# WASTEWATER EFFLUENT DISPOSAL OPTIONS PLANNING DOCUMENT

***REVISED DRAFT* – OCTOBER 26, 2023**

Prepared for:
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**Disclaimer:** *The information in this analysis has been compiled from many different sources, and many general assumptions have been made to compare the alternatives herein. This analysis includes assumptions of public acceptance to various treatment and disposal methods that reflect recent sentiments, which may change in the future.*

**This Report was prepared by:**

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# 1 Background

The City of Marathon (City) provides wastewater services to its residents at five individual wastewater treatment plants (WWTPs) located throughout the City's service area. The City is responsible for maintenance and operation of these treatment facilities and associated conveyance system. The Florida Keys Aqueduct Authority (FKAA) provides retail and wholesale drinking water to the residents of Marathon including drinking water treatment plants and water lines.

The City provides advanced wastewater treatment with effluent disposal though shallow injection wells at each of its five WWTP's. The current use of shallow injection wells for treated wastewater effluent disposal has been the subject of litigation and The City entered into an Injunctive Relief and Stay of Litigation in early 2023 (**Appendix A**) to retain an engineering firm mutually agreeable to the litigating parties to develop an analysis of options for alternatives to the continued use of shallow injection wells. Juturna Consulting LLC was retained by the City in June 2023 to perform this analysis.

Twelve effluent disposal options have been identified that could replace the current shallow well systems located at each of the WWTP's:

- 1A- Single deep injection well
- 1B- Five deep injection wells
- 1C- Two new deep injection wells at Areas 4 and 6 WWTPs
- 1D Single deep injection well at Crawl Key
- 2A- Public access reuse with partial salinity treatment
- 2B- Public access reuse with full salinity treatment
- 3- Indirect potable reuse
- 4- Direct potable reuse
- 5- Bulk reuse and deep well injection at Area 6 WWTP
- 6- Bulk reuse with supply to Duck Key and deep well injection
- 7- Bulk reuse and indirect potable reuse
- 8- Bulk reuse and direct potable reuse

These options include wastewater disposal through new deep injection well(s), development of reclaimed (non-drinking water) water system(s) by the City, and multi-barrier treatment for either indirect or direct potable (drinking water) reuse. Each of the alternatives has been evaluated using non-cost criteria as well as cost-based criteria. Juturna Consulting estimated capital costs, as well as annual operating and maintenance costs and potential water sales revenues for each of the alternatives over a 30-year assessment period beginning in 2030.

This study then compared the twelve alternatives using both non-cost and cost criteria to identify the relative strengths for potential solutions to the effluent disposal issue.

A significant stakeholder outreach effort was performed as this evaluation was developed. As of this writing the Juturna team met with the following stakeholders regarding aspects of the evaluation:

- Florida Department of Protection- Tallahassee- injection wells permitting.
- Florida Department of Protection- South Florida District- drinking water permitting using treated wastewater effluent.
- Florida Department of Protection- Southeast Florida District- drinking water permitting using treated wastewater effluent.
- South Florida Water Management District – alternative water supply planning, permitting, and funding.
- Florida Keys Aqueduct Authority- cost estimates for recent utility projects, potential for future potable reuse development, utility billing rates, supplemental reclaimed water supply to Duck Key.
- Monroe County School District- potential reclaimed water supply bulk user.
- Valhalla Resort- potential reclaimed water supply bulk user.

**Commented [s1]:** FYI, we are still trying to meet with Marine sanctuary, Airport, Golf Course, City Parks, and other bulk users. We will update in the final report.

Stakeholders were presented with the evaluation-in-progress to gather stakeholder observations and insights that could have a bearing on the evaluation, particularly non-cost evaluation criteria (such as permitting complexity and reclaimed acceptance). The details of the stakeholder outreach effort are included in **Appendix B**.

## 1.1 Existing Wastewater Utility Infrastructure

The City's wastewater system includes both collection and treatment. The average annual wastewater production for the total of all five of its facilities (shown in **Figure 1.1**) for a recent 12-month period was 0.95 million gallons per day (mgd). Projected wastewater production is expected to steadily increase to 1.65 mgd by 2060, as shown in **Table 1.1**., which compares individual WWTP capacities to individual WWTP service area flow projections. These projected flows are "straight line" and in some cases the projections exceed the existing permitted capacity in the future. Projections should be updated annually considering the future impacts of Monroe County's Rate of Growth Ordinance (ROGO), and future land use; accordingly, the actual future flows could taper off rather than continue to grow on a straight line.

This options analysis evaluated alternatives that consider current and future wastewater effluent quantities produced from each of the five City facilities. There are approximately 75 miles of gravity pipelines, vacuum mains and force mains that collect then convey wastewater to these five treatment facilities.

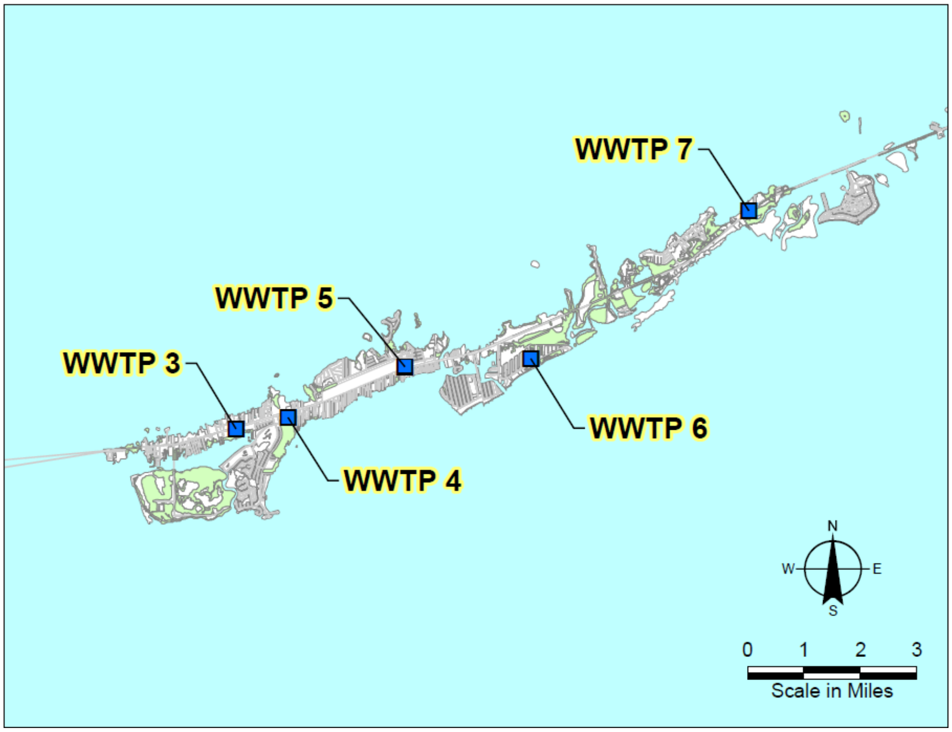



**Figure 1.1: City of Marathon Wastewater Treatment Plants**

The City recently constructed a one-mile long force main to convey some of the wastewater entering Area 3 WWTP, to Area 4 WWTP. Other than this new force main, the five City WWTP facilities are not interconnected.

**Table 1.1: Permittied Capacity, Current and Projected Wastewater Effluent Flows, million gallons per day (mgd)**

| Treatment Facility | Permitted Capacity | 12 months ending June 2023 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|
| Area 3 WWTP | 0.167/ 0.25 *increase pending* | 0.154 | 0.28 | 0.30 | 0.32 | 0.33 |
| Area 4 WWTP | 0.40 | 0.327 | 0.34 | 0.39 | 0.44 | 0.49 |
| Area 5 WWTP | 0.45 | 0.345 | 0.35 | 0.37 | 0.39 | 0.41 |
| Area 6 WWTP | 0.20 | 0.095 | 0.10 | 0.12 | 0.14 | 0.16 |
| Area 7 WWTP | 0.20 | 0.039 | 0.10 | 0.15 | 0.20 | 0.25 |
| Total | 1.417 / 1.5 | 0.960 | 1.17 | 1.33 | 1.49 | 1.65 |

### 1.1.1 Wastewater Collection and Treatment

Since 2012, the wastewater collection systems have been expanded to all customers within the service area of any of the City WWTP's, and at this time City staff report 100% of the properties in the City requiring wastewater services are connected to the City's system.

Wastewater generated in each service area is collected and transported to the nearest WWTP by a system of gravity, vacuum, and pumped force main(s). There are a total of approximately 75 miles of collection lines in the City.

The City provides wastewater treatment using the sequencing batch reactor (SBR) process to achieve tertiary, or advanced treatment in compliance with the effluent discharge requirements set by the Florida Department of Environmental Projection (FDEP). Most of the City's treatment plants utilize the sequencing batch reactor (SBR) process, however the Area 5 plant uses a membrane bioreactor (MBR) system. Both SBR and MBR use biological processes to treat wastewater, but the MBR system also combines a membrane filtration step into the treatment approach. A generalized schematic of the SBR process is shown in **Figure 1.2**. Treated effluent is discharged through shallow injection wells located at each plant site; residual sludge is hauled off site to mainland Florida for further processing/treatment or composting.


**Figure 1.2: Generalized Schematic of Sequencing Batch Reactor (SBR) treatment Process**

WWTP's 3, 4, 6 and 7 are located on property owned by the City. WWTP 5 is located on property leased from Monroe County at the Florida Keys Marathon International Airport. With the exception of the WWTP 6 site, City-owned property for expansion through adding additional facilities is somewhat limited at each of the other WWTP locations.

### 1.1.2 Reclaimed Distribution System

The City has installed a limited reclaimed distribution system (for non-potable water, i.e. outdoor water use) at all WWTP's except Area 6 for limited irrigation of parks, highway medians, and in the case of Area 4, a golf course. These reclaimed distribution systems are off-line at this time due to elevated salinity levels in the treated wastewater; and this change has also allowed for reduced staffing. The reclaimed distribution system could be reactivated in the future or incorporated in to a larger reclaim project alternative if the influent salinity levels are reduced (by implementing a comprehensive infiltration/inflow control program), or if the City adds salinity treatment and staffing at the associated WWTP serving a particular reclaimed distribution system. Activation of existing inactive reclaimed distribution systems, or expansion of a new system would require FDEP review and approval.

