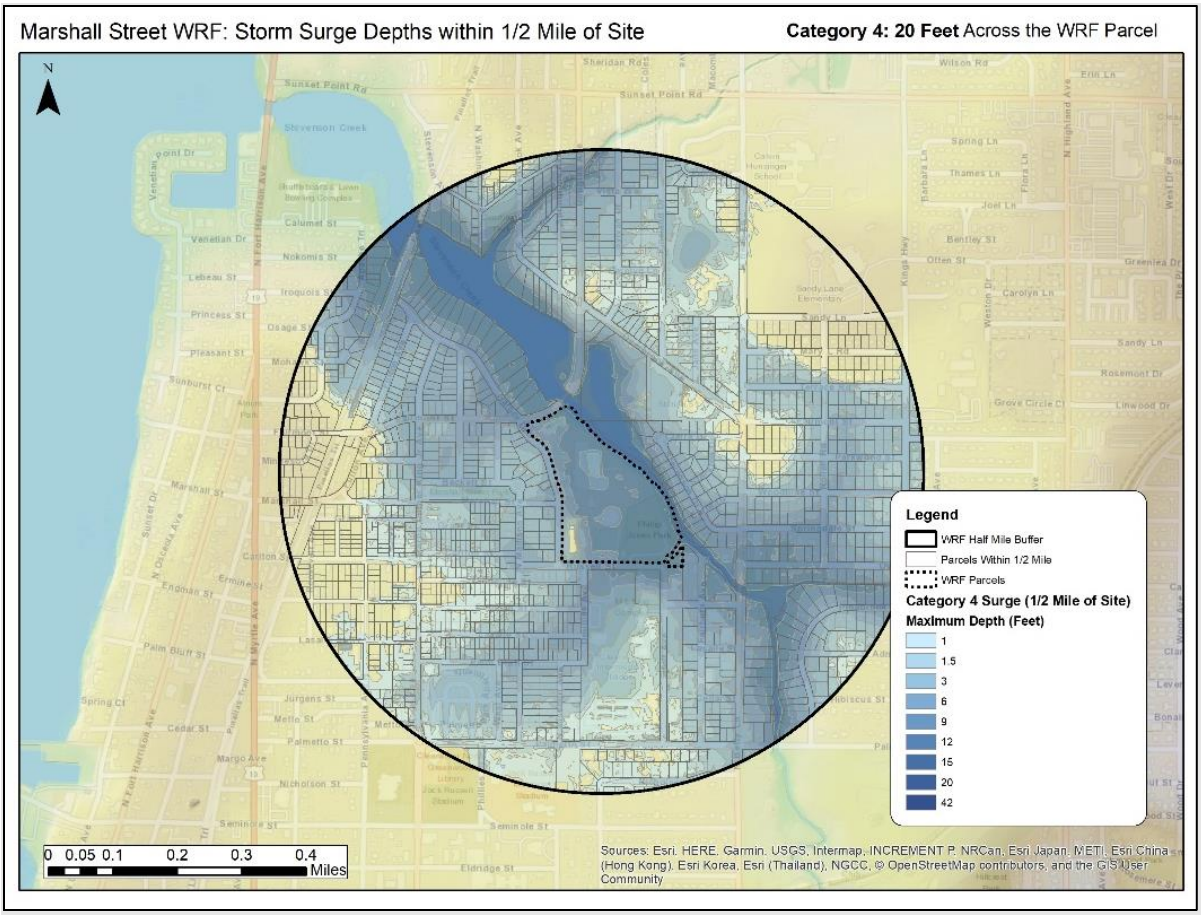


Figure 2-25 - Estimated Maximum Depths of Inundation from a Category 4 Hurricane Storm Surge to Marshall Street WRF (1/2 Mile Radius of Site)

ATKINS
Member of the SNC-Lavalin Group

Category 5

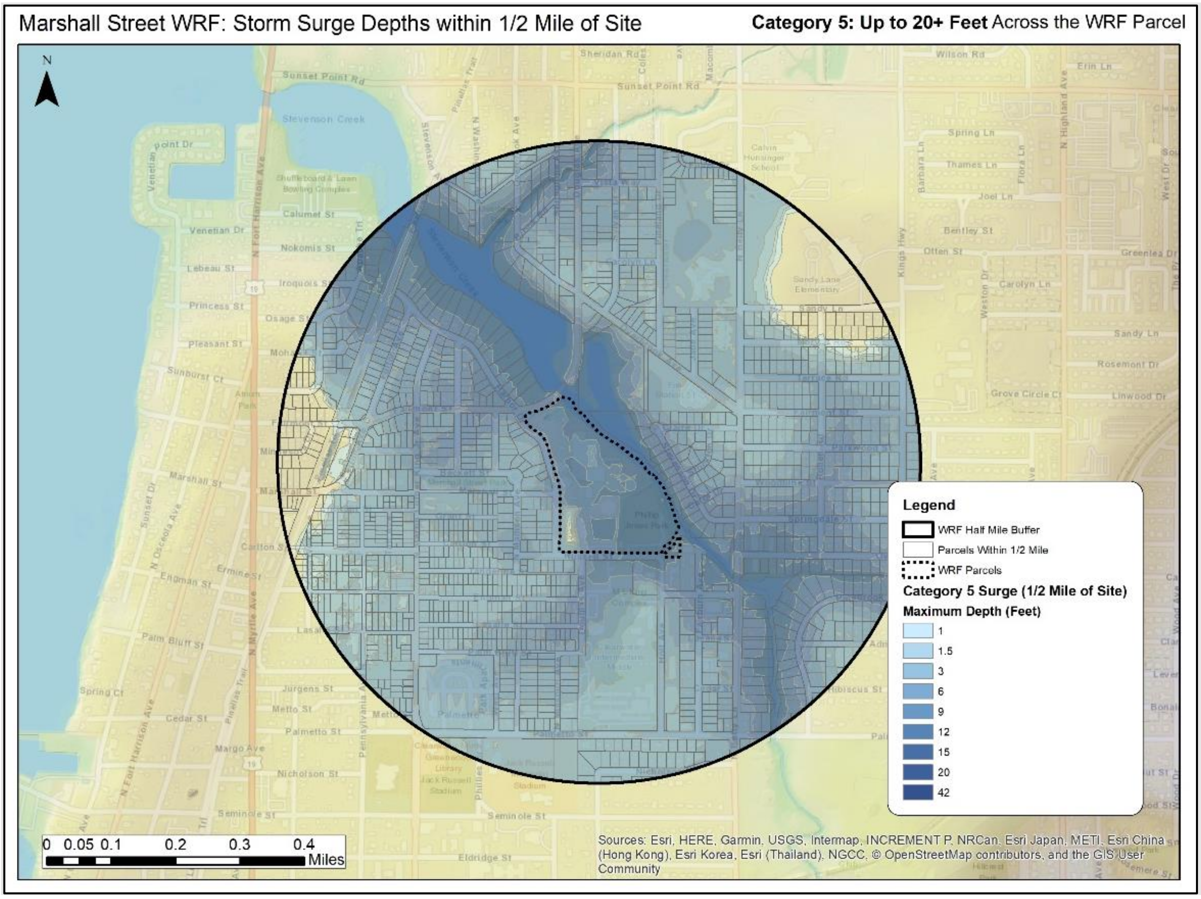


Figure 2-26 - Estimated Maximum Depths of Inundation from a Category 5 Hurricane Storm Surge to Marshall Street WRF (1/2 Mile Radius of Site)

2.4.4.2. East WRF

Category 1

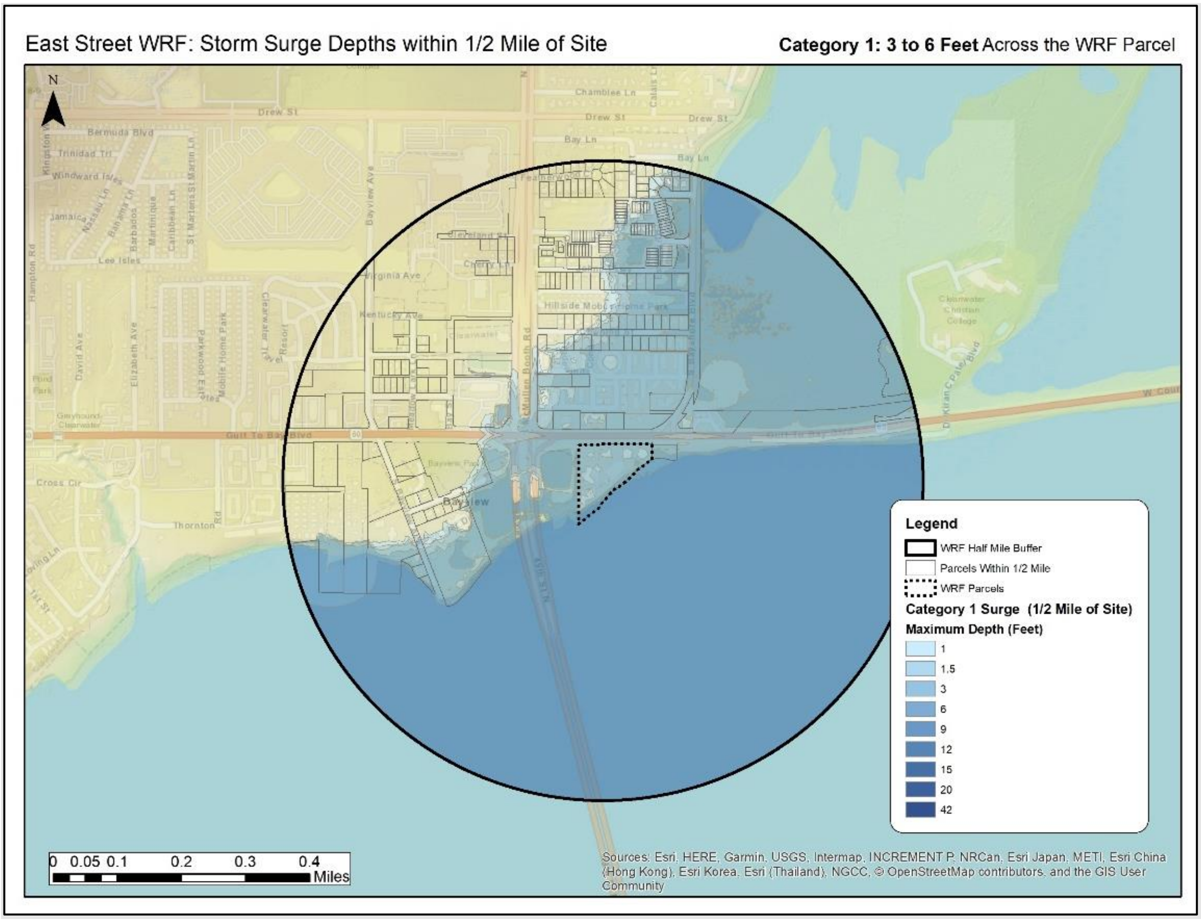


Figure 2-27 - Estimated Maximum Depths of Inundation from a Category 1 Hurricane Storm Surge to East WRF (1/2 Mile Radius of Site)

Category 2

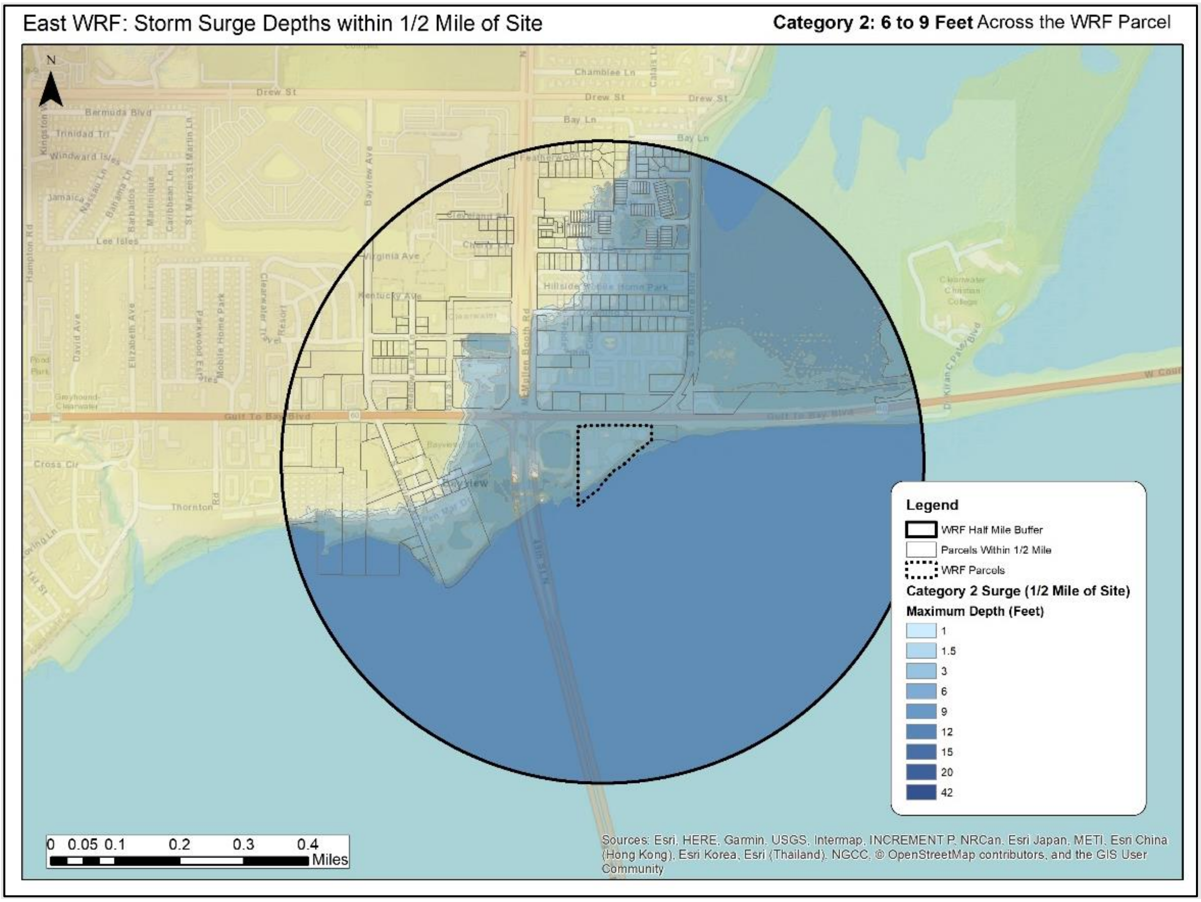


Figure 2-28 - Estimated Maximum Depths of Inundation from a Category 2 Hurricane Storm Surge to East WRF (1/2 Mile Radius of Site)

Category 3

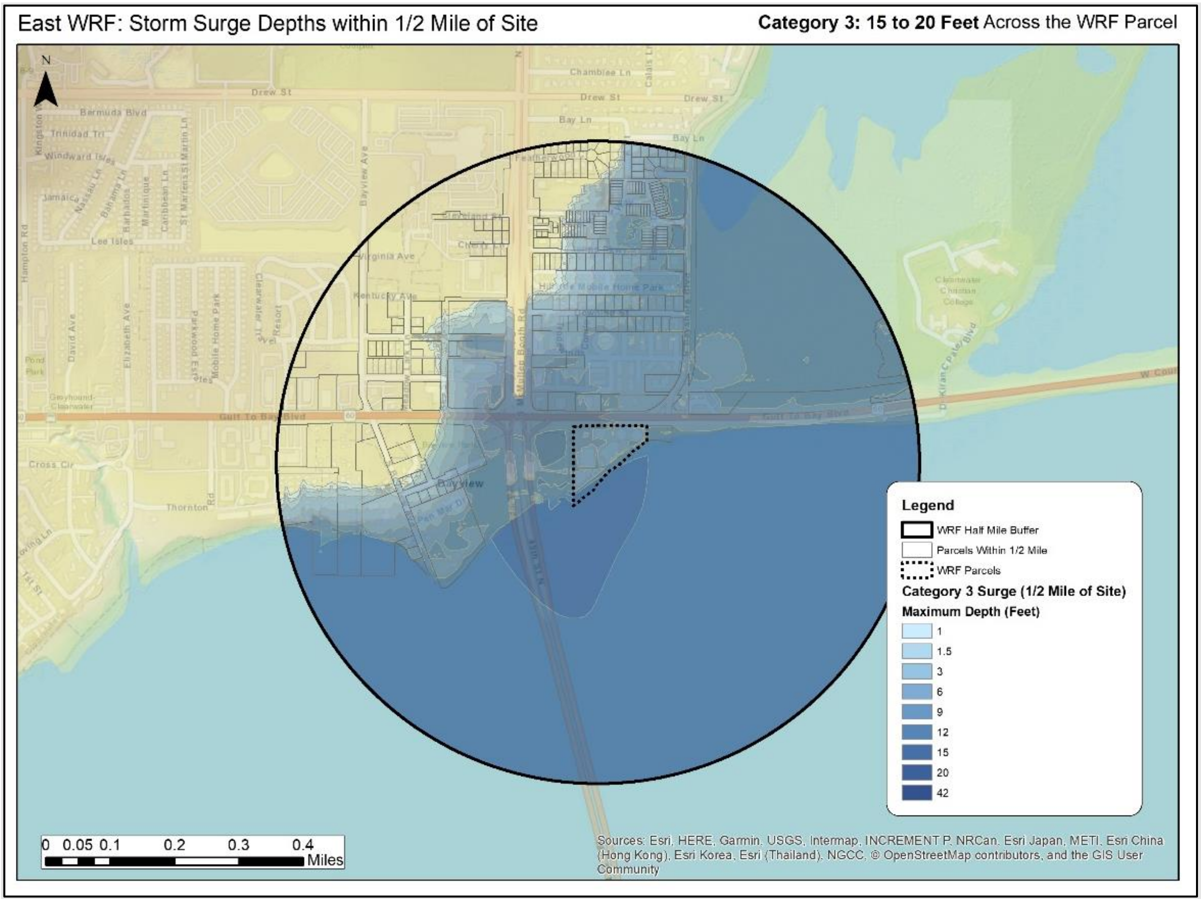


Figure 2-29 - Estimated Maximum Depths of Inundation from a Category 3 Hurricane Storm Surge to East WRF (1/2 Mile Radius of Site)

Category 4

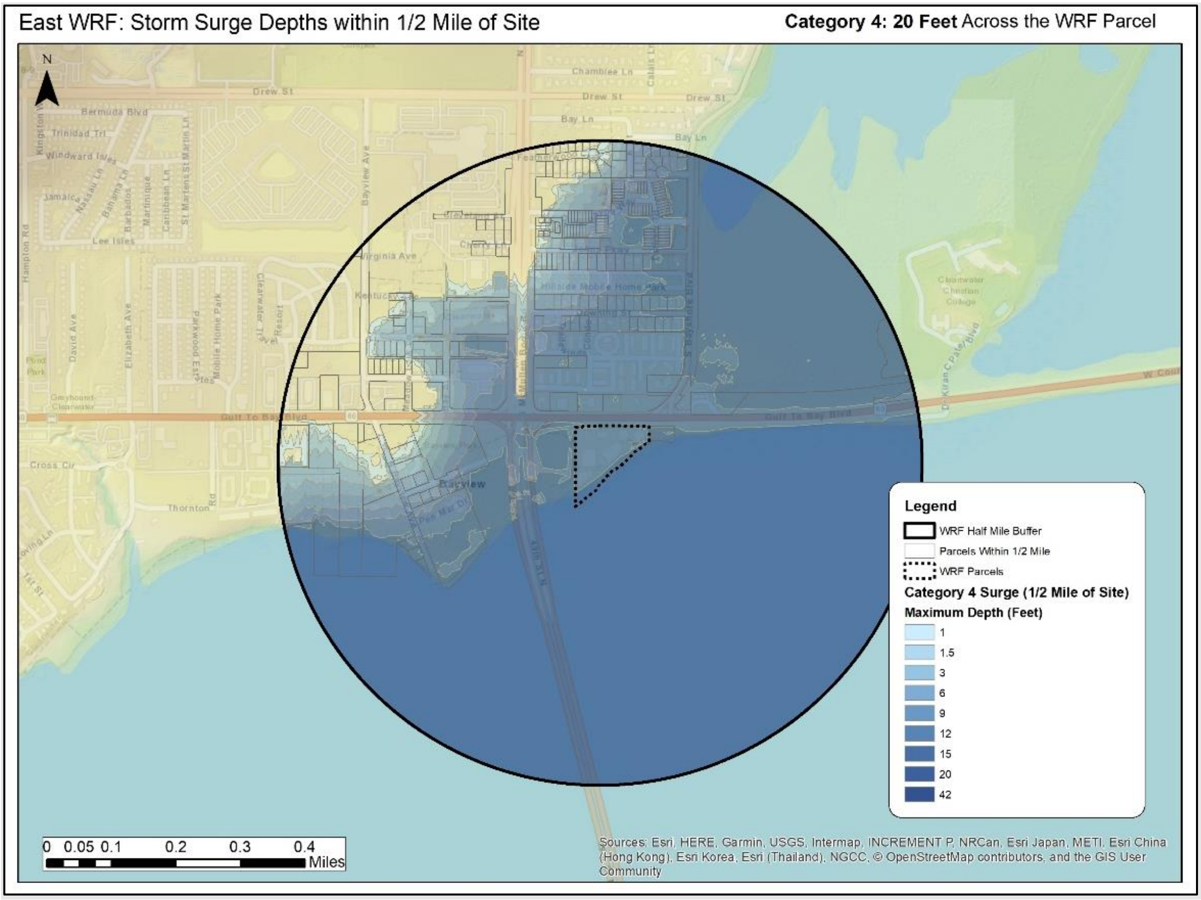


Figure 2-30 - Estimated Maximum Depths of Inundation from a Category 4 Hurricane Storm Surge to East WRF (1/2 Mile Radius of Site)

Category 5

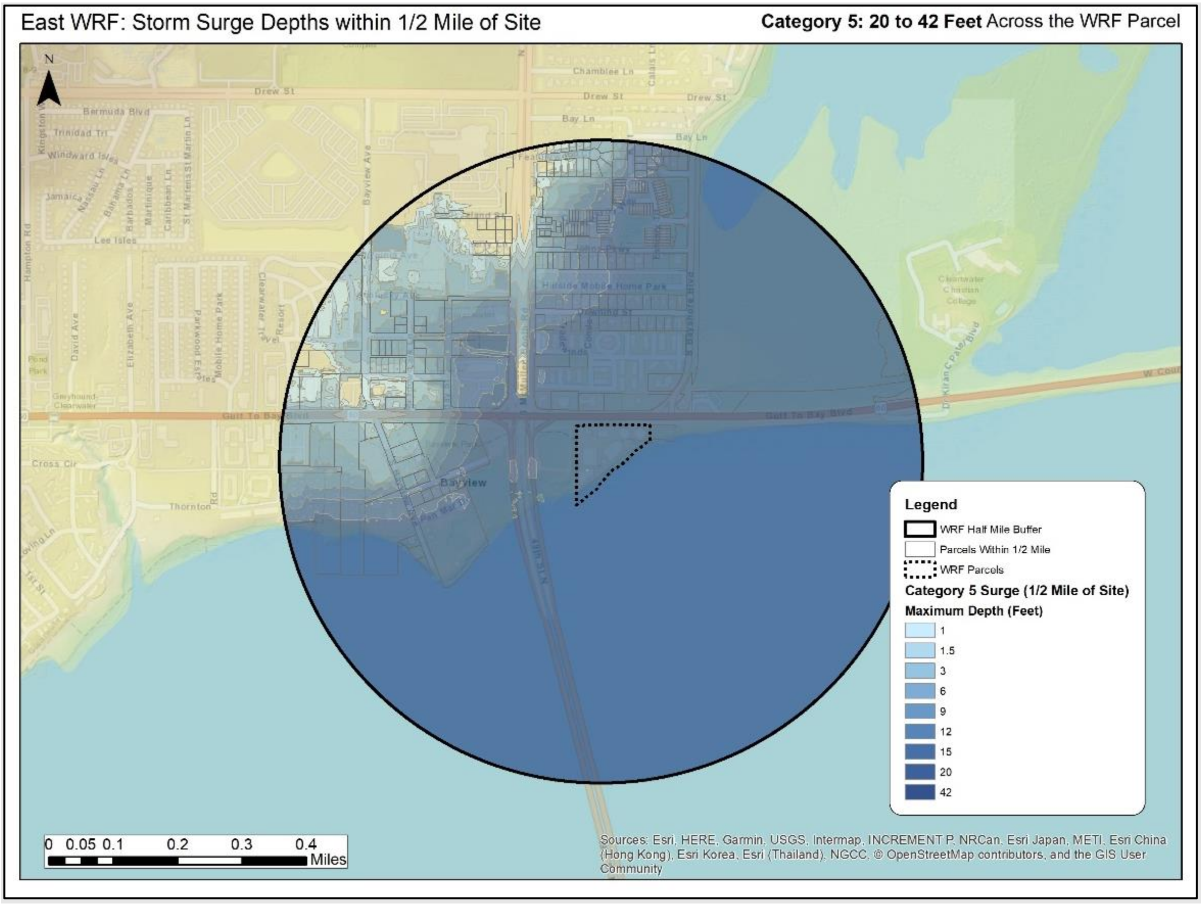


Figure 2-31 - Estimated Maximum Depths of Inundation from a Category 5 Hurricane Storm Surge to East WRF (1/2 Mile Radius of Site)

2.4.4.3. Northeast WRF

Category 1

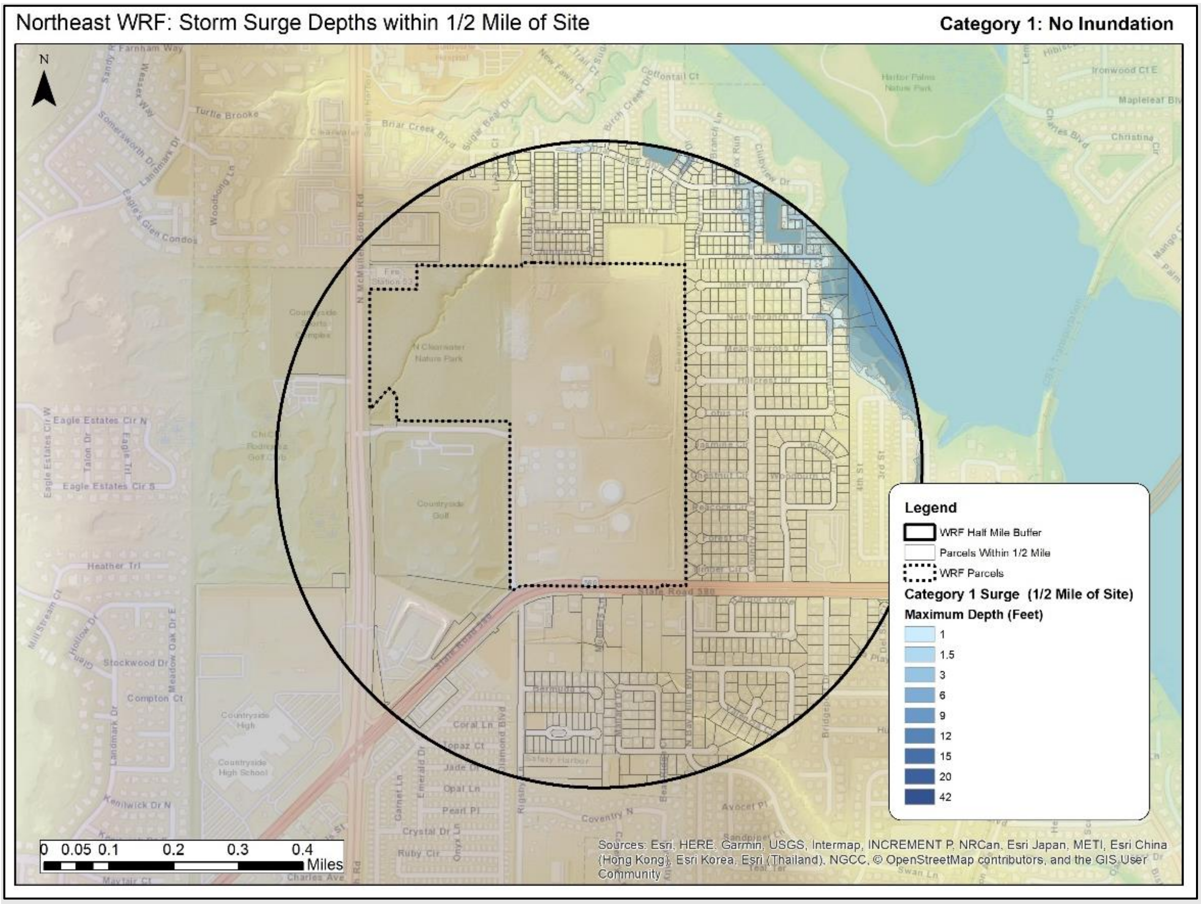


Figure 2-32 - Estimated Maximum Depths of Inundation from a Category 1 Hurricane Storm Surge to Northeast WRF (1/2 Mile Radius of Site)

Category 2

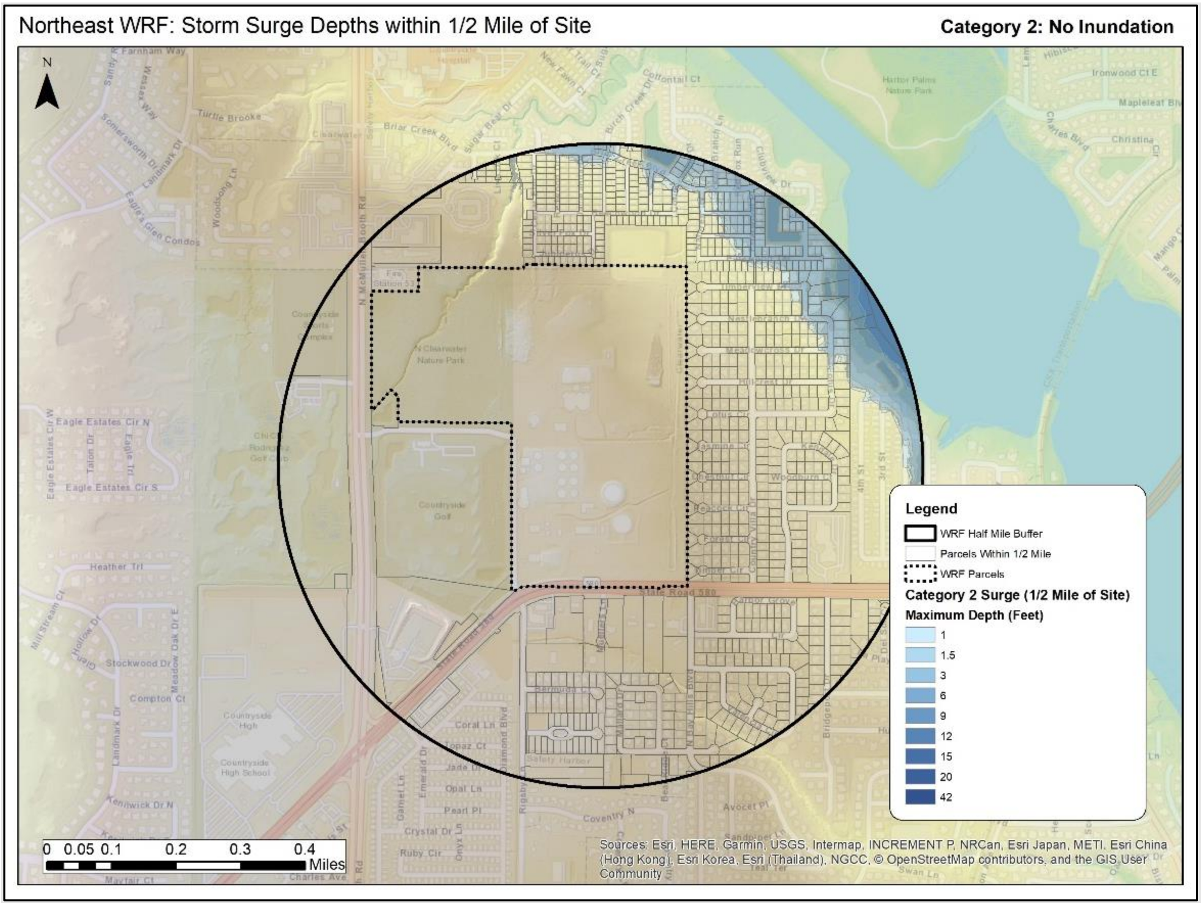


Figure 2-33 - Estimated Maximum Depths of Inundation from a Category 2 Hurricane Storm Surge to Northeast WRF (1/2 Mile Radius of Site)

Category 3

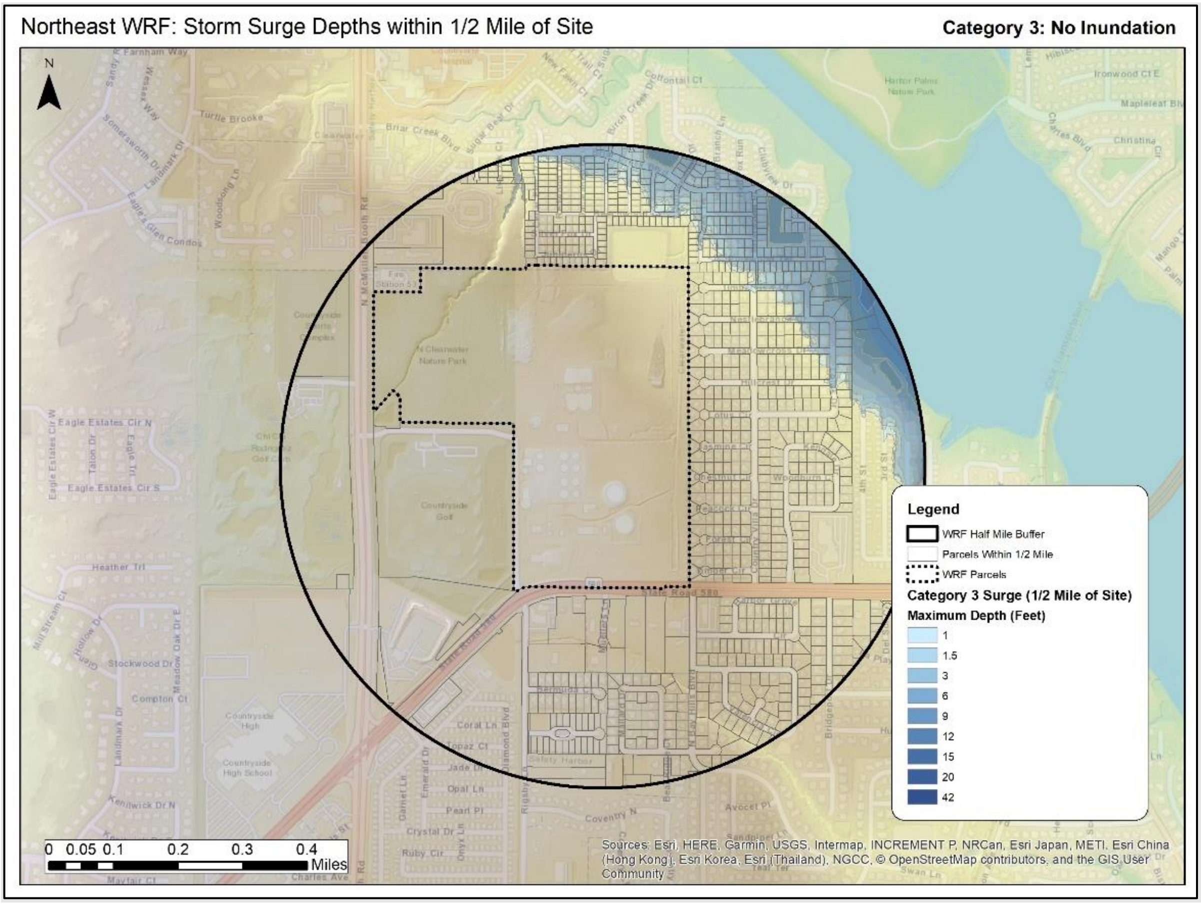


Figure 2-34 - Estimated Maximum Depths of Inundation from a Category 3 Hurricane Storm Surge to Northeast WRF (1/2 Mile Radius of Site)

Category 4

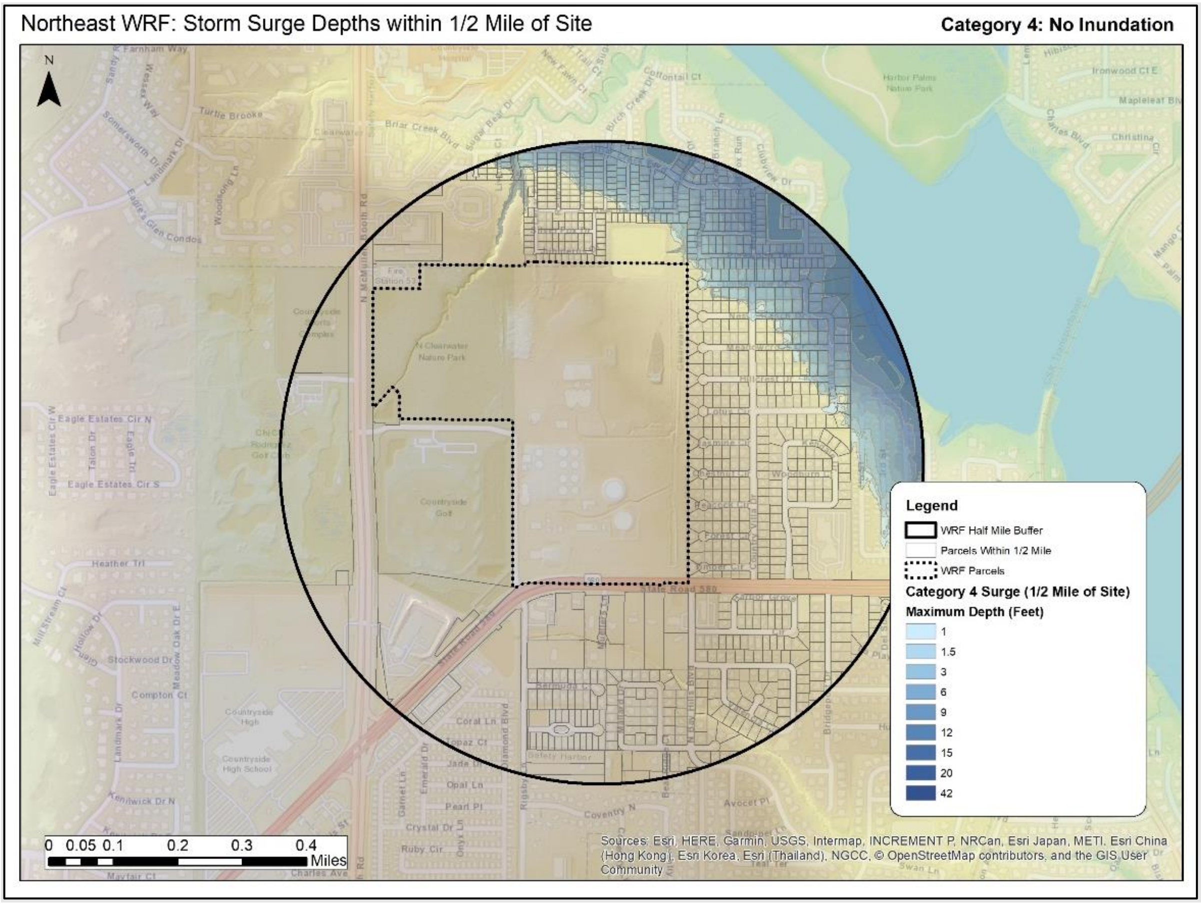


Figure 2-35 - Estimated Maximum Depths of Inundation from a Category 4 Hurricane Storm Surge to Northeast WRF (1/2 Mile Radius of Site)

Category 5

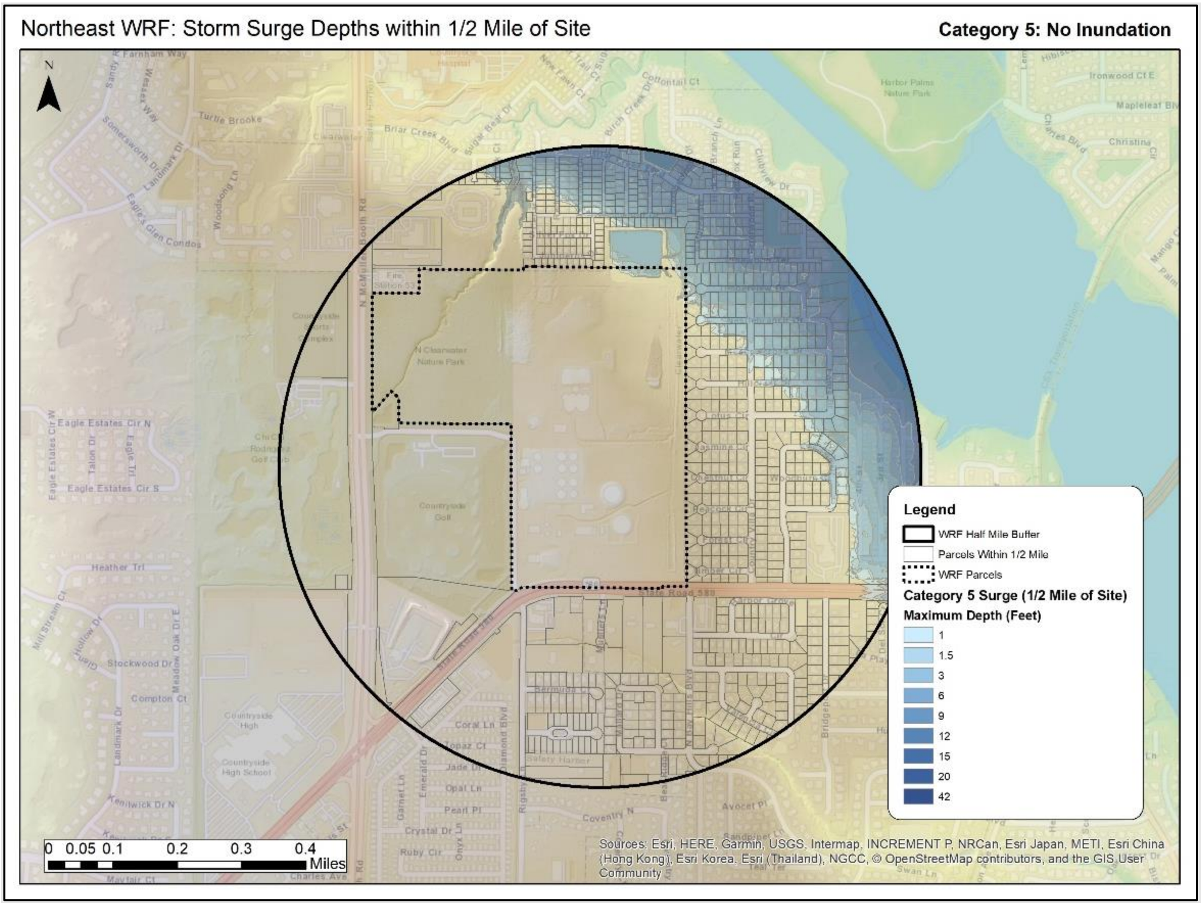


Figure 2-36 - Estimated Maximum Depths of Inundation from a Category 5 Hurricane Storm Surge to Northeast WRF (1/2 Mile Radius of Site)

2.4.5. Mitigation and Adaptation Strategies Development

After evaluating potential exposures to hazards and the resulting vulnerabilities, it is necessary to develop potential mitigation or adaptation strategy options for enhancing the WRFs' resilience to climate variability and coastal hazards.

The information provided below is intended to support the City with making decisions regarding investing in resiliency improvements at an existing WRF vs. relocating or consolidating WRFs. The outputs of this section are intended to provide high-level planning considerations for each site relative to its (primarily) flood exposures. When utilized in coordination with other aspects of the master planning process, it should help the City when considering:

- Costs and benefits of any resilience actions compared as part of consolidation or relocation actions.
- Timeline of expected threat of flooding and the required upgrades to aging infrastructure components.
- Conceptual level ranges of costs for constructing and maintaining protective infrastructure.
- Lessening the response and recovery requirements following a disaster and applying lessons learned for future similar situations.