## 1.2 FKAA Drinking Water Supply

The Florida Keys Aqueduct Authority (FKAA) is responsible for treatment and delivery of drinking water to the residents of Monroe County including Marathon, as outlined in FS 76-441. The main source of FKAA drinking water is supplied from the J. Robert Dean water treatment facility located on the mainland and is pumped through a water line that conveys drinking water all the way to Key West. The FKAA is developing an additional four (4) mgd water supply at Stock Island south of Marathon. The FKAA is also in the early stages of potential development of a new four (4) mgd reverse osmosis (RO) desalination facility that would be located on land owned by the FKAA at Crawl Key on the northeastern end of Marathon between City WWTP's 6 and 7. Evaluation of potable reuse alternatives are an expectation of the Stay of Litigation (**Appendix A**), however, at this time FKAA has no current plans to design, build or operate a potable reuse water treatment plant.

## 1.3 Driving factors for Change

The City's future wastewater treatment infrastructure decisions are influenced by developments external to the City. These include state and local actions that have or will bear on the alternative(s) for future wastewater effluent disposal or reuse, for the City of Marathon.

At the State level, Florida is continuing on a path that over time will discourage disposal and require the increasing beneficial reuse of treated wastewater. Beneficial reuse is also considered by Water Management Districts when they evaluate new or renewal water use permits.

### 1.3.1 Stay of Litigation

Notwithstanding the City's compliance with its discharge permits at all five of its WWTP's, the City entered into a Stipulated Interim Injunctive Relief and Stay of Litigation (Stay) with a citizens group "Friends of the Lower Keys" in February 2023 regarding claims over impacts alleged to be caused by the City's current use of shallow injection wells for wastewater effluent disposal. This options analysis scope was authorized by the City pursuant to the Stay, and mirrors the applicable elements of the Stay, which is attached as **Appendix A**.

### 1.3.2 Other Specific State Requirements

The alternatives evaluated by this study are also influenced by other state initiatives. Florida Statutes 403.086 set certain standards for wastewater treatment applicable to the Florida Keys. Specifically, ocean outfalls are prohibited and injection wells for design capacities greater than 1 mgd must be cased to a minimum depth of 2,000 feet. Some of the alternatives (including those combining WWTP's 3, 4 and 5, or more) presented herein are impacted by this statutory depth requirement because their combined flows will exceed 1 mgd if these systems are combined for effluent disposal.

The State of Florida, through the Legislature, FDEP and the Water Management Districts has been encouraging beneficial reuse, rather than just disposal, of wastewater effluent. The 2021 Senate Bill 64 requires utilities discharging to surface water to discontinue by 2032. Examples of beneficial reuse include use of treated wastewater for reclaimed (non-drinking) purposes. Reclaimed water use examples include golf course watering, residential and commercial outdoor irrigation and industrial uses such as concrete mixing, etc. If a higher level of treatment is used, the treated wastewater can be reused to produce drinking water.

Florida Administrative Code Chapter 62-565 is being developed to address regulatory permitting, pilot testing, treatment, monitoring and staffing requirements for potable reuse: i.e., treating wastewater effluent to drinking water standards. For wastewater treatment to produce drinking water, there are two general approaches- indirect potable reuse (at Marathon this would include aquifer recharge injection followed by recovery from separate recovery wells followed by reverse osmosis treatment of the recovered saline waters), or direct potable reuse (often called pipe-to-pipe, this would be treatment by reverse osmosis and additional treatment barriers as required to meet drinking water standards).

In the 2023 legislative session HB 1379 was passed to increase regulatory restriction of nutrient pollution, require long-range planning where applicable to meet nutrient reduction goals and increase funding for wastewater improvement projects in environmentally vulnerable locations.

# 2 Evaluation Criteria

The twelve (12) alternatives developed for this wastewater disposal options planning document to eliminate the use of shallow wells for treated wastewater effluent disposal, were evaluated for their relative strengths based on non-cost criteria, and cost criteria. Both types of criteria are important to evaluate the full spectrum of characteristics for each alternative for a thorough understanding of each on their own, and relative to each other.

## 2.1 Non-Cost Evaluation Criteria

Non-Cost evaluation criteria are intended to portray characteristics of an alternative that, although ultimately critical to success, focus on ability to implement the project and project acceptance (i.e., what is the difficulty to develop the alternative from concept through startup, and how does the alternative garner and maintain stakeholder support and meet the project's intended goals for the long term?). For this analysis, sixteen (16) non-cost criteria were identified, grouped into three categories, assigned weights, and applied to each of the twelve alternatives to develop a total non-cost criteria score. The non-cost criteria are listed in **Table 2.1**.; A complete tabulation of the non-cost criteria is in **Appendix C**.

**Table 2.1: Non-Cost Evaluation Categories and Criteria Weighting**

| Category | Criteria | Assigned Weight |
|---|---|---|
| Project Viability | Consideration in 2000 Monroe County Sanitary Wastewater Master Plan | 5 |
| | Public Outreach | 20 |
| | Permitting Complexity | 20 |
| | FKAA Buy-in Potential | 10 |
| | Bulk User Agreements | 5 |
| | Grant Funding Potential | 15 |
| | Environmental Vulnerability | 10 |
| | Property Acquisition | 10 |
| Project Constructability | Traffic/Access Impacts | 10 |
| | Project Duration | 20 |
| | Bridge Crossings | 5 |
| | Project Integration Complexity | 10 |
| Project Benefit | Potable Reuse Production | 20 |
| | Reclaimed Reuse Production | 5 |
| | Supply Reliability | 10 |
| | Beneficial Reuse % | 10 |
| **Total Non-Cost Possible Points** | | **185** |

### 2.1.1 Project Viability

The Project viability Category includes criteria that influence the ease with which a multi-year project alternative can "get off the ground" and maintain the momentum necessary for completion. Project viability represents 95 of 185 points of the non-cost criteria score.

The first touchstone is how an alternative aligns with the area's previous long-term planning (some alternatives in this evaluation such as developing drinking water supply using treated wastewater effluent by some method, were not on the visible horizon at the time previous regional planning was performed). Although it is not critical that the alternative aligns totally with previous long-term planning, it is important for the sake of continuity to relate the project feasibility to previous long-term planning.

Interaction with, and support from, the public, apart from the permitting agencies, is another non-cost evaluation criteria. The level and criticality of public outreach can be correlated to the expected public participation in the alternative, i.e., the public can be expected to have a greater interest in reuse of treated wastewater for irrigation, and an even greater level of interest for reuse of treated wastewater as a drinking water supply.

Permitting is a requirement for any wastewater or drinking water project. Some of the alternatives presented herein require more extensive permitting meaning a greater investment in time and cost (for pilot studies, engineering reports, etc.); the direct potable reuse alternatives, will be subject to permitting rules that have not been finalized as of this writing. A list of the anticipated permits and their relative level of complexity is presented in **Table 2.2** below, and a more detailed description of the permitting complexity analysis can be found in **Appendix D**.

**Table 2.2: Applicable Permits for Alternatives**

| Permitting Agency and Permit Type | Permit Category (General or Individual) | Relative Complexity (1- lowest, 5 highest) |
|---|---|---|
| FDEP Permit for Pump Station Expansion/Modification/Revision | General | 1 |
| SFWMD Permit for Monitor Well | General | 1 |
| FDEP Permit for Sewage Collection System - Pipeline | General | 1 |
| FDEP Permit for Sewage Collection System - New Pump Station | Individual | 1 |
| FDEP Permit for Class I Underground Injection Control - Well | Individual | 2 |
| FDEP Permit for Bulk User Re-Use – Wastewater Facility | General | 2 |
| FDEP Permit for Bulk User Re-Use – Land Application of Wastewater | General | 2 |
| FDEP Permit for Reverse Osmosis Treatment | General | 3 |
| FDEP Permit for Production Well – Well Construction | General | 3 |
| SFWMD Consumptive Water Use Permit | Individual | 4 |
| FDEP Permit for Potable Re-Use | Individual | 5 |

FKAA buy-in potential relates to the level of interest the FKAA would have in an alternative; FKAA interest as a project partner can have a bearing on the access of an alternative- i.e., if the FKAA would be interested in receiving treated wastewater meeting its own reclaimed water quality standards as a supplemental source for use at Duck Key.

Other party agreements could also be critical for an alternative's success. The best example of this is the need for a firm commitment from bulk users to utilize reclaimed water for a period of time sufficient to reduce treated wastewater disposal through injection wells and provide a reliable revenue source.

Certain components of some of the alternatives could be strong candidates for construction grants from state or other external sources, increasing their score for this category. Examples of these project elements include those associated with reuse of treated wastewater effluent as a new drinking water supply source.

Environmental vulnerability, although a sensitive topic given the successful compliance by the City with its existing wastewater treatment facilities and the litigation which has been stayed at the current time, is one of the non-cost criteria for this evaluation. All the alternatives cease the use of shallow wells for routine wastewater injection as a primary disposal method; but subject to regulatory approval, they could be kept as a backup disposal method. Our scope of work did not include an evaluation of the fate and transport of nutrients. However, we did consider the possibility that some alternatives would have a greater risk of reintroducing nutrients or other constituents of concern to the environment than other alternatives. For example, for our scoring we determined that certain alternatives, such as reclaimed water use by land application, could be perceived to have a higher potential for entry of nutrients into the near-shore environment (specifically during severe storm events including very heavy sustained rains and hurricanes).

Property acquisition is a greater requirement for some alternatives than others. All the existing wastewater treatment sites are land-constrained with the exception of Area 6. Land area for new acquisition is at a premium within the City of Marathon, and this evaluation assumes sufficient right of way can be obtained from the City itself and FDOT for transmission and distribution lines (although construction costs would be higher in congested areas), and also assumes minimal property acquisition in fee for the additional treatment, pump stations and new deep injection wells in the various alternatives.

**Table 2.3: Project Viability Evaluation Category**

| Criteria | Description | Scoring | | Maximum Score |
|---|---|---|---|---|
| Consideration in 2000 Monroe County Sanitary Wastewater Master Plan | Was the project alternative considered in previous planning? | 5 | Project Option Considered in previous Master Plans | 5 |
| | | 0 | Project Option Not Considered in previous Master Plans | |
| Public Outreach | What level of public outreach can be expected for successful | 20 | Project requires minimal public outreach | 20 |
| | | 10 | Project requires some outreach | |

| | | | | |
|---|---|---|---|---|
| | project implementation? | 0 | Project requires significant public outreach | |
| Permitting Complexity | What permits are required and how difficult will they be to obtain? | 20 | Project requires less than 10 permits | 20 |
| | | 10 | Project requires 10 - 20 significant permits | |
| | | 0 | Project requires more than 20 or more significant permits | |
| FKAA Buy-in Potential | Does the project alternative affect, positively or negatively, the FKAA? | 10 | Beneficial Reuse for FKAA Reuse Customers, or co-located Deep Injection Well | 10 |
| | | 7.5 | FKAA Potable Demand Reduction due to Offset from Reuse for Irrigation | |
| | | 5 | No impact to FKAA | |
| | | 2.5 | Potable Reuse into Regional System and Offset from Reuse for Irrigation | |
| | | 0 | Potable Reuse into Regional System | |
| Third Party Agreements | Does the project alternative rely on negotiation of third-party agreements for reuse supply, property, treatment or Disposal? | 5 | Project Requires no third-party agreements | 5 |
| | | 2.5 | Project requires 1 - 10 Agreements | |
| | | 0 | Project requires 10 + agreements | |
| Grant Funding Potential | Does the project alternative include elements that | 15 | High Potential - highly ranked for funding from FDEP, SFWMD (regional) | 15 |

| | | | | |
|---|---|---|---|---|
| | would attract grant funding opportunities? | 7.5 | Moderate potential to be highly ranked for FDEP, SFWMD funding | |
| | | 0 | Low potential to be highly ranked for FDEP/SFWMD funding | |
| Environmental Vulnerability | Does the proposed alternative have a perceived or potential continued environmental degradation? | 10 | Lowest potential | 10 |
| | | 7.5 | Low | |
| | | 5 | Medium | |
| | | 2.5 | High | |
| | | 0 | Highest potential | |
| Property Acquisition | How many property parcels are required for the alternative? | 10 | No property acquisition required | 10 |
| | | 5 | 1 – 5 parcels required | |
| | | 0 | 6 – 10 parcels required | |
| Total Project Viability Possible Points | | | | 95 |

### 2.1.2 Project Constructability

Project constructability criteria address characteristics that only occur during the construction phase-and although temporary, can show one alternative to be more attractive than another. Project Constructability represents 45 of 185 points of the non-cost criteria score.

Traffic/Access Impacts criteria are directly related to the number of miles of pipeline required for an alternative- all the alternatives except 1B, require between nine(9)and ninety (90) miles of new pipelines. The linear nature of the City's geography means that construction methods will need to be used that keep streets open as alternative traffic routes are few and far between.

Project duration is an important factor when considering alternatives- the length of a project may be critical to maintaining public support for its completion.

Bridge crossings along US-1, which is controlled by the FDOT, are an additional consideration; pipelines crossing the bridges must either meet FDOT requirements, or if they cannot, will require additional permitting complexity for subaqueous crossings. Technologies such as horizontal directional drilling under the channels may be a cost-effective alternate solution, but we did not evaluate these types of options at this stage of the process- this issue would be refined during the design/permitting phase.

Project integration complexity is important when commissioning and long-term operating the individual project components as a system of the whole. An example of low complexity would be maintaining individual wastewater plant operations with a new deep injection well for each. Alternatives that have higher integration complexity would combine the treated wastewater effluent to a central location with integration of the individual pumping systems that feed the central line. Adding treatment to reduce salinity for a reclaimed system, and the larger pumping stations required for distribution of reclaimed water, are also more complex to integrate.

Constructability evaluation criteria address the amount of complexity to construct and integrate operations of the elements of a project alternative, and the level of impacts to emergency services and other inconvenience to the public during construction. **Table 2.4** lists how each of the project constructability criteria were scored for the project alternatives.

**Table 2.4: Project Constructability Category**

| Criteria | Description | Scoring | | Maximum Score |
|---|---|---|---|---|
| Traffic/Access Impacts | What level of inconvenience to the public and impacts to emergency services, etc. is expected? | 10.0 | None | 10 |
| | | 7.5 | 1 to 20 miles of New Pipe | |
| | | 5.0 | 21 - 40 miles of New Pipe | |
| | | 2.5 | 41 - 60 miles of New Pipe | |
| | | 0.0 | > 60 miles of new pipe | |
| Project Duration | How long will the construction of all project elements require? | 20 | 4 years | 20 |
| | | 10 | 6 years | |
| | | 0 | 8 years | |
| Bridge Crossings | How many bridge crossings or subaqueous | 5.0 | No Bridge Crossings Required | 5 |
| | | 2.5 | 1 - 5 Bridge Crossings Required | |

| | | | | |
|---|---|---|---|---|
| | directional drills required? | 0.0 | > 5 Bridge Crossings Required | |
| Project Integration Complexity | How difficult will it be to integrate the individual project elements for full operation? | 10 | Minor complexity and integration requirements | 10 |
| | | 5 | moderate complexity and integration requirements | |
| | | 0 | significant complexity and integration requirements | |
| Total Project Constructability Possible Points | | | | 45 |

### 2.1.3 Project Benefit

Project benefit criteria include the amount of tangible benefit that can be assigned for each alternative. Although all alternatives will meet the stated goal of eliminating the use of shallow wells for effluent disposal, some of the project alternatives can be expected to yield additional tangible benefits. Project benefit criteria represent 45 of 185 points of the total non-cost criteria score.

Potable reuse production recognizes how much of the treated wastewater effluent will be reused as a new drinking water supply. This could be an important consideration when competing for construction grants for certain project elements from the South Florida Water Management District or from FDEP.

Reclaimed reuse production is a measure of how much of the treated wastewater effluent will be used reclaimed water (primarily for irrigation). Reclaimed water use can also be an important consideration when competing for construction grants.

Supply reliability identifies if an alternative will increase the availability of drinking water during an emergency including pipeline outages or hurricane events.

**Table 2.5** lists how each of the project benefit criteria were scored for the project alternatives.

**Table 2.5: Project Benefit Category**

| Criteria | Description | Scoring | | Maximum Score |
|---|---|---|---|---|
| Potable Reuse Production | Does the alternative produce new potable (drinking water) supply? | 20 | Potable reuse production greater than 500,000 gpd | 20 |
| | | 10 | Potable reuse production up to 500,000 gpd | |
| | | 0 | No Potable Reuse potential | |
| Reclaimed Reuse Production | Does the alternative produce reclaimed water for reuse by the public and/or bulk users? | 5.0 | Reclaimed reuse production greater than 500,000 gpd | 5 |
| | | 2.5 | Reclaimed reuse production between 1 gpd and 500,000 gpd | |
| | | 0 | No Reclaimed reuse production | |
| Supply Reliability | Will the project provide drinking water supply in the event of planned (scheduled shutdowns for maintenance) or unplanned (storms, line breaks, etc.) events? | 10 | Improved regional supply reliability | 10 |
| | | 5 | Improved supply reliability only to Marathon | |
| | | 0 | No effect on potable supply reliability | |
| Beneficial Reuse % | To what extent will the project reuse the available treated wastewater effluent? | 10 | 75-100% Beneficial Reuse | 10 |
| | | 6.67 | 50% to 74 % beneficial Reuse | |
| | | 3.33 | 1% to 49% beneficial Reuse | |
| | | 0 | No beneficial Reuse | |

| | |
|---|---|
| Total Project Benefit Possible points | 45 |

## 2.2 Cost Evaluation Criteria

One goal of this project is to provide a "concept screening" of the evaluation alternatives. This will allow decision makers a better understanding of both the cost and non-cost issues associated with alternatives before moving forward with a specific solution and detailed design. At this stage of the analysis the amount of design information available for each of the alternatives is very low. Consequently, the methods used for estimating costs, and the accuracy of those estimates are limited.

The Association for the Advancement of Cost Engineering (AACE-I, or AACE International) has systematically assessed the relationship between project information and cost estimating accuracy. The AACE-I has organized cost estimates into five general classes of increasing accuracy, and an explanation of their classification can be found in the AACE-I publication entitled: Cost Estimate Classification System (AACE International Recommended Practice No. 56R-08 – August 7, 2020. Table 1. https://aacei-pittsburgh.org/wp-content/uploads/2021/11/cost-estimating-classification-system.pdf ).

The cost estimating accuracy for this project is commensurate with a Class 5 estimate, or the lowest level of available project information. According to AACE-I, Class 5 estimates are appropriate when 0-2 percent of design information is available, such as in the case of the alternatives evaluated in this analysis.

As projects progress, the amount of information available increases, the cost estimating methodology changes, and the accuracy of estimates improves. For example, at the Class 3 stage at least 10-40 percent of design information should be available, and cost estimates are expected to be appropriately accurate for budget authorization. By the Class 1 stage cost estimates should be ready for bidding purposes.

We expect that as the City's alternative effluent disposal project moves forward, the accuracy of cost information will increase. At this stage, a Class 5 estimate is appropriate for concept screening and a comparison of alternatives. The detailed results of the cost evaluation are provided in **Appendix D**, and a summary is provided in Section 4, Results.

## 2.3 Methodology for Estimating Costs

The cost-based evaluation of the twelve alternatives is comprised of three main components: 1. Capital costs, 2. Annual operations & maintenance (O&M) costs, and 3. Revenues.

The analysis assumed that 100 percent of the capital costs would be incurred at the start of the project, chosen to be 2030. Each alternative was analyzed over a 30-year operating period from 2030-2060, and the final results included a 30-year life cycle cost for each alternative.

The analysis process involved four main steps, and each step is summarized in subsequent sections with details of assumptions provided in **Appendix E**:

1. "Unit costs" were developed for the analysis based on projects comparable to the conceptual alternatives.
2. Size, quantity, and flow information was gathered for each alternative.
3. The data from steps 1 and 2 was combined in a spreadsheet model to calculate total costs.
4. All the cost components were combined into a 30-year life cycle cost and ranked from lowest to highest cost.

The capital cost calculation differed slightly from the calculations for O&M and revenues regarding changes over time. As previously stated, capital costs were fixed at one point in time, whereas some O&M costs and revenues are expected to change over the decades as WWTP effluent flows change. For the purpose of developing this model, the City provided Juturna Consulting with straight-line WWTP effluent forecasts (**Table 1.1**) for each decade until 2060. The analysis used that flow information to forecast O&M costs and revenues for each of the three decades, 2030's, 2040's, and 2050's.

### 2.3.1 Methodology for Estimating Unit Costs

Given the goal of providing a Class 5 estimate, we chose a "unit cost" approach to calculating project costs. Unit costs are average costs per unit of size, and when unit cost information is combined with size or quantity data, the total cost of a system can be calculated arithmetically in a spreadsheet. Unit costs can be applied to both capital costs as well as annual O&M costs.

For example, 8-inch pipe installed underground to convey wastewater can be described by a unit cost of dollars per linear foot of installed pipe. This unit cost can then be multiplied by the expected quantity or size of material or equipment that will be used in the project. The sum total of all of the costs for materials and resources used in the project is the estimate of the project cost. Although the approach sounds simple in terms of its mathematics, many assumptions are required in developing the information required.