2.4.5.1. General Options for Mitigation and Resilience for Water Treatment/reclamation Facilities

Many WRFs are located along water bodies in areas vulnerable to potential flooding, similar to what has been identified with Marshall Street and the East WRF. The US Environmental Protection Agency (EPA) has provided a starting point for reviewing resilience opportunities. Communities that look to improve the resilience of these sites tend to focus on two key areas; power and pumps:

- Power Supply
  - Emergency generators
  - Elevation of critical electrical components
  - Agreements with suppliers to fuel generators
  - Procuring vehicles to obtain/distribute fuel

- Pumps
  - Replace with submersible pumps
  - Increase capacity for sump pump
  - Install watertight doors and temporary (or permanent) berms for waterproofing

Other elements of the facilities (or assets that relate to the facilities) also have susceptibility to impacts from potential flooding and include:

- Piping
  - Need to mitigate inflow and infiltration with options like lining of the collection system and assessment of manholes
  - Potential insulation

More significant considerations could include relocating East and/or the Marshall Street facilities as both sites are susceptible to flooding from storm surge and 100-yr events (exacerbated further with increased sea level rise expected at the shoreline).

The EPA has developed a tool called CREAT (Climate Resilience Evaluation and Awareness Tool[3]) which has been designed to help drinking water, wastewater, and stormwater utility owners and operators understand and adapt to climate change risks. The CREAT tool is referenced in this first technical memo but will be evaluated for use in a future task of this project once the consolidation scenarios have been determined. Chapter 6 of the guidance document focuses on adaptation planning and includes some recommendations for consideration by

[3] For more information, visit Climate Resilience Evaluation and Awareness Tool Version 3.1 Methodology Guide (epa.gov)

the City. Another helpful resource within the tool is a set of default unit costs for adaptation measures. These Default unit-cost values for each measure were developed using data from publicly available sources, such as EPA, the Federal Emergency Management Agency and RSMeans, including available case-study reports for projects implemented at utilities. If local cost information is available from the City, those could be utilized in lieu of the default ranges. The following table shows the default costs per the tool.

Table 2-3 - Unit Costs for Adaptive Measures per US EPA CREAT Tool

Adaptive Measure	Default Unit-Cost Range
Construct	
Back-up power	$250 to $800 per kilowatt of capacity
Levee	$80 to $220 per linear foot
Low-head dam	$3,411 to $29,333 per linear foot
Sea wall	$350 to $760 per linear foot
Temporary flood barrier	$63 to $750 per linear foot
Ecosystem / Land Use	
Erosion and sediment control	$12 to $1750 per linear foot
Fire management	$660 to $1,500 per acre treated
Wetlands for flood protection	$4,700 to $154,300 per acre-foot of stormwater captured
Green infrastructure	
Bioretention facilities	$7 to $26 per square foot of bioretention infrastructure
Green roofs	$8 to $40 per square foot of green roof
Permeable pavement	$10 to $22 per square foot of permeable pavement
New Supplies and Demand Management	
Demand management	$465 to $980 per acre-foot
Desalination - inland	$375 to $1,290 per acre-foot
Desalination - seawater	$1,600 to $3,250 per acre-foot
Groundwater / aquifer recharge with possible conjunctive use	$90 to $1,100 per acre-foot
Increased storage	$0.005 to $4 per gallon of storage
Interconnections	$95 to $1,250 per linear foot
Municipal water reuse system - nonpotable	$300 to $2,000 per acre-foot
Municipal water reuse system – potable	$800 to $2,000 per acre-foot
Rainwater collection / use - rain barrels	$70 to $300 per residential rain barrel system (or household)
Repair/Retrofit	
Altered treatment – total dissolved solids	$2.7M to $3.8M per MGD
Distributed treatment	$600,000 to $10.4M per MGD
Infiltration reduction	$1,000 to $5,000 per number of laterals
Leakage reduction	$100 to $200 per acre-foot
Retrofit intakes	$450,000 to $3.1M per MGD
Retrofit intakes – Invasive species	$18,000 to $76,000 per MGD
Silt removal	$5 to $20 per cubic yard
Sewage separation	$240 to $300 per linear feet of pipe being separated

Ideally, within the tool, the potential mitigation measures are assigned a threat relevance value since the site may be exposed to different flood or climate hazards to which the measure may or may not be applicable. This feature would serve as an initial filter for sorting through options that can then be evaluated based on more relevant criteria.

2.4.5.2. Marshall Street WRF Overview

The Marshall Street WRF is exposed to many of the current and future flood scenarios expected to occur. The table below presents a summary of the impacts after walking the site, capturing elevations of critical equipment, and evaluating potential inundation scenarios. Backup material to this project includes spreadsheets that identify each piece of critical equipment, its elevation, its potential depth of inundation per flood scenario, and its priority for mitigation (low, medium, and high).

Table 2-4 - Marshall Street WRF - Localized Flooding

	Current FEMA and Pinellas Vulnerability Assessment		
Marshall Street WRF	**100yr FEMA (2021)**	**100yr Pinellas Vulnerability Study (2018 base)**	**500yr Pinellas Vulnerability Study (2018 base)**
Count of equipment potentially flooded	35	36	97
Percent of all equipment flooded	34%	35%	94%
Average depth that flooded equipment is inundated (feet) per each scenario	1.58	3.44	3.55

Table 2-5 - Marshall Street WRF - Storm Surge Flooding

	NHC Storm Surge				
Marshall Street WRF	**Category 1 Storm Surge**	**Category 2 Storm Surge**	**Category 3 Storm Surge**	**Category 4 Storm Surge**	**Category 5 Storm Surge**
Count of equipment potentially flooded	37	99	100	100	100
Percent of all equipment flooded	36%	96%	97%	97%	97%
Average depth that flooded equipment is inundated (feet) per each scenario	4.44	4.48	10.43	15.43	37.43

Table 2-6 - Marshall Street WRF - SLR and Future 100-Year Flooding Conditions

	Future Conditions		
Marshall Street WRF	**SLR 2040 High (MHHW/528HPY Depth)**	**SLR 2070 Intermediate (MHHW/528HPY Depth)**	**100yr Pinellas Vulnerability Study (2070)**
Count of equipment potentially flooded	0	0	93
Percent of all equipment flooded	0%	0%	90%
Average depth that flooded equipment is inundated (feet) per each scenario	0.00	0.00	2.67

Many of the potential depths of inundation exceed feasible measures/costs to mitigate the equipment without significant investment and possibly redesign of the site. For instance, many of the structures have equipment already elevated to a level a couple feet below the existing ceiling height of the structure housing it. To elevate the equipment higher would require a thorough retrofit of the building. Similarly, the potential depths of flood waters, particularly for anything at a Category 2 hurricane storm surge or higher, could inundate buildings to levels that would impact venting and other required openings. Thus, waterproofing the doors or other armoring alone would likely not be feasible.

Site specific recommendations include:

Recommended actions for this site will be based on protecting equipment against the FEMA 100-year flood event plus 30 inches of sea level rise. Due to their extremity, storm surges associated with Category 2 or more hurricanes, would overwhelm any of the recommended adaptation strategies. The most vulnerable location on this site, due to its elevation, is the Control Building. The first floor of the building sits at elevation 7.00. The majority of electrical equipment mounted on the walls in the main room is located near the floor elevation. Raising any equipment that is near floor level in this location is not recommendable, as it would have to be raised several feet to place it above the level of potential submergence. Although the main room of the building has ample headroom, this would also put the equipment out of reach of operators and would not be amenable to easy operation or maintenance. For many of the electric pieces of equipment in other parts of the building, the lack of available headspace makes raising it not feasible. The building has previously been fitted with flood walls around the perimeter of the building. The flood walls extend to elevation 12.00. This was apparently the selected flood protection elevation, as the 3 blowers located at the center of the main room are installed with their base at approximately elevation 12.00. Extending the existing flood walls to above the identified flood threat level, as well as installing flood barriers at exterior openings to block flood pathways and sealing specific rooms with critical equipment is the recommended strategy for this building. The most critical piece of equipment in this building is the emergency generator located in the alum storage room. The base of the generator sits at approximately elevation 9.00. which means, going by the flood threat level of 13.40 the generator would see a 4.4 foot submergence.

The other critically vulnerable structure on site is the influent pump station with the main sewage pumps, located in a lower floor well below grade, the pumps’ electric motors, also located below grade and the associated Motor Control Center (MCC)located on the first floor. The building in its entirety, however, will be replaced in the next few years with a new pump station to be located on the site of a recently demolished digester tank. Here, the recommendable strategy for the new pump station is installing submersible pumps with submersible motors and locating MCCs and other critical electrical equipment above the flood threat elevation.

2.4.5.3. East WRF Overview

The East WRF is exposed to many of the current and future flood scenarios expected to occur. The table below highlights the concerns after walking the site, capturing elevations of critical equipment, and evaluating potential inundation scenarios. Backup material to this project includes spreadsheets that identify each piece of critical equipment, its elevation, its potential depth of inundation per flood scenario, and its priority for mitigation (low, medium, and high).

Table 2-7 - East WRF - Localized Flooding

	Current FEMA and Pinellas Vulnerability Assessment		
East WRF	**100yr FEMA (2021)**	**100yr Pinellas Vulnerability Study (2018 base)**	**500yr Pinellas Vulnerability Study (2018 base)**
Count of equipment potentially flooded	54	39	68
Percent of all equipment flooded	78%	57%	99%
Average depth that flooded equipment is inundated (feet) per each scenario	3.26	2.43	4.45

Table 2-8 - East WRF - Storm Surge Flooding

	NHC Storm Surge				
East WRF	Category 1 Storm Surge	Category 2 Storm Surge	Category 3 Storm Surge	Category 4 Storm Surge	Category 5 Storm Surge
Count of equipment potentially flooded	54	68	69	69	69
Percent of all equipment flooded	78%	99%	100%	100%	100%
Average depth that flooded equipment is inundated (feet) per each scenario	3.26	5.45	16.36	16.36	38.36

Table 2-9 - East WRF - SLR and Future 100-Year Flooding Conditions

	Future Conditions		
East WRF	**SLR 2040 High (MHHW/528HPY Depth)**	**SLR 2070 Intermediate (MHHW/528HPY Depth)**	**100yr Pinellas Vulnerability Study (2070)**
Count of equipment potentially flooded	0	0	62
Percent of all equipment flooded	0%	0%	90%
Average depth that flooded equipment is inundated (feet) per each scenario	0.00	0.00	3.81

Many of the potential depths of inundation exceed feasible measures/costs to mitigate the equipment without significant investment and possibly redesign of the site. For instance, many of the structures have equipment already elevated to a level a couple feet below the existing ceiling height of the structure housing it. To elevate the equipment higher would require a thorough retrofit of the building. Similarly, the potential depths of flood waters, particularly for anything at a Category 2 hurricane storm surge or higher, could inundate buildings to levels that would impact venting and other required openings. Thus, waterproofing the doors or other armoring alone would likely not be feasible.

Site specific recommendations include:

Recommended actions for this site will be based on protecting equipment against the FEMA 100-year flood event plus 30 inches of sea level rise. Due to their extremity, storm surges associated with Category 2 or more hurricanes, would overwhelm any of the commended adaptation strategies.

The most critical function at the facility is to maintain wastewater moving through the system. Equipment that pumps the wastewater through the facility is rated the most critical, followed by electrical and control equipment that supports this function. The influent pumping station, the internal recycle pump station (Archimedes screw pumps), the filter pump station, the filters themselves and the filter backwash pumps are considered the most critical components.

The headworks equipment, which functions to remove grit and other solid material (screenings), are not critical for keeping the flow of water moving through the facility. However, the screens will need to be maintained in functional condition or monitored and clean manually if needed to keep them from blinding and possibly overflowing the screen channels.

The influent pump station is already fitted with submersible pumps. The pumps themselves are not vulnerable to flooding damage. The wet well hatches at grade level are not watertight and could allow flood water to enter the wet well and mix in with the wastewater flow, causing both an increased flow to be handled by the pump station and potentially, contamination from mixing of the flood water with the wastewater. To address this, the existing floor hatches above the wet well should be replaced with watertight hatches.

The Internal recycle pump station is not vulnerable to flooding damage. The motors for the screw pumps are located at the top of the structure, as well as the pump control panels. No mitigation action is needed.

The filter pump station was reported during the site visit to be scheduled to be redesigned and reconstructed. For future construction, the same recommendation regarding watertight hatches applies to the filter pump station.

The other piece of critical equipment to point out is the emergency generator. The existing generator is located at an elevation above the flood threat elevation, and no action is required.

2.4.5.4. Northeast WRF Overview

As the site is not directly exposed to flood hazards from any of the scenarios identified, there are limited recommendations for the Northeast WRF. The site is located within the Possum Branch watershed and the watershed master plan has not been updated in some time. An update may reveal some localized flood potential to the site that is not currently identified. Other climate considerations, such as temperature extremes (hot and cold) could require retrofits to pipes. The more challenging temperature concern may be the ability for workers to operate outside for long periods of time due to extreme heat. Appendix B's Urban Heat Island Impacts provides relative heat exposure maps for all three sites.

2.4.5.5. Mitigation and Adaptation Strategies Summary

The information provided should help the City with making decisions regarding investing in resiliency improvements at an existing WRF vs. relocating or consolidating WRFs.

Costs and benefits of any resilience actions should be integrated as cost factors within the larger assessment of consolidation or relocation actions. Appendix A provides detailed assessment of each significant piece of equipment (estimated replacement cost, priority for mitigation, impact of failure of the equipment) within the East and Marshall Street WRF's that are exposed to flood hazards. The Northeast WRF does not have any noteworthy exposure to flood hazards and is thus not assessed at the same level as the others.

The timeline of expected threat of flooding includes immediate risks. Although this report is future looking, many of the surge hazards are present today, particularly for a worst-case Category 2 or higher hurricane. The tidal impacts of the sea level rise scenarios over the next 30 to 50 years indicate that those vulnerabilities remain contained to the shoreline when evaluated by themselves. However, those conditions will exacerbate flood exposures in combination with storm surge events and may impact future flows when evaluating the entire system; not just the inside-the-fence evaluations of the WRFs themselves.

City staff have not indicated many instances of WRF failures due to flooding in the past. Minor events have resulted in some of the equipment being relocated or elevated onsite but documentation for any operational impacts was not available for this assessment. It is still recommended to have documentation of impacts captured to improve any future responses to flood events.

During the development of this document, six consolidation scenarios were provided to Atkins with the intent of determining a relative scoring of the alternatives with climate vulnerability factors included.

The 6 scenarios were as shown below:

Table 2-10 - WRF Consolidation Scenarios

Scenario Number	Scenario Name	Description	Total # of WRFs	Score 1 = Least Favorable 3 = Most Favorable	Justification for Score
1	Maintain Existing WRFs (Baseline Scenario)	No consolidation. Maintain as three separate WRFs.	3	1	Keeps EWRF and MSWRF in flood-prone locations
2	All at NEWRF	Complete consolidation. Consolidate all MSWRF and EWRF flow to NEWRF.	1	3	Removes EWRF and MSWRF flood concerns
3	MSWRF to NEWRF	Partial consolidation. Consolidate by directing all MSWRF flow to NEWRF. Maintain EWRF as-is.	2	2	Keeps EWRF in flood-prone location
4	EWRF to NEWRF	Partial consolidation. Consolidate by directing all EWRF flow to NEWRF. Maintain MSWRF as-is.	2	2	Keeps MSWRF in flood-prone location
5	MSWRF+EWRF to New WRF	Partial consolidation. Consolidate by directing all MSWRF and EWRF flow to a new WRF. Maintain NEWRF as-is.	2	3	Removes EWRF and MSWRF flood concerns
6	All at New Regional WRF	Complete consolidation. Divert all flow from all three WRFs to a new facility at a location that is not one of the existing WRFs.	1	3	Removes EWRF and MSWRF flood concerns

The scenarios were to be scored as:

- Score of 1 – Lowest Score/Least Favorable: Potential for significant impacts by climate hazards: flood events, sea level rise, storm surge
- Score of 2: Potential for some impacts by climate hazards: flood events, sea level rise, storm surge
- Score of 3 – Highest Score/Most Favorable: Low potential for significant impacts by climate hazards: flood events, sea level rise, storm surge

Atkins' scoring of the consolidation scenarios is noted here:

Scenarios 2, 5, and 6 score as 3 since they eliminate the major flood concerns at both EWRF and MSWRF. Scenarios 3 and 4 score a 2 as they mitigate some of the overall vulnerability. Scenario 1 scores a 1 as it keeps both flood prone WRFs intact, EWRF and MSWRF. While MSWRF has less flood exposure than EWRF, the difference is minimal and both plants have potential to be inundated in most flood scenarios.

Once the final consolidation scenario is selected, additional analysis of both inside-the-fence and systemwide climate considerations for sustainability and resilience should be performed to incorporate elements of the full master-planning process.

Appendices

Appendix A. Facility Level Equipment Assessment

The following pages provide a detailed assessment of each piece of equipment that was reviewed for both the Marshall Street and East Water Reclamation Facilities. As the Northeast WRF does not have any documented flood risk to the events evaluated, its equipment was not evaluated at this level of detail. Within each assessment, the following items are identified:

Attribute	Value
Facility	Name of the WRF
Building/ Area	Specific location within the WRF
Asset/ Operation	Equipment/operation evaluated
Measured Height of Asset Above Floor (ft)	Feet above the finished floor elevation
Finished Floor Elevation (ft)	Floor elevation provided by record drawings
Elevation of Asset (ft)	Addition of the two elements above (finished floor and heigh above floor)
Elevation of Flood Threat (ft)	A site-specific measure that is essentially the FEMA 100-year elevation plus 30 inches
100yr FEMA 2021	The August 2021 FEMA FIRM map elevation for the 100-year (1% annual chance) flood event
100yr Pinellas Vulnerability Study (2018 base)	100-year (1% annual chance) flood event from the Pinellas County flood vulnerability assessment (finalized in 2021/2022)
500yr Pinellas Vulnerability Study (2018 base)	500-year (0.2% annual chance) flood event from the Pinellas County flood vulnerability assessment (finalized in 2021/2022)
Category 1 Storm Surge	Category 1 storm surge elevation ranges (provided by the Tampa Bay Regional Planning Council and Pinellas County Emergency Management. Height represents the upper bound for worst case event.
Category 2 Storm Surge	Category 2 storm surge elevation ranges
Category 3 Storm Surge	Category 3 storm surge elevation ranges
Category 4 Storm Surge	Category 4 storm surge elevation ranges
Category 5 Storm Surge	Category 5 storm surge elevation ranges
SLR 2040 High (MHHW/528HPY Depth)	A future condition as provided from the Pinellas County flood vulnerability assessment. The 528 hour per year (HPY) depth is representative of the expected Mean Higher High Water at the time frame under a High scenario.
SLR 2070 Intermediate (MHHW/528HPY Depth)	A future condition as provided from the Pinellas County flood vulnerability assessment. The 528 hour per year (HPY) depth is representative of the expected Mean Higher High Water at the time frame under an Intermediate scenario.
100yr Pinellas Vulnerability Study (2070)	A future condition as provided from the Pinellas County flood vulnerability assessment that combines future tidal estimate with 100-year flood event.
Replacement Cost for Asset	An estimate of the cost to replace the asset.
Impact to Facility Operations from Asset Failure	Brief description of the consequence for the asset not being able to function properly
Low Priority for Mitigation	Least important to overall site functionality
Moderate Priority for Mitigation	Somewhat critical to operation
High Priority for Mitigation	Critical to operation of the facility being able to function properly.
Other notes	General notes or items needing further information

Vulnerability							Potential Depth (Feet) of Flooding Per Scenario											Consequences		Priority for Mitigation			Adaptation	
Facility	Building/ Area	Asset/ Operation	Measured Height of Asset Above Floor (ft)	Finished Floor Elevation (ft)	Elevation of Asset (ft)	Ground	100yr FEMA 2021	100yr Pinellas Vulnerability Study (2018 base)	500yr Pinellas Vulnerability Study (2018 base)	Category 1 Storm Surge	Category 2 Storm Surge	Category 3 Storm Surge	Category 4 Storm Surge	Category 5 Storm Surge	SLR 2040 High (MHHW/ 528HPY Depth)	SLR 2070 Intermediate (MHHW/ 528HPY Depth)	100yr Pinellas Vulnerability Study (2070)	Approximate Replacement Cost for Asset	Impact to Facility Operations from Asset Failure	Low	Moderate	High	Recommended Action	Other notes
Marshall Street WRF	Chemical Building	Storage Tank	0.75	12	12.75		-3.75	-1.85	1.25	-0.75	2.25	8.25	13.25	35.25	-3.75	-3.75	0.25	$ -	Dislodged/Spill				No action needed	Equipped with tie-downs
Marshall Street WRF	Chemical Building	Storage Tank	0.75	12	12.75		-3.75	-1.85	1.25	-0.75	2.25	8.25	13.25	35.25	-3.75	-3.75	0.25	$ -	Dislodged/Spill				No action needed	Equipped with tie-downs
Marshall Street WRF	Chemical Building	Storage Tank	0.75	12	12.75		-3.75	-1.85	1.25	-0.75	2.25	8.25	13.25	35.25	-3.75	-3.75	0.25	$ 7,000.00	Dislodged/Spill		✓		Tie-Downs	
Marshall Street WRF	Chemical Building	Storage Tank	0.75	12	12.75		-3.75	-1.85	1.25	-0.75	2.25	8.25	13.25	35.25	-3.75	-3.75	0.25	$ 7,000.00	Dislodged/Spill		✓		Tie-Downs	
Marshall Street WRF	Chemical Building	Storage Tank	0.75	12	12.75		-3.75	-1.85	1.25	-0.75	2.25	8.25	13.25	35.25	-3.75	-3.75	0.25	$ 7,000.00	Dislodged/Spill		✓		Tie-Downs	
Marshall Street WRF	Chemical Building	3 67.6 gph pumps		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 7,500.00	Loss of Cholrination		✓		Tie-Downs	model: kmi62P60
Marshall Street WRF	Chemical Building	2 27.2 TKM pumps		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00	Loss of Chlorination		✓		Raise Skid	model: km102p106
Marshall Street WRF	Chemical Building	2 36.7 gph pumps		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,400.00	Loss of Chlorination		✓		Raise Skid	model: km102p138
Marshall Street WRF	Chemical Building	Devicenet panel	1.25	12	13.25		-4.25	-2.35	0.75	-1.25	1.75	7.75	12.75	34.75	-4.25	-4.25	-0.25	$ 3,000.00	Electrical failure		✓		Raise Panel	
Marshall Street WRF	Chemical Building	Storage Tank	0.75	12	12.75		-3.75	-1.85	1.25	-0.75	2.25	8.25	13.25	35.25	-3.75	-3.75	0.25	$ 7,000.00	Dislodged/Spill		✓		Tie-downs	
Marshall Street WRF	Chemical Building	Storage Tank	0.75	12	12.75		-3.75	-1.85	1.25	-0.75	2.25	8.25	13.25	35.25	-3.75	-3.75	0.25	$ 7,000.00	Dislodged/Spill		✓		Tie-Downs	
Marshall Street WRF	Chemical Building	3 67.6 gph pumps		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 7,500.00	Loss of Dechlor	✓			Raise Skid	model: kmi62P60
Marshall Street WRF	Chemical Building	ROCHA control Panel		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00	Loss of Chlor/Dechlor			✓	Seal Room	
Marshall Street WRF	Chemical Building	Siemens transformer		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 2,500.00	Electrical failure			✓	Seal Room	CATALOG#: 3F3Y030ST
Marshall Street WRF	Chemical Building	Siemens transformer	0.83	12	12.83		-3.83	-1.93	1.17	-0.83	2.17	8.17	13.17	35.17	-3.83	-3.83	0.17	$ 2,000.00	Electrical failure			✓	Seal Room	CATALOG#: 1F1R015
Marshall Street WRF	N Gen building	Transformer	0.67	12	12.67		-3.67	-1.77	1.33	-0.67	2.33	8.33	13.33	35.33	-3.67	-3.67	0.33	$ 2,700.00	Electrical failure			✓	Seal Bldg/Install Flood proof Doors	9T83B3873
Marshall Street WRF	N Gen building	YASKAWA MCC		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00	Loss of Pump Operation			✓	Seal Bldg/Install Flood proof Doors	0c70x0399L01
Marshall Street WRF	Filter Complex/MCC Room	Transformer	1.25	12.33	13.58		-4.58	-2.68	0.42	-1.58	1.42	7.42	12.42	34.42	-4.58	-4.58	-0.58	$ 2,700.00	Electrical failure			✓	Seal Room/Install Flood proof Doors	outside
Marshall Street WRF	Filter Complex /MCC Room	MCC		12.33	12.33		-3.33	-1.43	1.67	-0.33	2.67	8.67	13.67	35.67	-3.33	-3.33	0.67	$ 3,000.00	Electrical failure			✓	Seal Room/Install Flood proof Doors	
Marshall Street WRF	Filter Complex	Hypo Pump/WEG motor	0.50	12	12.50		-3.50	-1.60	1.50	-0.50	2.50	8.50	13.50	35.50	-3.50	-3.50	0.50				✓		Raise Pump	Item: 11532399
Marshall Street WRF	Filter Complex	NaOCl Storage tank		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 4,000.00	Dislodged/Spill		✓		Tie-Downs	
Marshall Street WRF	Filter Complex	Husky Compressor	0.42	12	12.42		-3.42	-1.52	1.58	-0.42	2.58	8.58	13.58	35.58	-3.42	-3.42	0.58	$ 200.00		✓			Raise Compressor	3 gal, 125 p, 2.4 scfm
Marshall Street WRF	Control Building	Electric Cabinent		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 3,000.00	Electrical failure			✓	Extend Flood Walls/Install Flood Barriers at entryways	Control Building is known to flood already
Marshall Street WRF	Control Building	Transfer Switch Cabinent		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 3,000.00	Electrical failure			✓	Extend Flood Walls/Install Flood Barriers at entryways	no longer in use
Marshall Street WRF	Control Building	Transformer		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 2,700.00	Electrical failure			✓	Extend Flood Walls/Install Flood Barriers at entryways	Square D Company
Marshall Street WRF	Control Building	Wall transformer		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 2,000.00	Electrical failure			✓	Extend Flood Walls/Install Flood Barriers at entryways	PNL-LP-2
Marshall Street WRF	Control Building	Wall transformer		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 2,000.00	Electrical failure			✓	Extend Flood Walls/Install Flood Barriers at entryways	PNL-LP4A
Marshall Street WRF	Control Building	Wall transformer		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 2,000.00	Electrical failure			✓	Extend Flood Walls/Install Flood Barriers at entryways	PNL-LP-4
Marshall Street WRF	Control Building	Electric Box		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,500.00	Electrical failure		✓		Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Control Building	Saftey Switch		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 250.00	Electrical failure		✓		Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Control Building	Splice Box		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 300.00	Electrical failure		✓		Extend Flood Walls/Install Flood Barriers at entryways	SSS-1
Marshall Street WRF	Control Building	Scum Panel		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,500.00	Electrical failure		✓		Extend Flood Walls/Install Flood Barriers at entryways	LP-4A
Marshall Street WRF	Control Building	Square D Start/stop		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 200.00	Electrical failure		✓		Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Control Building	Electric Box		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,500.00	Electrical failure		✓		Extend Flood Walls/Install Flood Barriers at entryways	208 VAC
Marshall Street WRF	Control Building	Electric Box		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,500.00	Electrical failure		✓		Extend Flood Walls/Install Flood Barriers at entryways	208 VAC
Marshall Street WRF	Control Building	Chemical Pump contol Panel		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 2,500.00	Loss of Chem Feed		✓		Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Control Building	ultraviolet disenfection unit		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,000.00		✓			Extend Flood Walls/Install Flood Barriers at entryways	Aquafine
Marshall Street WRF	Control Building	pump		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,200.00		✓			Extend Flood Walls/Install Flood Barriers at entryways	QR code on picture p/n 1051251
Marshall Street WRF	Control Building	pump		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,200.00		✓			Extend Flood Walls/Install Flood Barriers at entryways	p/n 1051251
Marshall Street WRF	Control Building	Pressure Relief Valve		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,500.00		✓			Extend Flood Walls/Install Flood Barriers at entryways	PR90-049-PVC-T-XX
Marshall Street WRF	Control Building	Storage Tank		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 2,000.00	Float	✓			Extend Flood Walls/Install Flood Barriers at entryways	Deionized Water
Marshall Street WRF	Control Building	Deionized water pump		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,500.00		✓			Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Control Building	Elevator		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 30,000.00		✓			Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Control Building	Kronos clock in/out		7	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 400.00		✓			Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Blower/MCC	Sorgel 3 phase general purpose transformer		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 11,000.00				✓	Seal Building/Install Flood Doors	75T3H
Marshall Street WRF	Blower/MCC	APG Transformer L-1		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 6,000.00				✓	Seal Building/Install Flood Doors	PNL-L-1

Vulnerability							Potential Depth (Feet) of Flooding Per Scenario											Consequences		Priority for Mitigation			Adaptation	
Facility	Building/ Area	Asset/ Operation	Measured Height of Asset Above Floor (ft)	Finished Floor Elevation (ft)	Elevation of Asset (ft)	Ground	100yr FEMA 2021	100yr Pinellas Vulnerability Study (2018 base)	500yr Pinellas Vulnerability Study (2018 base)	Category 1 Storm Surge	Category 2 Storm Surge	Category 3 Storm Surge	Category 4 Storm Surge	Category 5 Storm Surge	SLR 2040 High (MHHW/ 528HPY Depth)	SLR 2070 Intermediate (MHHW/ 528HPY Depth)	100yr Pinellas Vulnerability Study (2070)	Approximate Replacement Cost for Asset	Impact to Facility Operations from Asset Failure	Low	Moderate	High	Recommended Action	Other notes
Marshall Street WRF	Blower/MCC	Square D power Style Switchboard		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00				✓	Seal Building/Install Flood Doors	27693185-001
Marshall Street WRF	Blower/MCC	Square D power Style Switchboard		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00				✓	Seal Building/Install Flood Doors	27693185-001
Marshall Street WRF	Blower/MCC	Electric cabinent		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	
Marshall Street WRF	Blower/MCC	Surgelogic surge protective device		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 1,200.00	Electrical failure		✓		Seal Building/Install Flood Doors	FC4IMA24C
Marshall Street WRF	Blower/MCC	PowerPact Circuit breaker		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 800.00	Electrical failure		✓		Seal Building/Install Flood Doors	PJA36100U44A
Marshall Street WRF	Blower/MCC	PowerPact Circuit breaker		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 800.00	Electrical failure		✓		Seal Building/Install Flood Doors	PJA36080U41A
Marshall Street WRF	Blower/MCC	Square D circuit breaker		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 800.00	Electrical failure		✓		Seal Building/Install Flood Doors	MH36600
Marshall Street WRF	Blower/MCC	Square D power Style Switchboard		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 4,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	19874968-002
Marshall Street WRF	Blower/MCC	Square D power Style Switchboard		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 4,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	19874968-001
Marshall Street WRF	Blower/MCC	Square D Cicuit Breaker		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 800.00	Electrical failure		✓		Seal Building/Install Flood Doors	s/n: 08504209801
Marshall Street WRF	Blower/MCC	PowerPact Circuit breaker		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 800.00	Electrical failure		✓		Seal Building/Install Flood Doors	1PJA36100U33A
Marshall Street WRF	Blower/MCC	Square D MCC		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	FO: 1987-4966-004
Marshall Street WRF	Blower/MCC	Square D MCC		12.00	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	FO: 1987-4968-004
Marshall Street WRF	Control Bldg/Alum Storage	Storage Tank		7.00	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 7,000.00	Float		✓		Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Control Bldg/Alum Storage	Storage Tank		7.00	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 7,000.00	Float		✓		Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Control Bldg/Alum Storage	Level Indicator Cabinet		7.00	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 1,300.00			✓		Extend Flood Walls/Install Flood Barriers at entryways	rocha controls
Marshall Street WRF	Control Bldg/Alum Storage	CAT 3288 Generator		7.00	9.00		0.00	1.90	5.00	3.00	6.00	12.00	17.00	39.00	0.00	0.00	4.00	$ 20,000.00	Loss of Emergency Power			✓	Extend Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Control Bldg/Alum Storage	automatic battery charger		7.00	7.00		2.00	3.90	7.00	5.00	8.00	14.00	19.00	41.00	2.00	2.00	6.00	$ 3,000.00			✓		Extend Flood Walls/Install Flood Barriers at entryways	MBC6TT-24V-10A-L3C/NC
Marshall Street WRF	Sludge Dewatering	Pumps		8.63	8.63		0.37	2.27	5.37	3.37	6.37	12.37	17.37	39.37	0.37	0.37	4.37	$ 1,200.00				✓	Retrofit Bldg with Flood Walls/Install Flood Barriers at entryways	S/N CS7564: Emerson Motor Company
Marshall Street WRF	Sludge Dewatering	pumps		8.63	8.63		0.37	2.27	5.37	3.37	6.37	12.37	17.37	39.37	0.37	0.37	4.37	$ 1,200.00				✓	Retrofit Bldg with Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Sludge Dewatering	Air Compressor 1		8.63	8.63		0.37	2.27	5.37	3.37	6.37	12.37	17.37	39.37	0.37	0.37	4.37	$ 400.00			✓		Retrofit Bldg with Flood Walls/Install Flood Barriers at entryways	
Marshall Street WRF	Sludge Dewatering	Motor		8.63	8.63		0.37	2.27	5.37	3.37	6.37	12.37	17.37	39.37	0.37	0.37	4.37	$ 700.00			✓		Retrofit Bldg with Flood Walls/Install Flood Barriers at entryways	Leeson
Marshall Street WRF	Sludge Dewatering	Motor		8.63	8.63		0.37	2.27	5.37	3.37	6.37	12.37	17.37	39.37	0.37	0.37	4.37	$ 600.00			✓		Retrofit Bldg with Flood Walls/Install Flood Barriers at entryways	MSP4-2300-A0K3
Marshall Street WRF	Sludge Dewatering	Metteler Toledo		8.63	8.63		0.37	2.27	5.37	3.37	6.37	12.37	17.37	39.37	0.37	0.37	4.37	$ 3,500.00			✓		Retrofit Bldg with Flood Walls/Install Flood Barriers at entryways	11494561CJ
Marshall Street WRF	Sludge Dewatering	CAT G3771		8.63	8.63		0.37	2.27	5.37	3.37	6.37	12.37	17.37	39.37	0.37	0.37	4.37	$ 20,000.00	Loss of Emergency Power			✓	Retrofit Bldg with Flood Walls/Install Flood Barriers at entryways	MJE01550
Marshall Street WRF	Odor Control	Air Compressor	4.42	8.63	13.05		-4.05	-2.15	0.95	-1.05	1.95	7.95	12.95	34.95	-4.05	-4.05	-0.05	$ 10,000.00		✓			Seal Building/Install Flood Doors	Sulair
Marshall Street WRF	Odor Control	PH meter	3.67	8.63	12.30		-3.30	-1.40	1.70	-0.30	2.70	8.70	13.70	35.70	-3.30	-3.30	0.70	$ 600.00		✓			Seal Building/Install Flood Doors	
Marshall Street WRF	Odor Control	Electric Cabinent	4.00	8.63	12.63		-3.63	-1.73	1.37	-0.63	2.37	8.37	13.37	35.37	-3.63	-3.63	0.37	$ 3,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	Panel 7-6A
Marshall Street WRF	Odor Control	E-class metering pump		8.63	8.63		0.37	2.27	5.37	3.37	6.37	12.37	17.37	39.37	0.37	0.37	4.37	$ 1,600.00		✓			Seal Building/Install Flood Doors	Intertek 3111781
Marshall Street WRF	Influent PS	Air compressor		11	11.00		-2.00	-0.10	3.00	1.00	4.00	10.00	15.00	37.00	-2.00	-2.00	2.00	$ -		✓			No Action/Pump Station to be Relocated	Sulair ISO 9001
Marshall Street WRF	Influent PS	Thermostatic Valve		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ -		✓			No Action/Pump Station to be Relocated	OUTSIDE: 02250096-738
Marshall Street WRF	Influent PS	Sulair Compressor		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ -		✓			No Action/Pump Station to be Relocated	OUTSIDE: 02250097-804
Marshall Street WRF	Influent PS	Control Panel		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ -				✓	No Action/Pump Station to be Relocated	grit king control panel OUTSIDE
Marshall Street WRF	Influent PS	Power Panel		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ -	Electrical failure			✓	No Action/Pump Station to be Relocated	grit king power panel OUTSIDE
Marshall Street WRF	Influent PS	Switch		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ -			✓		No Action/Pump Station to be Relocated	Mov1 OUTSIDE
Marshall Street WRF	Influent PS	Switch		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ -			✓		No Action/Pump Station to be Relocated	Grit pump 1 OUTSIDE
Marshall Street WRF	Influent PS	Influent Pumps & Motors		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ -				✓	No Action/Pump Station to be Relocated	Floods but it is moving to another building
Marshall Street WRF	Anaerobic Digester	Electric Box		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 1,500.00	Electrical failure		✓		Seal Building/Install Flood Doors	
Marshall Street WRF	Anaerobic Digester	Saftey Switch	2.17	12	14.17		-5.17	-3.27	-0.17	-2.17	0.83	6.83	11.83	33.83	-5.17	-5.17	-1.17	$ 250.00		✓			No action needed	Square D

Vulnerability							Potential Depth (Feet) of Flooding Per Scenario											Consequences		Priority for Mitigation			Adaptation	
Facility	Building/ Area	Asset/ Operation	Measured Height of Asset Above Floor (ft)	Finished Floor Elevation (ft)	Elevation of Asset (ft)	Ground	100yr FEMA 2021	100yr Pinellas Vulnerability Study (2018 base)	500yr Pinellas Vulnerability Study (2018 base)	Category 1 Storm Surge	Category 2 Storm Surge	Category 3 Storm Surge	Category 4 Storm Surge	Category 5 Storm Surge	SLR 2040 High (MHHW/ 528HPY Depth)	SLR 2070 Intermediate (MHHW/ 528HPY Depth)	100yr Pinellas Vulnerability Study (2070)	Approximate Replacement Cost for Asset	Impact to Facility Operations from Asset Failure	Low	Moderate	High	Recommended Action	Other notes
Marshall Street WRF	Anaerobic Digester	Saftey Switch	2.17	12	14.17		-5.17	-3.27	-0.17	-2.17	0.83	6.83	11.83	33.83	-5.17	-5.17	-1.17	$ 250.00		✓			No action needed	
Marshall Street WRF	Anaerobic Digester	Motor	1.00	12	13.00		-4.00	-2.10	1.00	-1.00	2.00	8.00	13.00	35.00	-4.00	-4.00	0.00	$ 1,200.00			✓		Seal Building/Install Flood Doors	95771712-001
Marshall Street WRF	Anaerobic Digester	Transformer		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00			✓		Seal Building/Install Flood Doors	CAT NO:2S1F
Marshall Street WRF	Anaerobic Digester	MCC		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	20087765-002
Marshall Street WRF	Anaerobic Digester	Electric Cabinent		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	
Marshall Street WRF	Anaerobic Digester	MCC-MS		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	
Marshall Street WRF	Digester Complex	Spiral Hext EXC		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 20,000.00			✓		Seal Building/Install Flood Doors	BFV 406
Marshall Street WRF	Digester Complex	Electric Box	3.58	12	15.58		-6.58	-4.68	-1.58	-3.58	-0.58	5.42	10.42	32.42	-6.58	-6.58	-2.58	$ 3,000.00	Electrical failure		✓		Seal Building/Install Flood Doors	
Marshall Street WRF	RDT Bldg	Polymer Storage tote		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 2,000.00	Dislodge/Spill	✓			No action needed	
Marshall Street WRF	RDT Bldg	Velodyne LCP		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 3,000.00		✓			Raise	VM-1P-300-D-0-A-1
Marshall Street WRF	RDT Bldg	Chemical Metering Pumps		12	12.00		-3.00	-1.10	2.00	0.00	3.00	9.00	14.00	36.00	-3.00	-3.00	1.00	$ 2,000.00	Loss of Chemical Feed	✓			No action needed	

						6	12	10.3	14	12	15	26	26	48	8.2	9	13							
Vulnerability							**Potential Depth of Flooding (Ft) Per Each Scenario**											**Consequences**		**Priority for Mitigation**			**Adaptation**	
Facility	**Building/ Area**	**Asset/ Operation**	**Measured Height of Asset Above Floor (ft)**	**Finished Floor Elevation (ft)**	**Elevation of Asset (ft)**	**Ground**	**100yr FEMA 2021**	**100yr Pinellas Vulnerability Study (2018 base)**	**500yr Pinellas Vulnerability Study (2018 base)**	**Category 1 Storm Surge**	**Category 2 Storm Surge**	**Category 3 Storm Surge**	**Category 4 Storm Surge**	**Category 5 Storm Surge**	**SLR 2040 High (MHHW/528HPY Depth)**	**SLR 2070 Intermediate (MHHW/528HPY Depth)**	**100yr Pinellas Vulnerability Study (2070)**	**Approximate Replacement Cost for Asset**	**Impact to Facility Operations from Asset Failure**	**Low**	**Moderate**	**High**	**Recommended Action**	**Other notes**
East WRF	Control Bldg/MCC Room	Emerson Control Panel	0.46	10	10.46		1.54	-0.16	3.54	1.54	4.54	15.54	15.54	37.54	-2.26	-1.46	2.54	$ 3,000.00	Electrical failure			✓	Seal Room/Install Flood proof Doors	Photo IMG_1959 LF
East WRF	Control Bldg/MCC Room	Eaton Pow-R-Line Switchboard	0.25	10	10.25		1.75	0.05	3.75	1.75	4.75	15.75	15.75	37.75	-2.05	-1.25	2.75	$ 3,000.00	Electrical failure			✓	Seal Room/Install Flood proof Doors	Sits on 3" slab
East WRF	Control Bldg/MCC Room	MMC - No. 1001	0.25	10	10.25		1.75	0.05	3.75	1.75	4.75	15.75	15.75	37.75	-2.05	-1.25	2.75	$ 3,000.00	Electrical failure			✓	Seal Room/Install Flood proof Doors	Sits on 3" slab A lot of components (influent pumps, filters, etc.) - need to break down more granularly for cost estimate?
East WRF	Control Bldg/MCC Room	ATS 1	0.25	10	10.25		1.75	0.05	3.75	1.75	4.75	15.75	15.75	37.75	-2.05	-1.25	2.75	$ 3,000.00	Electrical failure			✓	Seal Room/Install Flood proof Doors	Sits on 3" slab
East WRF	Control Bldg/Storage/ Transformer Room	Eaton Transformers (3)	0.25	10	10.25		1.75	0.05	3.75	1.75	4.75	15.75	15.75	37.75	-2.05	-1.25	2.75	$ 9,000.00	Electrical failure			✓	Seal Room/Install Flood proof Doors	Still in MCC building, same finished floor elevation Sits on a 3" slab
East WRF	Control Bldg/Storage/ Transformer Room	Rocha Control Panel	1.92	10	11.92		0.08	-1.62	2.08	0.08	3.08	14.08	14.08	36.08	-3.72	-2.92	1.08	$ 3,000.00	Electrical failure			✓	Seal Room/Install Flood proof Doors	Still in MCC building, same finished floor elevation
East WRF	Control Bldg/Outside of MCC Room	Diesel Fuel Storage Tanks (2)	0.00	9.5	9.50		2.50	0.80	4.50	2.50	5.50	16.50	16.50	38.50	-1.30	-0.50	3.50	$ 14,000.00	Water intrusion in the fuel will cause wear/rust in generator parts.		✓		No action needed/vent is above Flood Threat Elevation	IMG_1980 LF more detailed photos starting at 20220504_093147. Top of generator at 60" from ground. Generator is just outside of MMC building. Step off of curb about 6". (10' - 6" = 9.5') Elevation of asset includes equipment pad.
East WRF	Control Bldg/Elevated Generator Room	Generator G4222	6.00	9.5	15.50		-3.50	-5.20	-1.50	-3.50	-0.50	10.50	10.50	32.50	-7.30	-6.50	-2.50	$ 25,000.00				✓	No action needed/Asset is above Flood Threat Elevation	Numbers are estimates. Generator is just outside of MMC building. Step off of curb about 6". Platform was above all of our heads, about 6'
East WRF	Sludge Handling Building	AC	0.00	12.17	12.17		-0.17	-1.87	1.83	-0.17	2.83	13.83	13.83	35.83	-3.97	-3.17	0.83	$ 3,000.00	No air conditioning	✓				Just outside sludge handling building door
East WRF	Sludge Handling Building	Seepex Chemical Feed Pump	0.17	12.17	12.34		-0.34	-2.04	1.66	-0.34	2.66	13.66	13.66	35.66	-4.14	-3.34	0.66	$ 3,000.00	Pump may stop functioning, polymer not added to sludge.		✓		Raise	IMG_1983 LF Pump on low metal platform; height of platform estimated
East WRF	Sludge Handling Building	MCC No. 2000	0.42	12.17	12.59		-0.59	-2.29	1.41	-0.59	2.41	13.41	13.41	35.41	-4.39	-3.59	0.41	$ 3,000.00	Electrical failure		✓		Raise	Series 2100
East WRF	Sludge Handling Building	T2 - L Panel	1.17	12.17	13.34		-1.34	-3.04	0.66	-1.34	1.66	12.66	12.66	34.66	-5.14	-4.34	-0.34	$ 3,000.00	Electrical failure		✓		Raise	
East WRF	Sludge Handling Building	Sullair Air Compressor	0.33	12.17	12.50		-0.50	-2.20	1.50	-0.50	2.50	13.50	13.50	35.50	-4.30	-3.50	0.50	$ 37,000.00	Electrical failure	✓			Raise	Starting at image IMG_1993 LF and 20220504_095226 Model: 1809/A Air Press. Rated/Max: 125 / 135 PSIG
East WRF	Sludge Handling Building - Lower Level	Wemco Hidro Pump		2.17	2.17		9.83	8.13	11.83	9.83	12.83	23.83	23.83	45.83	6.03	6.83	10.83	$ 3,000.00	Pump may stop functioning - sludge cannot be pumped, process stops.		✓		replace with submersible	***ALL equipment in the lower level of the sludge handling building will be under water after a 100 year flood + sea level rise.** model no. 6X5 E5R-L-E25 700 gpm capacity 24ft head 1550 rpm
East WRF	Sludge Handling Building - Lower Level	XE AC Motor (4)		2.17	2.17		9.83	8.13	11.83	9.83	12.83	23.83	23.83	45.83	6.03	6.83	10.83	$ 18,400.00	Electrical failure - sludge cannot be pumped, process stops.		✓		replace with submersible	***ALL equipment in the lower level of the sludge handling building will be under water after a 100 year flood + sea level rise.** IMG_2001 LF HP: 10 RPM: 1175 Amp: 25/ 12.5 Volts: 230/ 460
East WRF	Sludge Handling Building - Lower Level	WAS Pump Panels (3)		2.17	2.17		9.83	8.13	11.83	9.83	12.83	23.83	23.83	45.83	6.03	6.83	10.83	$ 9,000.00	Electrical failure - wasted sludge cannot be pumped. Process stops.		✓		replace with submersible panel	***ALL equipment in the lower level of the sludge handling building will be under water after a 100 year flood + sea level rise.**
East WRF	Sludge Handling Building - Lower Level	Unidentified Panel (2)		2.17	2.17		9.83	8.13	11.83	9.83	12.83	23.83	23.83	45.83	6.03	6.83	10.83	$ 6,000.00	Electrical failure - unidentified sludge cannot flood pumped Process stops.		✓		replace with submersible panel	***ALL equipment in the lower level of the sludge handling building will be under water after a 100 year flood + sea level rise.** Panels in photos 20220504_094934 and IMG_2012 LF
East WRF	Influent Pump Station	Influent Pump Station Motor Feed J-Box Panel	3.50	10	13.50		-1.50	-3.20	0.50	-1.50	1.50	12.50	12.50	34.50	-5.30	-4.50	-0.50	$ 3,000.00					Raise	*Influent Pump Station vs Influent Structure on spreadsheet used in the field. Don't have a photo of exact measurement. Assumed structure to be 3ft high and panel to be another 6" above that based on looking at photo IMG_2018 LF.
East WRF	Influent Pump Station	US Filter Odor Control Panel	3.00	10	13.00		-1.00	-2.70	1.00	-1.00	2.00	13.00	13.00	35.00	-4.80	-4.00	0.00	$ 3,000.00	Electrical failure - odor will intensify around the facility. Toxic fume hazard in smaller, enclosed spaces.		✓		Raise	Don't have measurements, estimating measured height based off of IMG_2023 LF
East WRF	Influent Pump Station	Odor Control System Condensate Pump	1.00	10	11.00		1.00	-0.70	3.00	1.00	4.00	15.00	15.00	37.00	-2.80	-2.00	2.00	$ 4,000.00	Electrical failure - odor will intensify around the facility. Toxic fume hazard in smaller, enclosed spaces.		✓		Raise	Don't have measurements, estimating measured height based off of IMG_2023 LF
East WRF	Influent Pump Station	Odor Control System Motor	1.00	10	11.00		1.00	-0.70	3.00	1.00	4.00	15.00	15.00	37.00	-2.80	-2.00	2.00	$ 4,000.00	Electrical failure - odor will intensify around the facility. Toxic fume hazard in smaller, enclosed spaces.		✓		Raise	HP: 2 Volts: 115/ 230 Amps: 23/ 11.5 RPM: 3450
East WRF	Headworks	Grit Pumps (2)	0.58	5	5.58		6.42	4.72	8.42	6.42	9.42	20.42	20.42	42.42	2.62	3.42	7.42	$ 2,000.00	Electrical failure - grit will build up in process trains. Over time this may decrease process efficiently.		✓		replace with submersible panel	*At grade, no measurement information. On ~7" of pad. HP: 3 Volts: 230/400 Amps: 10.4/ 5.2 RPM: 865
East WRF	Headworks	Grit Pump Panel (2)	3.00	5	8.00		4.00	2.30	6.00	4.00	7.00	18.00	18.00	40.00	0.20	1.00	5.00	$ 6,000.00	Electrical failure - grit will build up in process trains. Over time this may decrease process efficiently.		✓		replace with submersible panel	
East WRF	Headworks	Flow meter	6.17	5	11.17		0.83	-0.87	2.83	0.83	3.83	14.83	14.83	36.83	-2.97	-2.17	1.83			✓			N/A Temporary meter	
East WRF	Headworks	Press Junction Box	5.00	5	10.00		2.00	0.30	4.00	2.00	5.00	16.00	16.00	38.00	-1.80	-1.00	3.00	$ 3,000.00	Electrical failure - screenings will not be pressed	✓			replace with submersible box	Measured Height Estimated based on IMG_2045.MOV LF
East WRF	Headworks	Wash Press	5.00	5	10.00		2.00	0.30	4.00	2.00	5.00	16.00	16.00	38.00	-1.80	-1.00	3.00	$ 15,000.00	Electrical failure - screenings will not be pressed	✓			Raise	Measured Height Estimated based on IMG_2045.MOV LF
East WRF	Headworks	Wash Press Motor	2.00	5	7.00		5.00	3.30	7.00	5.00	8.00	19.00	19.00	41.00	1.20	2.00	6.00	$ 500.00	Electrical failure - screenings will not be pressed	✓			Raise	Measured Height Estimated HP: 3 60 Hz 230/460 Volts 8.9/ 4.45 Amps

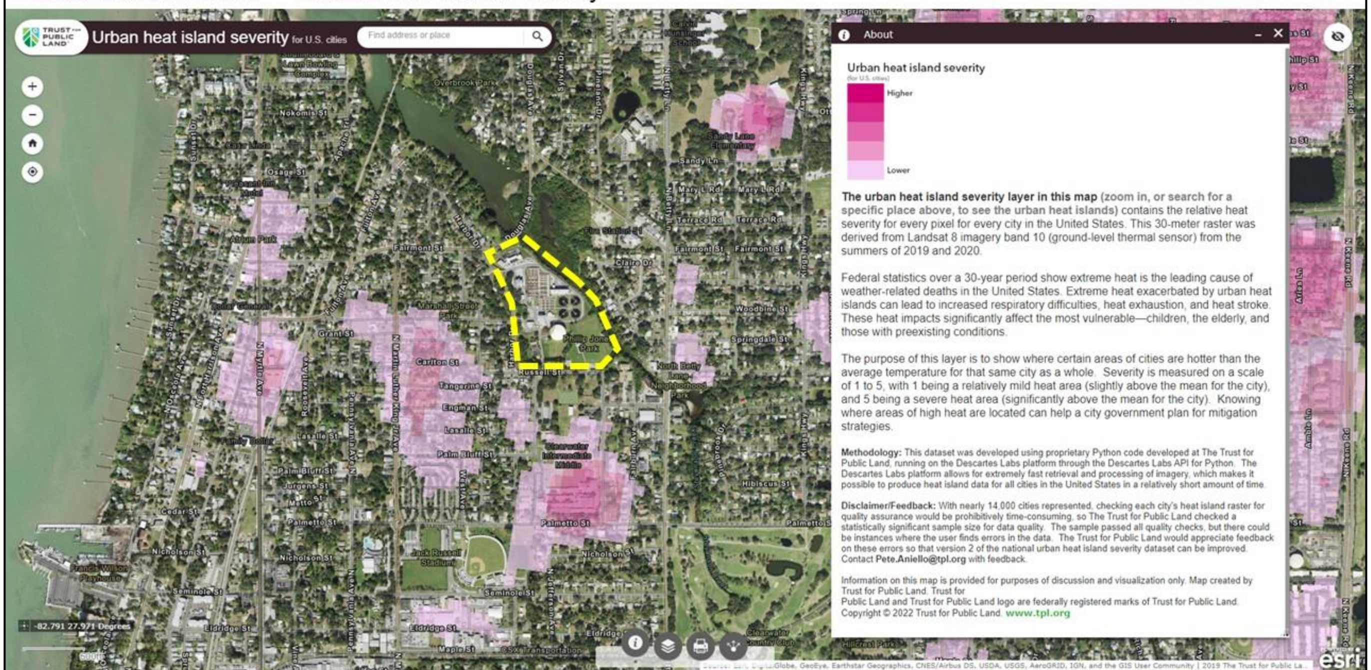
Vulnerability							Potential Depth of Flooding (Ft) Per Each Scenario											Consequences		Priority for Mitigation			Adaptation	
Facility	Building/ Area	Asset/ Operation	Measured Height of Asset Above Floor (ft)	Finished Floor Elevation (ft)	Elevation of Asset (ft)	Ground	100yr FEMA 2021	100yr Pinellas Vulnerability Study (2018 base)	500yr Pinellas Vulnerability Study (2018 base)	Category 1 Storm Surge	Category 2 Storm Surge	Category 3 Storm Surge	Category 4 Storm Surge	Category 5 Storm Surge	SLR 2040 High (MHHW/528HPY Depth)	SLR 2070 Intermediate (MHHW/528HPY Depth)	100yr Pinellas Vulnerability Study (2070)	Approximate Replacement Cost for Asset	Impact to Facility Operations from Asset Failure	Low	Moderate	High	Recommended Action	Other notes
East WRF	Headworks	Classifier Panel	4.50	5	9.50		2.50	0.80	4.50	2.50	5.50	16.50	16.50	38.50	-1.30	-0.50	3.50	$ 3,000.00	Electrical failure - process train stops		✓			Measured Height Estimated
East WRF	Headworks	Conveyor Junction Box and Panel	5.00	5	10.00		2.00	0.30	4.00	2.00	5.00	16.00	16.00	38.00	-1.80	-1.00	3.00	$ 3,000.00	Electrical failure - process train stops		✓		replace with submersible panel	Measured Height Estimated
East WRF	Headworks	EP100 Influent Structure Devicenet Panel	1.88	5	6.88		5.13	3.43	7.13	5.13	8.13	19.13	19.13	41.13	1.33	2.13	6.13	$ 3,000.00	Electrical failure - process train stops			✓	Raise	IMG_2052 LF
East WRF	Headworks	Barscreen Control Panel	1.67	5	6.67		5.33	3.63	7.33	5.33	8.33	19.33	19.33	41.33	1.53	2.33	6.33	$ 3,000.00	Electrical failure - wastewater will not be screened, pipes could become clogged and effluent quality will be compromised			✓	replace with submersible panel	Influent Monitoring Location Site
East WRF	Headworks	UPS for Barscreen and Grit System	2.42	5	7.42		4.58	2.88	6.58	4.58	7.58	18.58	18.58	40.58	0.78	1.58	5.58	$ 3,000.00	Electrical failure - wastewater will not be screened, pipes could become clogged and effluent quality will be compromised		✓		replace with submersible panel	
East WRF	Headworks	Grit Pump and Grit Chamber Panel	1.25	5	6.25		5.75	4.05	7.75	5.75	8.75	19.75	19.75	41.75	1.95	2.75	6.75	$ 5,000.00	Electrical failure - grit will build up in process trains. Over time this may decrease process efficiently.		✓		replace with submersible panel	
East WRF	Headworks	Grit System Power Panel	2.67	5	7.67		4.33	2.63	6.33	4.33	7.33	18.33	18.33	40.33	0.53	1.33	5.33	$ 3,000.00	Electrical failure - grit will build up in process trains. Over time this may decrease process efficiently.		✓		replace with submersible panel	
East WRF	Sulfur Dioxide Building	Sodium Bisulfite Filling Station Rocha Control Panel	3.33	5	8.33		3.67	1.97	5.67	3.67	6.67	17.67	17.67	39.67	-0.13	0.67	4.67	$ 3,000.00	Electrical failure - chemical cannot be added to wastewater		✓		Raise	Outside of building
East WRF	Sulfur Dioxide Building	Chemical Feed Pump (2)	1.00	10	11.00		1.00	-0.70	3.00	1.00	4.00	15.00	15.00	37.00	-2.80	-2.00	2.00	$ 1,000.00	Electrical failure - chemical cannot be added to wastewater		✓		Raise	Model: KM102P106 Capacity: 27.2 GPH Max Pressure: 150 PSI Serial No: 202108019
East WRF	Sulfur Dioxide Building	Chemical Feed Pump Motor (2)	1.67	10	11.67		0.33	-1.37	2.33	0.33	3.33	14.33	14.33	36.33	-3.47	-2.67	1.33	$ 1,000.00	Electrical failure - chemical cannot be added to wastewater		✓		Raise	HP: 0.75 Volts: 230/460 Amps: 2.28/1.14 RPM: 1750 Hz: 60
East WRF	Sulfur Dioxide Building	Digital AC Drive for Chemical Feed Pumps (2)	2.17	10	12.17		-0.17	-1.87	1.83	-0.17	2.83	13.83	13.83	35.83	-3.97	-3.17	0.83	$ 1,000.00	Electrical failure - chemical cannot be added to wastewater		✓		Raise	AC Motor Speed Control NEMA 4X / IP65 Guardian Equipment, Inc.
East WRF	Sulfur Dioxide Building	Sodium Bisulfite Storage Tanks (2)	0.58	10	10.58		1.42	-0.28	3.42	1.42	4.42	15.42	15.42	37.42	-2.38	-1.58	2.42	$ 13,600.00	Potential for floating tanks	✓			Tie-Downs	IMG_2081 LF
East WRF	Sulfur Dioxide Building	Control Panel CH 101	0.83	10	10.83		1.17	-0.53	3.17	1.17	4.17	15.17	15.17	37.17	-2.63	-1.83	2.17	$ 3,000.00	Electrical failure		✓		Raise	
East WRF	Sulfur Dioxide Building	EP101 Analyzer Room Remote I/O Panel	2.00	10	12.00		0.00	-1.70	2.00	0.00	3.00	14.00	14.00	36.00	-3.80	-3.00	1.00	$ 3,000.00	Electrical failure		✓		Raise	If this room (Photo 20220504_102844) is the analyzer room then control panel CH 101 is there as well)
East WRF	Sulfur Dioxide Building	Control Panel R4A	3.00	10	13.00		-1.00	-2.70	1.00	-1.00	2.00	13.00	13.00	35.00	-4.80	-4.00	0.00	$ 3,000.00	Electrical failure		✓		Raise	
East WRF	Sulfur Dioxide Building	Bermad Valve Rocha Control EP-FM-1	3.33	5	8.33		3.67	1.97	5.67	3.67	6.67	17.67	17.67	39.67	-0.13	0.67	4.67	$ 3,000.00	Electrical failure			✓	Raise	South of the Sulfur Dioxide Building
East WRF	Sulfur Dioxide Building	Meter (right of the Bermad Valves)	3.33	5	8.33		3.67	1.97	5.67	3.67	6.67	17.67	17.67	39.67	-0.13	0.67	4.67	$ 1,000.00	Loss of function	✓			Raise	South of the Sulfur Dioxide Building
East WRF	Filter Complex	Aerzen Delta Blowers (2)	3.25	5	8.25		3.75	2.05	5.75	3.75	6.75	17.75	17.75	39.75	-0.05	0.75	4.75	$ 20,000.00	Electrical failure - process aeration fails		✓		Raise	Adjacent to the Filter Complex On 6" pad
East WRF	Filter Complex	Control Panels for Blowers (2)	4.25	5	9.25		2.75	1.05	4.75	2.75	5.75	16.75	16.75	38.75	-1.05	-0.25	3.75	$ 6,000.00	Electrical failure - process aeration fails		✓		Raise	Adjacent to the Filter Complex
East WRF	Chlorine Storage Building	Chemical Storage Tanks (3)	0.50	10	10.50		1.50	-0.20	3.50	1.50	4.50	15.50	15.50	37.50	-2.30	-1.50	2.50	$ 20,400.00	Float possibility	✓			Tie-Downs	
East WRF	Chlorine Storage Building	Sodium Hypochlorite Filling Station - Rocha Control Panel	0.00	5	5.00		7.00	5.30	9.00	7.00	10.00	21.00	21.00	43.00	3.20	4.00	8.00	$ 3,000.00	Electrical failure	✓			NA	*Did not measure height as bottom was flush with chlorine storage building floor meaning measured height would be 10. However, this control panel is not 5 ft from the ground. Perhaps not taking into account the pavement.*
East WRF	Chlorine Storage Building	Chemical Feed Pumps (4)	1.67	10	11.67		0.33	-1.37	2.33	0.33	3.33	14.33	14.33	36.33	-3.47	-2.67	1.33	$ 5,000.00	Electrical failure		✓		Raise	(2) Model: KM102P138 Capacity:36.7 GPH Max Pressure: 150 PSI (1) Model: KM162P60 Capacity 67.6 GPH Max Pressure: 150 PSI (1) Very old pump, limited information Ratio: 45 RPM: 1750 Torque: 796
East WRF	Chlorine Storage Building	Chemical Feed Motors (4)	2.08	10	12.08		-0.08	-1.78	1.92	-0.08	2.92	13.92	13.92	35.92	-3.88	-3.08	0.92	$ 5,000.00	Electrical failure - wastewater will not receive disinfection step, can not be released to the environment		✓		Raise	(3) HP: 0.5 0.37 KW Volts: 230/460 AMPS: 1.54/0.77 RPM: 1735 (1) Inverter Drive Motor - Old, limited information HP: 0.5
East WRF	Chlorine Storage Building	Control Panel	3.13	5	8.13		3.88	2.18	5.88	3.88	6.88	17.88	17.88	39.88	0.07	0.88	4.88	$ 3,000.00	Electrical failure - wastewater will not receive disinfection step, can not be released to the environment		✓		Raise	Panel is at the back of the building
East WRF	Internal Recycle Pump Station	Junction Box 1 - ATS 3	0.10	10	10.10		1.90	0.20	3.90	1.90	4.90	15.90	15.90	37.90	-1.90	-1.10	2.90	$ 3,000.00	Electrical failure - wastewater cannot be recycled through facility			✓	Seal building/Install Flood proof Doors	Generator Room
East WRF	Internal Recycle Pump Station	Junction Box 2 - ATS 2	0.10	10	10.10		1.90	0.20	3.90	1.90	4.90	15.90	15.90	37.90	-1.90	-1.10	2.90	$ 3,000.00	Electrical failure - wastewater cannot be recycled through facility			✓	Seal building/Install Flood proof Doors	Generator Room
East WRF	East of Second Anoxic Tanks	Walchem E-Class Metering Pump	4.83	5	9.83		2.17	0.47	4.17	2.17	5.17	16.17	16.17	38.17	-1.63	-0.83	3.17	$ 1,000.00	Electrical failure - magnesium sulfate won't be added to trains.	✓			Raise	Plugged into wall outlet on outside of second anoxic tanks. Connected to a magnesium (?) sulfate storage tank on a pad.

Vulnerability							Potential Depth of Flooding (Ft) Per Each Scenario											Consequences		Priority for Mitigation			Adaptation	
Facility	Building/ Area	Asset/ Operation	Measured Height of Asset Above Floor (ft)	Finished Floor Elevation (ft)	Elevation of Asset (ft)	Ground	100yr FEMA 2021	100yr Pinellas Vulnerability Study (2018 base)	500yr Pinellas Vulnerability Study (2018 base)	Category 1 Storm Surge	Category 2 Storm Surge	Category 3 Storm Surge	Category 4 Storm Surge	Category 5 Storm Surge	SLR 2040 High (MHHW/528HPY Depth)	SLR 2070 Intermediate (MHHW/528HPY Depth)	100yr Pinellas Vulnerability Study (2070)	Approximate Replacement Cost for Asset	Impact to Facility Operations from Asset Failure	Low	Moderate	High	Recommended Action	Other notes
East WRF	Screw Pumps by Oxidation Reactor	Transformer	3.08	5	8.08		3.92	2.22	5.92	3.92	6.92	17.92	17.92	39.92	0.12	0.92	4.92	$ 3,000.00	Compromised electrical function			✓	Raise transformer	
East WRF	Filter Pump Station	Panel FPP-103	0.42	10	10.42		1.58	-0.12	3.58	1.58	4.58	15.58	15.58	37.58	-2.22	-1.42	2.58	$ 3,000.00	Electrical failure - filters will not function properly, wastewater will not be filtered.			✓	No action/ Pump Station is to be redesigned	Final Clarifier/ Oxidation Reactor Devicenet Panel
East WRF	Filter Pump Station	EP103 Final Clarifier/ Oxidation Reactor Devicenet Panel	2.00	5	7.00		5.00	3.30	7.00	5.00	8.00	19.00	19.00	41.00	1.20	2.00	6.00	$ 3,000.00	Electrical failure - filters will not function properly, wastewater will not be filtered.			✓	No action/ Pump Station is to be redesigned	
East WRF	Filter Pump Station	Filter Pump panels (2)	0.42	10	10.42		1.58	-0.12	3.58	1.58	4.58	15.58	15.58	37.58	-2.22	-1.42	2.58	$ 6,000.00	Electrical failure - filters will not function properly, wastewater will not be filtered.			✓	No action/ Pump Station is to be redesigned	Cannot see Panel ID Plates Measured height estimated IMG_2147
East WRF	Filter Pump Station	Filter Pump Panel No. 2	1.00	10	11.00		1.00	-0.70	3.00	1.00	4.00	15.00	15.00	37.00	-2.80	-2.00	2.00	$ 3,000.00	Electrical failure - filters will not function properly, wastewater will not be filtered.			✓	No action/ Pump Station is to be redesigned	Labeled as Filter Pump No. 2 Measured height estimated IMG_2147
East WRF	Filter Pump Station	Filter Pump Panel	2.00	10	12.00		0.00	-1.70	2.00	0.00	3.00	14.00	14.00	36.00	-3.80	-3.00	1.00	$ 3,000.00	Electrical failure - filters will not function properly, wastewater will not be filtered.			✓	No action/ Pump Station is to be redesigned	Cannot see Panel ID Plate Measured height estimated IMG_2147
East WRF	Filter Pump Station	Three (3) Panels Above	3.33	10	13.33		-1.33	-3.03	0.67	-1.33	1.67	12.67	12.67	34.67	-5.13	-4.33	-0.33	$ 9,000.00	Electrical failure - filters will not function properly, wastewater will not be filtered.			✓	No action/ Pump Station is to be redesigned	Measured Height Estimated Don't have photos of panels, see photo 20220504_110708
East WRF	RAS Pump Station	Scum Pump PLC Control Panel	1.79	6.5	8.29		3.71	2.01	5.71	3.71	6.71	17.71	17.71	39.71	-0.09	0.71	4.71	$ 3,000.00	Electrical failure - scum will not be wasted decreasing quality of process		✓		Raise	
East WRF	RAS Pump Station	Scum Pump On/Off Switch	5.00	6.5	11.50		0.50	-1.20	2.50	0.50	3.50	14.50	14.50	36.50	-3.30	-2.50	1.50	$ 3,000.00	Electrical failure - scum will not be wasted decreasing quality of process		✓		Raise	Estimated Measured Height
East WRF	RAS Pump Station	Meter	5.00	6.5	11.50		0.50	-1.20	2.50	0.50	3.50	14.50	14.50	36.50	-3.30	-2.50	1.50	$ 1,000.00	Can these function inundated?	✓			Raise	Estimated Measured Height
East WRF	RAS Pump Station	Scum Box Flushing Control Panel	5.00	6.5	11.50		0.50	-1.20	2.50	0.50	3.50	14.50	14.50	36.50	-3.30	-2.50	1.50	$ 3,000.00	Electrical failure - scum will not be wasted decreasing quality of process		✓		Raise	Estimated Measured Height
East WRF	RAS Pump Station	Baldor Reliance SuperE Severe Duty XEX Motor	1.00	6.5	7.50		4.50	2.80	6.50	4.50	7.50	18.50	18.50	40.50	0.70	1.50	5.50	$ 3,400.00	Electrical failure - sludge will not be removed decreasing quality of process nutrient removal		✓		Raise	Estimated Measured Height HP: 10 Volts: 230/460 Amps: 25/12.5 RPM: 1760 Hz: 60 Phase: 3
East WRF	RAS Pump Station	Elevated Pad	4.17	10	14.17		-2.17	-3.87	-0.17	-2.17	0.83	11.83	11.83	33.83	-5.97	-5.17	-1.17	$ 20,000.00						
East WRF	RAS Pump Station	RAS Pump On/Off Switch	6.75	10	16.75		-4.75	-6.45	-2.75	-4.75	-1.75	9.25	9.25	31.25	-8.55	-7.75	-3.75	$ 3,000.00	Electrical failure - sludge will not be removed decreasing quality of process nutrient removal		✓		No Action	Mounted on prior mentioned elevated pad
East WRF	RAS Pump Station	RAS Pump Control Panels (3)	8.17	10	18.17		-6.17	-7.87	-4.17	-6.17	-3.17	7.83	7.83	29.83	-9.97	-9.17	-5.17	$ 9,000.00	Electrical failure - sludge will not be removed decreasing quality of process nutrient removal		✓		No Action	Mounted on prior mentioned elevated pad

Appendix B. Urban Heat Island Impacts

While not a primary component of the vulnerability assessment, which focuses on flood exposure, some concerns were raised regarding heat when conversing with WRF operations staff during field visits. The key concerns focus on staff health when working outside as well as insulation for some of the chemical supply lines at the plant. With that in mind, the following maps provide an overview of relative heat impacts to the areas surrounding each site. The information is from the Trust for Public Lands[4] which is looking to update these maps on a more frequent basis as the data becomes available. The maps here represent temperatures studied during the summers of 2019 and 2020.

Marshall Street WRF – Urban Heat Island Severity

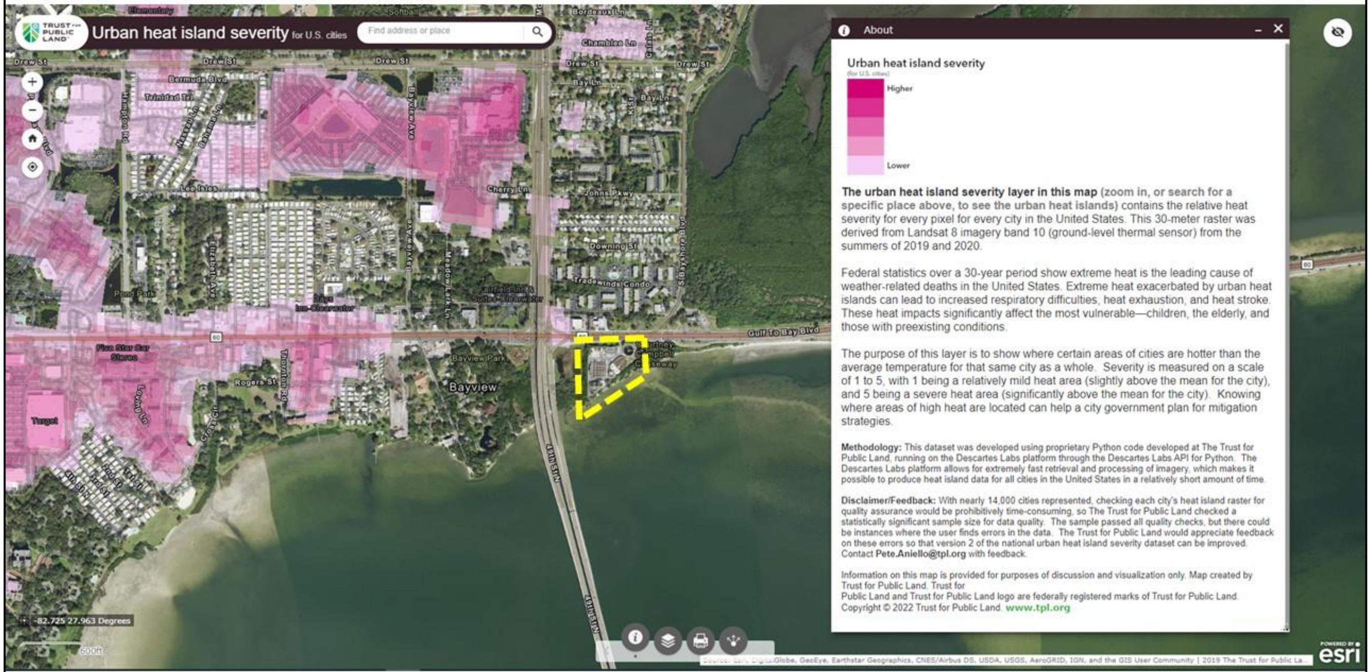


Source: Trust for Public Land: https://tpl.maps.arcgis.com/apps/webappviewer/index.html?id=1b6cad6dd5854d2aa3d215a39a4d372d

Figure B-1 - Relative Heat Exposure near Marshall Street WRF

[4] For more information, please visit: https://tpl.maps.arcgis.com/apps/webappviewer/index.html?id=1b6cad6dd5854d2aa3d215a39a4d372d

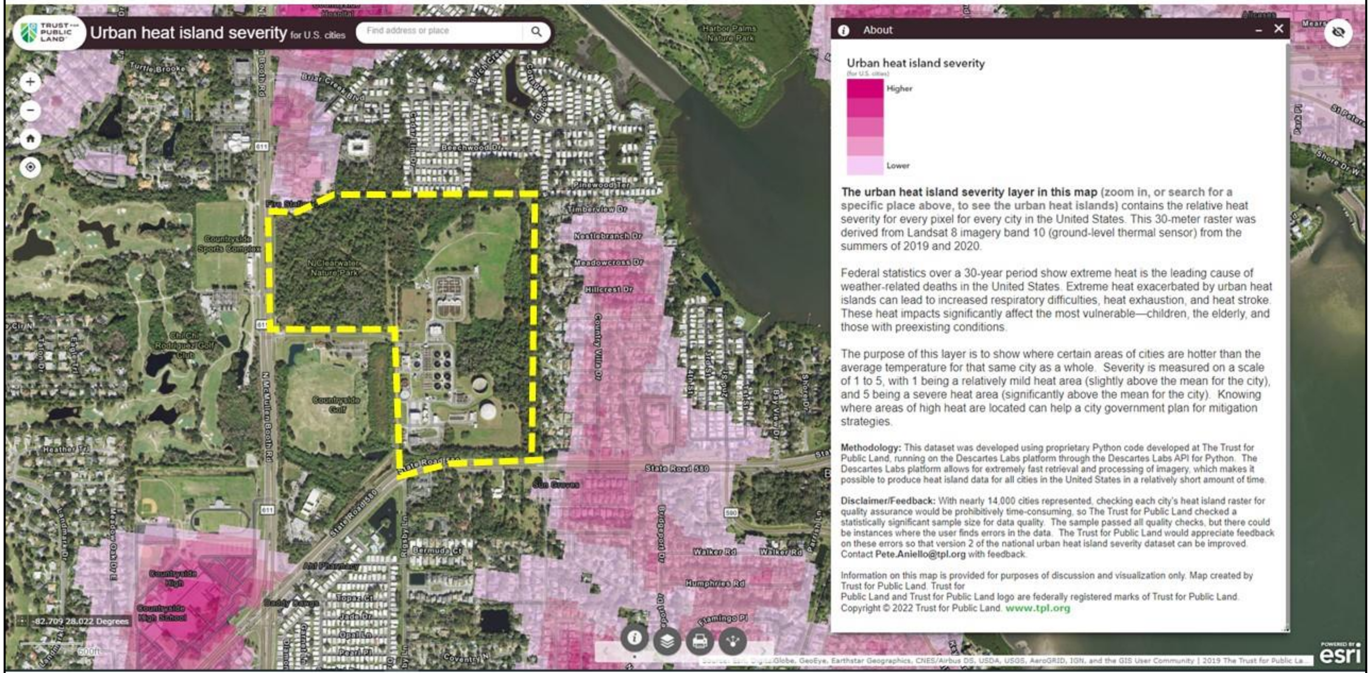
East WRF – Urban Heat Island Severity



Source: Trust for Public Land: https://tpl.maps.arcgis.com/apps/webappviewer/index.html?id=1b6cad6dd5854d2aa3d215a39a4d372d

Figure B-2 - Relative Heat Exposure near East WRF

Northeast WRF – Urban Heat Island Severity



Source: Trust for Public Land: https://tpl.maps.arcgis.com/apps/webappviewer/index.html?id=1b6cad6dd5854d2aa3d215a39a4d372d

Figure B-3 - Relative Heat Exposure near the Northeast WRF

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Appendix C. Regulatory Review and Emerging Issues

Legislation	Law / Rule / Guidance	Description / Requirements	Impacts & Recommendations
Clean Water Act – National Pollutant Discharge Elimination System (NPDES) (www.epa.gov/npdes)	Capacity, Management, Operation and Maintenance (CMOM) Program Guidance (www.epa.gov/npdes/npdes-sso-technical-reports-and-materials)	The EPA has provided NPDES technical reports and materials, including guidance for use by EPA, state inspectors, and the regulated community. The guidance identifies some of the criteria used by EPA to evaluate a collection system's **CMOM program** activities. The publications providing CMOM guidance and templates date from 1999 to 2005, with no recent modifications.	The City of Clearwater updated the CMOM program in 2021 and completed the Wastewater Collection System Master Plan in 2021. These documents support the CMOM and capital improvements needs of the collection system to reduce or eliminate future SSOs. The City should continue its efforts to implement the recommendations and activities outlined in these documents and continue to update the CMOM program as new regulatory guidance is published. Possible future update topics to the CMOM guidance include specific asset management principles or updates to the SSO rulemaking.
Florida State House Bill 53 (2021) - Public Works. (www.flsenate.gov/Session/Bill/2021/53)	Florida Statutes Chapter 403.9301 & 403.9302 (www.leg.state.fl.us/Statutes/)	Requires counties, municipalities, and special needs districts that provide a stormwater management system, program, or wastewater management service to develop a **20-year needs assessment analysis**. This first needs assessment analysis must be submitted to the Office of Economic and Demographic Research (OEDR) by June 30, 2022. The OEDR has advised utilities that the first submittal is not intended to include a detailed analysis of the system, rather, to understand the financial hurdles utilities face to support the need for increased State funds. Subsequent submittals, which are required in 5-year increments, will require more detailed information.	The City should leverage the capital improvements program (CIP) developed in this WRF Master Plan in subsequent OEDR submittals to characterize the City's financial requirements to operate and maintain the WRFs. The needs assessment and associated financial information may be used by the State to provide funding support for critical projects.

Legislation	Law / Rule / Guidance	Description / Requirements	Impacts & Recommendations
Florida State Senate Bill 712 (2020) - Environmental Resource Management or "The Clean Waterways Act" (www.flsenate.gov/ Session/Bill/2020/712)	Florida Administrative Code Chapter 62-600.700 (Effective December 6, 2021)	Public utilities or their affiliated companies shall submit **annual reports regarding transactions or allocations of common costs and expenditures on pollution mitigation and prevention** among the utility's permitted wastewater systems, including the prevention of SSOs, collection and transmission system pipe leakages, and inflow and infiltration. The annual report shall be submitted electronically to the applicable district office or delegated local program no later than June 30 of the year following the close of the fiscal year covered by the report.	The City should gather operations and maintenance data of the wastewater systems, including the prevention of SSOs, collection and transmission system pipe leakages, and inflow and infiltration to develop and submit the report. This report may be combined with the action plan annual progress report required per Chapter 62-600.705.
	Florida Administrative Code Chapter 62-600.705 (Pending legislature ratification during 2023 Florida legislative session). Florida Administrative Code Chapter 62-600.705 (Pending legislature ratification during 2023 Florida legislative session).	• WWTF permit applicants will be required to provide a **Power Outage Contingency Plan** (or updates) with the submittal of the facility's application to FDEP for a new operating permit, permit renewal, or substantial permit revision. The plan shall describe the general program and protocols to mitigate the impacts of power outages on the facility's collection /transmission system and pump stations. • WWTF permit applicants will be required to develop a **Collection System Action Plan** which includes a pipe assessment, repair, and replacement action plan with at least a 5-year planning horizon for all collection/transmission systems under the utility's control to mitigate sanitary sewer overflows (SSOs) and underground pipe leaks to the extent technically and economically feasible. An electronic summary of the **Collection System Action Plan** shall be submitted to FDEP with the facility permit application for any new permit, permit renewal, or substantial permit revision. • WWTF permit applicants shall submit **an annual report summarizing the Collection System Action Plan implementation** to the FDEP no later than June 30th of the year following the close of the fiscal year covered by the report.	The City should monitor the development of the rule and prepare the required reports for submittal if the rule is ratified. Updated information regarding FDEP's rulemaking can be found at https://floridadep.go/water/ water/content/water-resource-management-rules-development.

Legislation	Law / Rule / Guidance	Description / Requirements	Impacts & Recommendations
Florida State Senate Bill 712 (2020) - Environmental Resource Management or "The Clean Waterways Act" (www.flsenate.gov/ Session/Bill/2020/712)	Florida Administrative Code Chapter 62-610, 62-625, 62-550, and 62-555 (Pending legislature ratification during 2022 and 2023 Florida legislative session).	The Potable Reuse Commission in the "Framework for Potable Reuse in Florida, 2020" document directed **FDEP was directed to begin potable reuse rulemaking by December 2020** and to recognize reclaimed water as a source of drinking water. Draft rules have been developed and FDEP intends to first address Indirect Potable Reuse (IPR) and groundwater recharge requirements in Chapter 62-610, with rule adoption scheduled for summer 2022. This would be followed by additional revisions to address Direct Potable Reuse (DPR) in Chapter 62-610 (scheduled for 2023), including the Drinking Water Standards and Permitting, Construction, O&M of Drinking Water Systems of Chapters 62-550 and 62-555, respectively.	Should the City consider IPR or DPR in the future, specially to manage surface water discharge limitations, there will be a clear regulatory path to design, construct and operate IPR and DPR facilities. The City should continue to monitor the rule development. The proposed modifications to Chapters 62-550 and 62-555 (Drinking Water Regulations) could change significantly by the proposed rule adoption date of summer 2023 from the last draft issued in June 2021. The City currently has a ground water replenishment (GWR) facility permitted; however, the project is on hold.
Florida State Senate Bill 712 (2020) - Environmental Resource Management or "The Clean Waterways Act" (www.flsenate.gov/ Session/Bill/2020/712) And Florida State House Bill 1309 (2021) – Environmental Regulation (www.flsenate.gov/ Session/Bill/2021/1309)	Florida Statutes Chapter 403.0855 (www.leg.state.fl.us/ Statutes/) Florida Administrative Code Chapter 62-640 (Effective June 21, 2021)	The **biosolids rule revisions** were developed to minimize the migration of nutrients, specifically phosphorus, to prevent impairment to waterbodies. The rule revised the method to determine land application rates set by phosphorous concentration and prohibits application of biosolids to land with a seasonal high-water table within six inches of the soil surface or depth of the biosolids placement. Compliance of new rules to take place within 1 year for new permits or permit renewals issued after July 1, 2020 and within 2 year of the of the effective date for all permits (June 21, 2023).	Potential impacts to the City include higher costs for handling and disposal of biosolids. Impact to land application rates and land application locations. Further discussion about potential impacts and recommendations is included in the biosolids section of this TM.

Legislation	Law / Rule / Guidance	Description / Requirements	Impacts & Recommendations
Florida House of Representatives Senate Bill 64 (2021) – Reclaimed Water (www.myfloridahouse.gov/Sections/Bills/billsdetail.aspx?BillId=70198)	Florida Statutes Chapter 403.064(17) (www.leg.state.fl.us/Statutes/)	**Domestic wastewater utilities that dispose of effluent, reclaimed water, or reuse water by surface water discharge must eliminate non-beneficial surface water discharges** by January 1, 2032. A plan detailing how these discharges will be eliminated was required to be submitted to FDEP by November 1, 2021.	Black & Veatch prepared the City's "Surface Water Discharge Plan to Comply with Senate Bill 64" which was approved by FDEP in May 2022. Additional guidance for effluent management strategies to comply with Senate Bill 64 is included in the Effluent Management Strategies section of this TM.
	Florida Administrative Code Chapter 62-600.680 (Adopted December 6, 2021)	Facilities subject to the requirements of section 403.064(17), F.S., to implement a plan to eliminate nonbeneficial surface water discharge by January 1, 2032, shall electronically submit an **annual progress report** to the FDEP's Wastewater Management Program no later than November 1st each year.	The City should develop and submit annual progress reports to FDEP by the specified deadline.
	Florida Administrative Code Chapter 62-610.466(11) (Pending legislature ratification during 2023 Florida legislative session)	The Bill specifies the total dissolved solids allowable in **aquifer storage and recovery (ASR)** for non-potable reclaimed water.	This provision may allow ASR for reclaimed water be built in more locations. This provision may benefit the City should the City explore options to construct an ASR system for reclaimed water during the ongoing efforts within the City's Reclaimed Water Master Plan.
Florida State Senate Bill 712 (2020) – Environmental Accountability (www.flsenate.gov/Session/Bill/2020/1091)	Florida Statutes Chapter 403.086 (www.leg.state.fl.us/Statutes/)	The Bill makes numerous changes to the **penalties for violating Florida's environmental laws.** Most of these changes increase a penalty by 50 percent.	The City should note these changes for reference or informational purposes.

Legislation	Law / Rule / Guidance	Description / Requirements	Impacts & Recommendations
Florida State Senate Bill 712 (2020) – Environmental Accountability (www.flsenate.gov/ Session/Bill/2020/1091)	Florida Statutes Chapter 166.0481 (www.leg.state.fl.us/ Statutes/)	The Bill encourages counties and municipalities to establish a **sanitary sewer lateral inspection program** by July 1, 2022 and provides parameters for such a program.	Although this portion of the Bill relates to sewer laterals and it is voluntary, the City can consider expanding the sewer leak control required by the Clean Waterways Act to include sewer laterals for a more comprehensive and effective leak control program. Hillsborough County currently has an inflow and infiltration (I/I) program to identify collection mains and sewer laterals which may contribute I/I to the system. A condition assessment is performed in the identified areas and repairs are made to the collection system as necessary. On July 1, 2021, the City of St. Petersburg passed an ordinance for owner responsibility of private sewer repairs to defective laterals. Failure to repair a defective lateral under a certain timeframe will lead to fines. The City of St. Petersburg conducted a pilot program in 2021 which allowed residents, in predetermined neighborhoods, to apply for funding for private lateral line inspections and rehabilitation work.