For an AACE-I Class 5 estimate, accuracy expectations range between minus 50 per cent to plus 100 per cent, meaning a cost estimate of $100 would have an 80 percent chance of correctly predicting a final cost that is in the range of $50 to $200.

***Unit Costs for Capital***

Four main assumptions were followed in developing unit costs for this project:

1. Unit costs are representative of a broad set of sub-components.
2. Unit costs are adjusted to match the specific time and geographic location of the project.
3. Unit costs are intended to represent the price that a contractor would bid to provide the associated infrastructure as it would be installed and ready for use.
4. Unit costs are expected to apply over a wide, but limited range of sizes.

Although in theory, unit costs could be developed for every type of item that would be required for all the alternatives in this study, unit costs were only developed for a small set of broadly representative infrastructure categories. These infrastructure categories are listed in **Table 2.6**.

Throughout the analysis process, one of the key underlying assumptions was that each general category of unit costs would also include the cost of any associated parts required to make that system function. For example, the cost of piping was assumed to be a "turnkey" cost that includes all the appurtenant valves, valve enclosures, flow meters, valve actuators, transient control devices, instrumentation, and controls, et cetera that would be required to operate a system of transferring water between locations. In this way, the expectation is that each "general category" of unit costs represents the sum total of equipment and sub-systems that are related to that category.

**Table 2.6: Categories of Infrastructure with Estimated Unit Costs**

| General Category | Sub-groups | Unit Cost | Notes |
|---|---|---|---|
| Wells | Deep injection wells | $12,000,000 each | For disposal of wastewater effluent. |
| | Deep injection monitoring wells | $5,000,000 EA. | For monitoring any potential impacts of a DIW on the overlying aquifer(s). |
| | Intermediate depth injection wells | $5,000,000 EA. | For temporary underground storage of treated effluent, to be used in an Indirect Potable Reuse (IPR) system. |
| | Intermediate depth production wells | $5,000,000 EA. | For the recovery of treated effluent that was temporarily stored underground. |
| | Intermediate depth monitoring wells | $2,000,000 EA. | For monitoring any potential impacts of a DIW on the overlying aquifer(s). |
| Treatment facilities | Salinity treatment | $8,000,000 / MGD capacity | To be located at an existing WWTP, utilizing a treatment technology that is capable of removing salinity, such as reverse osmosis. |
| | Indirect potable reuse treatment plant | $12,000,000 / MGD capacity | To treat wastewater effluent that has been temporarily stored in the environment to drinking water standards. |
| | Direct potable reuse treatment plant | $15,000,000 / MGD capacity | To treat wastewater effluent to drinking water standards. |
| | Pilot Study | $2,250,000 EA. | One study required for new DPR or IPR treatment plants. |
| Piping | Transmission piping 4" diameter | $64 / linear foot | For moving treated effluent between locations. Same unit cost for reclaimed distribution piping. |
| | 6" diameter | $95 / LF | |
| | 8" diameter | $115 / LF | |
| | 10" diameter | $137 / LF | |
| | 12" diameter | $152 / LF | |
| Pumping | New pump stations | $600,000 / MGD capacity | Unit cost applies to pump station's designed peak capacity. |
| | Modified/expanded pump stations | $300,000 / MGD capacity | Unit cost applies to pump station's designed peak capacity. |

| | | | |
|---|---|---|---|
| Storage | Steel ground storage tank | $2,000,000 / MG capacity | Assumes unit cost ($/MG) applies over a wide range of sizes. |
| Meters | Residential service meters | $2,000 EA. | Assumes automatic meter reading technology used. |
| | Bulk customer meters | $4,000 EA. | Assumes automatic meter reading technology used. |

Information was gathered from a wide variety of sources in the process of estimating unit costs. However, priority was given to the most recent information, local to South Florida, and representative of the size and type of projects in the twelve alternatives.

When recent information was not available the analysis adjusted the cost by an inflation escalator. For simplicity's sake the analysis used the 2023 Consumer Price Index for Urban consumers, or CPI-U, which is published monthly by the Bureau of Labor Statistics (specifically, the July 2023 CPI-U was used).

The Florida Keys have a unique geography, and as a set of islands with only one main highway providing access, the cost of doing business in the Keys can be higher than in mainland Florida. For information sources gathered outside of the Keys, a locational cost adjustment factor of 1.5 was used, e.g., a cost of $100 in Orlando, Florida was adjusted to $150 for City of Marathon when appropriate.

Infrastructure projects often involve a complex chain of contractors, sub-contractors, equipment vendors, and design engineers, each providing different values to the project, and each having different sets of costs. To be consistent, the unit costs for this analysis were developed to represent the general contractor's cost to install equipment as a "turnkey" solution, ready for operation. The unit costs include the contractor's equipment costs, expenses, overhead and profit. The unit costs do NOT include "engineering, legal, and administrative" (ELA) costs, or a "contingency."

However, an overall project ELA and contingency cost was calculated in the spreadsheet model used for calculating total costs (described in a following section).

***Unit Costs for O&M***

The unit cost approach also works for estimating annual operations and maintenance (O&M) costs. The unit costs used for the annual O&M cost calculation are summarized in **Table 2.7**, and a description of details and assumptions is available in **Appendix F**.

The approach for O&M unit costs was similar to the one used for capital costs. The main difference was that O&M costs can change over time. In this analysis we identified those O&M costs that were likely to change over time, primarily due to the expectation that effluent flows would increase in time and certain costs are directly related to effluent flow.

Costs that do not change in relation to the quantity of output are sometimes referred to as "fixed," while costs that change in relation to output are "variable." Variable O&M costs are identified in **Table 2.7** with the statement "Flow-dependent cost."

Although the O&M unit costs are likely to change over time due to inflation, or changes in technology, at this stage of analysis we do not have sufficient information to make accurate predictions at that level of detail. Therefore, we assumed that O&M unit costs would not need to be adjusted over the 30-year analysis period.

**Table 2.7: Summary of Unit Costs for Operations & Maintenance**

| General Category | Sub-groups | Unit Cost | Notes |
|---|---|---|---|
| Staffing | Staffing | $100,000 / FTE | Average of all staffing categories. Includes benefits. |
| Wells | Cleaning | $30,000 / well/ YR | For contractor services. |
| | Sampling | $20,000 / well/ YR | For contractor services associated with collection and laboratory analysis of well monitoring samples. |
| | Integrity testing | $26,000 / YR | Annualized cost based on a testing frequency of 1 per 5 years. |
| Pumping | Electricity usage | $50,000 / MGD of pumping / YR | Flow-dependent cost, assuming an average annual flow, head, and electricity price. |
| | Repair & replace | 3% of capital cost / YR | Includes sinking fund investment for replacement of pumps. |
| Storage | Ground storage | Not included | Assumed that ground storage would have O&M costs that |

| | | | |
|---|---|---|---|
| | | | overlap with other categories such as staffing. |
| Reclaimed distribution | Reclaimed water distribution system | $2,000 / mile / YR | For corrective maintenance of buried infrastructure. |
| Meters | Residential | $10 / meter / YR | For corrective maintenance. Assumes an annual repair rate of 10% of meters. |
| | Bulk customer | $200 / meter / YR | For corrective maintenance. Assumes an annual repair rate of 10% of meters. |
| Treatment facilities | Repair & replace | 3% of capital cost / YR | Includes cost of periodic replacement of essential equipment and expendables, plus sinking fund for new facility. |
| | Electricity and chemical usage – Salinity treatment | $1.50 / 1,000 gallons | Flow-dependent cost, assuming an average annual flow. |
| | Electricity and chemical usage – IPR treatment | $3.00 / 1,000 gallons | Flow-dependent cost, assuming an average annual flow. |
| | Electricity and chemical usage – DPR treatment | $4.50 / 1,000 gallons | Flow-dependent cost, assuming an average annual flow. |

***Unit Rates for Revenue***

Revenue unit costs were based on the most recent water prices for the Florida Keys Aqueduct Authority (FKAA). According to the FKAA rate schedule, the price of 1,000 gallons of potable water is $7.92. This was rounded up to $8.00 per 1,000 gallons.

Reclaimed non-potable water for residential outdoor use is less valuable than potable water, and the price of $4.00 per 1,000 of reclaimed water was set as a discounted rate relative to potable water. This price is also comparable to other published rates for non-potable reclaimed water in the region.

Bulk users were given the lowest unit pricing because of the expectation for high consumption. Bulk user pricing was also set relative to the potable water price, with a price of $2.00 per 1,000 gallons.

### 2.3.2 Methodology for Estimating Sizes and Quantities

By definition, unit costs need to be paired with quantity or size information in order to predict a cost figure. In some cases, the estimation of sizes, quantities, and flows was obvious from the description of each alternative. The number of DIWs in each alternative is very straightforward. However, in other cases, measurements had to be taken, and assumptions made.

We selected the size of equipment and infrastructure based on estimates of future flows to the five Marathon WWTPs, with the expectation that the systems will be suitable for flows in 2060.

***Wells***

Deep injection wells (DIW) were assumed to have sufficient capacity to dispose of any potential flow generated by the WWTPs. There was no distinction made between a large or a small DIW, and therefore only a simple count of wells was required to model the associated costs. This assumption applied to both capital and O&M costs.

***Treatment Plants***

For the purpose of estimating capital costs, the treatment plants were sized based on expectations for future flows of WWTP effluent. For Alternatives 2A, 2B, 5, 6, 7 & 8 the added salinity treatment was sized based on the permitted capacity of the associated WWTPs.

For the indirect potable reuse (IPR) and direct potable reuse (DPR) treatment plants in Alternatives 3 and 4 respectively, the size was based on the expectations for the maximum daily combined flow of all WWTPs, with a small margin available for the future. For Alternatives 7 & 8, the IPR and DPR treatment plants were sized to match twice the 2060 Average Daily Flow (ADF) for WWTP Areas 5, 6, & 7. Plant sizing assumed that extremely high flows of WWTP effluent could be diverted to the DIW.

For the purpose of calculating O&M costs, the repair and replace (R&R) budget was based on the capital cost of each treatment plant. But for variable costs such as electricity and chemical usage, the treatment plant O&M cost was based on the ADF.

***Staffing***

Staffing estimates were based on a review of regulatory requirements in the Florida Administrative Code. The analysis assumed that implementation of a public access reuse system would require the use of computerized monitoring and controls for improved plant reliability, and an expansion of WWTP staffing to allow for 7-day per week coverage. Staffing requirements have not yet been finalized for new treatment technologies used in IPR and DPR. However, the analysis assumed that 24-hour per day, and 7-days per week operator staffing would be required at any new IPR or DPR facility. A summary of staffing assumptions is provided in **Appendix G**.