Appendix D. Biosolids Management Strategies

FINAL

CLEARWATER WRF MASTER PLAN: TASK 2.8 – BIOSOLIDS MANAGEMENT STRATEGY

Technical Memorandum

BV PROJECT NO. 408831
CITY PROJECT NO. 17-0007-UT

PREPARED FOR

City of Clearwater, Florida

26 DECEMBER 2023

BLACK & VEATCH

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1.0 Biosolids Management Strategy Development

Biosolids management programs in Florida are facing significant challenges because of issues related to increasingly stringent regulations. Recent changes to Chapter 62-640 of the Florida Administrative Code resulted in more limitations being placed on biosolids practices. These changes could include more stringent requirements for biosolids management practices, including more limitations on land application and additional monitoring and inspection requirements. The potential future changes in regulations can have far-reaching implications, especially for facilities that currently land apply Class B biosolids. This section presents discussions and evaluations to develop a biosolids management strategy that aligns with the City's goals and provide a sustainable approach for meeting current and anticipated future regulatory requirements.

1.1 Current Solids Operation

The City owns and operates three WRFs, EWRF, NEWRF, and MSWRF as noted in **Section 1.0** of the Final Future Strategies TM (City Project No. 17-0007-UT, December 2023). The following subsections provide an overview of the current solids process operations at these facilities.

1.1.1 East WRF

EWRF is a 5 mgd secondary treatment plant that produces waste activated sludge (WAS) only. Rotary drum thickeners (RDTs) are used to thicken WAS from approximately 1 percent total solids (TS) to 4 to 5 percent TS. The thickened WAS (TWAS) is stored in a holding tank until it is hauled to the NEWRF by a third party. A process flow diagram for solids processes at EWRF is presented on **Figure 1**.

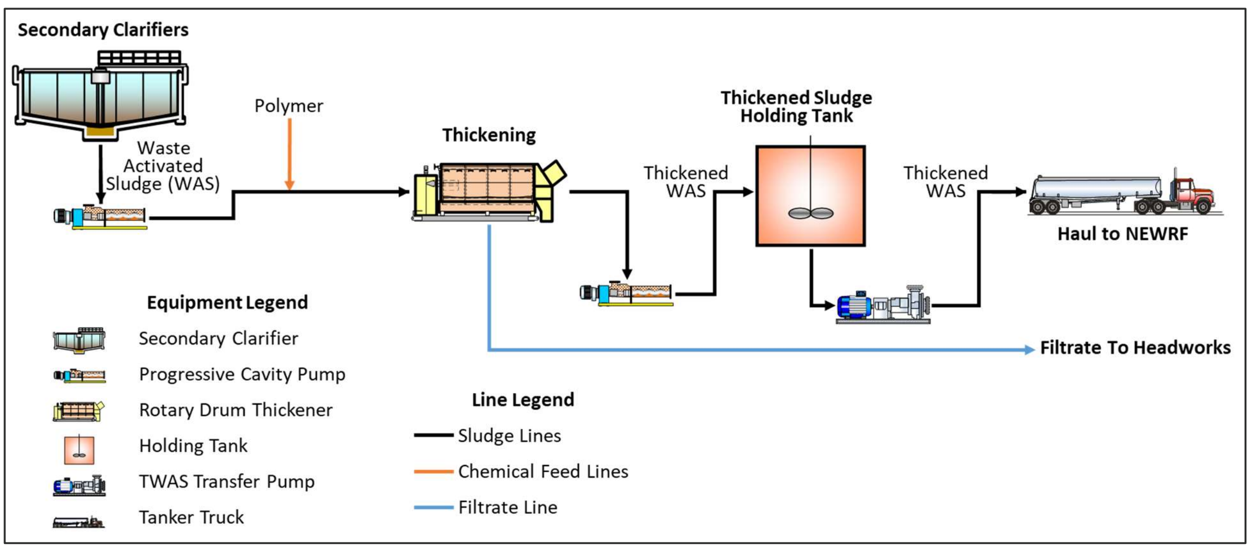

Figure 1 **EWRF Solids Process Flow Diagram**

1.1.2 Northeast WRF

NEWRF is permitted for 13.5 mgd. It currently utilizes a primary clarifier for removal of primary solids (PSL) from the influent. The City is in the process of installing primary filters to replace the primary clarifier. WAS from the secondary clarifiers is thickened by RDTs. PSL and TWAS from NEWRF are blended with TWAS from EWRF (refer to Subsection 1.1.1) and fed to the anaerobic digester. The digested sludge is transferred to a storage tank prior to dewatering. The City has one centrifuge and two belt filter presses (BFPs) for dewatering operations. The centrifuge is primarily used since it produces a dewatered biosolids cake at approximately 22 percent TS compared to the BFPs producing cake at 16 percent TS when they are used. Dewatered biosolids cake are hauled away by a third party for beneficial use. A process flow diagram for solids processes at NEWRF is presented on **Figure 2**. There are also aerobic digestion tanks at the NEWRF; however, they are not being operated.

Anaerobic digestion converts organic material (defined as volatile solids [VS]) to biogas, which is approximately 50 to 60 percent methane. The remainder of the biogas (40 to 50 percent) is carbon dioxide with some other micro-constituents. Approximately 50 percent of the VS in the blended digester feed is converted by anaerobic digestion, which reduces the amount of total solids leaving the plant as dewatered biosolids cake. Biogas is collected from the digester and flared. The City has a combined heat and power engine at this facility that could utilize biogas to produce electricity and heat as hot water; however, it is currently under construction. (Performance Contract Agreement – Energy Efficiency Study, Siemens, City Project No. 08-0048-UT). Hot water for digester heating is provided by boilers using natural gas.

In addition to one primary anaerobic digester, there is a smaller secondary digester; however, its cover fell into the tank and became wedged. City has plans to remove the cover and perform necessary rehabilitation to bring the secondary digester online.

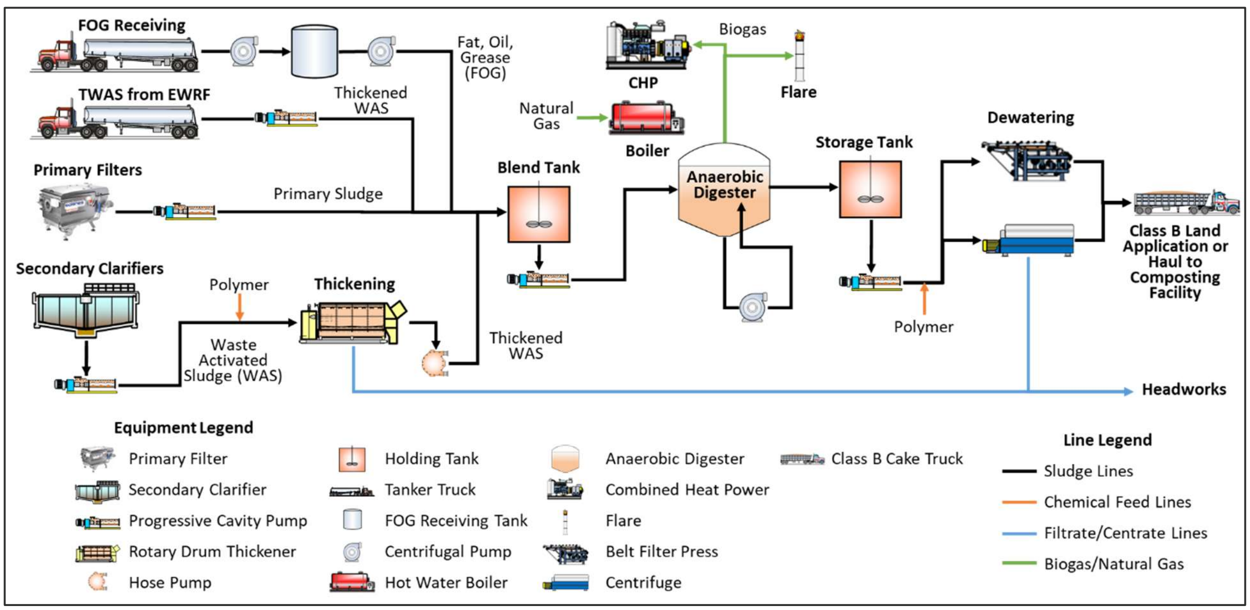

Figure 2 NEWRF Solids Process Flow Diagram

1.1.3 Marshall Street WRF

MSWRF is permitted for 10 mgd. It utilizes primary filters for removal of PSL from the influent and transfer PSL to the anaerobic digester. Only 20 to 25 percent of the influent flow is treated through primary filters. WAS from the secondary clarifiers is thickened by RDTs to approximately 6 percent TS and fed to the anaerobic digester. There is one primary anaerobic digester. At the time of this study, the digester tank was offline for cleaning and rehabilitating the digester cover. A secondary digester had been abandoned in place for a number of years and was recently demolished. Digested sludge is stored in a tank until it is dewatered by a centrifuge or a BFP. Similar to NEWRF, the centrifuge produces a cake at 22 percent TS, whereas the BFP produces 16 percent TS. Dewatered biosolids cake is hauled away by a third party for beneficial use. A process flow diagram for solids processes at MSWRF is presented on **Figure 3**.

A minimal amount of biogas from digestion is used for producing hot water for digester heating. The remainder of the biogas is flared off.

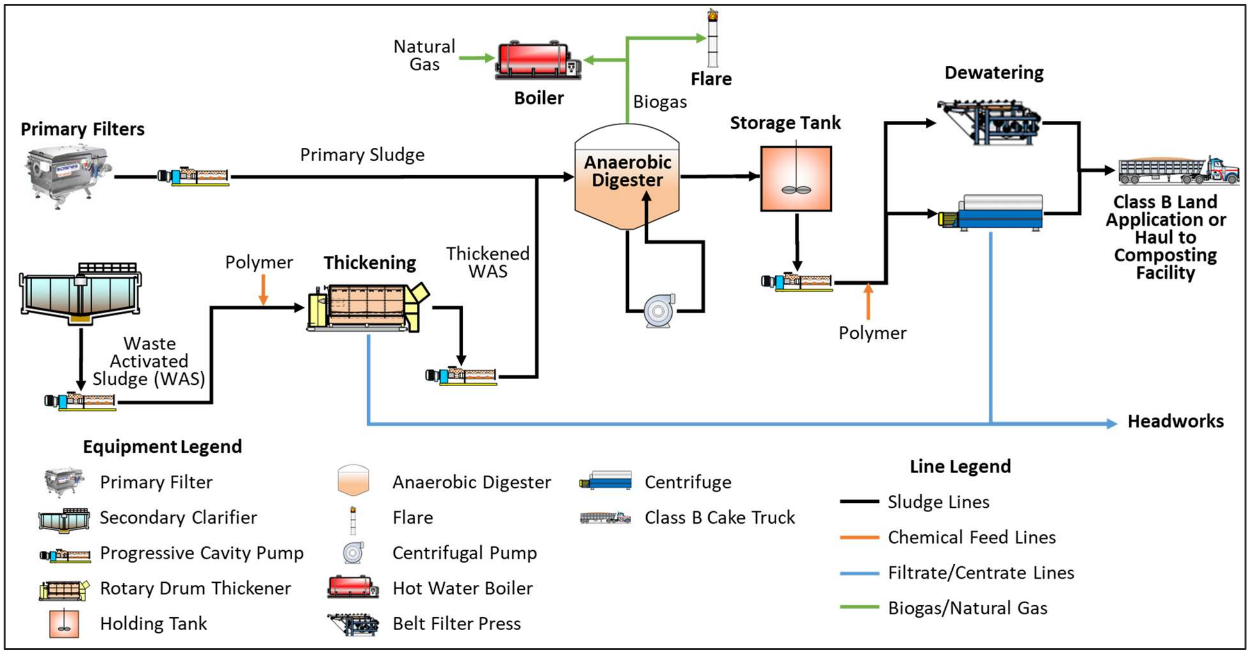

Figure 3 MSWRF Solids Process Flow Diagram

1.1.4 Biosolids Management Strategy

The City currently produces biosolids at two of its three WRFs. Biosolids refer to the residuals and sludge from wastewater treatment that have been sufficiently processed to comply with regulatory requirements for beneficial use. Both NEWRF and MSWRF utilize anaerobic digestion to meet pathogen reduction and vector attraction reduction requirements of EPA 503 and FDEP 62-640 requirements to produce Class B biosolids. The NEWRF biosolids include the processed sludge from the EWRF. The City contracted with two companies in 2021 to land apply Class B biosolids to sites permitted by these contractors. Class B biosolids from NEWRF are land applied by Merrell Brothers, Inc. and Class B biosolids from MSWRF are land applied by H&H Trucking. These contracts are applicable until 2025.

If there is no available land application site, both contractors have the option to take the City's biosolids to a Regional Management Facility (RMF) for further processing to meet Class AA requirements of FDEP 62-640. Under the current program, contractors use composting RMFs to bring Class B biosolids to Class AA standards. Having two contractors and two alternatives for final outlets provide maximum flexibility for the City. However, the City pays extra for biosolids to be processed at an RMF.

Figure 4 and **Figure 5** present historical Class B biosolids production from NEWRF and MSWRF, respectively. The City has historically relied on Class B land application, but in recent years a contractor had difficulty identifying suitable sites, and as a result, a majority of its biosolids were processed at a RMF (composting) facility in 2020 and 2021. It should be noted that the City had a different contractor than the current ones at the time and that contractor did not have enough land application sites for Class B biosolids. The updated rules of 62-640 for land application, which took effect in June 2021, also limited the available land application area in the region. The contract was rebid in the fall of 2021, and the City indicated that the new contractors seem to have enough land for continued application of Class B biosolids.

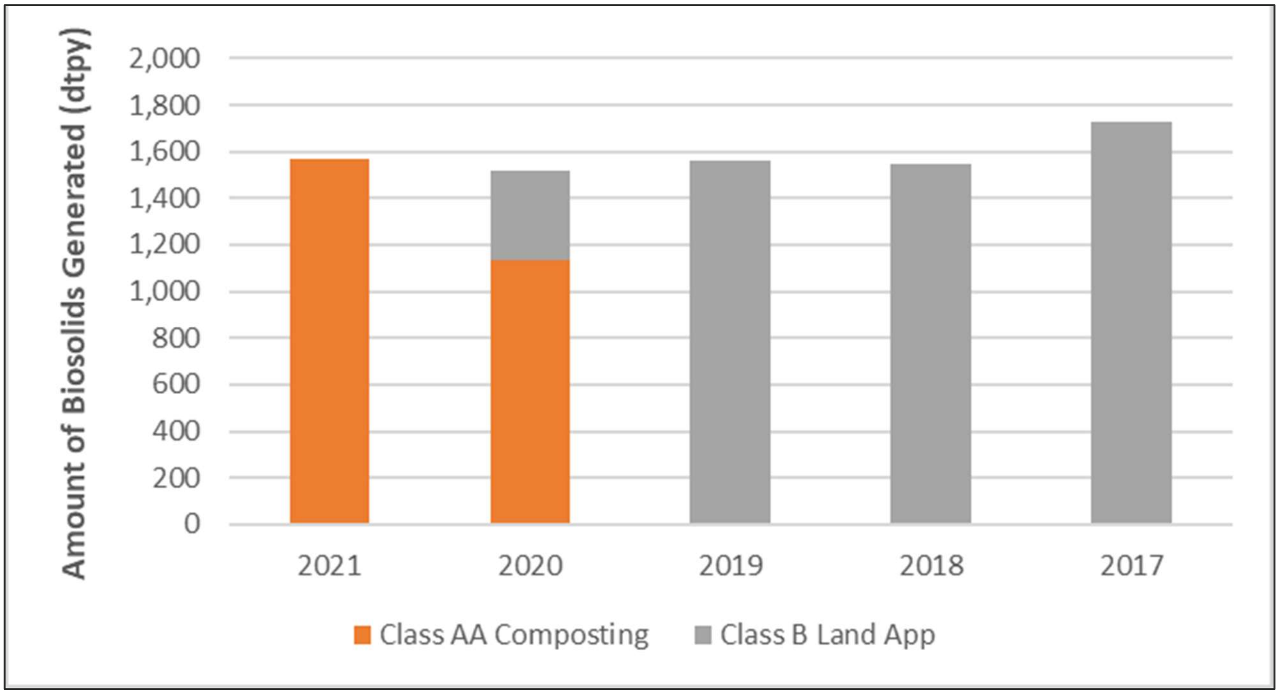

Figure 4 **NEWRF Historical Class B Biosolids Production**

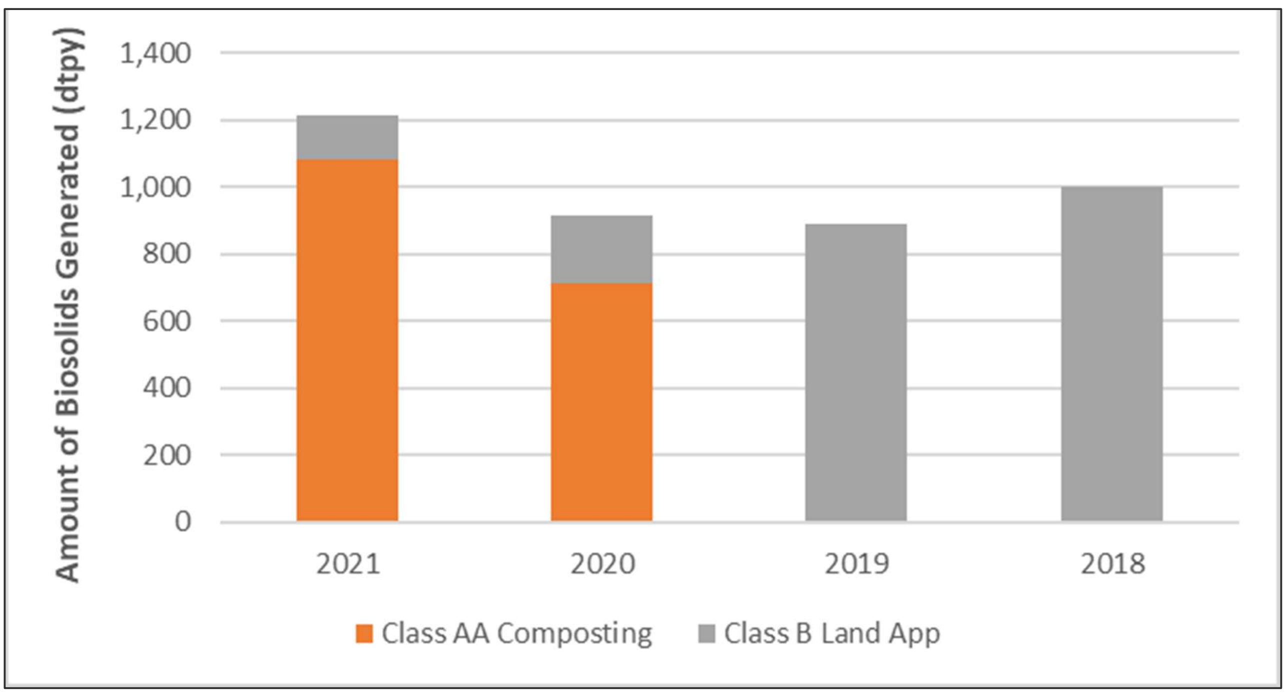

Figure 5 **MSWRF Historical Class B Biosolids Production**

1.2 Final Product Options of the Biosolids Management Strategy

The biosolids regulatory review presented in **Section 4.0** of the Future Strategies TM noted that the Florida Administrative Code 62-640 has been recently updated to minimize the migration of nutrients from biosolids land application sites to prevent impairment of waterbodies.

There are currently approximately 130 permitted land application sites in the state. Biosolids management firms (contractors) are typically the site permittee rather than the landowners or utilities. The 62-640 regulations require that nutrient management plans (NMPs) be developed for each land application site. The NMP is required to include a phosphorus assessment using the Florida P-index. The amount of biosolids that can be applied to a site must be based on the agronomic rate for either nitrogen or phosphorus, whichever is lower.

The revisions to the regulations for land application have generated several questions and concerns regarding the impact on land application programs. These concerns include the impact of the requirement (62-640.400 [14] prohibition) that biosolids not be applied to sites that have a seasonal high groundwater table less than 6 inches from the soil surface or within 6 inches of the intended depth of biosolids placement. The concern has to do with the way the seasonal highwater table is determined and the potential seasonal impact on currently permitted sites.

Other concerns are related to the Mehlich-3 extraction process, which is used to measure phosphorus, iron, and aluminum concentrations in the soil. These concentrations are used to estimate the "Capacity Index," which is a measure of the capacity of the soil to store phosphorus, and the "Percent Water Extractable Phosphorus," which is the percentage of phosphorus in a biosolids sample that is water extractable. Both were new requirements in the regulation.

These revisions to the land application regulations limit the available area for Class B biosolids land application. On the other hand, Class AA biosolids can be distributed and marketed as fertilizers because of their high level of treatment related to pathogens and stringent pollutant limits. Distribution and marketing of Class AA biosolids require a fertilizer license, or Class AA biosolids must be sold or given to someone with a fertilizer license as required by the regulation. When distributed as a fertilizer, Class AA biosolids are exempt from the FDEP nutrient restrictions associated with land application programs. While exempt from the FDEP restrictions, all fertilizers are regulated in a number of counties and communities. These regulations can impact the use of fertilizers during the summer months, June through September.

It is expected that Class B land application will have more stringent regulations in the future. Therefore, the City placed an emphasis on evaluating options that include management of Class AA products as well as Class B product. The following section summarizes the biosolids product options for the City to consider for its future biosolids management strategy.

1.2.1 Biosolids Products and Characteristics

It is critical to understand both how biosolids products differ and how those characteristics impact their use. Products initially assessed fall into the following four general categories:

- Class AA, A, or B biosolids cake.
- Class AA: Heat-dried biosolids.
- Class AA: Composted biosolids.
- Class AA: Manufactured soils (typically created with Class A cake, sand, and other materials).

Approximately 39 Florida facilities produce Class AA biosolid product; 192,879 and 26,717 dry tons are distributed and market in and outside Florida in 2018, respectively. Since the City is interested in Class AA products and Class A and B cake have a small number of potential markets, the focus in this study will be on Class AA products.

1.2.1.1 Dewatered Digested Biosolids Cake

Dewatered digested biosolids cake typically has a TS concentration less than 30 percent and is clay-like in appearance and consistency. This characteristic alone limits its use to bulk agriculture or silviculture applications (without subsequent processing), as it is difficult for urban users to manage because of the consistency and site access restrictions. **Figure 6** shows a typical application of biosolids on a pasture field. Other potential bulk uses include rapid vegetative establishment for disturbed sites to provide erosion control, e.g., burn area restoration and land reclamation. The City currently produces Class B digested cake at NEWRF and MSWRF.

Figure 6 Biosolids Cake Land Application for Agriculture

1.2.1.2 Thermally-Dried Biosolids

Thermally dried (dried) biosolids meet Class AA standards and have a TS concentration between 90 and 95 percent, depending on the drying system selected. The product's physical characteristics, which include particle size, shape, density (hardness), and dust content, vary widely, from uniform spheres with good density to irregular shaped products that have low density. **Figure 7** shows general characteristics of dried biosolids. The physical characteristics are affected by the type of biosolids being processed, e.g., digested versus undigested, as well as the type of drying system used. Drying has a minimal impact on product nutrient characteristics; therefore, the nutrient content of the digested material can be used to estimate dried product nutrient content.

Dried biosolids have been manufactured and used for decades in the U.S. Uniform, spherical pellets such as the ones generated by the South Cross Bayou WRF in Pinellas County, can be used to replace or supplement conventional fertilizer in agriculture but can also access higher-value outlets such as golf courses and other urban markets, as well as commercial fertilizer blenders. Moreover, because of their higher quality and physical characteristics, these uniform pellets are highly transportable, commanding prices that can support the development of distant markets. For example, dried biosolids from northern states are routinely marketed in the Sun Belt, and at least one Texas utility commanded prices "at the gate" (of the wastewater treatment plant) of $35/ton for their product, which was sold throughout the Midwest. It should be noted, however, that markets take considerable effort, time, and specialized expertise to develop and maintain. This high quality pellet product is typically sold in bulk or bags, depending on target market needs, while other dried products are typically marketed only in bulk form. Most producers will provide at least a portion of their product in bulk. Farmers and fertilizer blenders typically prefer the product in bulk form, so it can be loaded into spreaders or hoppers at the point of use. Homeowners typically prefer small bags, while commercial users may prefer totes or "super sacks" providing quantities of up to 2,000 lbs. Application rates for turf applications are similar to those for dewatered biosolids, ranging from 4 to 8 dry tons/acre (dt/ac), but this is dependent on the biosolids nutrient content, crops being grown, and other factors.

Parameter	Rotary Drum	Paddle	Belt	Belt	Belt	Belt (post-processed)
	Andritz	Komline	Andritz	Huber	Suez, Veolia/Kruger	Huber, Veolia/Kruger
Shape	Pellet	Granule/Irregular	Granule/Irregular	Irregular	"String"	Cylinder
Uniformity	Excellent	Good	Good	Poor	Poor	Excellent
Size (mm)	0.5-4	0.5-5	0.5-4	2-8	Not available	2-5 (length)
Density (lb/cf)	40-45	35-45	40-45	20-25	15-25	45
Hardness	Hard	Somewhat hard	Somewhat hard	Friable	Friable	Hard

Figure 7 General Characteristics of Heat Dried Biosolids

1.2.1.3 Compost

Compost is the product resulting from the controlled biological decomposition of organic waste and can include biosolids, as well as vegetable, yard, and wood wastes. Of the products studied, compost is the most familiar to most consumers in the region and nationally based on prior market surveys by Black & Veatch. The product is relatively dry (generally with a TS content greater than 60 percent), and easily handled, which is attractive to users. As a stand-alone product, compost is often used as topdressing by homeowners or turf managers (who typically spread the product at a depth of 1/4-inches to 1/2-inches on established lawns) or mixed directly into planting beds to improve poor soils (the compost provides nutrients and organic matter to the soil as it degrades). In neighboring states like Georgia, biosolids compost, including the well-known ERTH Food, can generally be purchased in bulk or bagged form by users; alternately, the compost can be spread with a hose by landscaping and maintenance services as shown on **Figure 8**. It is not uncommon, however, to see compost mixed with other materials such as sand to produce a topdressing and soil to produce a manufactured topsoil. For example, ERTH Products includes biosolids composts in specialty mixes they prepare for bioretention ponds and other uses. Composts are also used across the nation for erosion control and vegetative establishment in transportation construction projects.

Figure 8 Compost Spreading via Sprayer

1.2.1.4 Manufactured Soils

There is no standard agreement on the definition of "manufactured soils," also called "soil blends," "engineered soils," or "imported soils," which can vary widely depending on their ingredients, Class A cake, compost, sand, loam, sawdust, and so on. In the United States, utilities that generate a Class A dewatered biosolids cake, such as DC Water in particular, are exploring this market as a supplement to bulk agricultural outlets. Though not yet common practice, at least one facility, Tacoma, Washington, has successfully marketed manufactured soils, TAGRO® Mix and TAGRO® Potting Soil, for many years. Most manufactured soils are typically used for landscaping, incorporated as a top layer for urban applications such as lawn establishment and maintenance, or used as a soil mix in gardens. For turf and lawn uses, application rates can range from 1/4-inches depth for existing lawns to 1-inch for lawn establishment. These materials are also a key ingredient in the construction of bioswales and bioretention ponds, and the United States Compost Council (USCC) has developed specifications for their development and use.

1.3 Approach to Biosolids Management Strategy Development

The screening of treatment technologies and the final evaluation of selected treatment and management alternatives followed a two-step approach, as shown on **Figure 9**. The first step was the screening phase. During this phase, a wide range of solids processing technologies were evaluated based on high-level screening criteria, such as current industry experience and how the technology compared to the existing treatment system. Potential screening criteria were reviewed with the City during Task 2.8, Workshop No. 1 (April 22, 2022) and feedback was incorporated to finalize the criteria. The **Biosolids Screening Criteria TM, Black & Veatch, 2022** provides a description of the criteria and their use. Information used as the basis for screening of the technologies was based on engineering experience, literature, and vendor-provided data. During Task 2.8, Workshop No. 2 (May 18, 2022), the City and Black & Veatch reviewed all applicable technologies and screened them down to four alternatives to be evaluated further. Screening eliminated those technologies not deemed suitable for further evaluation. Section 1.4 provides an overview of the results of the screening process.

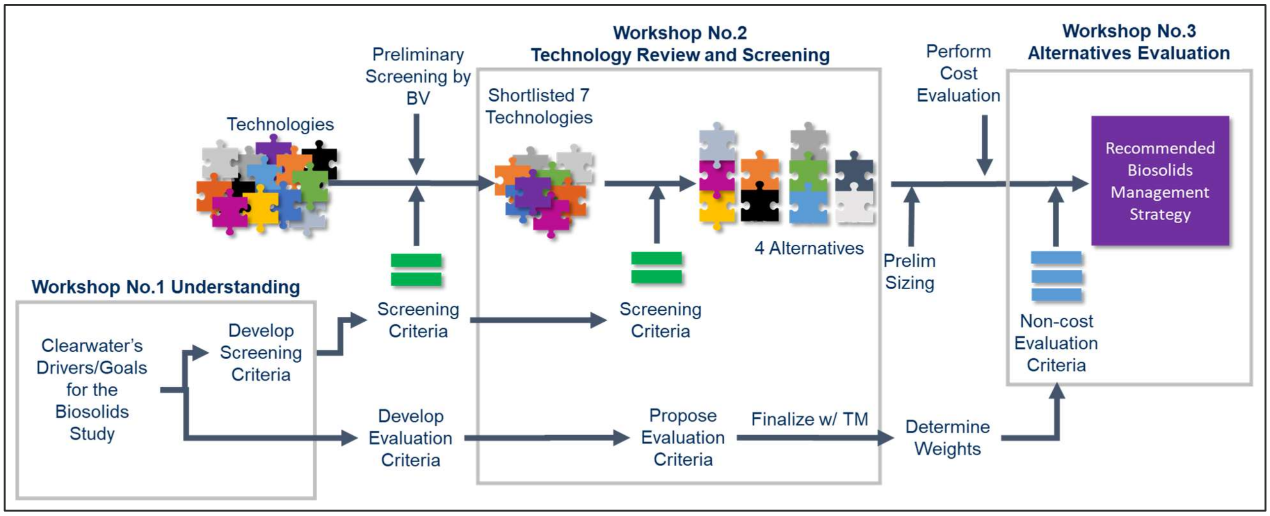

Figure 9 **Technology Screening and Alternatives Evaluation Process**

The selected technologies from the screening process were then used to develop complete management alternatives for evaluation as the second step. Black & Veatch developed preliminary sizing for the four shortlisted alternatives and estimated capital costs and annual operating costs. A defined set of non-economic criteria in conjunction with capital costs, annual operating costs, and life-cycle costs were used to identify the best-fit biosolids management approach for the City. The non-economic evaluation criteria were reviewed with the City during Task 2.8, Workshop No. 2 (May 18, 2022). Feedback was used to finalize these evaluation criteria, which are summarized in the **Biosolids Screening Criteria TM, Black & Veatch, 2022**. After the evaluation criteria were finalized, the City developed weights for each criterion. Black & Veatch presented preliminary sizing and capital and annual operations costs during Task 2.8, Workshop No. 3 (July 11, 2022). City staff then assigned a qualitative score to each alternative between 1 and 3 for each criterion. Section 1.5 provides further details on alternatives evaluation.

1.4 Technology Screening

Screening criteria were established with the City to support evaluation of the wide range of solids processing technologies in the marketplace and ultimate use and disposal practices to eliminate those that are considered unlikely to provide cost effective or reliable solutions for managing the City's biosolids in the future. **Table 1** presents the criteria used to screen technologies. At the end of the screening process, technologies that were deemed to be unsuitable for the City's needs were dropped from further evaluation with concurrence by the City.

Table 1 Screening Criteria

Criterion	Comparative Basis	Description
Final Biosolids Product Quality	Class AA Marketable Product	Class AA marketable product is preferred to open outlets and reduce dependence on third-party management.
	Class AA Cake for Land Application	Class A cake is preferred over Class B because of regulatory restrictions associated with Class B.
	Class B Cake for Land Application	Class B cake is a minimum requirement for this project.
Technology Maturity	Emerging	One or fewer North America operations with less than 2 years of successful track record.
	Early Development	One or more North America operations with 2 to 10 years of successful track record.
	Established	Many facilities and at least 10 years of proven performance history in North America.
Relative Life-Cycle Cost	Low/Moderate/High	Life-cycle cost of the alternative technology was rated against other technologies for similar size facilities based on Black & Veatch experience.
Compatibility with Existing and Planned Liquid and Solids Processes	Yes	Technologies are proven compatible with existing or potential liquid treatment technologies without significant sidestream impacts.
	Sidestream Issues	Potential for impacts on the liquid stream associated with treatment of sidestreams.
	Sludge Type Issues	If a technology is not suitable for all sludge types (PSL and WAS), preferences/restrictions will be noted as applicable.
	Unproven	If a technology is unproven, information is not available to determine potential sidestream impacts.
Operational Complexity	OK/Moderate/ Complex	An alternative technology was rated against the current operation at City WRFs and compared to other candidate technologies based on Black & Veatch experience.
Size/Footprint	OK/Moderate/ Significant	Ability to locate the new facility on-site or the potential to regionalize treatment elsewhere.

1.4.1 Solids Processing Technologies

A comprehensive list of technologies currently used in the industry for stabilizing wastewater sludge to meet Class AA/A or Class B pathogen removal and vector attraction reduction requirements is provided on **Figure 10**. **Biosolids Workshop No.2 Technology Review, Black & Veatch, 2022** provides information slides on all the technologies shown, which were reviewed during Task 2.8, Workshop No. 2 on May 18, 2022.

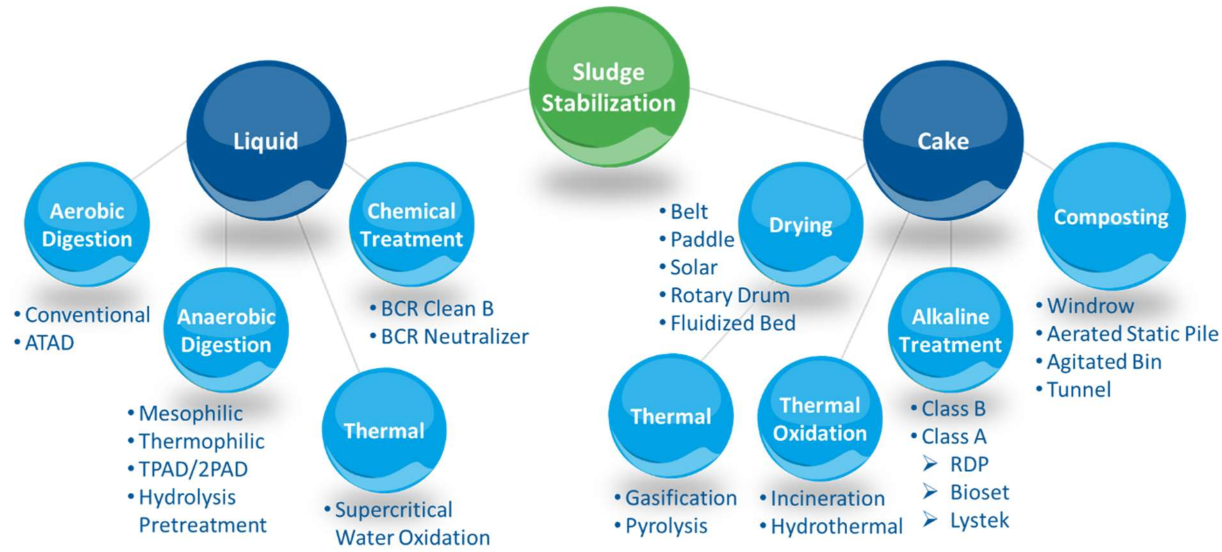

Figure 10 Possible Wastewater Sludge Stabilization Technologies and Enhancement Processes

Stabilization technologies include a variety of processes that are used to reduce volatility and odors, vector attraction, and pathogen content of solids. Stabilization can be achieved through chemical, thermal, or biological methods, or by using a combination of processes. Some stabilization options are applied to liquid sludge, such as digestion (anaerobic or aerobic), while other stabilization options can be applied to liquid or dewatered cake, such as lime addition. Post dewatering stabilization, such as thermal drying or incineration, also provide volume minimization and dramatic change in the solid's characteristics.

In addition to incineration, gasification and pyrolysis are emerging thermal conversion technologies that are being discussed with some interest in relation to biosolids treatment. Gasification involves the thermal conversion of the biosolids with a limited oxygen supply to produce a combustible gas known as "syngas." Pyrolysis involves the thermal conversion of biosolids without an oxygen supply producing a liquid fuel or bio-oil, a solid char, and syngas. Both technologies are considered as emerging technologies with respect to their application with biosolids. However, they both are seeing interest from utilities around the country because they claim to destroy PFAS compounds, similar to incineration, because of high operating temperatures and they are not subject to air emissions regulations that are required for incineration.

Digestion processes are the most widely used stabilization technologies for WRFs. Anaerobic digestion can be coupled with select treatment technologies to "enhance" the digestion process. Many of these process enhancements improve digester performance or provide methods of energy or resource recovery. In most cases, enhancements are not expected to change the inherent quality of the products generated through the digestion process.

1.4.2 Summary of Technology Screening

As part of the technology screening step, Black & Veatch reviewed all potential technologies against the City's current biosolids management program and available footprint at the WRFs. Based on this initial review, Black & Veatch preliminarily shortlisted eight technologies for further discussion with the City. These technologies are listed as follows:

- Status Quo: This alternative continues Class B land application of digested biosolids cake.
- Third-Party Processing: This alternative was same as Status Quo except that the digested biosolids cake would be hauled to an RMF for further processing to Class AA biosolids.
- Chemical Hydrolysis Pre-Treatment with Anaerobic Digestion: This alternative would reduce the amount of biosolids leaving the plant by enhancing the digestion. However, the digested biosolids cake would still be only suitable for land application.
- Implementation of Thermal Drying: This alternative would improve the final product to a Class AA biosolids granule or pellet and significantly reduce the number of trucks leaving the plant.
- Converting to Autothermal Thermophilic Aerobic Digestion (ATAD): This alternative considered replacing current anaerobic digestion processes with ATAD reactors to produce Class AA digested biosolids cake.
- Anaerobic Digestion Followed by Post-Aerobic Digestion (PAD): PAD implementation would further reduce the amount of digested solids while providing nutrient removal. The final product, however, would still be Class B biosolids.
- Class A/AA Chemical Stabilization: This alternative would replace the current anaerobic digestion operation at NEWRF and MSWRF with chemical stabilization to produce Class AA biosolids cake.
- Class B Chemical Stabilization: This alternative would replace the current thickening operation at EWRF with a chemical stabilization process to produce Class B biosolids for land application while eliminating hauling the TWAS from EWRF to NEWRF.

The biosolids processing technologies, including the preliminary shortlist presented above, were discussed with the City during the Task 2.8, Workshop No. 2 on May 18, 2022. **Biosolids Workshop No.2 Technology Review, Black & Veatch, 2022** presents a matrix that summarizes the considerations on each technology including the City's input during the workshop. Based on these discussions, the City determined to proceed with status quo, third-party processing (i.e., RMF) and thermal drying alternatives. The City considered any bulk land application practice, whether Class B or Class AA, as a risk for the future biosolids management program. Further, the City did not want to implement any process that requires chemical storage.

In addition to these three alternatives, City asked Black & Veatch to perform a high-level evaluation of the following two alternatives to determine whether these processes could be constructed within the NEWRF footprint.

- Composting at a City Facility: This alternative would implement a composting facility at the NEWRF to process digested biosolids from both NEWRF and MSWRF. The final product would be a Class AA product that could be used in urban applications as well as in bulk agriculture.
- Solar Dryer at a City Facility: This alternative would install a solar drying facility at the NEWRF to process digested sludges from both NEWRF and MSWRF. Although solar drying has the potential to achieve Class AA stabilization, it is more difficult to demonstrate regulatory compliance. The finished

product could be used for bulk agricultural applications, and if Class AA can be demonstrated, it may also be suitable for some urban applications.

Based on the future biosolids generation from City's WRFs, Black & Veatch determined that either a composting facility or a solar drying facility could be located at the NEWRF. Either facility would be sized to handle all solids from City facilities. Following Task 2.8, Workshop No. 2 (May 18, 2022) and further evaluations, the City and Black & Veatch further reviewed the technology alternatives on June 2, 2022. The following technologies were then shortlisted for further evaluation based on the input received during this meeting:

- Alternative 1 – Class B Land Application or RMF: Existing operation with 100 percent of digested biosolids to be land applied as Class B or 100 percent hauled to an RMF for further processing to Class AA.
- Alternative 2: City-wide composting facility at NEWRF to treat digested biosolids from NEWRF and MSWRF to Class AA compost standards.
- Alternative 3: City-wide solar drying facility at NEWRF to treat digested biosolids from NEWRF and MSWRF. As previously noted, the dried biosolids could potentially be classified as Class AA but will require significant testing to demonstrate compliance.
- Alternative 4: Thermal dryer at NEWRF to treat digested biosolids from NEWRF and a thermal dryer at MSWRF to treat digested biosolids from MSWRF. Both of these new facilities would produce Class AA dried biosolids.

1.5 Evaluation of Short-Listed Alternatives

A brief description of the four biosolids processing alternatives are provided below with a high-level mass balance under projected 2050 loading conditions.

1.5.1 Alternative 1: Class B Land Application or RMF

This option was identified as the baseline option to be carried through for detailed evaluation. Under this alternative, TWAS from EWRF will be hauled to NEWRF and blended with sludge from the NEWRF. The City will continue to process its solids through the anaerobic digestion processes at the NEWRF and MSWRF. To provide redundancy, a new digester tank will be installed. A redundant digester will allow the City to take a digester out of service for periodic cleaning and enable continued regulatory compliance if one digester is out of service because of unscheduled issues. The digested biosolids will be land applied as Class B (Alternative 1A) or hauled to a third-party operated facility (i.e., RMF) for further processing to Class AA. **Figure 11** presents a general process flow for this alternative.

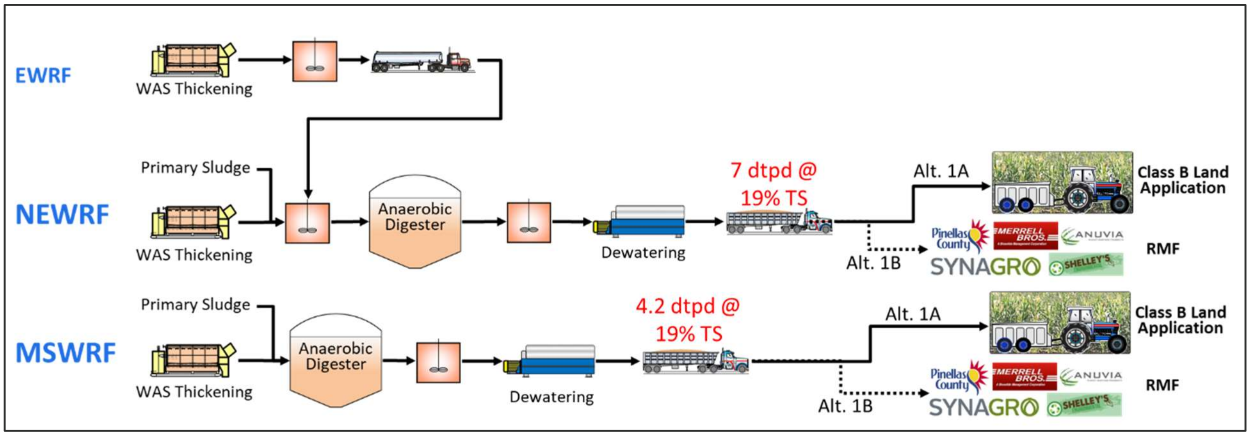

Figure 11 Anaerobic Digestion with Class B Land Application or RMF

Table 2 summarizes key elements associated with Alternative 1.

Table 2 Alternative 1 – Key Elements

Description
Improvements at EWRF
• Renewal and replacement of existing processes (RDTs)
Improvements at NEWRF
• Renewal and replacement of existing processes (RDTs, digestion equipment, and dewatering) • Addition of one redundant digester
Improvements at MSWRF
• Renewal and replacement of existing processes (RDTs, digestion equipment, and dewatering) • Addition of one redundant digester

Advantages and disadvantages of Alternative 1 are summarized in **Table 3**.

Table 3 Advantages and Disadvantages of Class B Land Application

Advantages	Disadvantages
Proven system/challenges are known	Requires new digester to provide redundancy
Biogas could be beneficially used for production of electricity or renewable natural gas	Unknowns with future regulatory requirements for Class B land application

Advantages and disadvantages of Alternative 1B are summarized in **Table 4**.

Table 4 Advantages and Disadvantages of RMF

Advantages	Disadvantages
The responsibility for end use processing would lie with a third-party contractor, which minimizes the City's operating burden	As a result of placing the responsibility for processing on a third party, the City loses control over the process.
Conversion of biosolids to a high value fertilizer product	There is a potential risk if the contractor goes out of business or increases pricing after the initial contract period.
Biogas could be beneficially used for production of electricity or renewable natural gas	A backup option would be required to mitigate against the risk of the treatment system going down. (Typically, this responsibility would be placed on the contractor.)

1.5.2 City-Wide Composting Facility at NEWRF

This option builds on the baseline (Alternative 1) to implement a City-owned-and-operated composting facility at NEWRF and produce high quality Class AA compost product.

Composting is identified as a process to further reduce pathogens (PFRP) by federal and state regulations and can be used to produce a Class AA product by meeting certain time and temperature requirements. The process requires large quantities of bulking material (i.e., amendment) to provide a suitably aerobic environment for decomposition of the biosolids. The bulking agent also helps to maintain an appropriate carbon to nitrogen ratio to facilitate the biochemical degradation process. Options available include "in vessel" composting, "static pile" composting, and "windrow" composting. In-Vessel Composting (IVC) technology was considered for this evaluation because it requires the least area compared to other options. Further, enclosing the process allows for better odor control of emissions than other types of composting, but it is still difficult to control all fugitive emissions.

Composting would require a large land area, would be relatively difficult to odor control, and operations would be highly visible to the neighbors surrounding the NEWRF. It will also require increased truck traffic because of the bulking material.

Under this scenario, digested biosolids cake from the MSWRF will be hauled to the IVC facility at the NEWRF. Digested biosolids cake from both facilities would be blended and mixed with bulking agent material and recycled over-sized material from the finished compost. Then, the mixed material will be placed in compost bays for approximately 24 days for active composting. Pathogen and vector attraction reduction occur during the active composting phase. Agitators move through the bays mixing the material, which helps to maintain aerobic conditions and ensure a quality product. Mixing in an IVC system is also required for regulatory compliance as a PFRP. There are four separate zones in a bay and each zone has a dedicated blower to provide the right amount of air to facilitate microbial degradation. Temperature probes installed along the compost bay monitors the process. After composting, the material is moved to curing piles for 30 days. Finally, finished compost is screened and large bulking agent particles are recovered and reused while the rest of the compost can be used as a marketable product. **Figure 12** presents a process flow for this alternative.

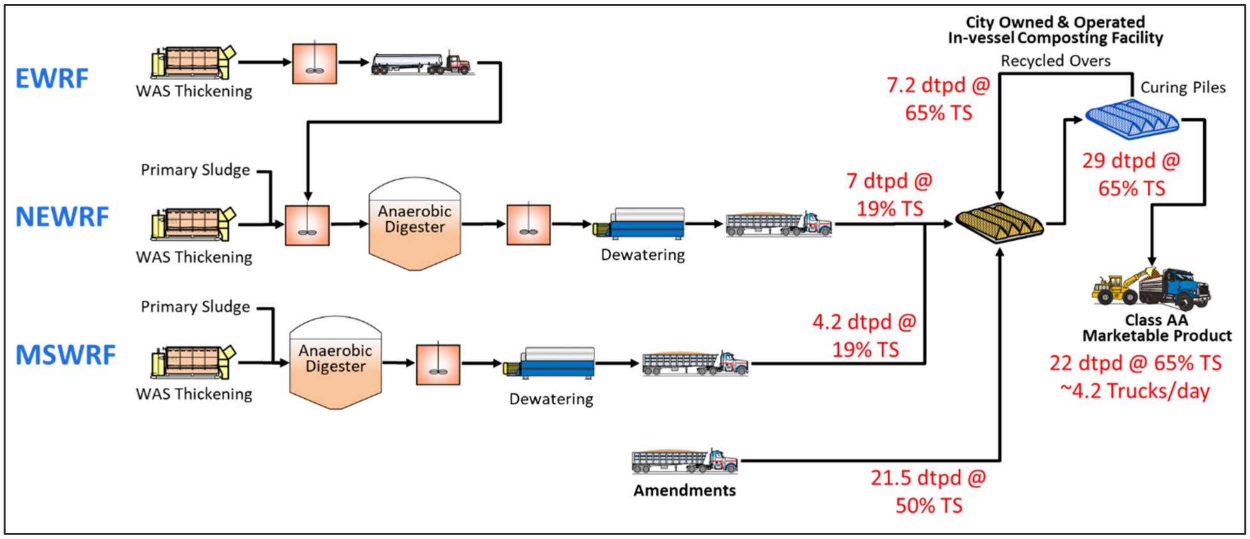

Figure 12 Process Flow Diagram for City-wide Composting Facility at NEWRF

Table 5 summarizes key elements associated with Alternative 2.

Table 5 Alternative 2 – Key Elements

Description
Improvements at EWRF
• Renewal and replacement of existing processes (RDTs)
Improvements at NEWRF
• Renewal and replacement of existing processes (RDTs, digestion equipment, and dewatering) • Addition of one redundant digester
Improvements at MSWRF
• Renewal and replacement of existing processes (RDTs, digestion equipment, and dewatering) • Addition of one redundant digester
IVC Facility at NEWRF
• Eight, 200-foot long IVC bays in an enclosed building, with two automatic agitators for mixing the bays • Covered amendment storage pad (70 feet by 65 feet) for 7 days of storage • Digested biosolids cake receiving and storage building (70 feet by 65 feet) for 5 days of storage • Pad (196 feet by 100 feet) for 30-day curing • Covered product storage pad (60 feet by 53 feet) for 7 days of product storage • Biofilter and fans for odor control

Figure 13 presents the conceptual layout of the IVC facility at NEWRF.

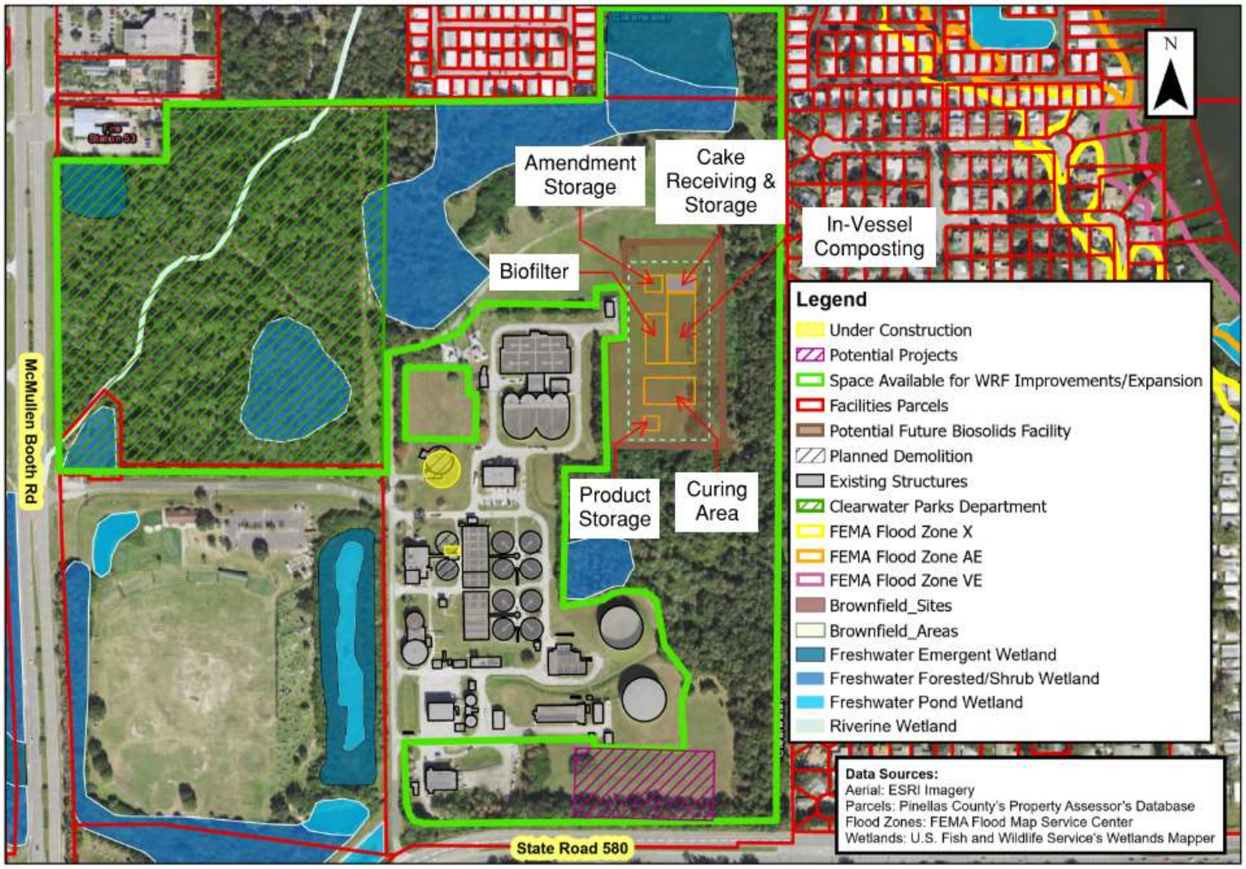

Figure 13 Composting Facility Layout at NEWRF

Advantages and disadvantages of City-wide composting facility alternative are summarized in **Table 6**.

Table 6 Advantages and Disadvantages of Implementing Composting at NEWRF

Advantages	Disadvantages
Composting process has low energy requirements	Large volumes of truck traffic (for the biosolids and the bulking agent)
The process would produce a Class AA composted product, which would have diverse outlets	A suitable bulking agent is required
Synergy with City's Solid Waste department (e.g., to secure bulking agent)	The process is space intensive
Final product is generally highly accepted by the public	The process is manually intensive

Advantages	Disadvantages
Allows digester gas to be utilized for other uses, such as power production	It is difficult to fully contain, capture, and treat all odorous emissions, increasing the potential for odor impacts to neighbors
	The operations would be visible to neighbors, including increased truck traffic and materials movement on the site

1.5.3 City-Wide Solar Drying Facility at NEWRF

This option builds on the baseline (Alternative 1) to implement a City-owned-and-operated solar drying facility at NEWRF and produce a dried product. The solar drying system is a greenhouse-like system that consists of a rectangular structure, translucent chamber, sensors to measure atmospheric drying conditions, air louvers, ventilation fans, mobile electromechanical device that agitates and moves the drying solids, and a microprocessor that controls the drying environment.

Similar to Alternative 2, the digested biosolids cake from MSWRF will be delivered to the NEWRF where it will be mixed with digested biosolids cake from that facility. The blended cake will be conveyed to the solar dryer. The turning mechanism in the solar dryer will distribute this cake and move it periodically to achieve uniform dryness using the heat from the solar radiation. The dried product will be stored in a covered area until it is hauled away or distributed as a marketable product. The facility will be capable of drying solids from 18 percent TS to 90 percent TS based on average climatic conditions for Clearwater, Florida. FDEP does not recognize solar dried product as a defined Class AA biosolids product in accordance with 62-640; therefore, there are two procedures that may be used to demonstrate compliance. One requires extensive testing of bacteria, enteric viruses, and viable helminth ova in the untreated sludge and in the finished biosolids on a regular basis. A second procedure would involve documenting operational criteria and pathogen reduction performance for an extended period and submitting that information to EPA for approval as a process equivalent to a PFRP.

A general process flow for a solar drying alternative for the City's biosolids is provided on **Figure 14**.

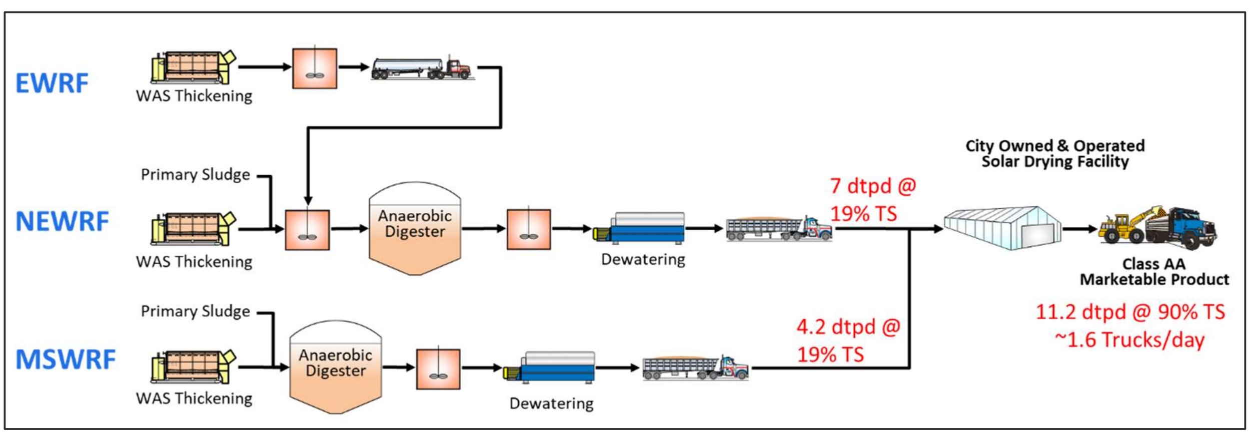

Figure 14 Process Flow Diagram for Solar Drying Facility at NEWRF

Table 7 summarizes key elements associated with Alternative 3.

Table 7 Alternative 3 – Key Elements

Description
Improvements at EWRF
• Renewal and replacement of existing processes (RDTs)
Improvements at NEWRF
• Renewal and replacement of existing processes (RDTs, digestion equipment, and dewatering) • Addition of one redundant digester
Improvements at MSWRF
• Renewal and replacement of existing processes (RDTs, digestion equipment, and dewatering) • Addition of one redundant digester
Solar Drying Facility at NEWRF
• Five greenhouses (40 feet by 420 feet each), including the following: o Traction drive o Sludge turning unit o Recirculation fans o Exhaust fans o Control system • Covered biosolids cake receiving pad (140 feet by 30 feet) for 5 days of storage • Covered product storage pad (40 feet by 30 feet) for 7 days of storage • Radial carbon system for odor control o Lower foul air strength and high volume of exhaust resulted in very large footprint for a biofilter and correspondingly high capital cost; therefore, an activated carbon system was assumed

Figure 15 presents the conceptual layout of the solar drying facility at NEWRF.

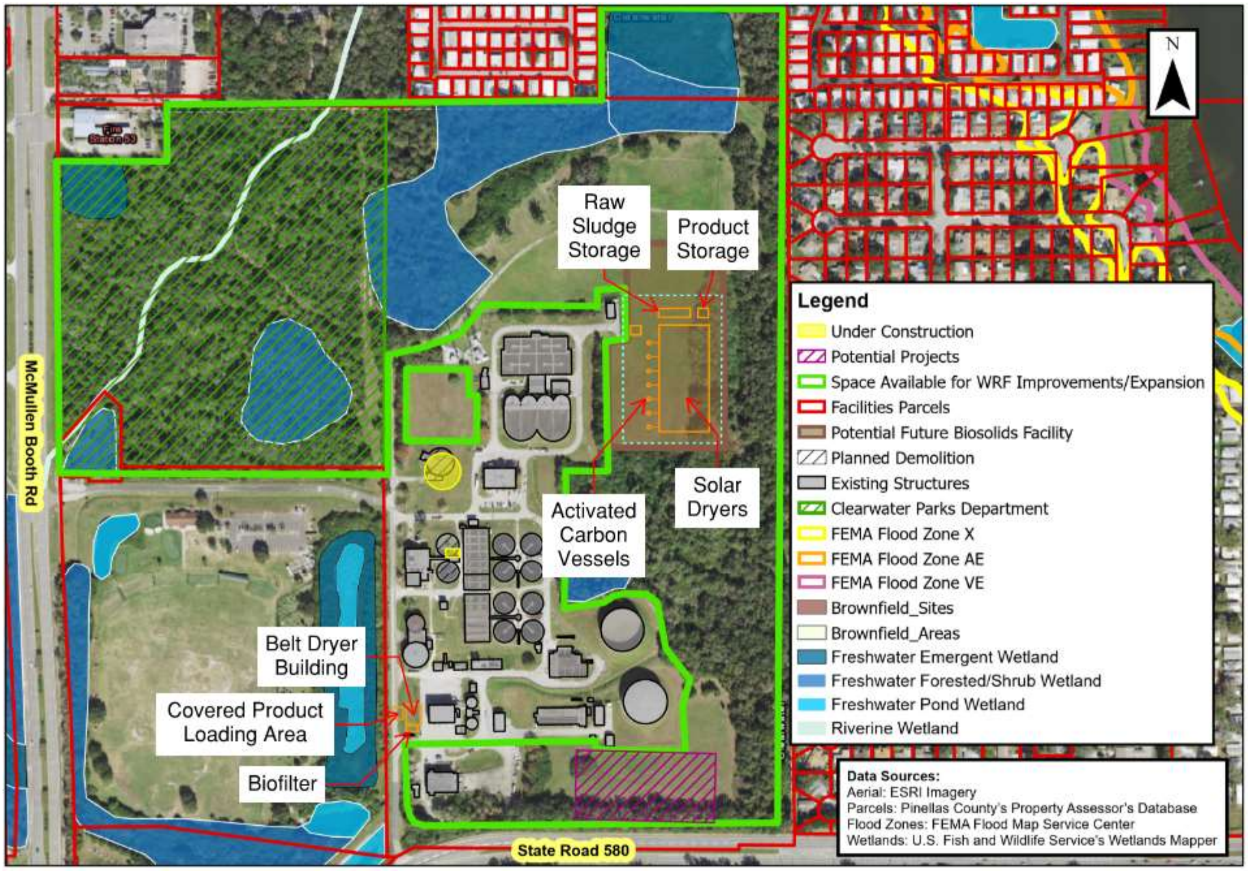

Figure 15 Solar Drying Facility Layout at NEWRF

Advantages and disadvantages of composting alternative are summarized in **Table 8**.

Table 8 Advantages and Disadvantages of a Solar Drying Facility

Advantages	Disadvantages
Maximizes volume reduction	Some truck traffic (for the biosolids from MSWRF)
Potentially marketable product with high degree of diversity in use	Large land requirement
Simple process	Increased risk of odors; off-gas requires treatment
Inherently more safe than thermal dryers	Site-specific permitting for Class AA
No natural gas required	

Advantages	Disadvantages
Allows digester gas to be utilized for other uses, such as power production	

1.5.4 Thermal Dryer at NEWRF and MSWRF

This option builds on the baseline (Alternative 1) to implement a thermal drying facility at NEWRF and MSWRF to produce high quality Class AA product. Under this scenario, a belt dryer will be installed at NEWRF and another belt dryer will be installed at MSWRF. Although there are different types of dryers that could be considered, a belt dryer system was assumed because of its simplicity, compatibility with the size of the facilities being considered, and the inherent safety associated with lower temperature drying systems. For this evaluation, it was assumed that a stacked, two-belt dryer would be used. Further evaluation of dryer systems is warranted if this technology is selected.

The digested biosolids cake from the dewatering process will be conveyed into cake receiving bins at the belt dryer system. A cake pump will transfer the solids to the upper belt in the dryer. As the belt moves along the dryer, the hot air will remove the moisture from the sludge cake. The dried solids will fall from the upper belt to a lower belt that operates in the opposite direction to increase the retention time in the dryer. The final dried product will drop from the lower belt to a conveyor and be transferred to the final product storage area. The moist air will be treated to remove condensate and some of it will be recirculated and heated to repeat the process. The rest of the air is exhausted to a biofilter to control odor. In a belt dryer system, heat is provided by hot water boilers or steam boilers, depending on the system and manufacturer.

A general process flow for this alternative is provided on **Figure 16**.

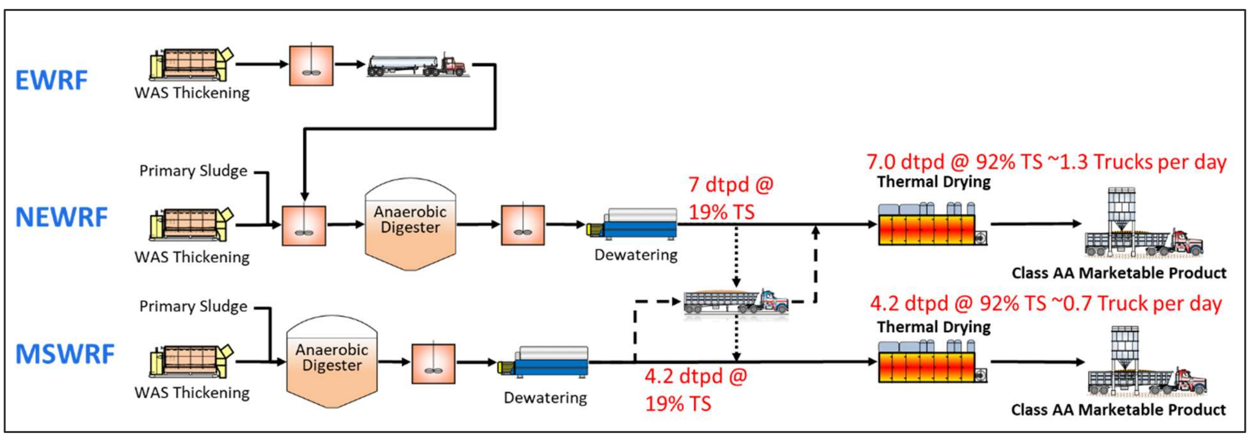

Figure 16 Process Flow Diagram for Thermal Dryer Implementation at Both NEWRF and MSWRF

Table 9 summarizes key elements associated with Alternative 4.

Table 9 Alternative 4 – Key Elements

Description
Improvements at EWRF
• Renewal and replacement of existing processes (RDTs)
Improvements at NEWRF
• Renewal and replacement of existing processes (RDTs, digestion equipment, and dewatering) • Addition of one redundant digester • Addition of a belt dryer system, including the following: o Cake hopper and cake feed pumps o Extruder system o Hot water boiler and heat exchangers o Dryer o Process fans o Exhaust fan o Outlet conveyor o Controls • Covered trailer parking area (product to be stored in a trailer) • Biofilter for odor control
Improvements at MSWRF
• Renewal and replacement of existing processes (RDTs, digestion equipment, and dewatering) • Addition of one redundant digester • Addition of a belt dryer system, including the following: o Cake hopper and cake feed pumps o Extruder system o Hot water boiler and heat exchangers o Dryer o Process fans o Exhaust fan o Outlet conveyor o Controls • Covered trailer parking area (product to be stored in a trailer) • Biofilter for odor control

Figure 17 presents the conceptual layout of the thermal dryer facility at NEWRF.

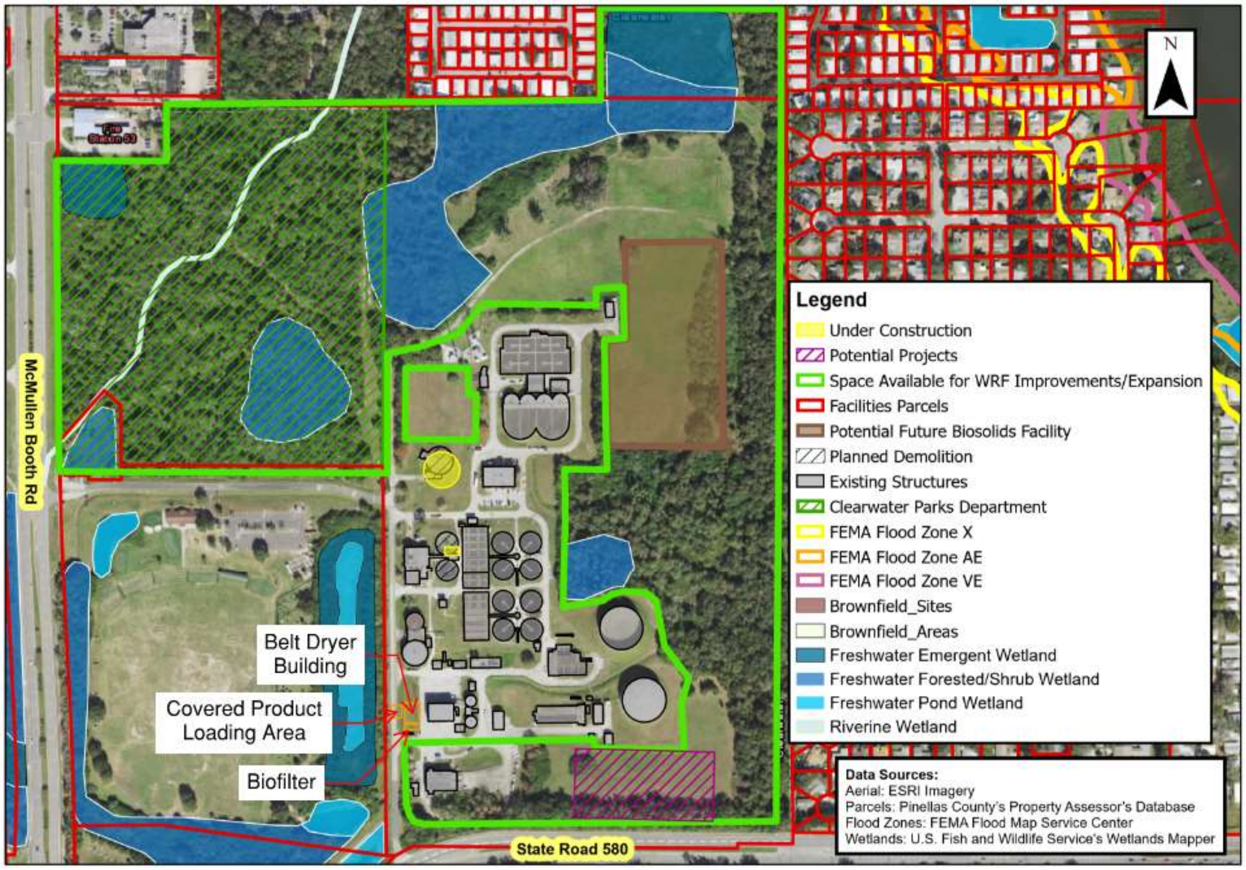

Figure 17 Site Layout for Thermal Dryer at NEWRF

Figure 18 presents the conceptual layout of the thermal dryer facility at MSWRF.

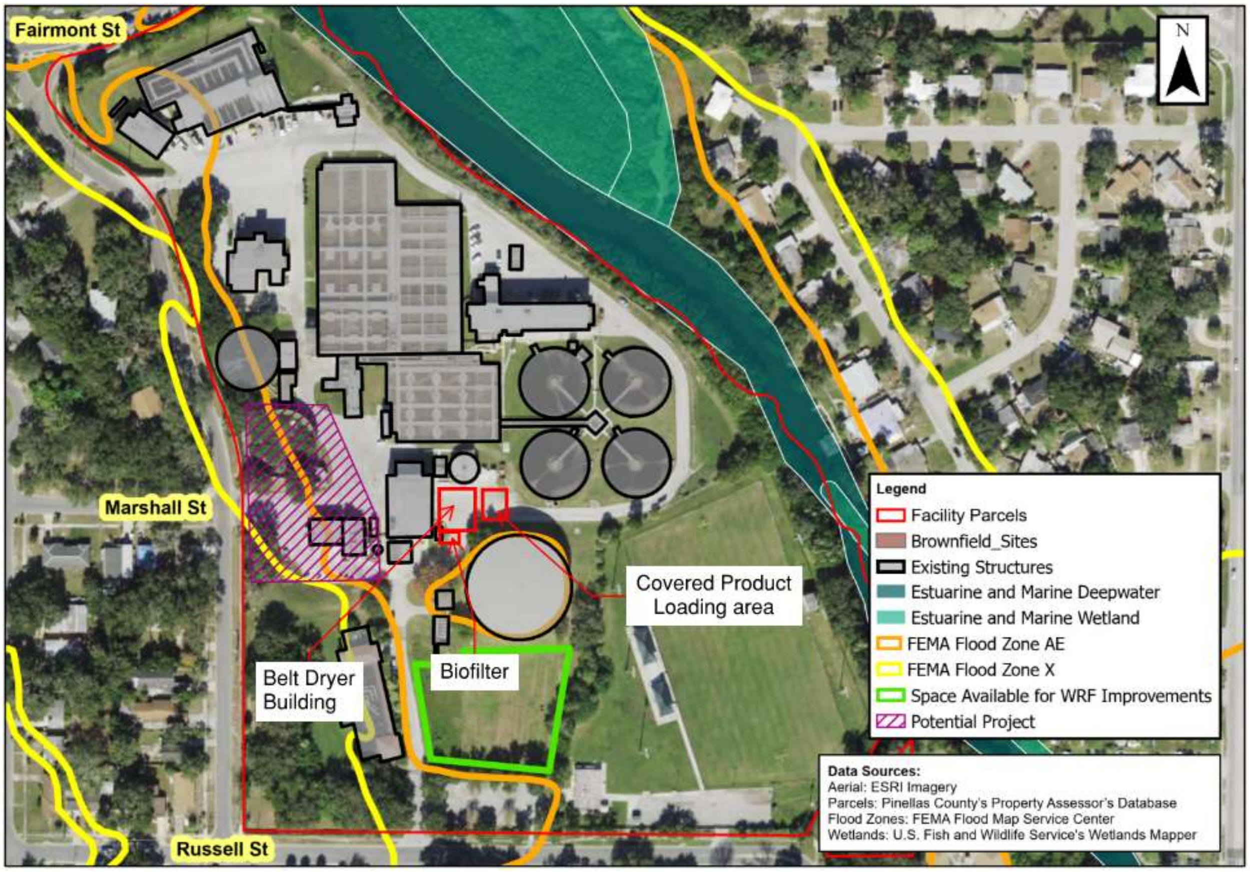

Figure 18 Site Layout for Thermal Dryer MSWRF

Advantages and disadvantages of thermal drying alternative are summarized in **Table 10**.

Table 10 Advantages and Disadvantages of Thermal Drying Alternative

Advantages	Disadvantages
Maximizes volume reduction resulting in least amount of truck traffic among the alternatives	Higher mechanical complexity
Marketable Class AA product with high degree of diversity in use	Need for natural gas to augment biogas, resulting in high operating costs
Revenue may be possible for dried product, but regional market conditions should be evaluated	Safety concerns due to explosion potential of dust, overheating, and fires
Digester gas can be used to offset some of the natural gas demand	

1.6 Economic Analysis of Short-Listed Alternatives

The financial evaluation included in this report consists of three major components: capital costs, O&M costs, and life-cycle cost. Life-cycle costs comprise the sum of the capital costs and the present worth of the O&M costs. The life-cycle costs represent the total amount of money the City would need at the outset of the project to construct and operate it for a given period (20 years for this evaluation). O&M costs are first calculated on an annual basis for a period of 20 years and those costs are then brought back to a present value for the purpose of life-cycle comparison. A further description of the methodology used for the financial evaluation is included in the following sections.

1.6.1 Conceptual Capital Cost Development

The conceptual capital cost was developed to compare alternatives relative to one another. The final cost of any project described in this TM will depend on the project complexity, labor and material costs, competitive market conditions, actual site conditions, final scope of work, implementation schedule, continuity of personnel, and engineering at the time the facility is designed and constructed. It is expected that a more detailed cost will be developed for the recommended biosolids management strategy during the next phase of this Master Planning project. Therefore, the conceptual capital costs presented in this section should only be used to compare relative differences in the alternatives.

The conceptual capital costs are in 2022 dollars and include 8 percent escalation to projected construction completion year of 2029. The estimates were developed using quotations from qualified equipment vendors, recent bid tabs, and recent cost estimates prepared for similar projects. The total costs include markups for contractor's general conditions, overhead and profit, engineering services during design and construction, administrative costs, and contingency. The capital cost factors used to develop the estimates are listed in **Table 11**. It should be noted that the capital costs include improvements with life expectancies of 20 years; therefore, a salvage value is not expected from the mechanical equipment.

Table 11 Capital Cost Factors

Component	Unit	Cost Factor
Direct Cost Subtotal (DCS)		
Equipment Installation cost	% of equipment cost	30
Mechanical	% of Equipment and Installation Costs	20
Electrical and Instrumentation & Control (including installation)	% of installed equipment and facilities	5 (Composting and Solar Dryer) 25 (Thermal Dryer)
Construction Subtotal (CS)		
Mobilization	% of DCS	5
Contractor's General Conditions, Overhead and Profit (OH&P)	% of DCS	40
Total Construction Cost (TCC)		
Construction Contingency (CC)	% of CS	30
Total Project Cost		

Component	Unit	Cost Factor
Engineering, Legal, and Administration	% of TCC	25

1.6.2 Operations and Maintenance Costs Development

The O&M costs include electricity, chemicals, labor, and general equipment maintenance. Current unit costs for O&M are based on information provided by the City staff, where available. The unit costs and escalation rates are presented in **Table 12**.

Electricity costs include the cost for operating process equipment based on the anticipated run times for annual average solids production and number of units in service. This includes electrical costs for associated equipment such as pumping, conveyance, fans, and blowers. In addition to electricity costs, fuel costs were considered for heavy equipment needed for composting and solar drying operations.

The thermal dryers under Alternative 4 will utilize digester gas as much as possible. When digester gas is not enough, it will be supplemented with natural gas. For Alternative 2 and 3, it was assumed that one CHP engine will be installed at each anaerobic digestion facility to produce power. The electricity produced by CHP engines was subtracted from the power demand for Alternatives 2 and 3.

Labor costs include the labor requirements to operate the equipment at the design loadings. For Alternatives 2 and 3, it was anticipated that the City will hire two full-time employees (FTEs) to operate the new facilities on a one shift per day basis. For Alternative 4, it was estimated that 0.5 FTE will be needed on a three shifts per day basis per dryer facility since this alternative assumes one dryer to be installed at NEWRF and another one to be installed at MSWRF. For maintenance, it was estimated that 1 FTE, 0.5 FTE, and 0.25 FTE per dryer facility will be needed for Alternatives 2, 3, and 4, respectively.

Table 12 O&M Unit Costs

Parameter	Unit	Current Unit Cost
Power (Electricity)	$/kWh	$0.07
Natural gas	$/Therm	$0.60
Fuel	$/gallon	$5.50
Labor	$/hr	$45.00
Equipment maintenance	% of Equipment Capital Cost	3% of Equipment
Amendment for composting	$/cubic yard	$5.00
Hauling to Class B land application	$/wet ton	$26.00

Parameter	Unit	Current Unit Cost
Third-Party Processing (includes hauling and tipping fees)	$/wet ton	$55.00

1.6.3 Life-Cycle Cost Development

A 20-year life-cycle cost was estimated based on the following assumptions:

- Cost year basis:
  - Construction: Ends in Fiscal Year 2029.
  - Operations start in Fiscal Year 2030.
  - Capital Cost and O&M Cost Estimates were brought back to 2022 dollars.
- Project life for equipment: 20 years.
- Project life for facilities: 50 years.
- O&M Expenditures Escalation Rate: 8 percent.
- Discount Rate: 4.7 percent.

1.6.4 Cost Evaluation Summary

Conceptual capital costs are presented on **Figure 19**. The capital cost for Alternative 1 (includes both 1A and 1B) covers renewal and replacement of the existing equipment and addition of redundant digesters at NEWRF and MSWRF. This cost is a baseline cost that would be included in all the alternatives. Therefore, only the conceptual capital cost for new processes beyond the baseline improvements are presented on **Figure 19**. Among the alternatives that require new infrastructure to be installed, Alternative 3 – Solar Drying had the lowest conceptual capital cost.

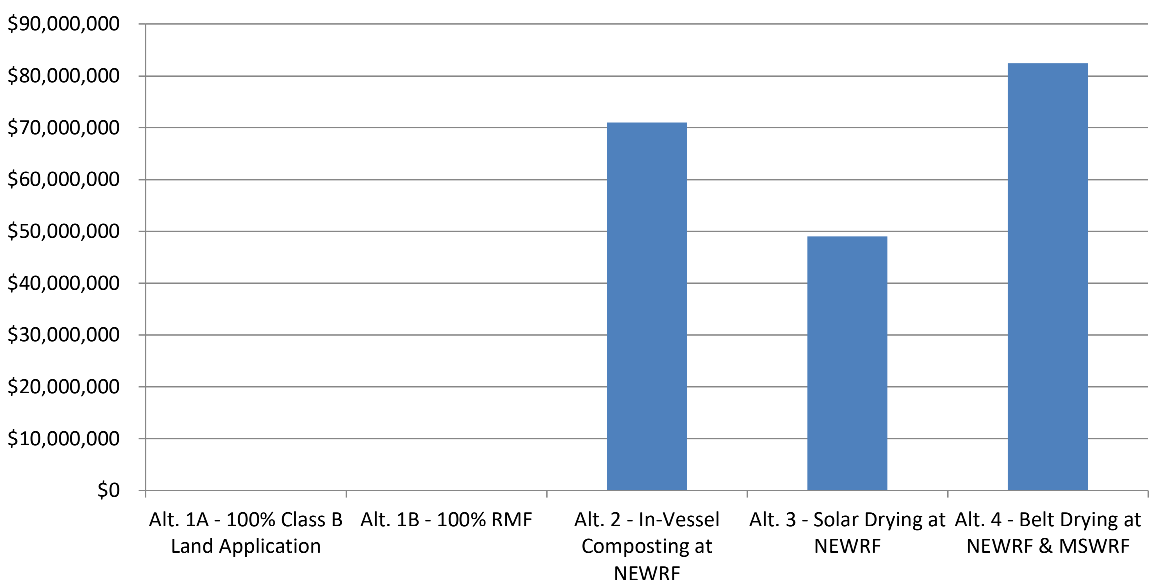

Figure 19 Conceptual Capital Costs for Biosolids Alternatives

Annual O&M costs to handle digested biosolids for each alternative are itemized on **Figure 20**Figure 22. Total annual O&M costs are presented on **Figure 21**. Alternatives 1B, 2, 4 and potentially Alternative 3 provide a high-quality Class AA biosolid product. Among these options, Alternative 2 – In-Vessel Composting shows the lowest annual O&M because of savings from electricity production utilizing digester gas and relatively low power demand of the process compared to Alternative 3 – Solar Drying. Both Alternative 2 and Alternative 3 have an annual O&M cost lower than Alternative 1B, which involves sending digested biosolids to a third-party operated RMF.

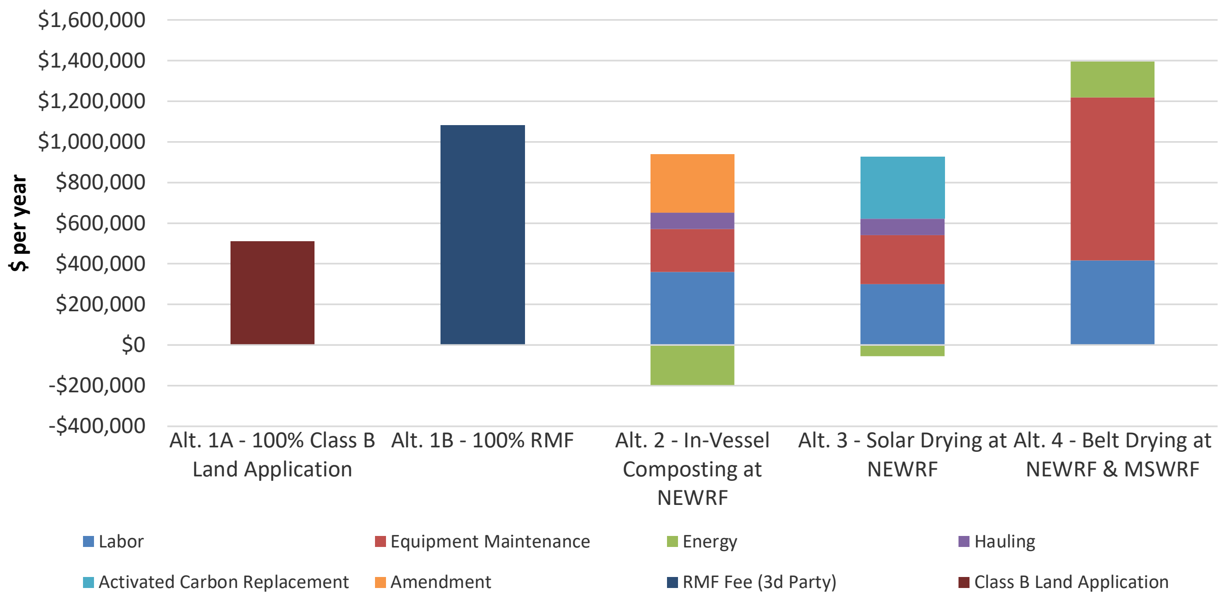

Figure 20 Itemized Annual O&M Costs ($ per year) for Alternatives

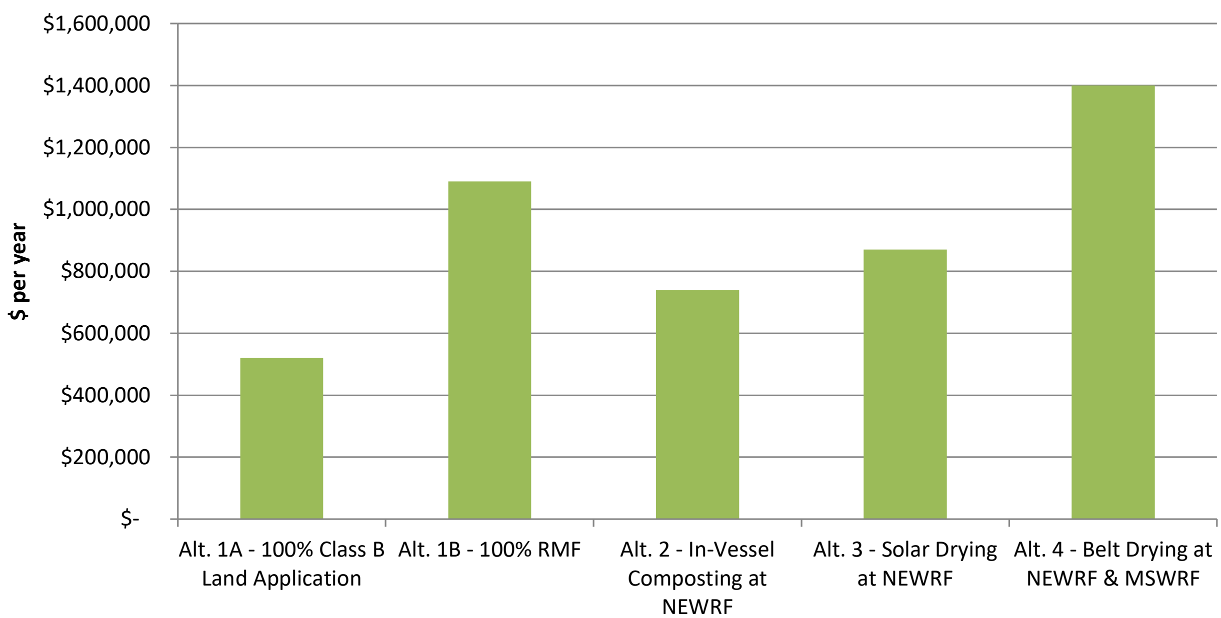

Figure 21 Total Annual O&M Costs ($ per year) for Alternatives

Figure 22 shows the life-cycle cost for 20-year operation. Based on the cost analysis, Alternative 3 – Solar Drying has the lowest life-cycle cost except Alternatives 1A and 1B. Alternative 4 – Thermal Drying has the highest capital cost and O&M costs because City would have to operate two drying facilities.