***Piping***

Pipe quantity requirements for each alternative were estimated by measuring distances on a map. In the case of Alternative 2A & 2B, public access reuse for residential customers, measurements were made for the entire Marathon service area, assuming all customers would have access to the service.

The same pipe quantities were used for estimating O&M costs as for capital costs.

Pipe diameters were estimated using flow information and the Hazen-Williams equation for head losses in pipes.

***Pumping***

For the conceptual design of pump stations, we assumed that a "peaking factor" would be required to accommodate high flows, and the accelerated transfer of effluent between locations. The assumptions for pump station sizing and flows are summarized in **Table 2.8** below.

**Table 2.8: Pump Station Sizing Assumptions**

| Alternative | Sizing |
|---|---|
| 1A – Single Deep Injection Well | 2 X 2060 ADF |
| 1B – Five Deep Injection Wells | No pumping required |
| 1C – Two Deep Injection Wells | 2 X 2060 ADF |
| 1D – Single Deep Injection Well at Crawl Key | 2 X 2060 ADF |
| 2A – Public Access Reuse with Partial Salinity Treatment | 4 X 2060 ADF |
| 2B – Public Access Reuse with Full Salinity Treatment | 4 X 2060 ADF |

| | |
|---|---|
| 3 – Indirect Potable Reuse (IPR) | 4 X 2060 ADF at WWTPs & 2 X 2060 ADF at Crawl Key |
| 4 – Direct Potable Reuse (DPR | 4 X 2060 ADF at WWTPs & 2 X 2060 ADF at Crawl Key |
| 5 – Bulk Reuse and Deep Injection Well | 2 X 2060 ADF |
| 6 – Bulk Reuse and Deep Well Injection at Area 4 and 7 WWTPs | 4 X 2060 ADF at WWTP 3&4, & 2 X 2060 ADF at WWTP 5, 6, & 7 |
| 7 –IPR and bulk reuse | 2 X 2060 ADF for Crawl Key, & 4 X 2060 ADF for non-potable reuse |
| 8 –DPR and bulk reuse | 2 X 2060 ADF for Crawl Key, & 4 X 2060 ADF for non-potable reuse |

***Storage***

No additional storage was modeled for Alternatives 1A-D, with the assumption that sufficient storage would be currently available at each of the five WWTPs. We used a combination of the permitted limits for WWTP average daily flow (ADF) and 2060 ADF projections to determine storage for the public-access reuse scenarios (2A, 2B). We used twice the 2060 ADF to determine storage needs for the remaining scenarios, with new storage to be provided at Crawl Key for Alternatives 3, 4, 7 & 8.

***Meters***

The number of residential meters was based on the total number of residential customers in Marathon, with the assumption that a public-access reuse program would eventually serve 100 percent of the customer base.

The number of bulk-service meters was based on discussions with potential bulk customers as part of an outreach effort to identify future customers.

***Property***

We estimated property needs for major systems (e.g., pump stations, well fields, and treatment plants) using engineering judgement. We assessed property availability using aerial imagery and data from the Monroe County Property Appraiser. This information was also presented to the City of Marathon project team for an additional verification.

### 2.3.3 Constructing the Spreadsheet Model

After we established unit costs and quantity information, we combined that data together using a spreadsheet model. The model was organized with one spreadsheet "tab" for each of the twelve alternatives. Each tab was organized into three sections to calculate capital costs, O&M costs, and revenues.

The spreadsheet sums each row of the model to calculate the subtotal of capital costs. However, this sub-total was not the final project cost. Two additional line items were added to account for "engineering, legal, and administrative" (ELA) costs, and a "contingency." To estimate ELA costs, a factor of 25 percent of the capital cost subtotal was added in to the final tally. An additional line item of 30 percent of the sum total of ELA and capital cost subtotal was also added in to account for contingencies. Mathematically, the grand total for capital costs equals:

Total Project Capital Cost = (subtotal of capital costs) * 1.25 * 1.30.

The spreadsheet model calculates O&M costs, and revenues in a similar manner to capital costs. The main difference is that O&M costs and revenues are expected to change over the 30-year modeling period due to growth in WWTP effluent flows. To accommodate changes over time, the model accounts for O&M costs and revenues by decade (2030's, 2040's, and 2050's).

### 2.3.4 Life Cycle Cost Analysis

We used a basic "life cycle cost" analysis to combine the three main components of capital cost, O&M, and revenues. The goal of combining these components was to simplify the cost comparison process, and the life cycle cost results were used for the cost ranking of the alternatives, as described in the "Results" section.

No inflation escalation was used in the analysis, and dollar values were all kept in "real" terms for the year 2023. In addition, no attempt was made to estimate residual values of the assets at the end of the 30-year period.

Since the overall assessment includes significant assumptions regarding cost, and very little detailed design information, there was no expectation that the cost calculations would have a high level of accuracy, and therefore the final cost numbers presented were rounded up to the nearest million dollars.

Similarly, without an expectation for highly accurate cost numbers, we chose a simple approach for discounting future flows of O&M costs and revenues. We used a discount rate of zero percent for the life cycle cost analysis in order to avoid introducing an artificial level of complexity that would not match the precision of the cost estimates.

At a discount rate of zero percent, the 30-year life cycle cost formula is:

$$LCC_{30} = \text{Capital cost} + (\text{30-year sum of O\&M costs}) - (\text{30-year sum of revenues})$$

A discount rate of zero percent implies that there is no preference between having $1 today or $1 in the future, which is counterintuitive for most economic circumstances. However, we tested other discount rates of 1-3 percent without having a large impact on the final alternative ranking process. With the expectation that the next level of project analysis would involve a more focused design and a feasibility assessment for the best alternatives, we decided to use the zero percent discount rate to best represent the level of accuracy provided in this phase of analysis.

# 3 Alternatives Description and Components

Juturna Consulting developed twelve (12) project alternatives that could be implemented to replace the current operation of wastewater effluent disposal by injection through the shallow well systems located at each of the WWTP's. Alternatives include wastewater disposal through new deep injection well(s), development of reclaimed (non-drinking water) water system(s), and indirect and direct potable (drinking water) reuse projects.

A number of high-level assumptions were made to evaluate the alternatives. These assumptions include:

- Reclaimed water treatment would be performed by the City.
- Drinking water treatment would be located at Crawl Key.
- All project alternatives are permittable.
- Property acquisition will be successful through negotiation.
- Public right of way is available for installation of new pipelines.

## 3.1 Alternative Descriptions

Alternatives 1A-1D are four different configurations that achieve 100% effluent disposal through deep injection well(s), with no beneficial reuse of treated wastewater effluent. The deep injection wells would be Class 1 injection wells approximately 3000 ft deep into the isolated boulder zone of the lower Floridan aquifer. **Figures 3.1** and **3.2** show a cross section of the Florida Keys and a hydrogeologic cross section of the underlying aquifers.

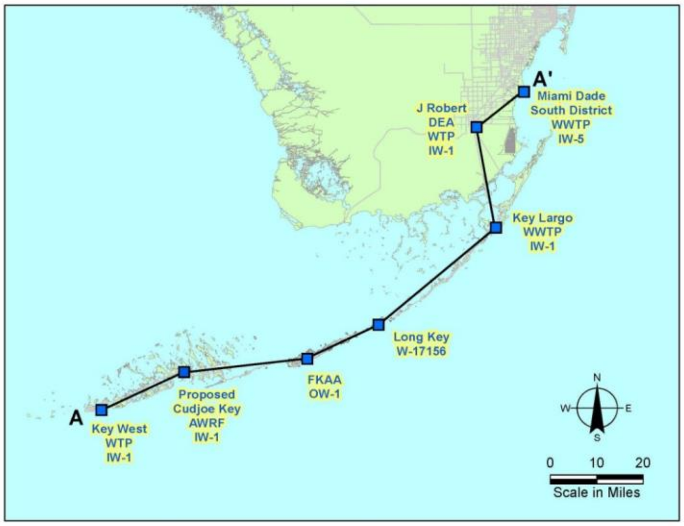
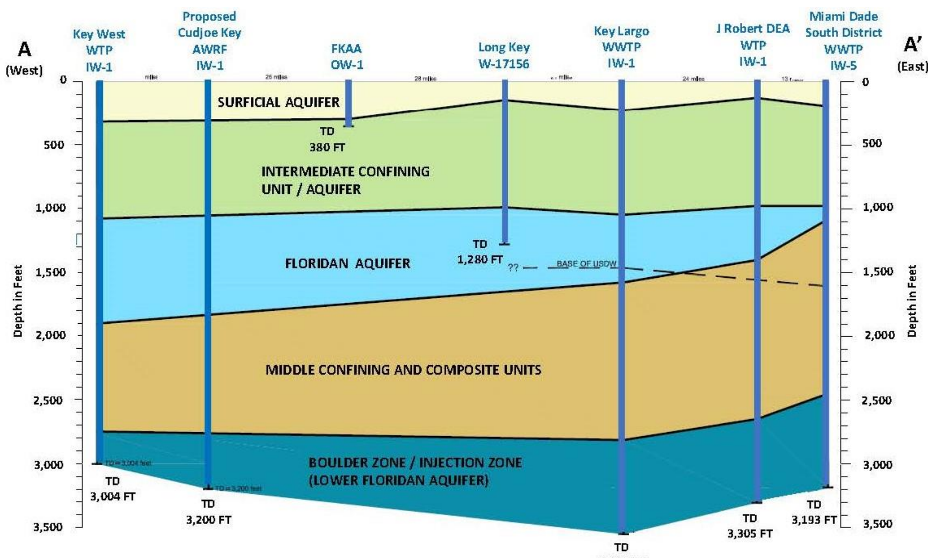



**Figure 3.1: Hydrogeologic Cross Section Location of the Florida Keys**




Adapted from Cudjoe Regional Advanced Water Reclamation Facility Deep Injection Well (DIW-1) and Dual Zone Monitoring Well (DZMW-1) Application, Prepared by CH2M Hill for Florida Keys Aqueduct Authority, July 2015.

**Figure 3.2: Hydrogeologic Cross Section of the underlying Aquifer System**

Alternative 1A - Single Deep Injection Well at Well 6 (**Figure 3.3**) A deep injection well would be located on City owned property near the Area 6 WWTP. 13 miles of effluent transmission main would route plant effluent from other areas to this central location for deep injection. The deep injection well will require a dual-zone monitoring well. Additional effluent storage may be needed. This alternative would require expansion of the pump stations at Areas 3, 4, and 5 as well as a new pump stations at Areas 6 & 7.

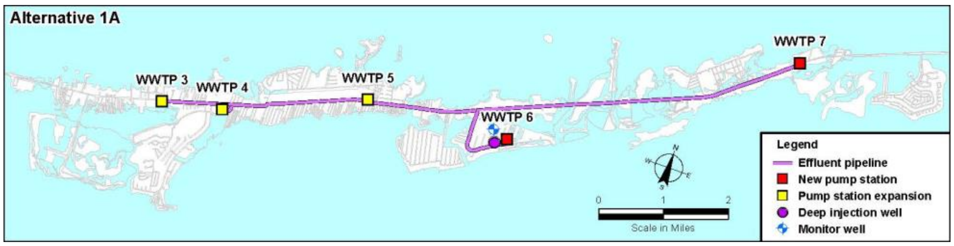



**Figure 3.3: Alternative 1A - Single Deep Injection Well Located at Area 6 WWTP**

Alternative 1B - Five Deep Injection Wells (**Figure 3.4**) This alternative includes five deep injection wells, one at each of the five plant locations. Each deep injection well requires a dual-zone monitoring well in the neighboring vicinity for construction of a total of 5 monitoring wells. Property acquisition or land easement agreements should be factored in to provide permittable distances for the required monitoring wells. While onsite effluent storage exists at plant locations, this may require an increase in storage capacity.

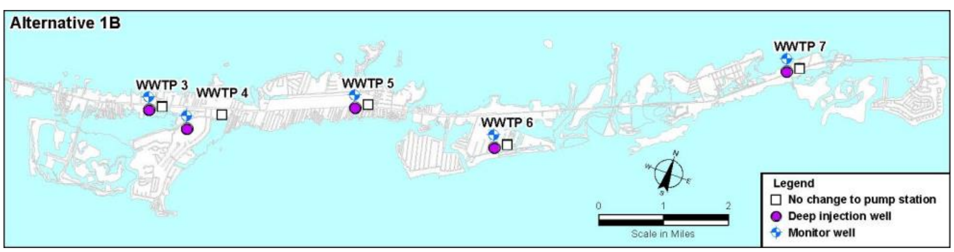



**Figure 3.4 – Alternative 1B Five Deep Injection Wells**

Alternative 1C - Two Deep Injection Wells (**Figure 3.5**) Areas 3, 4 and 5 would route to an offsite shared deep injection well near Area 4. A new deep injection well serving Areas 6 and 7 would be constructed. 9.5 miles of pipeline would be installed to convey effluent to the injection well locations. A dual-zone monitoring well is required for each of the 2 deep injection wells. While onsite effluent storage exists at plant locations, planning for an increase in storage capacity is expected. The system would require expanding the pump station at Areas 3, 4, and 5 and installing pump stations at Areas 6 & 7.

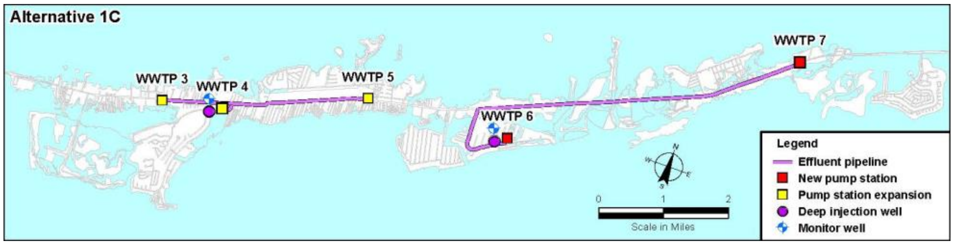



**Figure 3.5 Alternative 1C – Two Deep Injection Wells**

Alternative 1D - Single Deep Injection Well at Crawl Key (**Figure 3.6**) A deep injection well would be located at Crawl Key. 13 miles of effluent transmission main would route plant effluent from other areas to this location for deep injection. The deep injection well will require a dual-zone monitoring well. Additional effluent storage may be needed. This alternative would require expansion of the pump stations at Areas 3, 4, and 5 as well as a new pump stations at Areas 6 & 7. The DIW could also be used to dispose of future drinking water treatment plant concentrate.

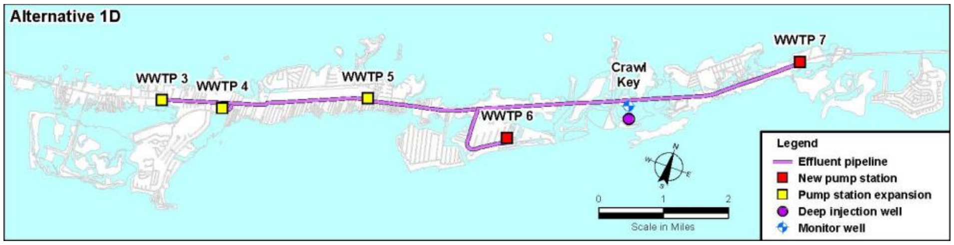



**Figure 3.6 Alternative 1D Single Deep Injection Well at Crawl Key**

Alternatives 2A and 2B include development of a reclaimed water system for public access throughout the City of Marathon. As is the case for all of the reclaim options (2A, 2B, 5, 6, 7 and 8) this analysis assumes the need for at least some additional treatment to reduce wastewater salinity. If one of these alternatives is selected for further development, the City should evaluate the cost of implementing a comprehensive infiltration/inflow control program as an alternative to building additional treatment for salinity reduction and the disposal of its concentrate.

We reviewed plant effluent salinity data from January 2022 to June 2023. The average value and range are summarized for each plant in **Table 3.1**. Most plants can tolerate TDS between 700 and 2000 ppm. Some turf grasses like Paspalum can tolerate TDS greater than 2000 ppm but need levels below 2000 ppm to germinate. Alternative 2A includes partial treatment for salinity at Areas 3, 4 and 5 WWTPs where average salinity is greater than 2000 ppm. Alternative 2B includes treatment at all five WWTPs.

**Table 3.1: Salinity Measurements in WWTP Effluent**

| WWTP | Salinity as TDS (ppm) | |
|---|---|---|
| | Average | Range |
| Area 3 | 2547 | 1750 - 4500 |
| Area 4 | 3028 | 1300 - 7981 |
| Area 5 | 4199 | 2100 - 9000 |
| Area 6 | 1328 | 652 - 2992 |
| Area 7 | 1800 | 464 - 4231 |

Alternative 2A – Public Access Reuse with Partial Salinity Treatment (**Figure 3.7**)
This alternative includes reactivation of the existing effluent distribution lines, and expansion of the reclaimed distribution system with 75 miles of distribution mains down every street in Marathon. For this alternative treatment is provided at plants where the effluent has an average salinity of greater than 2000 ppm as TDS. Effluent from Areas 3, 4, and 5 WWTPs would require salinity treatment, and would have a 75% recovery/25% concentrate split. The concentrate would require deep injection well injection and a monitoring well at the three WWTPs. Areas 6 and 7 would have 100% of the effluent available for public access reuse, for an overall beneficial reuse of 84% utilized as public access reuse.

The pump stations at the Area 3, 4, and 5 WWTPs would be expanded and new pump stations would be constructed at the Area 6 and 7 WWTPs. While onsite effluent storage exists at all plant locations, the planning for an increase in storage capacity is required.

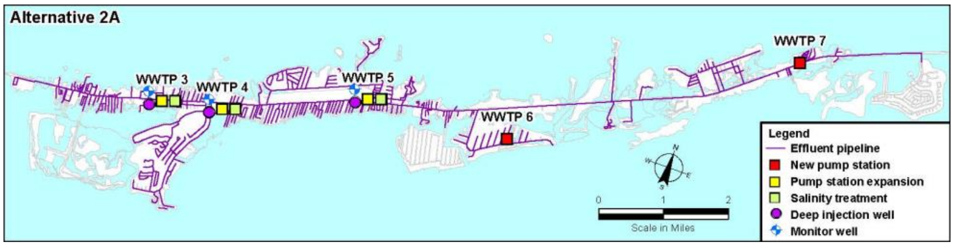



**Figure 3.7: Alternative 2A – Public Access Reuse with Partial Salinity Treatment**

Alternative 2B – Public Access Reuse with Full Salinity Treatment (**Figure 3.8**) This alternative includes construction of Reverse Osmosis (R/O) systems to reduce salinity at each of the five WWTP locations for public reuse applications. The current public reuse lines would be reactivated with an additional 75 miles of lines installed down every street in Marathon. Five deep injection wells and associated dual zone monitoring wells would be required. Pump stations at the Area 3, 4, and 5 WWTPs would be expanded and new pump stations would be constructed at Area 6 and 7 WWTPs. While onsite effluent storage exists at all plant locations, the addition of increase in storage capacity is included.

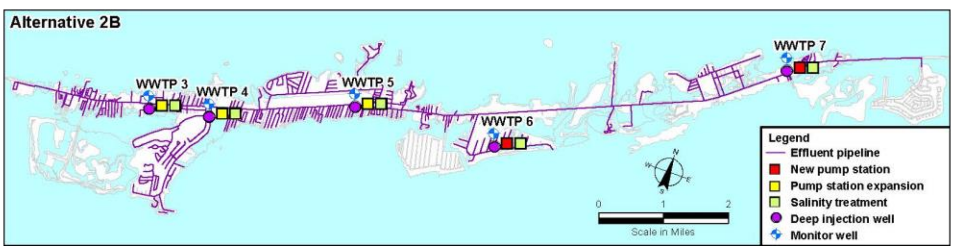



**Figure 3.8 Alternative 2B – Public Access Reuse with Partial Salinity Treatment**

Alternatives 3 and 4 present options for the City's treated wastewater effluent to be utilized as a drinking water through either indirect or direct potable reuse. We assume that the beneficial reuse produced would be 75% of the effluent disposal flow with a 25% concentrate waste that would require deep well injection for disposal.

Alternative 3 – Indirect Potable Reuse (IPR) (**Figure 3.9**) This alternative includes indirect potable reuse located at Crawl Key, including a 1,200 ft deep Class 5 aquifer recharge well into the > 10,000 TDS aquifer, surrounded by production wells, and potable water treatment, and 12 miles of piping to convey effluent from all five WWTPs to Crawl Key. Potable water treatment would include a microfiltration, reverse osmosis (R/O) with advanced oxidation, alkalinity adjustment, and final disinfection. The treatment would have an assumed recovery rate of 64% and would require a deep injection well for the 36% concentrate and a dual-zone monitoring well installed in the vicinity. Effluent and finished storage would be located at Crawl Key. Expansion of the pump stations at Areas 3, 4, and 5 as well as installation of pump stations at Area 6 and Area 7 would be required.