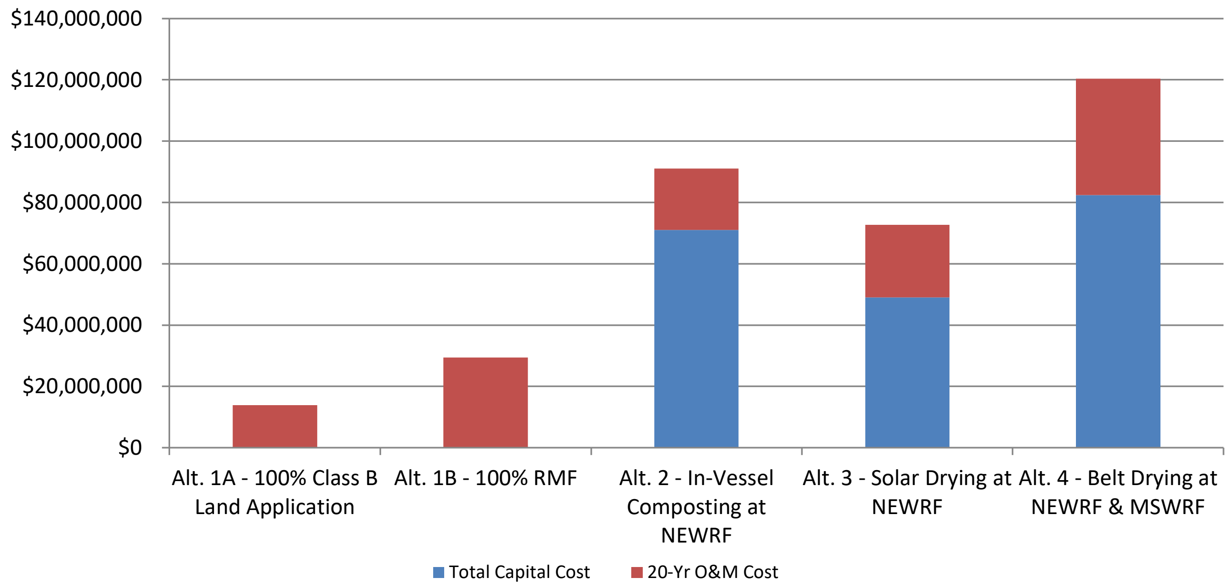

Figure 22 Comparison of 20-Year Life-Cycle Costs for Alternatives

1.7 Alternatives Evaluation

Cost is only one of the factors that must be considered in the selection of the City's biosolids management strategy. Equally important are factors such as long-term sustainability of the City's biosolids management program, the number and variety of distribution outlets, ability to react to future changes in environmental regulations, public perception of treatment processes and solids products, and adaptability of the program to growth and other changes in the area.

To evaluate non-cost criteria, a ranking process was set up based on a multi-attribute value approach. This method consists of establishing the criteria to be used to compare each alternative, developing weighting factors to be assigned to each criterion, and developing additive values, which consist of multiplying the score for the criteria by weighting factors and summing the results. The following equation summarizes the scoring methodology:

$$\text{Overall Score} = \Sigma W_a S_a$$

In this equation, the overall score is the total number of rating points received by each alternative. The higher overall scores represent the most favorable alternatives. W_a represents the weight assigned to each criteria "a" and S_a represents the individual rating score assigned to the option for the criteria "a". Each of these products was then summed over all criteria to develop the "overall score." The summed results were then ranked highest to lowest with the highest ranked alternative being the most favorable alternative from a noneconomic perspective.

Black & Veatch identified 19 criteria that could be used to assess the relative merits of the alternatives developed during the Task 2.8, Workshop No. 1 on April 22, 2022. The City and Black & Veatch narrowed down these criteria to 10 during the Task 2.8, Workshop No. 2 on May 18, 2022. These criteria were summarized in the Biosolids Screening Criteria TM dated July 7, 2022. The financial criteria were further discussed at Task 2.8, Workshop No. 3 on July 11, 2022, and it was determined that since life-cycle cost also included capital cost, then capital cost would be removed from the evaluation criteria.

The relative importance of each criterion may differ. The City assigned weighting factors to each criterion based on the drivers and goals for its biosolids management strategy. The criteria, scoring definitions, and weighting factors are presented in **Table 13**.

Table 13 Scoring Definitions and Weight of Each Evaluation Criterion

Evaluation Criterion	Score of 1 Inferior/ Disadvantageous	Score of 2 Neutral/Meets Objective	Score of 3 Superior/ Advantageous	Weight
Financial				
Life-Cycle Cost	High life-cycle cost	Intermediate life-cycle cost	Low life-cycle cost	14%
Social				
Public Acceptance	Appreciable risk of noise and odors and low public acceptance of product	Minimal increase in noise and odors and reasonable public acceptance of product	Low risk of noise and odors and good public acceptance of product	7%
Safety	Increased safety risk from new equipment and/or higher truck traffic as compared to existing program to haul finished product	Minimal increase in safety risk from new equipment and/or moderate truck traffic as compared to existing program to haul finished product	Low safety risk from new equipment and low truck traffic as compared to existing program to haul finished product	14%
Product Quality and Program Diversification	Product difficult to store and transport and does not allow for diversification	Product moderately easy to store and transport and allows for some diversification	Product easy to store and transport and allows for good diversification	11%
Environmental				
Regulatory Risk	Requires significant system changes to accommodate potential regulatory changes	Requires moderate system changes to accommodate potential regulatory changes	Requires minimal system changes to accommodate potential regulatory changes	13%

Evaluation Criterion	Score of 1 Inferior/ Disadvantageous	Score of 2 Neutral/Meets Objective	Score of 3 Superior/ Advantageous	Weight
Contract Risk	Totally dependent on third-party contract management and or limited potential contractors	Dependent on third-party contractors but multiple contractors for competition and improved reliability	No requirement for third-party contractor	9%
Functional				
Process Reliability	Appreciable risk of system component failure	Moderate risk of system component failure	Low risk of system component failure	12%
Operational Complexity and Maintainability	Complex system requiring high degree of specialized expertise and complex maintenance requirements over life of system	Moderately complex system requiring moderate degree of specialized expertise and moderately complex maintenance requirements over life of system	Simpler system requiring minimal degree of specialized expertise and simpler maintenance requirements over life of system	12%
Site Constraints	Larger footprint – difficult to accommodate on-site	Minimal increase in footprint	Smaller footprint – easier to accommodate on-site	8%

During the Task 2.8, Workshop No. 3 on July 11, 2022, each alternative was reviewed in terms of the criteria and a qualitative rating score between 1 and 3 was assigned to each criterion by City staff. Further, Black & Veatch Solids Process Specialists also scored each alternative separate from the City staff. The averages of all scores are rounded to the nearest integer as presented in **Table 14**.

Table 14 Summary of Alternatives Evaluation Scores

Evaluation Criterion	Alternative 1A Class B Land App		Alternative 1B RMF		Alternative 2 Composting		Alternative 3 Solar Dryer		Alternative 4 Thermal Dryer	
	Average Score	Weighted Score	Average Score	Weighted Score	Average Score	Weighted Score	Average Score	Weighted Score	Average Score	Weighted Score
Financial										
Life Cycle Cost	3.0	0.4	3.0	0.4	2.0	0.3	2.0	0.3	1.0	0.1
Social										
Public Acceptance	1.0	0.1	2.0	0.1	2.0	0.1	2.0	0.1	3.0	0.2
Safety	2.0	0.3	2.0	0.3	2.0	0.3	2.0	0.3	2.0	0.3
Product Quality and Program Diversification	1.0	0.1	2.0	0.2	3.0	0.3	2.0	0.2	3.0	0.3
Environmental										
Regulatory Risk	1.0	0.1	3.0	0.4	2.0	0.3	2.0	0.3	3.0	0.4
Contract Risk	1.0	0.1	3.0	0.3	3.0	0.3	3.0	0.3	3.0	0.3
Functional										
Process Reliability	2.0	0.2	3.0	0.4	3.0	0.4	2.0	0.2	2.0	0.2
Operational Complexity and Maintainability	3.0	0.4	3.0	0.4	2.0	0.2	2.0	0.2	2.0	0.2
Site Constraints	3.0	0.2	3.0	0.2	1.0	0.1	1.0	0.1	2.0	0.2
Weighted Total		**1.9**		**2.7**		**2.2**		**2.0**		**2.3**

When the analysis was complete for each alternative, the overall scores for each alternative were calculated using the weighting factors presented in **Table 13**. The overall total scores are provided in **Table 14**. Alternative 1B scored the highest for the following reasons:

- It is the lowest cost alternative to achieve Class AA since it does not require installing any new infrastructure.
- Implementation of composting or solar drying at NEWRF may have raised some concerns with the neighboring communities in terms of odor and aesthetics.
- There is lower contract risk than Alternative 1A since the City currently has multiple options for RMF within the region, including a possible facility to be built by Pinellas County in the near future.

1.8 Biosolids Summary and Next Steps

The results of the evaluations completed as part of this biosolids study effort indicate that the most appropriate biosolids management strategy for the City is to continue with the current operation while considering contractual and budgetary requirements to contract with a RMF for a long-term basis. This may also include working with Pinellas County as they develop their approach to implement a RMF within the County limits.

During the next phase of this project, Black & Veatch will perform a more detailed condition assessment of the infrastructure at each WRF, including solids processes. Further, process models for each facility will be updated to evaluate treatment capacity and optimize processes. The findings from these and other tasks that are related to the solids processes will be combined with the biosolids management strategy identified herein to develop a Biosolids Strategic Plan. This plan will also include budgetary requirements and schedule for the planning period.

FINAL

CLEARWATER WRF MASTER PLAN: TASK 2.8 - BIOSOLIDS SCREENING CRITERIA

Technical Memorandum

BV PROJECT NO. 408831
CITY PROJECT NO. 17-0007-UT

PREPARED FOR

City of Clearwater, Florida

7 JULY 2022

BLACK & VEATCH

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1.0 Introduction

This Technical Memorandum (TM) identifies the preliminary screening and technology evaluation criteria that will be used to compare various non-economic factors during development of the solids treatment and management alternatives for the City of Clearwater's (City) Water Reclamation Facility (WRF) Master Plan. There are two sets of criteria presented in this TM. The first set of criteria is at a higher level and will be used to shortlist four potential technologies for further evaluation. The second set of non-economic criteria will be used to evaluate the four shortlisted alternatives alongside economic factors. While economic factors will be considered only on a qualitative basis during the preliminary screening exercise for decision-making purposes, detailed capital costs, operating costs, and life-cycle costs will be developed for each pre-screened treatment and management alternative during the following evaluation phase.

2.0 Screening and Evaluation Criteria

The preliminary screening of treatment technologies and the final evaluation of selected solids treatment and management alternatives will be based on several non-economic criteria in addition to the economic factors. The non-economic criteria, although less definitive and more subjective than economic criteria, are equally important to the overall evaluation process. To minimize subjectivity and variability in interpretations of non-economic factors, each criterion must be clearly defined. A comparative scoring system can then be used to help compare the alternatives from a non-economic basis and establish the relative importance of a criterion; a composite score can be developed to compare each alternative.

The screening of treatment technologies and the final evaluation of selected treatment and management alternatives will follow a two-step approach as shown on Figure 1. During the preliminary screening phase, evaluation of a wide range of solids processing technologies will be evaluated based on current industry experience and how the technology compares to the existing treatment system. Information on the technologies will be based on engineering experience, literature, and vendor-provided data. The preliminary screening will eliminate those technologies that do not meet the City's long-term goals.

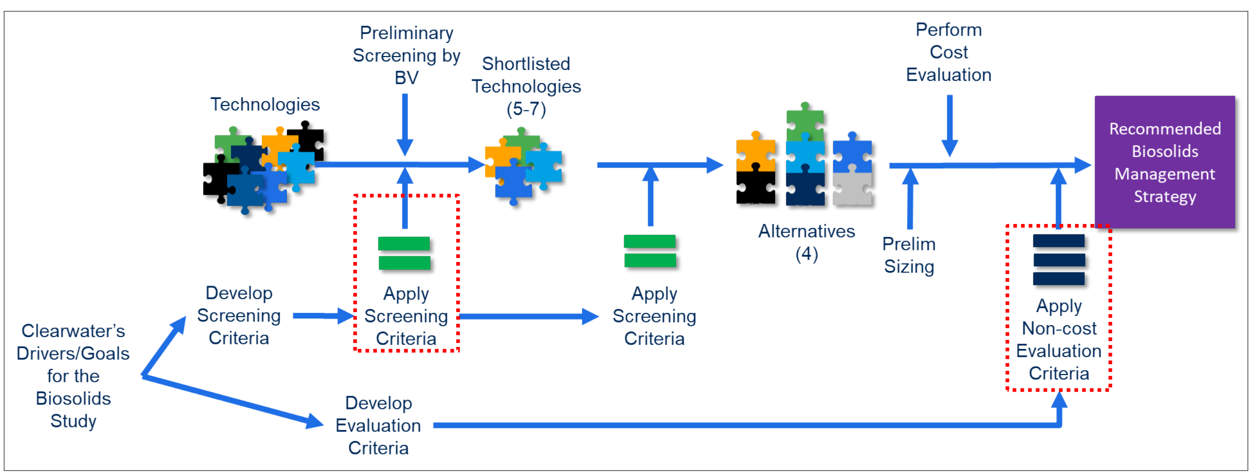


Figure 1 **Technology Screening and Alternatives Evaluation Process**

The selected technologies from the preliminary screening process will then be used to develop treatment alternatives for evaluation. A defined set of non-economic criteria in conjunction with capital costs, annual operating costs, and life-cycle costs will be used to identify the best-fit long-term solids treatment and biosolids management approach for the City.

The preliminary screening criteria and the evaluation criteria, including definitions for each criterion, are presented in this TM. The relative importance of these criteria and their composite weights will be discussed during a workshop with the City.

2.1 Preliminary Screening Criteria

Preliminary screening is the first of two phases in the technology selection process. The purpose of the screening phase is to examine a large number of potential treatment technology candidates and recommend a smaller subset of viable alternatives for more detailed evaluation in the alternatives evaluation phase.

The preliminary screening phase will grade the technologies using a set of minimum threshold criteria. The criteria used for preliminary screening are listed in Table 1. The preliminary screening criteria are intended to be (1) broad enough to include a wide range of technologies, (2) quantifiable to distinguish the technologies, and (3) forward-looking so that the preliminary screening criteria could be made more precise and quantitative for alternatives evaluation.

Preference will be given to technologies that have been proven at full-scale US facilities as opposed to those that have only been pilot-tested. Operational experience in Europe, Asia, or other locations will be considered but will not be considered as favorably as US experience. The reason for this preference is that the support network, including parts and trained service technicians, will likely be more extensive and readily available for technologies proven in the US market.

Table 1 Screening Criteria

Criterion	Comparative Basis	Description
Final Biosolids Product Quality	Class AA Marketable Product	Class AA marketable product is preferred to open up outlets and reduce dependence on third-party management.
	Class AA Cake for Land Application	Class A cake is preferred over Class B because of regulatory restrictions associated with Class B.
	Class B Cake for Land Application	Class B cake is a minimum requirement for this project.
Technology Maturity	Emerging	One or fewer North America operations with less than 2 years of successful track record.
	Early Development	One or more North America operations with 2 to 10 years of successful track record.
	Established	Many facilities and at least 10 years of proven performance history in North America.
Relative Life-Cycle Cost	Low/Moderate/High	Life-cycle cost of the alternative technology was rated against other technologies for similar size facilities based on Black & Veatch experience.
Compatibility with Existing and Planned Liquid and Solids Processes	Yes	Technologies are proven compatible with existing or potential liquid treatment technologies without significant sidestream impacts.
	Sidestream Issues	Potential for impacts on the liquid stream associated with treatment of sidestreams.
	Sludge Type Issues	If a technology is not suitable for all sludge types (primary sludge and waste activated sludge [WAS]), preferences/restrictions will be noted as applicable.
	Unproven	If a technology is unproven, information is not available to determine potential sidestream impacts.
Operational Complexity	OK/Moderate/ Complex	An alternative technology was rated against the current operation at City WRFs and compared to other candidate technologies based on Black & Veatch experience.
Size/Footprint	OK/Moderate/ Significant	Ability to locate the new facility on-site or the potential to regionalize treatment elsewhere.

2.2 Alternatives Evaluation Criteria

The four shortlisted biosolids technology alternatives will be evaluated using a framework. This framework consists of various evaluation criteria that are described in the following subsections. These criteria can be grouped as financial, social, environmental, and functional.

2.2.1 Financial Criteria

The financial criteria will compare capital costs, annual operations and maintenance (O&M), and life-cycle costs for each of the biosolids treatment and management alternatives. Capital costs will be developed using budgetary equipment cost quotations from vendors and costs from other Black & Veatch projects. O&M costs will be based on the City's current unit operation costs and will include elements such as O&M labor, power, consumables, chemicals, and maintenance. Where current costs are not available, costs from vendors or similar operations will be used. The capital, annual O&M, equipment replacement costs, revenue generation, as well as any remaining value, will then be used to develop the life-cycle cost over the planning period of 30 years for each alternative for comparison. The financial criteria proposed for evaluation of alternatives are summarized in Table 2.

Table 2 Financial Criteria for Alternatives Evaluation

Category	Criteria	Definition
Financial	Capital Cost	Relative conceptual level capital costs to design and construct the facility and supporting improvements.
	Life-Cycle Cost (including O&M cost)	Relative conceptual level life-cycle costs to operate and maintain the facility.

2.2.2 Social Criteria

The social component will reflect any social impacts of the treatment and management alternatives, including nuisance impacts to the local community from truck traffic, odor, and noise from plant operations. The social criteria proposed for evaluation of alternatives are summarized in Table 3.

Table 3 Social Criteria for Alternatives Evaluation

Category	Criteria	Definition
Social	Public Acceptance	• Degree to which the alternative would be accepted by the public considering noise, visual aesthetics, and odors. • Degree to which the final use of biosolids product has a positive or negative perception (or somewhere in between).
	Safety	• Degree to which the alternative presents safety risks to City employees or to the general public (from new equipment, truck traffic, etc.). • How well the facility can be secured from risks.
	Product Quality and Program Diversification	• How well the product be stored and transported. • Ability for the final product to be diverted to other end-uses if primary outlet is unavailable.

Public acceptance of new installations and operations is critical for a successful biosolids program. Issues such as odor, noise, traffic, and air quality need to be considered both during construction and operation of new facilities. Technologies or system alternatives that are likely to cause less public acceptance issues will be more favorable than those likely to cause more nuisance impacts to the local community.

All biosolids processing activities pose some level of risk of injury. However, some technologies or management practices may introduce a higher level of safety risk than others. Technologies that have a proven track record of safe operation at full scale will be preferred over technologies with questionable or limited data of safety records. Another aspect of biosolids treatment and management that poses a risk to the general public is truck traffic. Any technology option with a significant increase in truck traffic has a corresponding increased risk for accidents and will be rated less favorably.

The quality of biosolids products varies significantly with technologies and system alternatives. Treatment alternatives that generate a product that can be stored and transported easily and allow for a diverse management program through diversity and reliability of product outlets will enhance overall program reliability. Alternatives that include some diversity will be considered more favorably than alternatives relying on a single use or disposal practice. Class A cake will also be considered more favorably than Class B cake because of the restrictions on land application of Class B cake.

2.2.3 Environmental Criteria

The environmental component of the evaluation criteria addresses environmental impacts of the treatment and management options, including the ability to comply with regulatory requirements, maximize the use and recovery of resources from biosolids, and minimize risks from biosolids management contracts. The environmental criteria proposed for evaluation of alternatives are summarized in Table 4.

Table 4 Environmental Criteria for Alternatives Evaluation

Category	Criteria	Definition
Environmental	Regulatory Risk	• Ability of the alternative to comply with anticipated federal/state mandates for process and final use requirements. • Degree of difficulty to permit the technology alternative. • Ability of the alternative to provide flexibility to incorporate technological advances and meet future regulations.
	Contract Risk	• Dependence on third-party contractors (for example, a regional solution with a third-party) and potential restriction of competition between contractors due to specialized requirements.

The ease with which biosolids technologies allow compliance with existing regulations and provide flexibility for meeting reasonably anticipated future changes may vary with technology. To be viable, technologies and solutions must meet current regulatory requirements and be capable of being permitted. Permitting challenges can exist, however, and could increase the time required to implement an alternative. Technologies or alternatives that are expected to be easier to permit, or more likely to comply with future regulations, will be considered more favorably than those that are difficult to permit.

Technologies that reduce dependence on third-party contracts will be considered more favorably than those that are totally dependent. Consideration will also be given if the product or process adversely limits the potential number of contractors available.

2.2.4 Functional Criteria

In additional to life-cycle costs and benefits associated with a treatment alternative, the functional component of the evaluation criteria will reflect the indirect economic impacts to the utility. The functional criteria proposed for evaluation of alternatives are summarized in Table 5.

Table 5 Functional Criteria for Alternatives Evaluation

Category	Criteria	Definition
Functional	Process Reliability and Technology Risk	• Amount of the treatment technology's significant operating/installation experience. • Robustness of the system – relative likelihood of failure and consequence of that failure. • Ease of integration with existing processes.
	Operational Complexity and Maintainability	• Impact on time and labor required to operate and maintain the process. • Required skill and knowledge level needed to operate and maintain the system. • Ease of access and availability of spare parts.
	Site Constraints	• Facility footprint and ability to accommodate facility on-site. • Physical access for O&M activities and accessibility of process controls for automation.

The process reliability criterion is an indicator of a technology's or an alternative's overall reliability. A technology that has been widely used with documented operational data is considered more reliable than technologies still in the developmental stages. The advantages of a proven technology option typically include better defined costs and known operational issues such as maintenance requirements and better characterization of any byproducts generated. Technologies or system alternatives that are compatible with existing systems and operations will also be considered more favorably than those that require significant modifications to existing facilities.

Different technologies require different levels of O&M input, and this affects both staffing and training requirements. Complex processes often require specialized expertise and more extensive training. Complex systems will generally be more susceptible to downtime, which impacts overall process reliability.

Site constraints account for potential limitations of the specific WRF site and corresponding facility footprint requirements. Some technologies may be more suitable from a siting perspective at one WRF than at another.

3.0 Paired Matrix Comparison of Criteria

A “paired metric comparison” (PMC) exercise will be performed to weigh the evaluation criteria and assign a relative ranking to a criterion that indicates the degree of the criterion’s importance with respect to the other criteria. The exercise will involve an online survey completed by the City’s staff. The online survey method will be reviewed with City staff during one of the progress meetings. An example of the survey format is presented as Table 6.

Table 6 Evaluation Criteria Paired Metric Comparison Survey Example

Capital Cost is more important than:						
	Strongly Disagree	**Disagree**	**Slightly Disagree**	**Slightly Agree**	**Agree**	**Strongly Agree**
Life-Cycle Cost	☐	☐	☐	☐	☐	☐
Public Acceptance	☐	☐	☐	☐	☐	☐
Safety	☐	☐	☐	☐	☐	☐
Product Quality and Program Diversification	☐	☐	☐	☐	☐	☐
Regulatory Risk	☐	☐	☐	☐	☐	☐
Contract Risk	☐	☐	☐	☐	☐	☐
Process Reliability and Technology Risk	☐	☐	☐	☐	☐	☐
Operational Complexity and Maintainability	☐	☐	☐	☐	☐	☐
Site Constraints	☐	☐	☐	☐	☐	☐

An algorithm will then be used to convert the survey answers into a numeric weighting, so that the total of the 10 evaluation criteria weightings equals 100 percent. This weighting will set the relative importance of the various criteria to be used in the evaluation of treatment alternatives. Figure 2 shows an example evaluation criteria weighting that would be developed from the survey results.

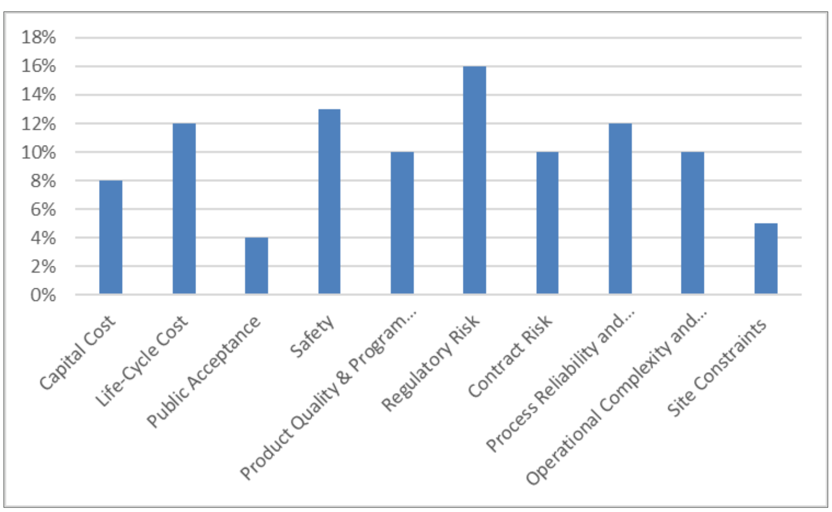


Figure 2 Example Sample Weighting of Evaluation Criteria from Survey Results [Not Final]

Each of the shortlisted treatment and management alternatives will then be evaluated using the evaluation criteria definitions and the weightings developed from the survey. To evaluate each alternative, voting participants will assign a score of 1 to 3 to each criterion, with a score of 3 being the most favorable. The evaluation criteria scoring definitions are presented in Table 7 and will serve as the basis for scoring each alternative.

Table 7 Evaluation Criteria Scoring Definitions

Evaluation Criterion	Score of 1 Inferior/Disadvantageous	Score of 2 Neutral/Meets Objective	Score of 3 Superior/Advantageous
Financial			
Capital Cost	High capital cost	Intermediate capital cost	Low capital cost
Life-Cycle Cost	High life-cycle cost	Intermediate life-cycle cost	Low life-cycle cost
Social			
Public Acceptance	Appreciable risk of noise and odors and low public acceptance of product	Minimal increase in noise and odors and reasonable public acceptance of product	Low risk of noise and odors and good public acceptance of product
Safety	Increased safety risk from new equipment and/or higher truck traffic as compared to existing program to haul finished product	Minimal increase in safety risk from new equipment and/or moderate truck traffic as compared to existing program to haul finished product	Low safety risk from new equipment and low truck traffic as compared to existing program to haul finished product
Product Quality and Program Diversification	Product difficult to store and transport and does not allow for diversification	Product moderately easy to store and transport and allows for some diversification	Product easy to store and transport and allows for good diversification
Environmental			
Regulatory Risk	Requires significant system changes to accommodate potential regulatory changes	Requires moderate system changes to accommodate potential regulatory changes	Requires minimal system changes to accommodate potential regulatory changes
Contract Risk	Totally dependent on third-party contract management and or limited potential contractors	Dependent on third-party contractors but multiple contractors for competition and improved reliability	No requirement for third-party contractor
Functional			
Process Reliability	Appreciable risk of system component failure	Moderate risk of system component failure	Low risk of system component failure
Operational Complexity and Maintainability	Complex system requiring high degree of specialized expertise and complex maintenance requirements over life of system	Moderately complex system requiring moderate degree of specialized expertise and moderately complex maintenance requirements over life of system	Simpler system requiring minimal degree of specialized expertise and simpler maintenance requirements over life of system
Site Constraints	Larger footprint – difficult to accommodate on-site	Minimal increase in footprint	Smaller footprint – easier to accommodate on-site

The weighted score for each treatment and management alternative will then be calculated by multiplying the criterion score by the weight for that criterion. The highest total weighted score will identify the most favorably rated treatment and management alternative.

4.0 Next Steps

Once City staff have reviewed this TM and provided feedback relative to the evaluation criteria and approach for weighting and scoring, Black & Veatch staff will develop the online survey to solicit feedback for weighting of the criteria. The results of the online survey weighting will be compiled and presented to the City for review. These results will then be used in the overall evaluation of the alternatives that will be developed.

For scoring of alternatives, Black & Veatch will provide a recommended score for each criterion for each alternative before Workshop No. 3. These scores will be reviewed and discussed during the workshop and finalized with City's input. The total weighted score for each alternative will be calculated at the end of that workshop and rank the alternatives accordingly.

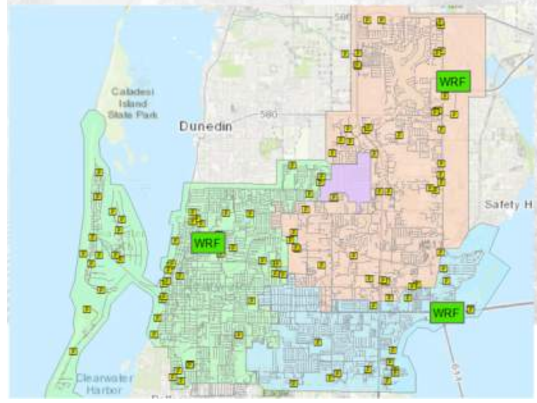
This Appendix is part of the Water Reclamation Facilities (WRF) Master Plan – Final WRF Strategies Technical Memorandum (City Project No. 17-0007-UT, December 2023).

CITY OF CLEARWATER
TASK 2.8 - BIOSOLIDS STUDY
PRE-SCREENING MATRIX TO RULE OUT NON-FEASIBLE BIOSOLIDS TECHNOLOGIES (UPDATED 5/18/22)

No.	Option	Final Biosolids Product Quality	Maturity of Technology (Proven application at similar scale operations)	Relative Life Cycle Cost	Compatibility with Liquid Treatment	Operational Complexity	Size/ Footprint	Carry Forward EWRF?	Carry Forward NEWRF?	Carry Forward MSWRF?	Notes (Yes for NE WRF could also be regional facility)	Slides
1	Thickening at EWRF + Status Quo at NE WRF & MS WRF	Class B Land Application	Established	Low	Yes	OK	OK	Yes	Yes	Yes	Includes future rehab and replacement costs of existing equipment. Will include necessary redundancy for digesters.	
2	3rd Party Processing (e.g. Composting, Merrell Bros, Anuvia, etc)	Class AA Refined Fertilizer	Established	Moderate	Yes	OK	OK	Yes	Yes	Yes	3rd Party composting is current practice. If raw cake is used then more hauling will be required. There is a risk of relying on a 3rd Party operation.	
3	Chemical Hydrolysis Pretreatment (CTHP) + Anaerobic Digestion (AnD)	Class B Land Application	Established in EU	High	Sidestream	Moderate	Moderate	No	Yes	Yes	Higher ammonia in the sidestream. Requires chemical addition to sludge. Improves VSR for WAS. One installation in Kenosha, WI. Could be Class AA if primary sludge is pasteurized or if no primary sludge. Not well established in US.	CLICK HERE
4	AnD + Thermal Dryer (Belt, Paddle, Drum, etc)	Class AA Granular Fertilizer	Established	High	Yes	Moderate	Moderate	No	Yes	Yes	Belt, paddle and drum are all established but belt or Paddle dryer makes more sense due to size of facilities. It could also be a regional solution. Would significantly reduce the amount of solids leaving the City facility.	CLICK HERE
5	Autothermal Thermophilic Aerobic Digestion (ATAD)	Class AA Fertilizer Land Application	Established	High	Yes	Moderate	Moderate	Yes	Yes	Yes	Primary solids can be a concern related to odor potential. Large tank capacity may be required. Provides comparable VSR to AnD and produce Class AA cake with better odor. Could be complex with PLC control and requires ferric for better dewatering.	CLICK HERE
6	AnD + Post Aerobic Digestion (PAD)	Class B Cake	Established	Moderate	Yes	OK	OK	No	Yes	Yes	Enhancement of Item No.1. PAD provides additional VSR and nitrogen removal but requires intermittent aeration. Not Class A product.	CLICK HERE
7	Class A/AA Chemical stabilization (e.g. Lime, BCR Neutralizer)	Class AA Fertilizer Land Application	Established	Moderate	Yes	Moderate	Moderate	Yes	Yes	Yes	Neutralizer is WAS-only for Class A/AA. Lime (Bioset, RDP) could be used for blended sludges. Chemically intensive, no mass reduction. Lower capital cost but higher operational cost.	CLICK HERE
8	Class B Chemical stabilization (e.g. Lime, BCR Clean B)	Class B Land Application	Established	Low	Yes	Moderate	Moderate	Yes	No	No	Some states moving away from Class B lime stabilization due to odor concerns. Chemically intensive, no mass reduction. Clean B could be an option for small facilities with WAS-only sludge. Lower capital cost but higher operational cost. Not Class A product.	CLICK HERE
9	Thermal Oxidation (Gasification/Pyrolysis)	Biochar & syngas or pyrogas	Early Development	High	Unproven	Complex	Significant	No	No	No	Could be a regional solution at one facility, but not yet proven in US at full-scale level (one small facility in CA operating pyrolysis for one year so far, others in development). May oxidize PFAS compounds but more research is needed. Could be a future addition if regulations change.	CLICK HERE
10	Thermal Hydrolysis Pretreatment (THP) + AnD	Class AA Fertilizer Land Application	Established	High	Sidestream	Complex	Moderate	No	No	No	Higher ammonia in the sidestream. Refractory organics in the sidestream which may affect effluent THM. Requires handling steam at 160 psi.	CLICK HERE
11	AnD + Partial Drying	Class B High Solids Cake Land Application	Emerging	High	Yes	Moderate	Moderate	No	No	No	No installations in US and one in EU. Not Class A and emerging process.	
12	Advanced AnD (Thermophilic, TPAD)	Class AA Fertilizer Land Application	Established	Moderate	Sidestream	Moderate	Moderate	No	No	No	Higher ammonia in the sidestream. Process could be odorous. Requires batch holding to meet pathogen reduction requirements for Class AA. Batch operation is more complicated to operate and not desired by the City.	CLICK HERE
13	Composting at City facilities	Class AA Refined Fertilizer	Established	Low	Yes	OK	Significant	No	Yes	No	Current practice through 3rd party (See Item No.2). Windrow and aerated static pile would require purchasing land if City operation. There may be footprint available at NEWRF for in-vessel. Allows City to market the product.	CLICK HERE
14	Solar dryer	Class AA dried product?	Established	Moderate	Yes	OK	Significant	No	Yes	No	Requires large footprint. Not approved as a stand-alone Class AA process in FL. May require testing for fecal coliform to prove Class AA.	CLICK HERE
15	Lystek	Class AA Liquid Cake	Early Development	High	Yes	OK	Significant	No	No	No	Requires large storage tank at the facility and injection under soil. Could be odorous. Early Development - Limited installations in US, non in FL.	CLICK HERE
16	Aerobic Digestion	Class B Cake	Established	High	Preferably WAS-only	Moderate	Moderate	No	No	No	Requires large tanks and continuous air. Could be odorous with primary sludge. Doesn't produce Class A cake. High in power (and LCC).	CLICK HERE
17	Incineration	Ash to landfill	Established	High	Yes	Complex	Moderate	No	No	No	There are no municipal sludge incinerators in FL. Would be challenging to permit. If operated at higher temperatures than typical, it may oxidize PFAS compounds.	CLICK HERE
18	Wet oxidation	Ash to landfill	Emerging	High	Unproven	Complex	OK	No	No	No	Unproven. Requires pumping to 3600 psi and high temperatures. Eliminates Class B/AA land application. Emerging technology with no know full scale installations.	CLICK HERE
19	Hydrothermal	Clay like material (mostly P), biocrude oil, syngas	Emerging	High	Unproven	Complex	Moderate	No	No	No	Unproven. Requires pumping to 3000 psi and 660+ degree F. Eliminates Class B/AA land application. Emerging technology with no know full scale installations.	CLICK HERE

Clearwater Water Reclamation Facilities Master Plan

Task 2.8 Biosolids Management Strategy Development
Workshop No.2: Technology Review and Screening Workshop



May 18, 2022

BLACK & VEATCH

Agenda

- Workshop Objectives
- Solids Projections
- Review of the Initial Solids Technologies Screening
- Shortlisting
- Task 2.8 Evaluation Criteria
- Next Steps

Workshop Objectives

Workshop Objectives

- Review and discuss the initial solids technologies screening performed
- Select and confirm up to four most viable solids technologies for further evaluation
- Discuss preliminary evaluation criteria

Solids Projections

Solids Projections

Parameter	Annual Average Solids Generation Rate* dry lb/Mgal	Projected Flow in 2050 MGD	Annual Average Solids Production dry lb/d	MM to AA Ratio*	Maximum Month Solids Production dry lb/d
EWRF	1,520	2.94	4,500	1.3	5,850
NEWRF	3,320	5.33	17,700	1.5	26,550
MSWRF	1,910	6.28	12,000	1.4	16,800
		TOTAL	34,200	1.44	49,200

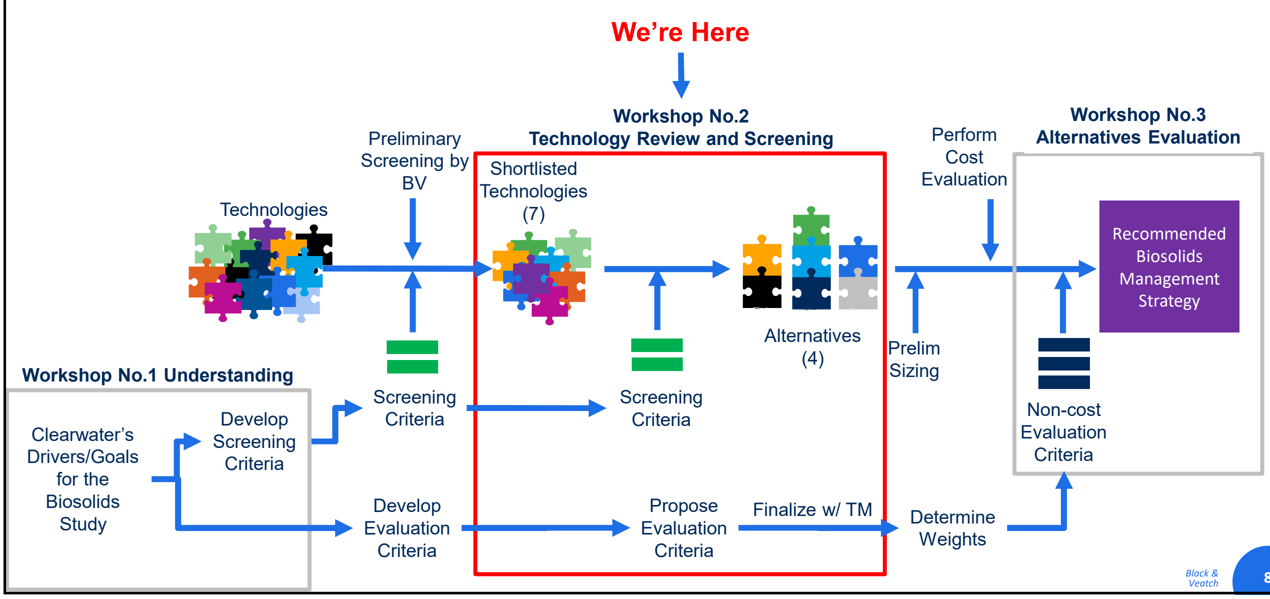
***Based on historical data**

MM: Maximum Month

AA: Annual Average

Review of the Initial Solids Technologies Screening

Biosolids Management Strategy Development



Criteria Used for Preliminary Screening

- Final Biosolids Product Quality
- Maturity of Technology
  - Emerging – successfully tested at small scale
  - Early Development - limited applications
  - Established – Numerous applications and/or long track record
- Relative Life Cycle Cost
- Compatibility with existing and planned liquid and solids processes
- Operational Complexity
- Size / Footprint

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Preliminary Screening Results (Please See Handout)

PLEASE REFER TO UPDATED MATRIX ON THE FIRST PAGE

No.	Option	Final Biosolids Product Quality	Maturity of Technology (Proven application at similar scale operations	Relative Life Cycle Cost	Compatibility with Liquid Treatment	Operational Complexity	Size/ Footprint	Carry Forward EWRF?	Carry Forward NEWRF?	Carry Forward MSWRF?	Notes (Yes for NE WRF could also be regional facility)
1	Thickening at EWRF + Status Quo at NE WRF & MS WRF	Class B Land Application	Established	Low	Yes	OK	OK	Yes	Yes	Yes	Includes future rehab and replacement costs of existing equipment.
2	3rd Party Processing (e.g. Composting, Merrell Bros, Anuvia, etc)	Class AA Refined Fertilizer	Established	Moderate	Yes	OK	OK	Yes	Yes	Yes	3rd Party composting is current practice.
3	Chemical Hydrolysis Pretreatment (CTHP) + Anaerobic Digestion (AnD)	Class B Land Application	Established in EU	High	Sidestream	Moderate	Moderate	No	Yes	Yes	Higher ammonia in the sidestream. Requires chemical addition to sludge. Improves VSR for WAS. One installation in Kenosha, WI. Could be Class AA if primary sludge is pasteurized.
4	AnD + Thermal Dryer (Belt, Paddle, Drum, etc)	Class AA Granular Fertilizer	Established	High	Yes	Moderate	Moderate	No	Yes	Yes	Belt or Paddle dryer makes more sense due to size of facilities [illegible] regional solution. Would significantly reduce the [illegible] City facility.
5	Autothermal Thermophilic Aerobic Digestion (ATAD)	Class AA Fertilizer Land Application	Established	High	Yes	Moderate	Moderate	Yes	Yes	Yes	Primary solids can be a [illegible] may be requi[illegible]
6	AnD + Post Aerobic Digestion (PAD)	Class B Cake	Established	Moderate	Yes	OK	OK	No	Yes	Yes	[illegible] and nitrogen removal
7	Class A/AA Chemical stabilization (e.g. Lime, BCR Neutralizer)	Class AA Fertilizer Land Application	Established	Moderate	Yes	Moderate	Moderate	Yes	[illegible]	[illegible]	[illegible] A/AA. Lime (Bioset, RDP) could be used for [illegible] chemically intensive, no mass reduction.
8	Class B Chemical stabilization (e.g. Lime, BCR Clean B)	Class B Land Application	Established	Low	Yes	Moderat[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] tates moving away from Class B lime stabilization due to odor concerns. Chemically intensive, no mass reduction. Clean B could be an option for small facilities with WAS-only sludge.
9	Thermal Oxidation (Gasification/Pyrolysis)	Biochar & syngas or pyrogas	Early Development	High	[illegible]	[illegible]	[illegible]	No	Maybe	Maybe	Could be a regional solution at one facility, but not yet proven in US at full-scale level (one small facility in CA operating pyrolysis for one year so far, others in development).
10	Thermal Hydrolysis Pretreatment (THP) + AnD	Class AA Fertilizer Land Application	[illegible]	[illegible]	[illegible]	Complex	Moderate	No	No	No	Higher ammonia in the sidestream. Refractory organics in the sidestream which may affect effluent THM. Requires handling steam at 160 psi.
11	AnD + Partial Drying	Class B High Soli[illegible]	[illegible]	High	Yes	Moderate	Moderate	No	Yes	No	No installations in US and one in EU
12	Advanced AnD (Thermophi[illegible]	[illegible]	[illegible]lished	Moderate	Sidestream	Moderate	Moderate	No	No	No	Higher ammonia in the sidestream. Process could be odorous.
13	C[illegible]	[illegible]ertilizer	Established	Low	Yes	OK	OK	No	No	No	Current practice through 3rd party (See Item No.2). Would require purchasing land if City operation.
[illegible]	[illegible]	Class AA dried product?	Established	Moderate	Yes	OK	Significant	No	No	No	Requires large footprint. Not approved as a stand-alone Class AA process in FL.
[illegible]	[illegible]	Class AA Liquid Cake	Early Development	High	Yes	OK	Significant	No	No	No	Requires large storage tank at the facility and injection under soil. Could be odorous.
16	Aerobic Digestion	Class B Cake	Established	High	Preferably WAS-only	Moderate	Moderate	No	No	No	Requires large tanks and continuous air. Could be odorous with primary sludge.
17	Incineration	Ash to landfill	Established	High	Yes	Complex	Moderate	No	No	No	There are no municipal sludge incinerators in FL. Would be challenging to permit.
18	Wet oxidation	Ash to landfill	Emerging	High	Unproven	Complex	OK	No	No	No	Unproven. Requires pumping to 3600 psi and high temperatures. Eliminates Class B/AA land application.
19	Hydrothermal	Clay like material (mostly P), biocrude oil, syngas	Emerging	High	Unproven	Complex	Moderate	No	No	No	Unproven. Requires pumping to 3000 psi and 660+ degree F. Eliminates Class B/AA land application.