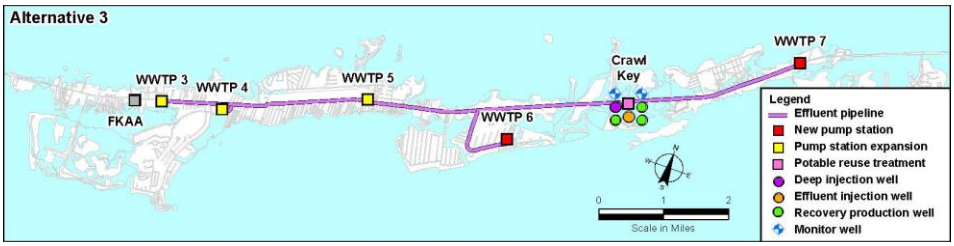



**Figure 3.9: Alternative 3 - Indirect Potable Reuse**

<u>Alternative 4 - Direct Potable Reuse</u> (**Figure 3.10**) This alternative includes construction of a single direct potable reuse facility at Crawl Key. Effluent from all areas would be piped to this central treatment location. Construction of 12 miles of new piping to connect effluents from each plant. Potable water treatment would include a membrane filtration, reverse osmosis (R/O) system with advanced oxidation alkalinity adjustment, and final disinfection. The treatment facility would have a 25% waste stream requiring a deep injection well for brine disposal and a dual zone monitoring well in the vicinity.

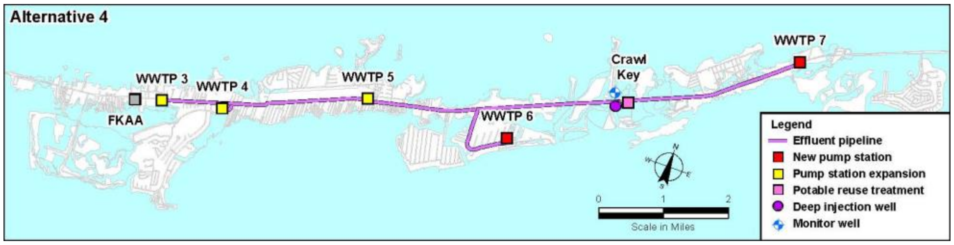



**Figure 3.10: Alternative 4 Direct Potable Reuse**

Alternatives 5 and 6 present options for an expanded City reclaimed system focusing on bulk users and do not provide a reclaimed system throughout the City. Beneficial reuse of the treated wastewater effluent would be between 40 and 65%.

Alternative 5: Bulk Reuse and Deep well Injection (**Figure 3.11**) This alternative includes a combination of bulk user reuse for Areas 3, 4, and 5 and a deep well at Area 6 for flows from areas 6 and 7. It includes expansion of the existing public access distribution with 10 miles of piping installed for committed bulk user applications throughout Areas 3, 4, and 5. 6.5 miles of piping would be required to convey the effluent between plant 7 and plant 6. Deep injection wells would be required at Areas 4 and Area 6 with a dual-zone monitoring well installed in the vicinity of each. This alternative assumes reverse osmosis treatment at Area 4 to remove salinity for bulk user irrigation.

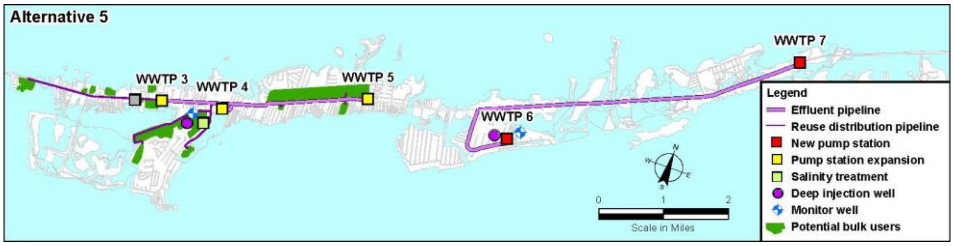



**Figure 3.11: Alternative 5 - Bulk Reuse and Deep Well Injection**

Alternative 6 – Bulk Reuse including Duck Key and Deep Well Injection (**Figure 3.12**) This alternative includes a combination of deep injection wells and bulk user conventional reuse. Areas 3 and 4 would have bulk user reuse (for parks, golf course, and newer developments) and 6 miles of new distribution mains. This alternative includes a deep injection well backup installed at or near the Area 4 WWTP. Additionally, Area 7 would provide treated effluent as a reclaimed water product through agreement with FKAA to Duck Key to offset additional public access reuse need in that development.  This connection requires 2 miles of transmission effluent piping and a reverse osmosis system to treat effluent to acceptable application standards for the FKAA who has indicated it requires less than 700 ppm of total dissolved solids for it's reclaim system. A deep injection well would also be used for disposal of surplus effluent from the Area 5, 6, and 7 WWTPs. This injection well would be connected by 8.5 miles of effluent transmission main to the Area 7 WWTP. Each deep injection well would require a dual zone monitoring well.

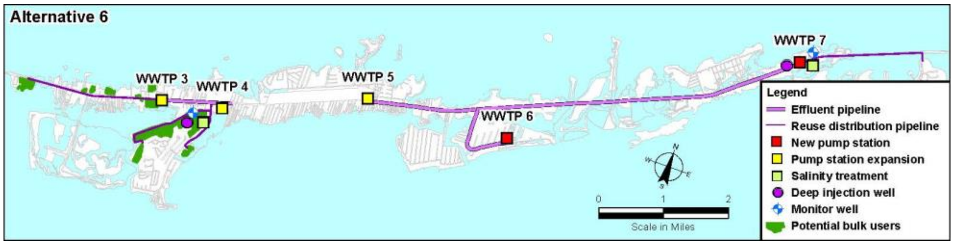



**Figure 3.12: Alternative 6- Bulk Reuse including Duck Key and Deep Well Injection**

Alternatives 7 and 8 are combinations of a reclaimed system by the City for bulk users and development of drinking water at Crawl Key either through direct or indirect treatment methods. Beneficial reuse of treated wastewater is estimated to range between 70-75%.

Alternative 7 – IPR and Deep Well Injection (**Figure 3.13**) This alternative includes a combination of bulk user reuse and indirect potable reuse. It includes 3 miles of new distribution piping in areas 3 and 4, and reverse osmosis (R/O) for salinity removal. A deep injection well would be required at or near Area 4 for the injection of brine. 8 miles of piping would be required to convey the effluent between Areas 5, 6 and 7 to connect to the indirect potable reuse site at Crawl Key, where it would be treated to injection standards, injected, extracted and treated to potable distribution standards, and treatment waste would be disposed of via deep injection well. The two proposed deep injection wells would each require a dual-zone monitoring well.

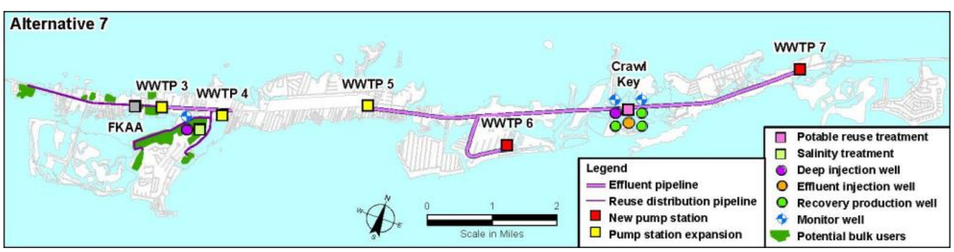



**Figure 3.13: Alternative 7-IPR and Deep Well Injection**

Alternative 8 – DPR and Deep Well Injection (**Figure 3.14**) This alternative includes a combination of bulk user conventional reuse and direct potable reuse. Areas 3 and 4 would have bulk user reuse (for parks, golf course, and newer developments). The alternative includes replacement/augmentation of existing effluent distribution system with 1 mile of piping to connect plants 3 and 4 and 8 miles of new lines for bulk users near Areas 3 and 4 with a deep injection well backup installed at Area 4 WWTP. Direct potable reuse treatment would be located at Crawl Key for effluent from areas 5, 6, and 7. Treatment would be achieved by membrane filtration, reverse osmosis, advanced oxidation, alkalinity adjustment and final disinfection. Connecting plants at Areas 5, 6, and 7 requires installation of 8.5 miles of effluent transmission piping.

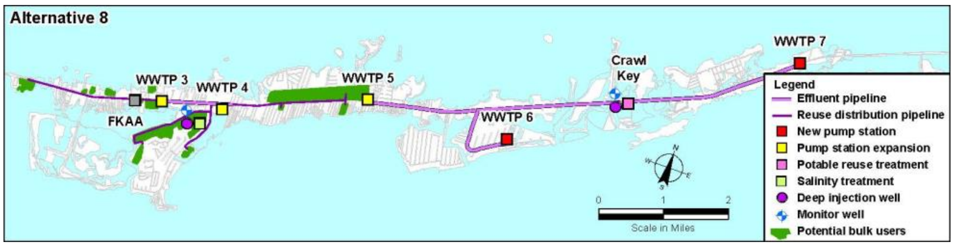



**Figure 3.14: Alternative 8 – DPR and Deep Well Injection**

# 4 Results

This evaluation includes non-cost criteria and 30-year life cycle cost (LCC) estimates. These scores are presented in this results section, and combined to give an overall comparative evaluation of the alternatives. The information is summarized in this section, but the methodology used for the calculations is explained in greater detail in Section 2 and the Appendices.

All the twelve alternatives that we evaluated are capable of meeting the primary project objective of providing an effective wastewater effluent disposal method. All the alternatives utilize one or more deep injection wells (DIW), which are either the primary effluent disposal method or a secondary method for those alternatives that provide additional water treatment and beneficial reuse.

For the purposes of this analysis, we assumed that properly designed and operated DIWs are capable of effectively disposing of wastewater effluent. This analysis did not include an investigation into the expected fate and transport of wastewater effluent after it is disposed of in a DIW. Instead, the assumption that a DIW will effectively dispose of wastewater effluent is based on past findings by state and federal regulators, including the copious data gathered by the FDEP in regard to Class I DIWs in South Florida.

In addition to meeting the primary objective of effluent disposal, we found that eight of the alternatives, numbered 2A through 8, can provide some "beneficial use" for treated effluent. This secondary project goal would be achieved through supplemental treatment processes ranging from the addition of salinity removal at existing WWTPs, all the way to highly advanced, multi-barrier treatment plants. Although beneficial reuse projects can work in theory, they are also limited by practical constraints such as budget and public acceptance. This analysis uses the non-cost and cost criteria to quantify those practical constraints and identify the project alternatives that have the best chance of being implemented.