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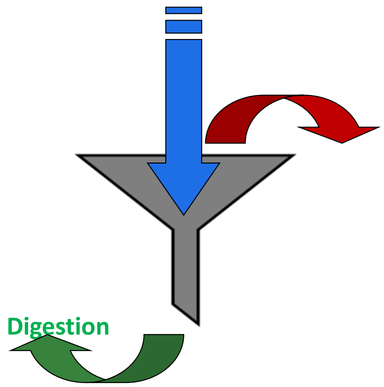
Initial Solids Technologies Screening

POTENTIAL

1. Status Quo (R&R) + 3rd Party Processing
2. Composting at NEWRF
3. Solar Dryer at NEWRF
4. ~~Chemical Hydrolysis + Anaerobic Digestion (AnD)~~
5. AnD + Thermal Dryer
6. Autothermal Thermophilic Aerobic Digestion (ATAD)???
7. ~~AnD + Post Aerobic Digestion~~
8. ~~Chemical Stabilization (Class AA or Class B)~~
9. ~~Gasification/Pyrolysis~~

POTENTIAL BIOSOLIDS PROCESS



NOT RECOMMENDED

1. Class B Aerobic Digestion
2. Thermal Hydrolysis + AnD
3. Chemical Stabilization (MS WRF & NE WRF)
4. Solar Dryer (Standalone)
5. Incineration
6. Wet Oxidation
7. Hydrothermal Processing

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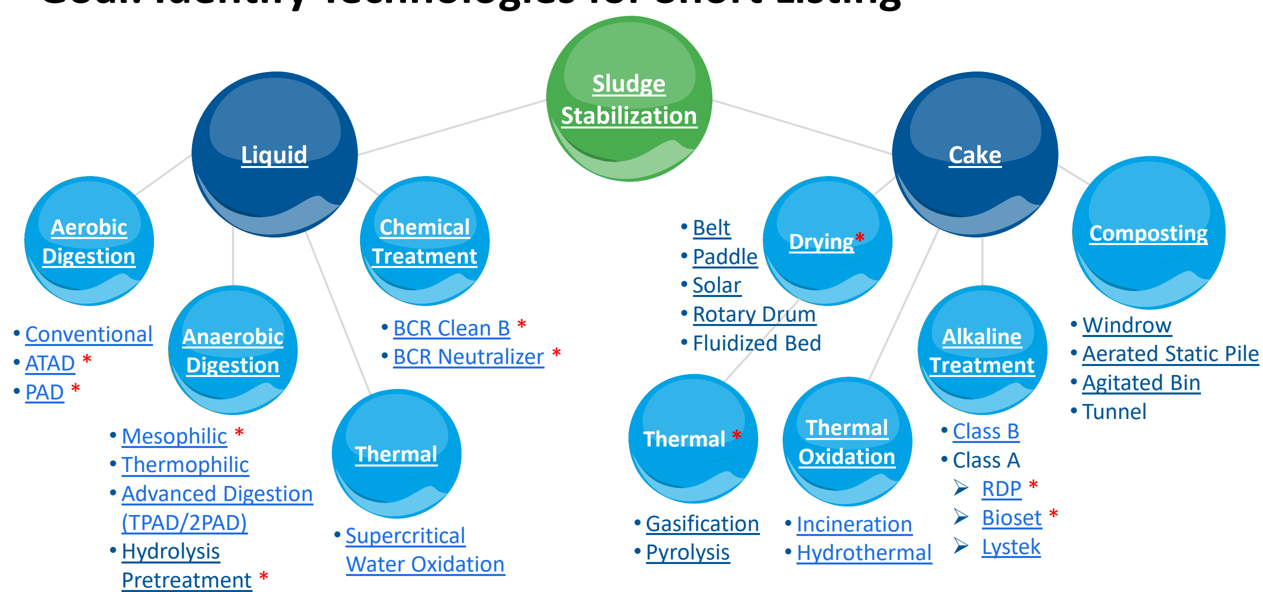
Goal: Identify Technologies for Short Listing



*Selected for further discussion

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Shortlisting

Alternatives to Move Forward

Alternative No.	Description	NEWRF	MSWRF	EWRF
1	Class B Land Application with RMF backup	AnD	AnD	Thicken and Haul to NEWRF
2	Class AA marketable product	AnD+Dryer	AnD+Dryer	Thicken and Haul to NEWRF
3				
4				

All options consider R&R at the existing facilities as necessary

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Evaluation Criteria

Proposed Evaluation Criteria

- Capital Cost
- Life Cycle Cost
- Public Acceptance
- Product Quality and Program Diversification
- Regulatory Risk
- Contract Risk
- Process Reliability and Technology Risk
- Operational Complexity and Maintainability
- Site Constraints

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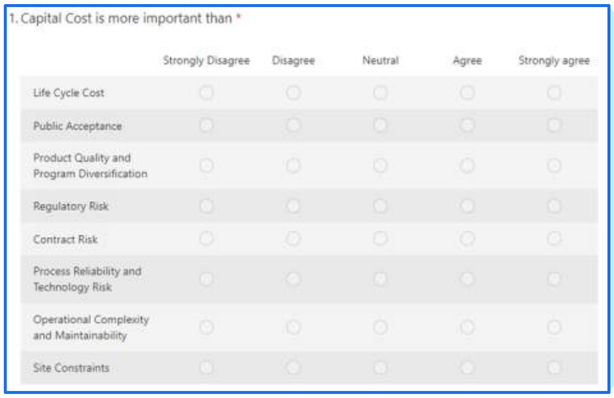
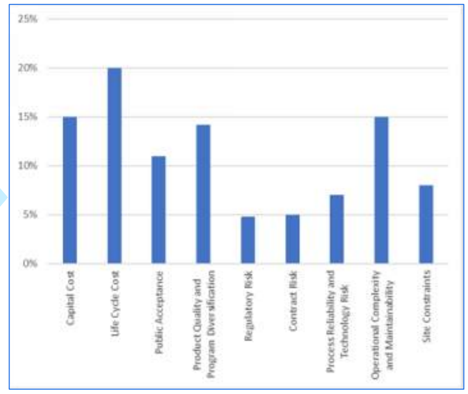
Determining Weight for Each Criteria


1. Capital Cost is more important than *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Life Cycle Cost	○	○	○	○	○
Public Acceptance	○	○	○	○	○
Product Quality and Program Diversification	○	○	○	○	○
Regulatory Risk	○	○	○	○	○
Contract Risk	○	○	○	○	○
Process Reliability and Technology Risk	○	○	○	○	○
Operational Complexity and Maintainability	○	○	○	○	○
Site Constraints	○	○	○	○	○



- Complete an online survey
- Use an algorithm to convert survey answers to a numeric weighting
- Total of all criteria equals 100 percent

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Next Steps

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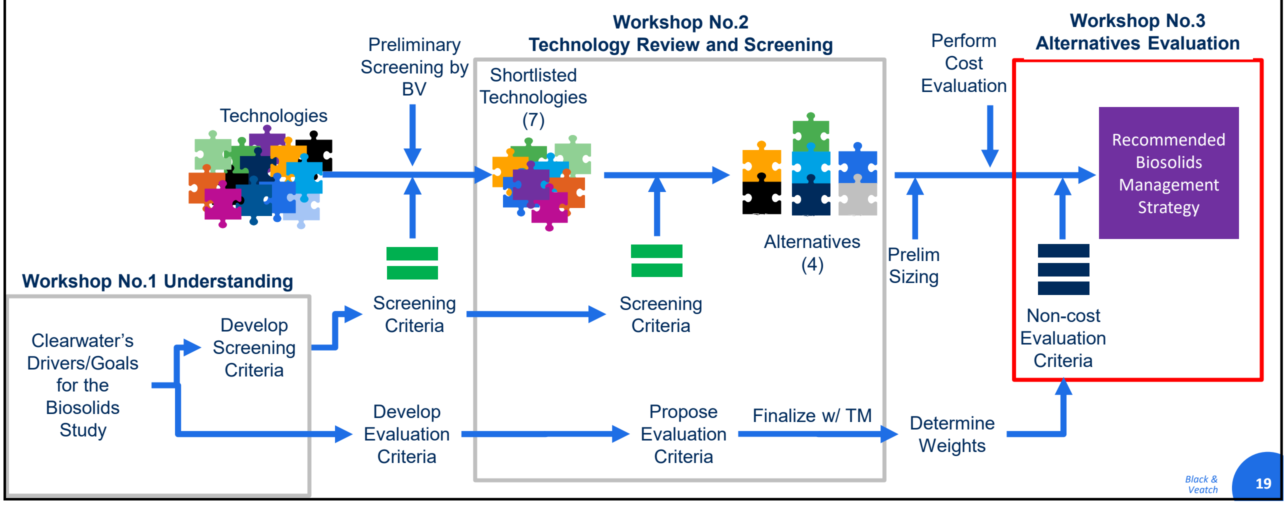
Biosolids Management Strategy Development



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Thank you !

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Overview of Technologies

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THP and Digesters in Medina, OH

Liquid Stabilization Technologies

- Aerobic Digestion (AD)
- Anaerobic Digestion (AnD)
- Chemical Treatment
- Thermal Treatment

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Aerobic Digestion (AD)

- Established technology
- Small to medium size facilities
- Aerobic microorganisms consume oxygen and biodegradable organic matter
- End product is Class B (Conventional AD) or Class A (ATAD)

Conventional

ATAD

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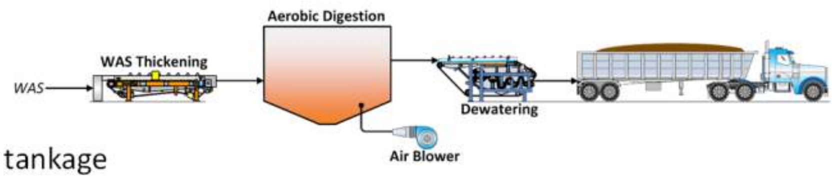
Conventional AD



- Produces Class B biosolids
- Best suited for WAS only
- Thicken to reduce digestion tankage
- 38% VSR (through AD) can be difficult in extended air plants
  - Use SOUR ≤ 1.5 mg O_2/hr/g TS at 20ºC to comply with VAR requirements
- Simple operation
  - Add sludge, mix/aerate for short period, settle, decant
  - Foaming a concern (maintain DO of 1-2 mg/l)
- Relatively high energy requirements (mixing, aeration)
  - 20-40 cfm/1,000 cf for WAS

Operation*	15ºC	20ºC
Single stage SRT	60 days	40 days
Series SRT	42 days	28 days

* PSRP per 503, series operations may require waiver

Advantages and Disadvantages: Conventional AD

ADVANTAGES

- Established technology
- Produces Class B biosolid
- Well suited for WAS
- Straightforward operations
- Minimal equipment requirements
- No dangerous or explosive gases

DISADVANTAGES

- Used primarily in plants with less than 5 mgd
- Significant tankage requirements (greater HRT than anaerobic digestion)
- Thickening required (pre-digestion or recuperative)
- High energy requirements
- Lower cake solids when dewatered
- Potential odors at start of aeration
- Permitting required for Class B land app sites

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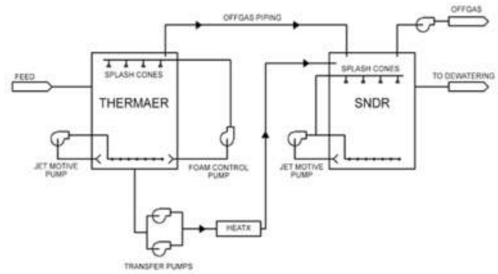
Autothermal Thermophilic Aerobic Digestion (ATAD)

- Typically a batch reactor digestion system
  - Thermophilic reactor (45-65 deg. C)
  - Mesophilic storage (25-40 deg. C)
- Reactor SRT 12 - 14 days followed by extended aerated storage
- VSR as high as 50% to 70%
- Higher cake solids (TS 20%+)
  - Dual conditioning (ferric and polymer) required
- Lower odor product
- Approximately 20+ systems in operation (ThermAer)



Middletown, OH – Largest ATAD in U.S.
(26 MGD rated capacity, processing 14.5 MGD, producing ~1500 dt/yr)

Advantages and Disadvantages: ATAD

ADVANTAGES

- Proven process
- Suitable for both WAS and PS
- Produces Class A biosolids
- High VSR (50% - 70%)
- Increased cake solids
- Reduced tankage requirements compared to AD
- Relatively simple operations
- No dangerous or explosive gases
- Lower odor product

DISADVANTAGES

- Requires efficient pre-digestion thickening to 6% TS
- High energy requirements
- Foaming could be an issue
- Post-digestion storage is critical to improve dewatering and sidestream quality (i.e. ammonia)
- Dual conditioning required (coagulant & polymer) for dewatering
- Process odor control required
- Class A cake suitable for agricultural outlets only (without subsequent processing)

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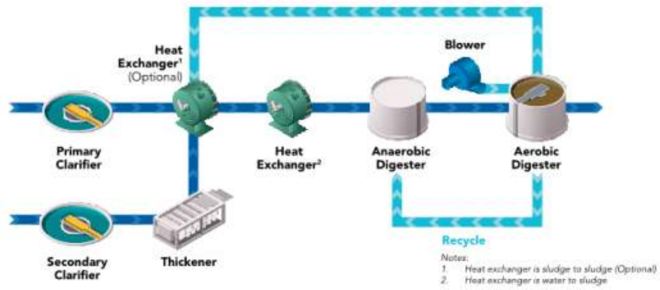
AnD+Post-Aerobic Digestion (PAD)

- Additional VSR (+10% lower solids)
- Significant ammonia reduction (90%+ reduction)
- Improved sludge dewaterability
- Reduction in struvite
- Odor reduction
- Relatively high capital and O&M costs
- Large area required



Source: DigestivorePAD – Ovivo exclusive licensing agreement with DC Water

Advantages and Disadvantages: AnD+PAD

ADVANTAGES

- Increased pathogen reduction (could be Class A in some systems)
- Increased VS reduction and biogas production
- May reduce foaming
- Reduced cake solids for dewatering
- Lower N in the recycle stream
- Lower P in the recycle stream with chemical addition

DISADVANTAGES

- Limited installations
- High capital cost
- Increased operational complexity over conventional
- Requires heat management to control the temperature in the reactor

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Anaerobic Digestion (AnD)

- Established technology
- Medium to large facilities
- Anaerobic microorganisms consume biodegradable organic matter
- End product is Class B (Conventional) or Class A/AA (Advanced)

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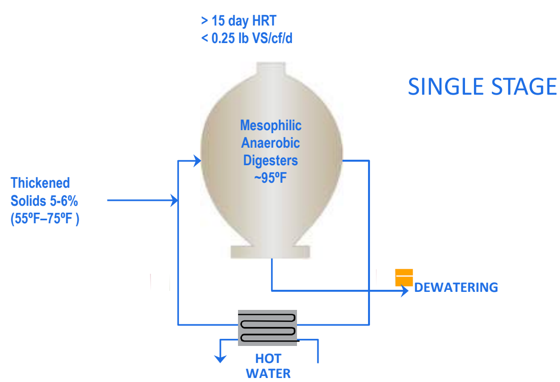
Mesophilic Anaerobic Digestion (AnD)

- Produces Class B biosolids
- VAR > or = 38% VSR
- Digester sizing
  - 15 to 20 days SRT at 95°F
- What to watch
  - Sludge loading
  - VFA:Alkalinity
  - pH
- Different configurations available



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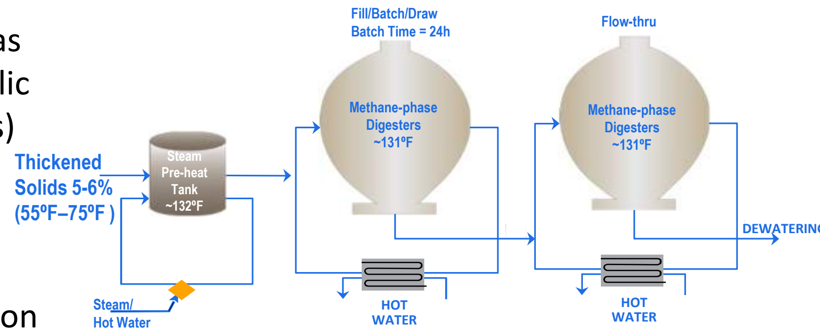
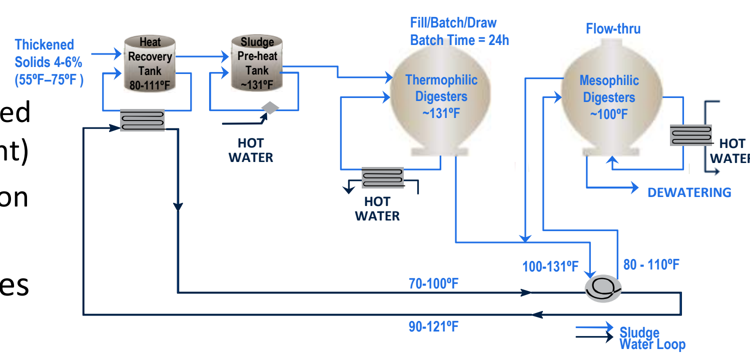
Thermophilic Anaerobic Digestion

- Significantly greater biogas production than mesophilic (lower SRT, faster kinetics)
- More sensitive to temperature change than mesophilic
- Greater pathogen reduction
- High O&M costs
  - Heat production year-round
  - Mixing



Temperature Phased Anaerobic Digestion (TPAD)

- Requires high thermophilic temperatures (>131°F) in first stage
  - High energy costs (unless paired with sustainable pre-treatment)
  - Enhanced pathogen destruction (Class A biosolid)
- Lower mesophilic temperatures (>95°F) in second stage
  - Energy cost to pump cooling water required
  - Removes VS, reduced volume



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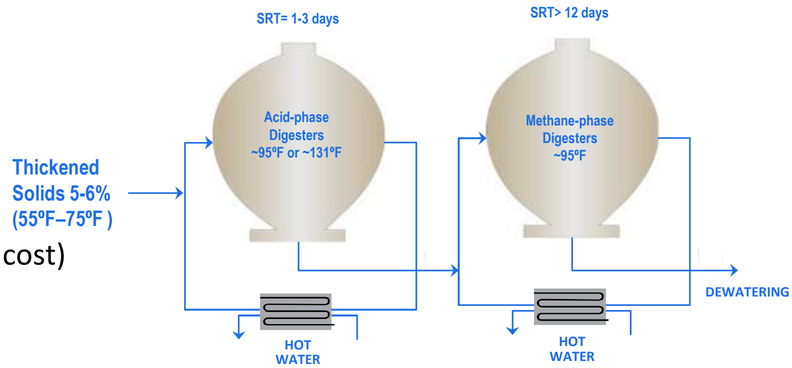
Acid/Gas Phased Digestion

- Acid phase:
  - Acidic pH – Accelerates hydrolysis (faster than conventional)
  - Heating required (energy cost)
  - Could be mesophilic or thermophilic
- Gas Phase:
  - Faster rate of biogas production
  - May provide stable operation (site specific)



Advantages and Disadvantages: Anaerobic Digestion

ADVANTAGES

- Proven process
- Solids mass reduction
- Class B biosolids or Class A/AA biosolids if acid digester is semi-batch thermophilic
- Biogas available for beneficial use

DISADVANTAGES

- Can be unstable (foam issues) with WAS only (pre-treatment should improve stability)
- Tankage can be substantial
- Advanced systems increase complexity, especially for heating systems
- Gas handling equipment requirements

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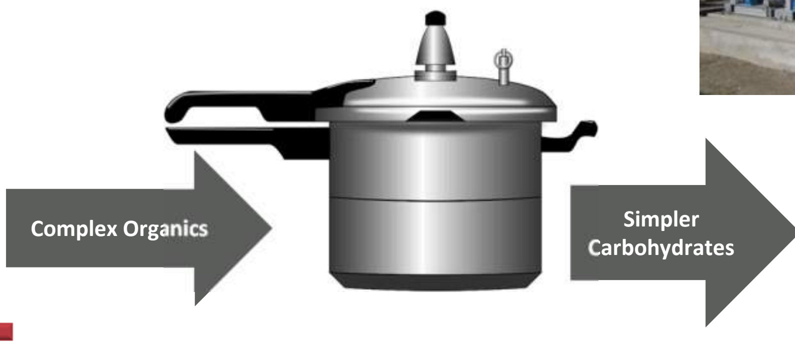
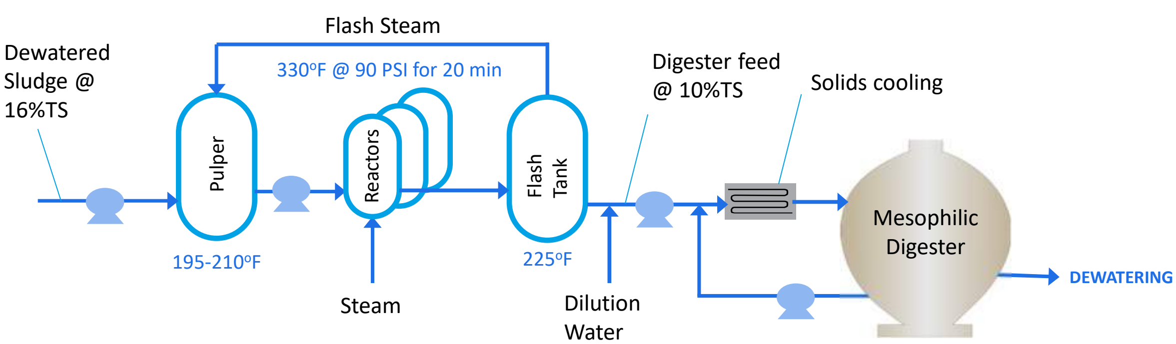
Thermal Hydrolysis Pretreatment (THP)

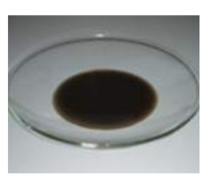
- Lysis – Break cells apart
- Thermal – Add heat
- Hydro – With water (Solubilization)

Medina, OH – Cambi B-2 THP (15 MGD)



THP Schematic (Cambi)





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Advantages and Disadvantages: THP+AnD

ADVANTAGES

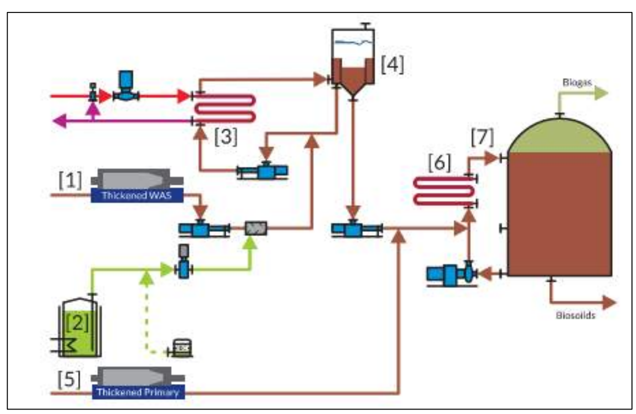
- Proven process with installations at 10 dtpd to 450 dtpd plants
- Can accept cake
- Produces Class A/AA biosolids
- Improves digestion of WAS
- Reduces new digester tankage needs by ~50%
- Improves dewaterability
- Reduces mass for transport
- Low odor product
- High VS reduction (50-55% VSR for WAS only)
- Biogas production for use

DISADVANTAGES

- Additional mechanical equipment beyond AnD (sludge screening, pre THP-dewatering process, cake bin, THP units, gas handling)
- Higher capital cost than some other technologies
- Steam boiler operation (vs hot water boiler)
- Increased sidestream nitrogen & phosphorus load
- Class A cake suitable for agricultural outlets only (without subsequent processing)

Thermo-Chemical Hydrolysis (TCHP)+AnD: PONDUS by CNP

- Handles only WAS
  - Not Class A/AA for PS+WAS
  - Class A/AA for WAS only
- Lowers WAS viscosity = less digester capacity needed
- Low caustic dose (1.75 l/m^3) added
- Sludge heated to 140-160°F before reactor, attains 160-180°F in reactor
  - Hot water or CHP waste heat if available
- Operates at atmospheric pressure



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Advantages and Disadvantages: TCHP+AnD (PONDUS)

ADVANTAGES

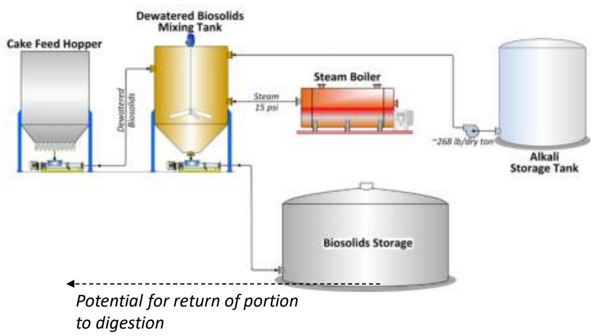
- Produces Class A biosolids (WAS only)
- Does not require elevated pressure or steam
- Relatively simple operation
- Small footprint
- Reduces new digester tankage (if WAS only)
- Increased biogas production for use
- Reduces dewatering polymer requirement

DISADVANTAGES

- Limited experience in U.S. (one facility)
- Additional mechanical equipment (beyond AnD)
- Requires chemical handling and addition
- Increased side-stream Nitrogen & Phosphorus load
- Class A cake suitable for agricultural outlets only (without subsequent processing)

Physical-Chemical Hydrolysis (PCH): Lystek

- Can be used with raw or digested solids cake
- Relatively simple process - lower temp and pressure than THP
- Processes 1%-35% solids with combination of:
  - Heat - 15 psi steam injection
  - Alkali (raise pH to 9.5-10 to facilitate hydrolysis dosing 190-270 lb/dt)
  - High shear mixing (max. 1000 rpm)
- Produces pumpable biosolids (13-16%)
- VAR is solids injection (if combined with digestion can do bench test)
- Four US installations



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Advantages and Disadvantages: PCH (Lystek)

ADVANTAGES

- Processes cake, can be raw
- Produces Class A biosolids
- Improves digestion of WAS
- Relatively simple hydrolysis process, lower temp and pressure than THP
- Low odor product
- High VS reduction when combined with digestion (50-55% VSR)
- Biogas production for use when combined with digestion

DISADVANTAGES

- Limited experience in the U.S.
- Injection required for VAR unless paired with digestion
- Additional mechanical equipment required (if done with AnD)
- Steam boiler operation (vs water boiler)
- Liquid storage requirements (extensive)

Chemical Stabilization

- Innovative Technology
- Small to medium size facilities
- End product meets Class B (Clean B) or Class A (Neutralizer)
- Proprietary systems

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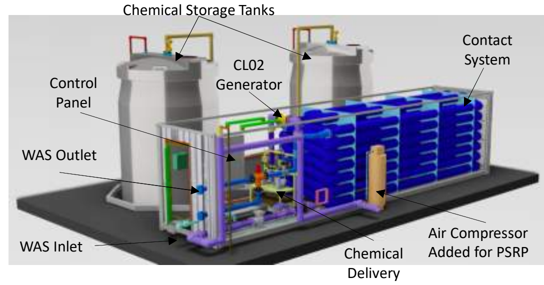
Chemical Stabilization: BCR Clean B

- Sulfuric acid and sodium chlorite are mixed to form chlorine dioxide
- EPA approved PSRP equivalent process for liquid WAS only (≤2% solids)
  - Compressor required to ensure DO > 1 mg/l at inlet
- VAR via SOUR or incorporation
- 10 minute reaction time
- Dewaterability (reported)
  - Polymer↓20-30%
  - Cake solids↑ 5%



Advantages and Disadvantages: BCR Clean B

ADVANTAGES

- Small process footprint
- Easily implemented
- Low capital cost
- Can meet Class B requirements
- Simple operations
- Low odor product
- Possible cake TS concentration increase

DISADVANTAGES

- Class B for WAS only
- Limited experience, all at smaller facilities
- Chemical handling
- Chemical delivery during emergencies
- Proprietary
- High chemical costs
- Stringent feed requirements to comply with PSRP equivalency
- Products suitable for agricultural outlets only (without subsequent processing)

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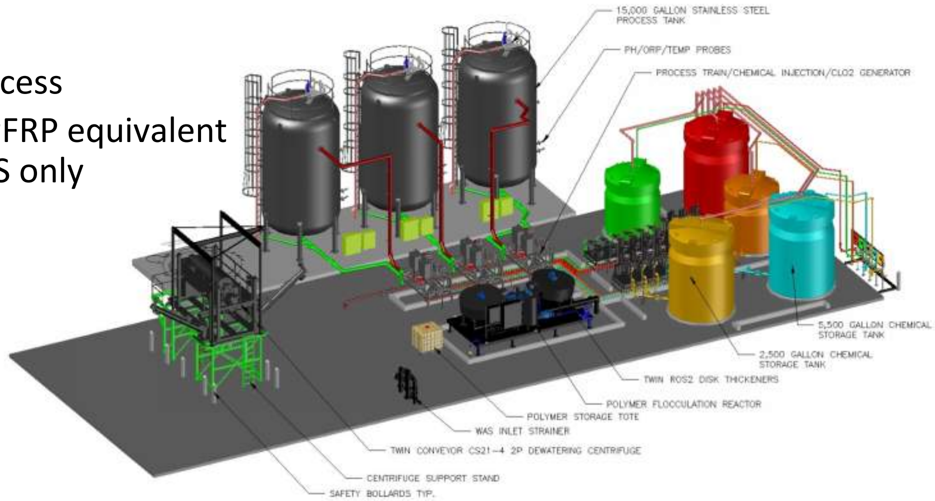
Chemical Stabilization: BCR Neutralizer

- 8-hr Class A Process
- EPA approved PFRP equivalent process for WAS only



Thicken to 4% → Inject CL02 → Hold for 1 hr → Add H2SO4 → Add NaNO3 → Hold for 6 hrs → Add NaOH → Dewater

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Advantages and Disadvantages: BCR Neutralizer

ADVANTAGES

- Small process footprint
- Easily implemented
- Can meet Class A requirements (WAS only)
- Simple operations
- Low odor product
- Possible cake TS concentration increase

DISADVANTAGES

- Innovative technology
- Class A for WAS only
- Limited experience in the US
- Chemical handling
- Chemical delivery during emergencies
- High chemical costs
- Proprietary
- Stringent feed requirements to comply with PFRP equivalency
- Products suitable for agricultural outlets only (without subsequent processing)

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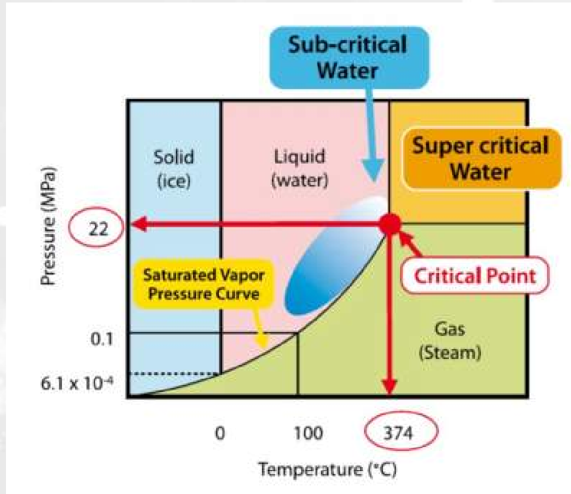
Thermal Treatment

- Emerging technology
- Medium size facilities
- Proprietary systems



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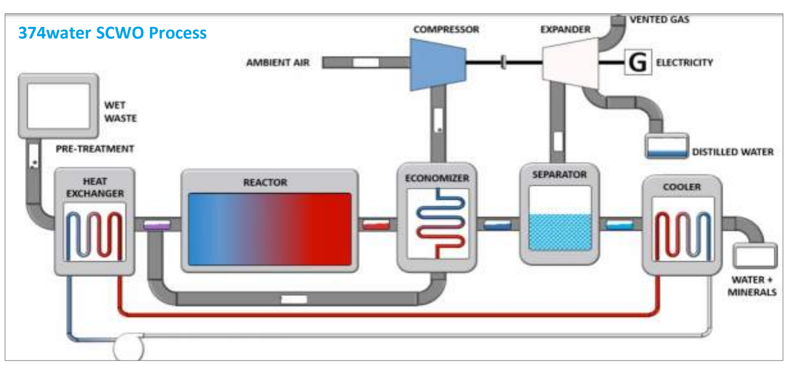
Thermal Treatment: Supercritical Water Oxidation (SCWO)

- Influent sludge (3-10% TS) at 3,200 psi and >705°F
- Air/Oxygen injection into sludge
- Temperature rises to 1,000-1,150°F in the reactor
- Economizer to heat influent solids (auto thermal)
- Produce steam, CO_2, N_2, H_2O, inerts
- Report of corrosion issues and scaling in HEX
- OC San considering piloting 374Water SCWO system



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Advantages and Disadvantages: SCWO

ADVANTAGES

- Very small footprint
- Excess energy in the form of electric power, steam or hot water
- Complete oxidation of organics to CO_2, COD Removal > 99.9 percent
- High quality effluent as clean water and N_2 discharge
- Low air emissions
- Immobilization of heavy metals in form of hydrox ides, carbonates and insoluble phosphates

DISADVANTAGES

- Emerging technology (demo plants in Ireland and Spain)
- High initial investment cost
- High operation costs (high pressure pumping, applied heat, cooling)
- Reports of corrosion issues in post-reactor HEX
- Scaling formation caused by salt deposition
- Feed waste must be homogenous and free from grit (<100 µm)
- Scale up of SCWO is challenging, due to the increased size and number of heat exchangers and pumps and increased complexity of maintenance and operations

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Cake Stabilization Technologies

- Composting
- Alkaline Treatment
- Drying
- Thermal Oxidation
  - Cake
  - Dried Material

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Composting

- Established technology
- Aerobic, thermophilic, exothermic process
- Produces Class A biosolids
- Marketable, well accepted product
- Requires carbon source (amendment/bulking agent)
- Proper siting and operations are key to odor management
- Space intensive

Composting Processes

Windrow

Aerated Static Pile (ASP)

Agitated Bin

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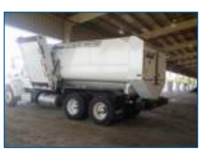
Windrow Composting



Mixing
- Combine solids and bulking agent (woody wastes)
- Target 40% TS, 30:1 (C:N)

Pile Construction
- Create long piles, size determined by turner

Active Composting
- Maintain 131°F for 15 days, turning 5 times
- Turn windrow to aerate, "fluff," control temperature
- Leave in pile for 21-30 days

Screening
- Screen wood from compost
- Return some screened material to process

Curing
- Leave in piles for 30-90 days
- Class AA (PFRP)

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Advantages and Disadvantages: Windrow Composting

ADVANTAGES

- Proven process
- Suitable for both WAS and PS (PS can exacerbate odors)
- Can be combined with other processes (digestion)
- Produces Class A biosolids suitable for agricultural AND urban uses
- Relatively low capital cost for windrow systems (pad, rolling stock)
- Relatively low O&M (dependent on amendment source)
- Relatively simple operation

DISADVANTAGES

- Land and labor intensive process
- High truck traffic (cake + amendment + product)
- Requires amendment/bulking agent
- Process odors is a significant concern
- Climate can impact process efficiency. Often open to atmosphere but can be covered

Aerated Static Pile (ASP) Composting

- Long piles, aerated at base through trenches or perforated pipes
  - Positive or negative forced aeration. Negative exhausts to biofilter.
- Regulatory compliance
  - 3 days at 131°F to meet Class AA (PFRP)
  - 38% VSR
- Typical active composting = 14-21 days
- Process control options
  - Manual temperature readings / blower adjustments
  - Thermocouple readings, temp controlled blower ops
- Can be covered or uncovered

Advantages and Disadvantages: ASP Composting

ADVANTAGES

- Proven, simple process
- Suitable for both WAS and PS (PS can exacerbate odors)
- Can be combined with other processes (digestion)
- Suitable for co-processing of some organics
- Produces Class A biosolids suitable for agricultural AND urban uses
- Smaller footprint than windrow composting
- Better process control than windrow
- Can provide biofilter to treat odorous exhausts

DISADVANTAGES

- Land and labor intensive process
- High truck traffic (cake + amendment + product)
- Energy intensive
- Requires amendment/bulking agent
- Process odors a concern if process not covered
- When geotextile covers used, cover management an issue

Agitated Bin Composting

- Mix placed at front end of ~ 260 ft X 10 ft bins with in-floor aeration
- Agitator mixes and moves material through bin over 21-30 day period.
- Regulatory Compliance:
  - 3 days at 131°F to meet Class AA (PFRP)
  - 38% VSR
- Thermocouples guide floor aeration system
- Compost removed for curing at end of bin
- Interior odors a significant issue

Advantages and Disadvantages: Agitated-bin Composting

ADVANTAGES

- Proven, simple process
- Suitable for both WAS and PS (PS can exacerbate odors)
- Can be combined with other processes (digestion)
- Produces Class A biosolids suitable for agricultural AND urban uses
- Smaller footprint than windrow composting
- Better process control than windrow or ASP
- Biofilter can treat odorous exhausts

DISADVANTAGES

- Land intensive process
- High truck traffic (cake + amendment + product)
- Energy intensive
- Requires amendment/bulking agent
- High capital cost
- Process odors/moisture significant concern in building
- Ventilation needs result in very large odor control requirements

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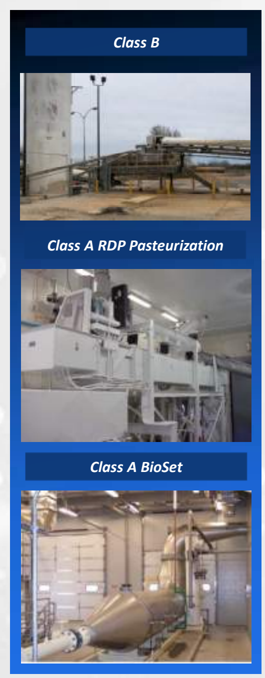
Alkaline Stabilization

- Established technology
- Small to large scale
- Addition and mixing of lime, or lime/heat/chemical combination
- Meets Class B or Class A and VAR
- Lime doses 0.2 – 0.8 ton/dry ton solids



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Class B Lime Stabilization

- Lime mixed with solids at 0.2-0.5 ton/dry ton solids
- Regulatory compliance
  - PSRP = pH >12 for 2 hrs
  - VAR = pH >11.5 for an additional 22 hrs
  - Often stored onsite to ensure

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Advantages and Disadvantages: Class B Lime Stabilization

ADVANTAGES

- Proven, simple process
- Suitable for both WAS and PS
- Lime could be a value to local agricultural community
- Low capital cost
- Small footprint
- Suitable for a wide range of plant sizes
- Easily implemented
- Can be used intermittently

DISADVANTAGES

- Strong odor potential at process, storage and land application sites
- Lime deliveries during emergencies
- Dust production associated with lime, corrosive to equipment, can create adverse work environment
- High O&M costs
- Increase in mass/volume

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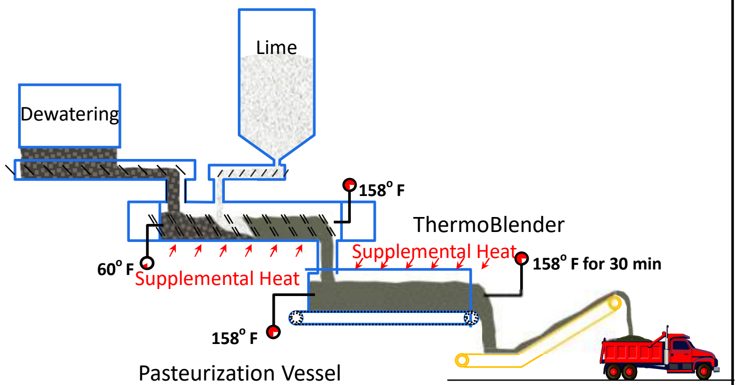
Alkaline Stabilization: RDP EnVessel Pasteurization

- Class A with heat
- Lime dose = 0.2-0.3 ton/dry ton solids for pH 12
  - 0.5 ton lime/ton for cake < 20% solids to make a more “marketable” product
- Product suitable for agricultural use only



Advantages and Disadvantages: RDP EnVessel Pasteurization

ADVANTAGES

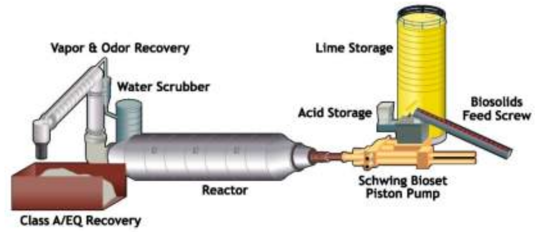
- Proven, relatively simple process
- Suitable for both WAS and PS
- Produces Class A biosolids
- Lime could be a value to local agricultural community
- Low capital cost
- Small footprint
- Suitable for a wide range of plant sizes

DISADVANTAGES

- Odor potential at both process and land application sites
- Lime deliveries during emergencies
- Dust production associated with lime, corrosive to equipment, can create adverse work environment
- High O&M costs
- Increase in mass/volume

Alkaline Stabilization: Schwing BioSet

- Class A with lime + sulfamic acid
- EPA PFRP approval to operate @131°F for 40 min (ammonia impacts pathogen kill)
- Reactor time = 1 hr
- Lime dose ~0.5 to 1 ton/dt solids
- Cake solids increase commensurate to lime
- Product suitable for agricultural only
- Reportedly maintains pH for 6 months
- Schwing will market product (with subsequent drying) as Revinu



Advantages and Disadvantages: Schwing BioSet

ADVANTAGES

- Proven, relatively simple process
- Suitable for both WAS and PS
- Produces Class A biosolids
- Lime could be value to local agricultural community
- Low capital cost
- Small footprint
- Can be installed as Class B with provision to go to Class A
- May have ability to have vendor market product

DISADVANTAGES

- Odor potential at both process and land application sites
- Dust production associated with lime
- High O&M costs
- Increase in mass/volume

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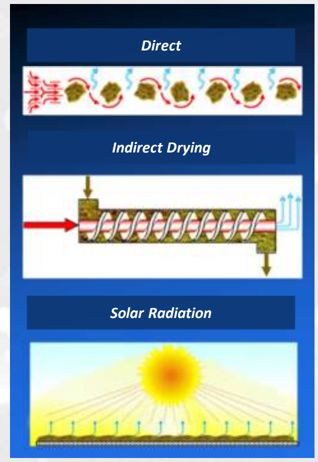
Drying

- Established Technology
- Small to large size facilities
- Thermal
  - Indirect (conduction)
    - Paddle
  - Direct (convection)
    - Belt
    - Rotary drum
- Solar



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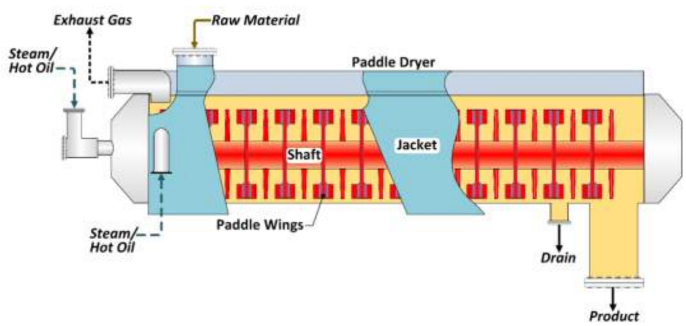
Paddle Dryer



- Continuous feed indirect dryer
- Uses steam or hot oil to heat augers (300 to 350°F)
- Potential use for waste heat
- Irregular product with fines
- Generally small to medium size applications
- Long shutdown cycle (3-12 hrs, depending on heat system used)

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Advantages and Disadvantages: Paddle Drying

ADVANTAGES

- Proven process
- Suitable for both WAS and PS (PS less desirable for product quality and operability)
- Can be combined with other processes (digestion and co-processing of organics)
- Produces Class A biosolids
- Significant volume reduction
- Applicable for small plants
- Relative ease of operation (compared to rotary drum)
- Low capital cost

DISADVANTAGES

- Best suited for homogeneous feed
- Typically dusty and irregular product
- Fuel costs
- Safety must be addressed
- Long start up/shut down compared to other dryers

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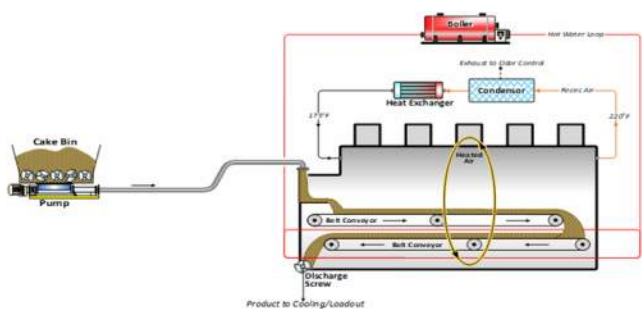
Belt Dryers

- Continuous feed, direct dryer
- Lower operating temperatures (205-330ºF) than other dryers
- Larger dryer footprint due to cooler temperatures
- Continuous feed, convective system
- Uses steam or hot oil via HEX to dry or gas burner depending on vendor
- Product quality varies depending on feed system
  - Can be low density, generally irregular shape



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Advantages and Disadvantages: Belt Drying

ADVANTAGES

- Proven process
- Suitable for both WAS and PS
- Can be combined with other processes (digestion and co-processing of organics)
- Produces Class A biosolids
- Significant volume reduction
- Applicable for small plants
- Relative ease of operation (compared to rotary drum)
- Good product quality (dependent on feed mechanism e.g. back mixing with Andritz)
- Low temperature – can take advantage of waste heat

DISADVANTAGES

- Best suited for homogeneous feed
- Irregular product quality (dependent on feed mechanism e.g. extruded systems)
- Fuel costs
- Safety must be addressed

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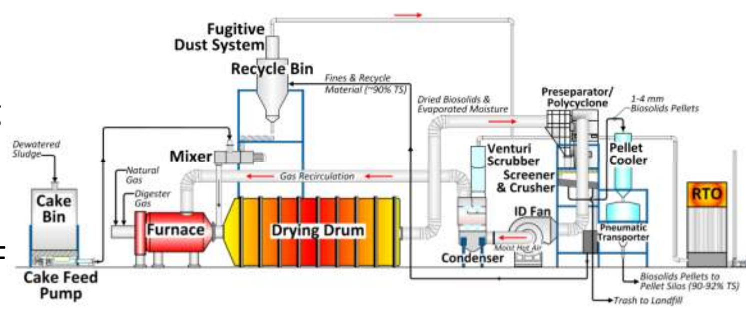
Rotary Drum Dryer

- Continuous feed direct drying system
- Solids heated to ~ 200^{o}F
- Hot gases heated to ~ 1,000^{o}F
- Creates hard, uniform pellet, 92% solids content
- Typically applied at larger facilities
- Often run by private firms (Synagro, NEFCO, etc)



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Advantages and Disadvantages: Rotary Drum Dryer

ADVANTAGES

- Proven process
- Suitable for both WAS and PS (PS less desirable for product quality and operability)
- Can be combined with other processes (digestion and co-processing of organics)
- Produces Class A biosolids
- High quality pellet offers most diverse market opportunities and revenue potential
- Significant volume reduction

DISADVANTAGES

- Best suited for homogeneous feed
- High capital cost
- High fuel costs (if operated without biogas)
- Safety must be addressed
- More complicated O&M than other dryers
- Thermal oxidation required for odor control

Dried Product Comparison – General Characteristics






Parameter	Rotary Drum	Paddle	Belt	Belt	Belt	Belt (post-processed)
	Andritz	Komline	Andritz	Huber	Suez, Veolia/Kruger	Huber, Veolia/Kruger
Shape	Pellet	Granule/Irregular	Granule/Irregular	Irregular	"String"	Cylinder
Uniformity	Excellent	Good	Good	Poor	Poor	Excellent
Size (mm)	0.5-4	0.5-5	0.5-4	2-8	Not available	2-5 (length)
Density (lb/cf)	40-45	35-45	40-45	20-25 (1)	15-25 (2)	45
Hardness	Hard	Somewhat hard	Somewhat hard	Friable	Friable	Hard

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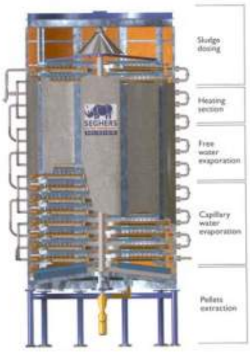
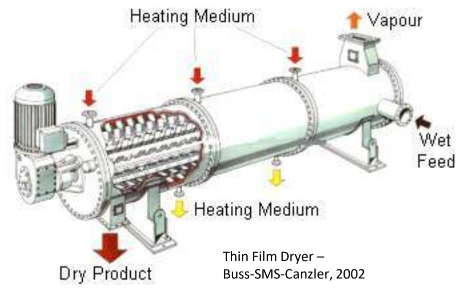
Other Drying Systems

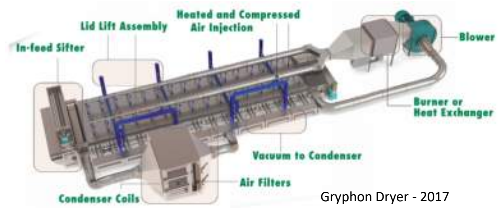


Multi-Tray Dryer - Keppel Seghers, 2014

Fluidized Bed Dryer – Schwing Bioset, 2015



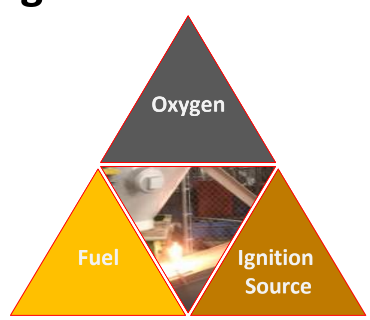
Thin Film Dryer – Buss-SMS-Canzler, 2002



Gryphon Dryer - 2017

Safety Considerations with Thermal Drying

- Typical safety concerns
  - Fire in process or storage
  - Dust explosions
- Methods of addressing risk
  - Extensive monitoring:
    - CO & O2, Temperature
  - Suppression:
    - N gas inertion systems in silos
    - Automated quench systems
    - Regimented startup/shutdown procedures
  - Explosion relief



- Fuel: Volatiles in biosolids, Dust, Gas
- Ignition Source: Sparks (static electricity), High Temperature
- Oxygen: System Leaks

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Solar Drying

- Relatively new/innovative technology (early 1990s)
- Uses solar energy to evaporate moisture from biosolids
- Dewatered cake spread in 6-8” layer, left for ~20 days
- Site-specific permitting for Class A biosolids (Alt 3)
- Varying approaches to solids distribution in “greenhouse”
- Dirt like product, >70% TS
- Odor control usually needed

Advantages and Disadvantages: Solar Drying

ADVANTAGES

- Suitable for WAS
- Can be combined with other processes (digestion or post-processing)
- Can produce Class A biosolids (site-specific)
- Solids volume reduction
- Simplicity/ease of operation
- Low energy
- Low operations cost

DISADVANTAGES

- Not well suited for PS unless digested
- Limited experience in the US
- Space intensive
- High capital costs
- High power cost because of fans used to exhaust moist air
- Irregular product size
- Potential odor
- Storage required for periods of low product demand

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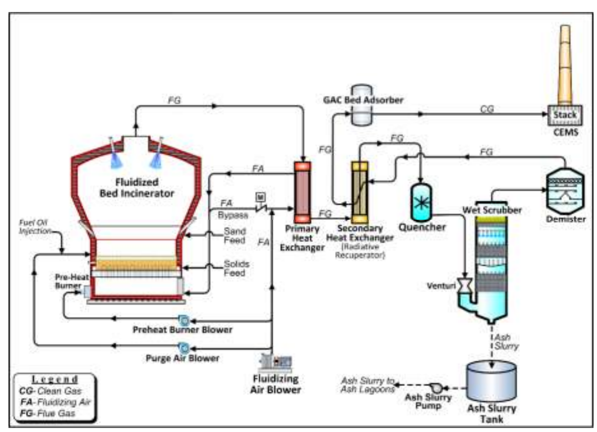
Thermal Oxidation

- Solids are oxidized to form CO_2, H_2O and inert solids
- Cake
  - Established technology
- Dried material
  - Innovative and Emerging technology

Incineration

- Dewatered solids are burned in a combustion chamber
- Heat recovery for energy production is possible
- Two types
  - ➢ Multiple Heart – Old technology
  - ➢ Fluidized Bed – All new installations



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Advantages and Disadvantages: Incineration

ADVANTAGES

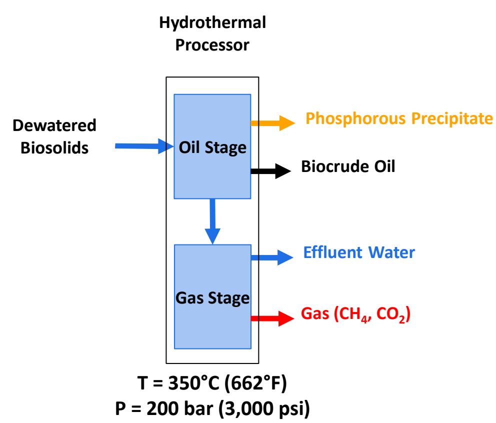
- Can be combined with other processes (i.e. digestion)
- Solids volume reduction
- May destruct PFAS
- Smaller footprint than gasification and digestion technologies

DISADVANTAGES

- Concerns with emissions control by FDEP
- Used at medium to large scale facilities
- Complex process to operate
- High capital cost
- High operations cost

Hydrothermal Processing

- Uses temperature and pressure to convert wet organic matter to biocrude oil and methane gas in less than an hour
- Captures phosphorus as a precipitate with other inorganics
- Effluent water is clear and sterile with COD <100



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History of Hydrothermal Processing

- Enersludge by Environmental Solutions Inc (ESI)
- STORS by ThermoEnergy Corporation
  - Foster Wheeler Environmental and Battelle were co-developers
  - Demonstration facility in Japan in 1990s
  - EPA sponsored pilot at Colton, CA in 2000 [1-3 gpm feed]
- CWT
  - Full-scale facility in Carthage, MO, in 1998
    - Primarily processed turkey renderings, but some wastewater sludges, closed due to odors soon after opening

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History of Hydrothermal Processing (continued)

- SlurryCarb by EnerTech
  - Demonstration facility in Japan on MSW, 1997
  - Full-scale facility constructed Rialto, CA, 2008-2010 timeframe. ~$160 million
    - Closed 2012. Issues with sidestream dissolved solids
- Genifuel
  - Process developed by US Dept of Energy – Licensed to Genifuel
  - Demonstration facilities under development at Vancouver and Central Contra Costa Sanitation District

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Advantages and Disadvantages: Hydrothermal Processing

ADVANTAGES

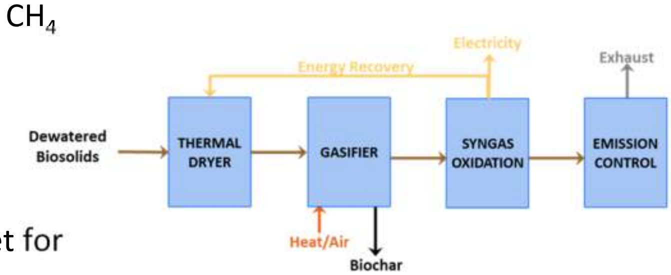
- Does not require upstream drying
- Final products can be beneficially used
- May destruct some PFAS with high operation temperature

DISADVANTAGES

- Innovative and emerging technology (demo facilities under development)
- Suitable for medium to large scale facilities
- Complex process to operate
- Limited experience
- Sidestream quality was critical issue for first large scale operation with wastewater sludges

Gasification

- Oxidizing organic compounds to CO, CH_4 and H_2 under high temperature and controlled amount of O2
- Syngas – low quality gas, generally requires treatment for use
- Generates biochar – reported market for product but more research on soil applications are needed (reference Dr. Sally Brown, University of Washington)



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History of Gasification

- Prime Energy –
  - Pilot in Philadelphia, PA, approximately 2002 timeframe. Ran on-and-off for ~4 years. City ultimately implemented thermal drying
  - Pilot in Tulsa, OK in 2008. City implemented pasteurization instead
- Stamford, CT – Pilot of multiple vendors in 2008-2009, not implemented due to cost
- MaxWest - Sanford, FL – full scale facility developed ~2009-2013
  - Issues with dryer and gasifier, both replaced during development
  - Declared bankruptcy and closed Sanford in 2013, sold in 2015

Gasification Systems for Biosolids

Vendor	Location	US Status
Ecoremedy	Morrisville, PA	Early 2021 acceptance, removed 2022
	Edmonds, WA	Under construction, replacing incinerator
Aries Clean Energy	Linden-Roselle, NJ	Full-scale facility, 430 tons/day Scheduled for startup 2021, not operating as of April 2022
	Lebanon, TN	Full scale facility, operational in 2016 up to 64 tons/day of wood waste, tires, and WWTP sludge.
	Taunton, MA & Sayreville, NJ	In planning

Others who have pursued biosolids gasification – Nexterra, Liberty Energy

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Advantages and Disadvantages: Gasification

ADVANTAGES

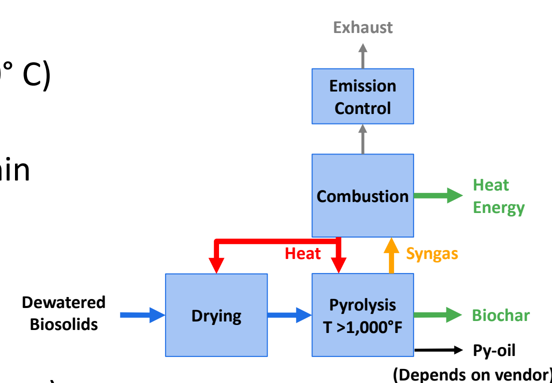
- Less space requirement
- Syngas can be used as fuel
- Final product is biochar, inert material with some reported market demand
- May destruct PFAS with use of thermal oxidizer on the flue gas

DISADVANTAGES

- Suitable for medium to large scale facilities
- High temperatures and residence times in the pyrolysis unit
- Requires upstream drying
- Complex process to operate
- High capital cost
- Limited experience with biosolids (One facility in construction in NJ, another one in operation in TN but mixes with wood waste)
- Unknow sidestream quality
- Limited information on air emissions

Pyrolysis

- Thermochemical decomposition of organic matter in the absence of oxygen (400 – 600° C)
- Syngas – low quality gas, generally requires treatment for beneficial use or utilized within the process
- Generates biochar – potential market for product but more research on soil applications is needed
(ref: Dr. Sally Brown, University of Washington)



Biochar

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Pyrolysis Systems for Biosolids

Vendor	Location	Status
BioForceTech (PYREG)	Silicon Valley, CA	Operational since 2017 1,200 dtpy dried solids (80% TS)
	Europe (by PYREG)	Five installations on WWTP sludge
Kore Infrastructure	Los Angeles, CA	Started 2021, 24 dtpd, mixed materials
Anaergia	Rialto, CA	Mixed waste facility Pyrolysis not yet operational
	Encina, CA	Piloted, not selected
Eisenmann Corporation Pyrobuster	ARA Pustertal, South Tyrol, Italy	Have learned through third parties this facility proved to be a net energy consumer (not a producer as marketed)
	Dinkelsbuhl, Germany	

BioForceTech, Silicon Valley, CA

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History of Pyrolysis – Bioforcetech

- A full scale facility in Silicon Valley Clean Water facility in CA since 2017.
- Designed to process half of the digested sludge production, 1,200 ton/yr at 80% DS
- Two step process
  - BioDryer – batch operation to remove moisture from 20% DS to achieve 80% DS
  - P-FIVE - Pyrolysis reactor to generate syngas and biochar at 600 to 1,650 deg F Syngas is burned in a flameless burner. Some heat is used for the process.
- Due to flameless burner, low NOx emission. Wet scrubber is used for SOx removal. Requires air permit.

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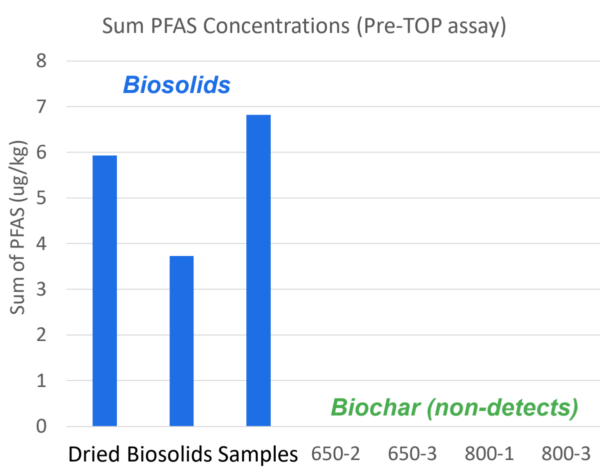
Pyrolysis Removes PFAS in Solids, <u>but Where do They Go</u>?



- No closure on the mass balance
- No methods for analyzing py-gas and py-oil
- Preliminary data <u>show PFAS compounds in py-oil</u> that were not in biosolids

BV Project: Innovation & Research Portfolio 2022 (McNamara, et al)

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Advantages and Disadvantages: Pyrolysis

ADVANTAGES

- Final product is biochar, inert material with some reported market demand
- May destruct PFAS with high operation temperature

DISADVANTAGES

- Suitable for medium to large scale facilities
- High temperatures and residence times in the pyrolysis unit
- Requires upstream drying process
- Complex process to operate
- Limited experience
- Unknow sidestream quality
- Limited information on air emissions

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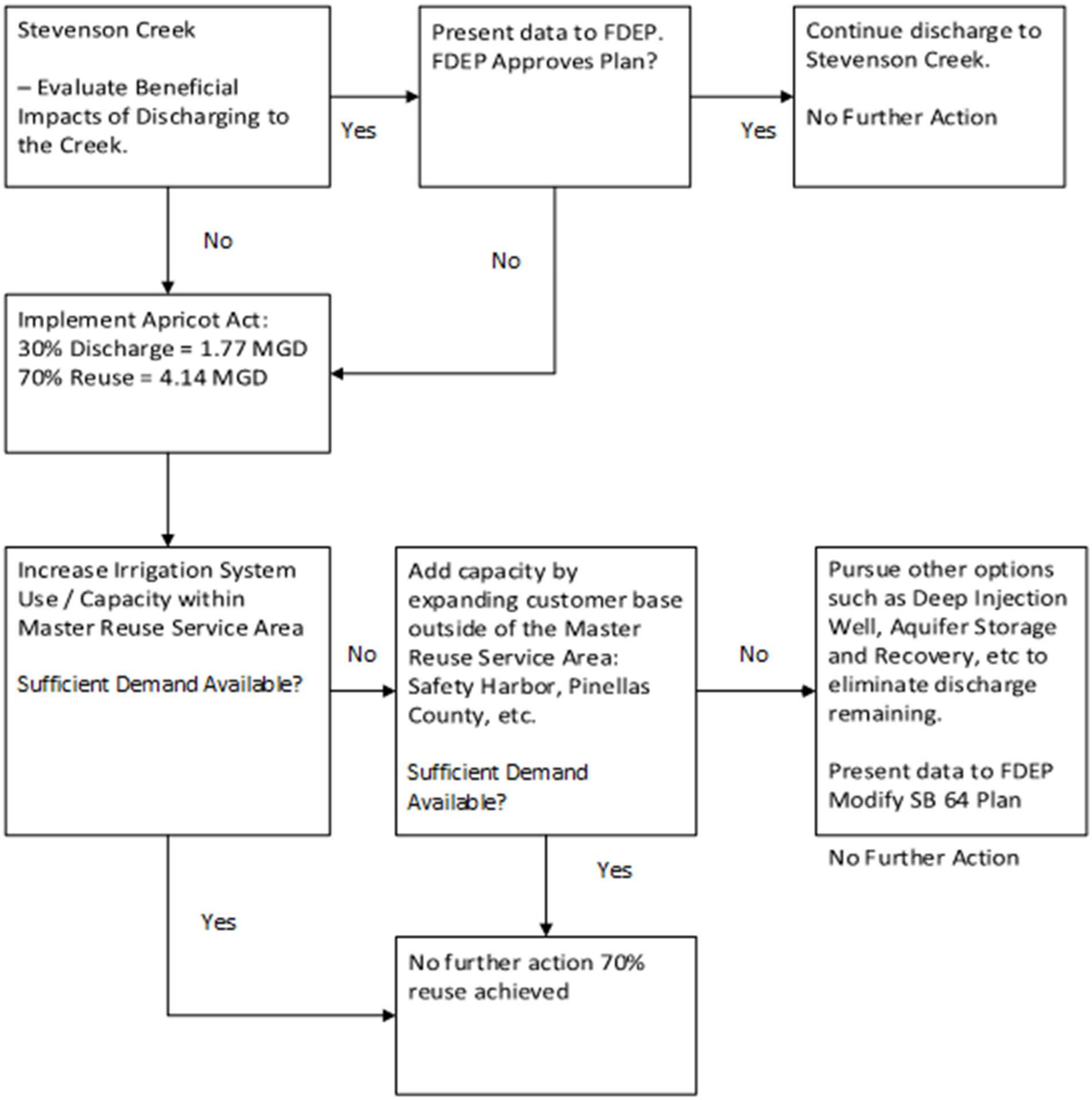
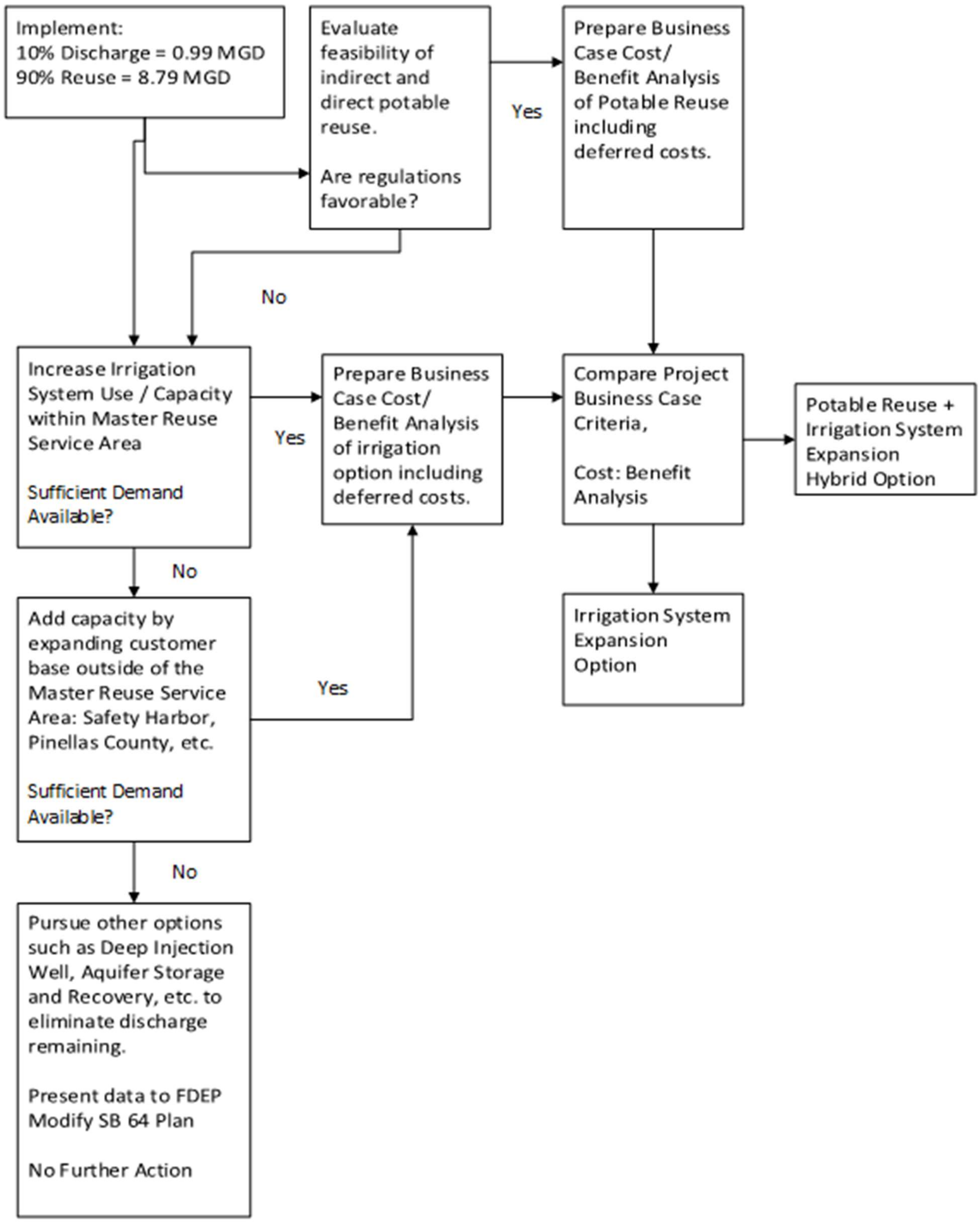
Appendix E. Decision Trees for the Senate Bill 64 Plan

MSWRF SB64 Compliance Decision Tree



EWRF and NEWRF SB64 Compliance Decision Tree



Appendix F. WRF Consolidation Scenarios – Long List

This Appendix is part of the Water Reclamation Facilities (WRF) Master Plan – Final WRF Strategies Technical Memorandum (City Project No. 17-0007-UT, December 2023).

Appendix D - WRF Consolidation Scenarios - Long List

	Divert Flow
x	Receive Flow

Scenario No.	Name/ Description	Full Flow or Partially Diverted Flow	NEWRF	MSWRF	EWRF	Other Location	Total # of WRFs
1	Keep as-is	Existing flows + 2050 projected	x	x	x		3
2	Keep as-is	Divert flow from two plants into third	x	x	x		3
3	Keep as-is	Divert flow from two plants into third	x	x	x		3
4	Keep as-is	Divert flow from two plants into third	x	x	x		3
5	Keep as-is	Divert flow from one plant into second plant	x	x	x		3
6	Keep as-is	Divert flow from one plant into second plant	x	x	x		3
7	Keep as-is	Divert flow from one plant into second plant	x	x	x		3
8	Keep as-is	Divert flow from one plant into second plant	x	x	x		3
9	Keep as-is	Divert flow from one plant into second plant	x	x	x		3
10	Keep as-is	Divert flow from one plant into second plant	x	x	x		3
11	Consolidate into 2 plants, split flow	Split entire flow from one facility into remaining two		x	x		2
12	Consolidate into 2 plants, no split for diverted flow	Divert entire flow from one facility into another facility		x	x		2

	Divert Flow
x	Receive Flow

13	Consolidate into 2 plants, no split for diverted flow	Divert entire flow from one facility into another facility		x	x		2
14	Consolidate into 2 plants, split flow	Split entire flow from one facility into remaining two	x		x		2
15	Consolidate into 2 plants, no split for diverted flow	Divert entire flow from one facility into another facility	x		x		2
16	Consolidate into 2 plants, no split for diverted flow	Divert entire flow from one facility into another facility	x		x		2
17	Consolidate into 2 plants, split diverted flow	Split entire flow from one facility into remaining two	x	x			2
18	Consolidate into 2 plants, no split for diverted flow	Divert entire flow from one facility into another facility	x	x			2
19	Consolidate into 2 plants, no split for diverted flow	Divert entire flow from one facility into another facility	x	x			2
20	Consolidate into 2 plants, divert flow to new	Divert entire flow from two facilities into new facility and keep existing flows for third facility	x			x	2
21	Consolidate into 2 plants, split flow to new	Split entire flow from two facilities into remaining facility and new facility	x			x	2
22	Consolidate into 2 plants, divert flow to new	Divert entire flow from two facilities into new facility and keep existing flows for third facility		x		x	2
23	Consolidate into 2 plants, split flow to new	Split entire flow from two facilities into remaining facility and new facility		x		x	2

Appendix D - WRF Consolidation Scenarios - Long List

	Divert Flow
x	Receive Flow

24	Consolidate into 2 plants, divert flow to new	Divert entire flow from two facilities into new facility and keep existing flows for third facility			x	x		2
25	Consolidate into 2 plants, split flow to new	Split entire flow from two facilities into remaining facility and new facility			x	x		2
26	Consolidate into 1 plant	Divert entire flow from two facilities into third facility	x					1
27	Consolidate into 1 plant	Divert entire flow from two facilities into third facility		x				1
28	Consolidate into 1 plant	Divert entire flow from two facilities into third facility			x			1
29	Consolidate into 1 plant	Divert entire flow from two facilities into new facility				x		1

Appendix G. Cost Tables for WRF Consolidation

This Appendix is part of the Water Reclamation Facilities (WRF) Master Plan – Final WRF Strategies Technical Memorandum (City Project No. 17-0007-UT, December 2023).

	Expansion/Improvement Costs Per Scenario					
Process Improvement	Scenario 1 Maintain Existing WRFs	Scenario 2 All at NEWRF	Scenario 3 MSWRF to NEWRF	Scenario 4 EWRF to NEWRF	Scenario 5 MSWRF+EWRF to New WRF	Scenario 6 All at New Regional WRF
EQ Tanks	$ 4,000,000	$33,600,000	$42,400,000	$4,000,000	$10,800,000	$28,000,000
Headworks	-	$10,125,000	-	-	$13,500,000	$15,000,000
Fermentation Tanks	-	$1,100,000	-	-	$1,956,000	$2,448,000
First Anoxic Tanks	-	$3,520,000	-	-	$6,264,000	$7,824,000
Oxidation Ditch	-	$13,500,000	-	-	$4,560,000	$5,724,444
Post Anoxic	-	$3,184,800	-	-	$6,795,000	$8,484,000
Re-aertion	-	$310,000	-	-	$551,112	$688,890
Secondary Clarifier	-	$675,000	-	-	$3,600,000	$3,168,000
Filters	-	$972,000	-	-	$6,750,000	$8,437,500
Chlorine Tanks	-	$672,000	-	-	$875,000	$1,093,750
Pump Station	-	$120,000	-	-	$960,000	$1,166,400
Balance of Plant	$1,400,000	$12,183,080	$14,840,000	$1,400,000	$16,032,839	$18,912,244
Total	$5,400,000	$80,591,880	$57,240,000	$5,400,000	$72,640,951	$100,947,228
Total[1,2]	$6,318,000	$94,292,500	$66,970,800	$6,318,000	$84,989,913	$118,108,257

[1] Total includes 17% added for engineering fees.
[2] In NPV calculation, Total was estimated over an installment period of 6 years and adjusted for inflation.

	Additional Pumping Power Usage and Costs					
Basin	Scenario 1 Maintain Existing WRFs	Scenario 2 All at NEWRF	Scenario 3 MSWRF to NEWRF	Scenario 4 EWRF to NEWRF	Scenario 5 MSWRF+EWRF to New WRF	Scenario 6 All at New Regional WRF
MSWRF	-	1,123,561	1,123,561	-	1,123,561	1,470,624
MSWRF/EWRF	-	182,905	130,636	52,269	182,905	215,240
EWRF	-	470,328	-	470,328	470,328	601,824
Total kWh per Year[1]	-	1,776,794	1,254,197	522,597	1,776,794	2,287,688
Total Pumping Cost per Year[,2,3]	$0	$124,376	$87,794	$36,592	$124,376	$160,138

[1] Total kWh per year in addition to current kWh per year from pumping.
[2] Cost assume $0.07 per kWh per Duke Energy Data received from City
[3] Total Pumping Cost per year in addition to current pumping costs per year.

	Scenario 5 MSWRF+EWRF to New WRF	Scenario 6 All at New Regional WRF
Land Size (AC)	30	65
$/AC	$1,500,000	$1,500,000
Total	$45,000,000	$97,500,000
Total[1]	$49,500,000	$107,250,000
[1]Total includes 10% for site demolition		

	Collection System Improvement Costs Per Scenario					
Collection System Improvement	Scenario 1 Maintain Existing WRFs	Scenario 2 All at NEWRF	Scenario 3 MSWRF to NEWRF	Scenario 4 EWRF to NEWRF	Scenario 5 MSWRF+EWRF to New WRF	Scenario 6 All at New Regional WRF
Force Main Installation	-	$134,630,230	$87,463,114	$47,167,117	$134,630,231	$179,059,207
Force Main Improvement	-	$36,618,049	$29,467,970	$10,150,079	$36,618,049	$52,692,005
Upgrade Lift Station	-	$4,779,681	$3,944,959	$834,722	$4,779,681	$6,356,976
New Lift Station Installation	-	$5,935,684	$3,114,848	$2,820,836	$5,935,684	$7,894,460
Install MSWRF Plant Transfer Station	-	$2,139,621	$2,139,621	-	$2,139,621	$2,845,696
Install EWRF Plant Transfer Station	-	$1,706,705	-	$1,706,705	$1,706,705	$2,269,918
Total	-	$188,809,971	$126,130,512	$62,679,459	$188,809,971	$251,117,261
Total[1,2]	-	$220,907,666	$147,572,700	$73,334,967	$220,907,666	$293,807,196
[1] Total includes 17% added for engineering fees. [2] In NPV calculation, Total was estimated over an installment period of 6 years and adjusted for inflation.						

	Decommissioning Cost per Scenario					
Decommission WRF	Scenario 1 Maintain Existing WRFs	Scenario 2 All at NEWRF	Scenario 3 MSWRF to NEWRF	Scenario 4 EWRF to NEWRF	Scenario 5 MSWRF+EWRF to New WRF	Scenario 6 All at New Regional WRF
NEWRF	-	-	-	-	-	$7,000,000
MSWRF	-	$5,185,185	$5,185,185	-	$5,185,185	$5,185,185
EWRF	-	$2,592,593	-	$2,592,593	$2,592,593	$2,592,593
Total	$0	$7,777,778	$5,185,185	$2,592,593	$7,777,778	$14,777,778
Total[1,2]	$0	$9,100,000	$6,066,666	$3,033,334	$9,100,000	$17,290,000
[1] Total includes 17% added for engineering fees. [2] In NPV calculation, Total was estimated over an installment period of 6 years and adjusted for inflation.						

Appendix H. Poll Anywhere Results

Clearwater WRF Master Plan-Consolidation Scoring Evaluation
Poll Everywhere Results

This Appendix is part of the Water Reclamation Facilities (WRF) Master Plan – Final WRF Strategies Technical Memorandum (City Project No. 17-0007-UT, December 2023).

Clearwater WRF Master Plan - Consolidation Scoring Evaluation
What is the right capitalization for million gallons per day?

Response	Via	Screen name	Created At
MGD	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 8:06
MGD	Activated Multi-Page Survey	Jeremy	6/30/2022 8:08
MGD	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 8:08
MGD	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:08
MGD	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 8:08
MGD	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 8:09
MGD	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 8:09

Criteria 1: System Reliability and Resilience; Scenario 1 (Maintain Existing WRFs)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:36
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 8:37
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:01
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:02
2	Activated Multi-Page Survey	Jeremy	6/30/2022 9:02

Criteria 1: System Reliability and Resilience; Scenario 2 (All to NEWRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Jeremy	6/30/2022 8:14
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 8:14
1	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:02
1	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:03
1	Activated Multi-Page Survey	Rich Gardner	6/30/2022 9:04
1	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:04

Criteria 1: System Reliability and Resilience; Scenario 3 (MSWRF to NEWRF)

Response	Via	Screen name	Created At
1	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 8:15
1	Activated Multi-Page Survey	Jeremy	6/30/2022 8:15
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:03
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:09
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 9:10
2	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:11

Criteria 1: System Reliability and Resilience; Scenario 4 (EWRF to NEWRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 8:15
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 8:16
3	Activated Multi-Page Survey	Jeremy	6/30/2022 8:16
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:11
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 9:12
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:18

Criteria 1: System Reliability and Resilience; Scenario 5 (MSWRF+EWRF to New WRF)

Clearwater WRF Master Plan-Consolidation Scoring Evaluation
Poll Everywhere Results

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 8:20
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 8:21
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:22
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:14
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:14
3	Activated Multi-Page Survey	Jeremy	6/30/2022 9:15
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:18

Criteria 1: System Reliability and Resilience; Scenario 6 (All to New Regional WRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 8:23
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 8:23
1	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:15
1	Activated Multi-Page Survey	Rich Gardner	6/30/2022 9:16
2	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:16
2	Activated Multi-Page Survey	Jeremy	6/30/2022 9:16
1	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:16

Criteria 2: Maintenance Reliability and Resilience; Scenario 1 (Maintain Existing WRFs)

Response	Via	Screen name	Created At
1	Activated Multi-Page Survey	Rich Gardner	6/30/2022 9:20
1	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:20
1	Activated Multi-Page Survey	Jeremy	6/30/2022 9:20
1	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:20
1	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:20
1	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:20
1	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:21

Criteria 2: Maintenance Reliability and Resilience; Scenario 2 (All to NEWRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:21
3	Activated Multi-Page Survey	Rich Gardner	6/30/2022 9:22
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:22
3	Activated Multi-Page Survey	Jeremy	6/30/2022 9:22
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:22
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:22
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:22

Criteria 2: Maintenance Reliability and Resilience; Scenario 3 (MSWRF to NEWRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:11
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 8:24
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:23
1	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:23
1	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:23
2	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:23

2	Activated Multi-Page Survey	Jeremy	6/30/2022 9:23

Criteria 2: Maintenance Reliability and Resilience; Scenario 4 (EWRF to NEWRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:11
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:23
2	Activated Multi-Page Survey	Jeremy	6/30/2022 9:25
2	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:26
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:28
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:28

Criteria 2: Maintenance Reliability and Resilience; Scenario 5 (MSWRF+EWRF to New WRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:11
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:26
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:29
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:29
3	Activated Multi-Page Survey	Jeremy	6/30/2022 9:29
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:29
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:30

Criteria 2: Maintenance Reliability and Resilience; Scenario 6 (All to New Regional WRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:11
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:31
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:34
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:34
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:34
2	Activated Multi-Page Survey	Jeremy	6/30/2022 9:35

Criteria 3: Ease of Operations; Scenario 1 (Maintain Existing WRFs)

Response	Via	Screen name	Created At
1	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:12
1	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:40
1	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:41
1	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:42
1	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:42
1	Activated Multi-Page Survey	Jeremy	6/30/2022 9:42
1	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:43

Criteria 3: Ease of Operations; Scenario 2 (All to NEWRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:12
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:41
3	Activated Multi-Page Survey	Jeremy	6/30/2022 9:42
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:43
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:43

3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:43
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:44

Criteria 3: Ease of Operations; Scenario 3 (MSWRF to NEWRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:12
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:41
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:45
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:45
2	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:45
2	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:45
2	Activated Multi-Page Survey	Jeremy	6/30/2022 9:45

Criteria 3: Ease of Operations; Scenario 4 (EWRF to NEWRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:12
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:41
2	Activated Multi-Page Survey	Jeremy	6/30/2022 9:45
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:46
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:46
2	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:46
2	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:46

Criteria 3: Ease of Operations; Scenario 5 (MSWRF+EWRF to New WRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:12
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:41
3	Activated Multi-Page Survey	Jeremy	6/30/2022 9:46
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:49
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:49
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:49
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:49

Criteria 3: Ease of Operations; Scenario 6 (All to New Regional WRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:12
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:42
3	Activated Multi-Page Survey	Jeremy	6/30/2022 9:46
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:50
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:50
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:50
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:50

Criteria 4: Climate and Environmental Vulnerability; Scenario 1 (Maintain Existing WRFs)

Response	Via	Screen name	Created At
1	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:12
1	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:52

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1	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:52
1	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:52
1	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:53
1	Activated Multi-Page Survey	Jeremy	6/30/2022 9:53

Criteria 4: Climate and Environmental Vulnerability; Scenario 2 (All to NEWRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:12
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:53
3	Activated Multi-Page Survey	Jeremy	6/30/2022 9:53
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:53
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:54
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:54

Criteria 4: Climate and Environmental Vulnerability; Scenario 3 (MSWRF to NEWRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:12
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:53
2	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:54
1	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:54
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:54
2	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:55
2	Activated Multi-Page Survey	Jeremy	6/30/2022 10:49

Criteria 4: Climate and Environmental Vulnerability; Scenario 4 (EWRF to NEWRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:13
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:53
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:55
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:55
2	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:55
2	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:55
2	Activated Multi-Page Survey	Jeremy	6/30/2022 10:49

Criteria 4: Climate and Environmental Vulnerability; Scenario 5 (MSWRF+EWRF to New WRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:53
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:56
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:56
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:56
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:56
3	Activated Multi-Page Survey	Rich Gardner	6/30/2022 9:56
3	Activated Multi-Page Survey	Jeremy	6/30/2022 10:49

Criteria 4: Climate and Environmental Vulnerability; Scenario 6 (All to New Regional WRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:13

3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:53
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:56
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:57
3	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:57
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:57
3	Activated Multi-Page Survey	Jeremy	6/30/2022 10:50

Criteria 7: Public Perception - Scenario 1 (Maintain Existing WRFs)

Response	Via	Screen name	Created At
1	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:53
2	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:58
1	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 9:59
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 9:59
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 9:59
1	Activated Multi-Page Survey	Rich Gardner	6/30/2022 10:00
1	Activated Multi-Page Survey	Jeremy	6/30/2022 10:50

Criteria 7: Public Perception - Scenario 2 (All to NEWRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:13
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:53
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 9:58
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 10:06
3	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 10:07
3	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 10:09
3	Activated Multi-Page Survey	Jeremy	6/30/2022 10:51

Criteria 7: Public Perception - Scenario 3 (MSWRF to NEWRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:13
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:54
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 10:05
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 10:09
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 10:09
2	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 10:09
2	Activated Multi-Page Survey	Jeremy	6/30/2022 10:51

Criteria 7: Public Perception - Scenario 4 (EWRF to NEWRF)

Response	Via	Screen name	Created At
2	Activated Multi-Page Survey	Rich Gardner	6/30/2022 8:13
2	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:54
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 10:05
2	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 10:10
2	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 10:10
2	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 10:10
2	Activated Multi-Page Survey	Jeremy	6/30/2022 10:51

Clearwater WRF Master Plan-Consolidation Scoring Evaluation
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Criteria 7: Public Perception - Scenario 5 (MSWRF+EWRF to New WRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:54
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 10:05
1	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 10:12
1	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 10:12
1	Activated Multi-Page Survey	Rich Gardner	6/30/2022 10:12
1	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 10:12
1	Activated Multi-Page Survey	Jeremy	6/30/2022 10:52

Criteria 7: Public Perception - Scenario 6 (All to New Regional WRF)

Response	Via	Screen name	Created At
3	Activated Multi-Page Survey	Michael Flanigan	6/30/2022 9:54
3	Activated Multi-Page Survey	Travis R Teuber	6/30/2022 10:05
1	Activated Multi-Page Survey	Rich Gardner	6/30/2022 10:15
1	Activated Multi-Page Survey	Kervin St. Aimie	6/30/2022 10:15
1	Activated Multi-Page Survey	Kaylynn Price	6/30/2022 10:15
1	Activated Multi-Page Survey	Christina Goodrich	6/30/2022 10:16
1	Activated Multi-Page Survey	Jeremy	6/30/2022 10:52