## 4.1 Non-Cost Criteria Evaluation

As outlined in Section 2, the alternatives were evaluated for the project viability, constructability, and benefit. **Table 4.1** lists the total non-cost scores in each category and the overall total of the non-cost scoring; the same results are shown graphically in **Figure 4.1**. Detailed scoring is provided in **Appendix C**.

Total non-cost scores out a possible highest score of 185, range from a high of over 102.5 (Alternatives 1A, 1B and 1D - 100 % deep well injection), and

Alternative 4 (development of drinking water supply) to a low of 40.00 (Alternatives 2A & 2B - public reuse with additional salinity treatment).

None of the Alternatives achieved a possible maximum score of 185; this is to be expected since the non-cost criteria cover a wide range of considerations some of which are opposed to each other (such as treated wastewater effluent disposal by deep well injection vs. beneficial reuse of treated wastewater effluent) so alternatives that score highly for one particular non-cost characteristic will not necessarily score highly in others.

**Table 4.1: Summary of Non-Cost Evaluation Scoring**

| Alternative | Non-Cost Scoring by Category | | | Total |
|---|---|---|---|---|
| | Viability | Constructability | Benefit | Non-Cost Score |
| **1A** | 65.00 | 40.0 | 0.00 | 105.00 |
| **1B** | 60.00 | 45.0 | 0.00 | 105.00 |
| **1C** | 50.00 | 42.5 | 0.00 | 92.50 |
| **1D** | 70.00 | 40.0 | 0.00 | 110.00 |
| **2A** | 20.00 | 5.0 | 15.00 | 40.00 |
| **2B** | 20.00 | 5.0 | 15.00 | 40.00 |
| **3** | 30.00 | 15.0 | 36.67 | 81.67 |
| **4** | 47.50 | 15.0 | 40.00 | 102.50 |
| **5** | 42.50 | 25.0 | 11.67 | 79.17 |
| **6** | 45.00 | 25.0 | 8.33 | 78.33 |
| **7** | 27.50 | 10.0 | 29.17 | 66.67 |
| **8** | 30.00 | 10.0 | 32.50 | 72.50 |

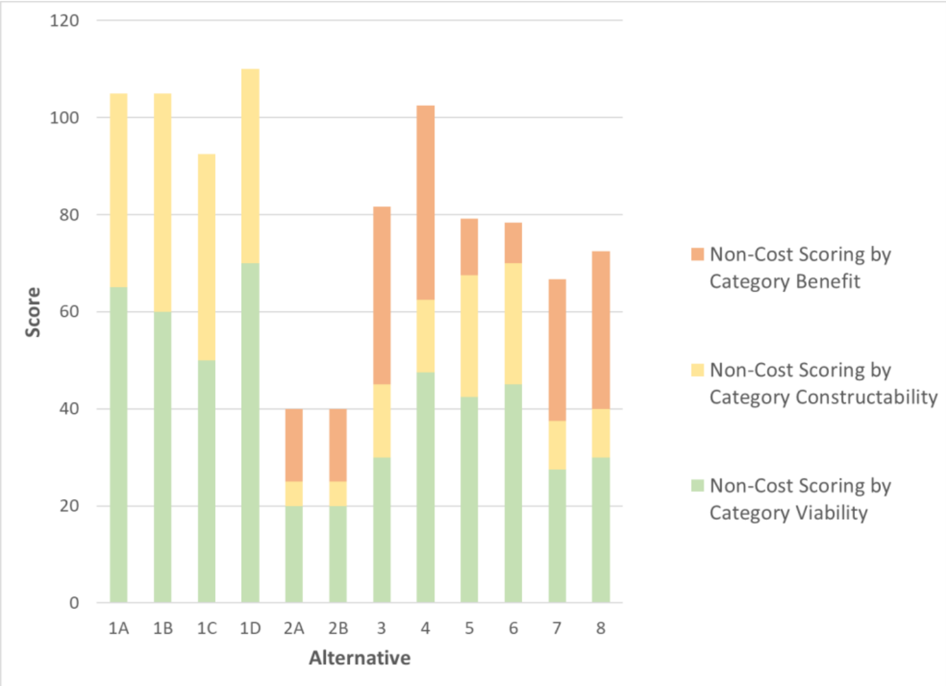



**Figure 4.1 Summary of Non-Cost Evaluation Scoring**

The non-cost analysis reflects a prominent division in the twelve proposed alternatives. Alternatives 1A-1D generally scored much higher than the remaining eight alternatives, 2A through 8. The exception was Alternative 4, direct potable reuse, which matched the highest total score mainly because it had the highest "benefit."

Insights can be drawn by a review of the individual category scores within the total non-cost criteria score to compare the characteristics of the Alternatives. The results of this review are summarized below.

**Viability**: From the project viability perspective, Alternatives 1A, 1D and 1B (100 % disposal by deep well injection) score the highest for project viability. This is because they do not require significant public outreach and require minimal property acquisition. Alternatives 2A, 2B (expansion of the existing reclaim system) and 7 and 8 (development of potable water in conjunction with expansion of the City's reclaim system) score the lowest for project viability. This is because these alternatives require significant public outreach for use of reclaim water for irrigation or for drinking water supply, require more miles of new pipeline, and will be more difficult and time consuming to permit, and project success will rely on agreements bulk users.

**Constructability**: From the constructability standpoint, Alternatives 1A, 1B, 1C and 1D score the highest. This is because they do not have a significant number of miles of pipeline, do not require treatment and the project components will be relatively easy to integrate for operation. Again, Alternatives 2A, 2B, 7 and 8 have the lowest constructability score- they have many more miles of pipelines and their associated access issues during construction, include new treatment facilities and have the longest construction periods, and represent systems that will be more complex to integrate for operation.

**Project Benefit:** From the project benefit perspective, Alternatives 3 and 4 (development of drinking water using City treated wastewater effluent by either direct or indirect potable reuse treatment) and Alternatives 7 and 8 have the highest project benefit score. This is because these alternatives will reuse 100% of the treated wastewater effluent. Here, alternatives 1A, 1B, 1C and 1D have the lowest score because they dispose of all treated effluent and reuse none of it; although Alternative 1D (a deep injection well at Crawl Key) could be used for disposal of concentrate from a drinking water project (e.g., Alternatives 3, 4, 7 or 8).

## 4.2 Cost Evaluation

All public projects are subject to budgetary, or cost, constraints. As described in Section 2, this cost evaluation is comprised of three components: capital costs, O&M costs, and revenues. These cost components were used to evaluate and rank alternatives. Finally, all three cost components were combined using a 30-year lifecycle cost (LCC) analysis, with the most optimal alternatives having the lowest LCC.

### 4.2.1 Capital Cost

In brief, capital cost estimates for each alternative were based on the combination of "unit costs" with estimated project quantities. A summary of capital costs is provided in **Table 4.2** below, and detailed calculations can be found in **Appendix E**.

**Table 4.2: Capital Costs**

| Alternative | Total Capital Cost |
|---|---|
| **1A** | $43,000,000 |
| **1B** | $166,000,000 |
| **1C** | $80,000,000 |
| **1D** | $43,000,000 |
| **2A** | $216,000,000 |
| **2B** | $300,000,000 |
| **3** | $139,000,000 |
| **4** | $111,000,000 |
| **5** | $118,000,000 |
| **6** | $142,000,000 |
| **7** | $188,000,000 |
| **8** | $159,000,000 |

In general, the estimated capital costs increase along with the complexity of the alternatives. The simplest alternatives use only one or more DIWs, which also includes any associated monitoring wells. More complex alternatives, use both DIWs and provide some form of water treatment, along with provisions for beneficial use of the treated water.

The three alternatives with the lowest capital cost are 1A, 1C, and 1D. These three alternatives have two major cost components, the transmission piping network required to transfer treated effluent, and the DIW(s) themselves. At an estimated capital cost of $17 million each (including monitoring well), the DIW accounts for over half of the capital cost of Alternatives 1A and 1D.

Alternative 1C is more expensive than 1A and 1D because it utilizes two DIWs. 1C does not require as much transmission piping as 1A and 1D, but any cost savings that comes with less piping is overwhelmed by the cost of an additional DIW. Alternative 1B is significantly more expensive than 1A, 1C, and 1D for the same reason. Although 1B does not require transmission piping, it does use a DIW at each of the five area WWTPs, and consequently the capital cost is dominated by the cost of five DIWs. Alternatives 1B and 1C also require additional land to build more DIWs, and Alternative 1B in particular would require a significant investment in real estate to locate five new wells.

The remaining eight alternatives also include DIWs. But they also add complexity in the form of additional treatment and systems for distributing treated water.

Alternatives 3, 4, 5, and 6 fall in the middle tier of capital costs. Alternatives 3 & 4 both utilize advanced, multi-barrier, treatment plants to convert treated effluent into potable-quality drinking water. The main capital expense for these two alternatives is the cost of the treatment plants. However, Alternative 3 is expected to have a higher capital cost than Alternative 4 because it uses a system of intermediate injection and recovery wells to provide some temporary underground storage and "natural treatment" for the effluent prior to final treatment at the plant.

Alternatives 5 and 6 only provide supplemental salinity removal treatment at existing WWTPs, but they also include capital costs for distributing the non-potable public access reuse water to customers. Both alternatives also utilize a second DIW, which adds significantly to costs, as we have seen. In addition, both Alternative 5 and 6 would require a significant investment in real estate to implement.

The highest capital cost tier includes the previously mentioned Alternative 1B, along with Alternatives 7, 8, 2A and 2B.

Alternatives 7 and 8 are "hybrid" options that include both potable-grade treatment and salinity reduction for non-potable reuse. Consequently, these two alternatives have a high level of complexity and high associated capital costs. They include all of the previously mentioned high capital cost components such as: advanced treatment plants, salinity treatment, a second DIW, non-potable reuse distribution networks, and associated real estate purchases. In addition, Alternative 7 also requires the injection well and recovery wells required for indirect potable reuse, making its capital cost higher than Alternative 8.

The highest capital cost alternatives are 2A and 2B. Alternative 2A uses three DIWs, salinity-reduction treatment, and includes a new network of non-potable reuse distribution piping that covers the entire City of Marathon. The non-potable reuse water distribution network required for both 2A and 2B accounts for roughly one third of the capital costs in either scenario. These costs are comprised of the extensive piping network to cover the entire service area, new pump stations and storage tanks, plus the installation of residential meters for each customer. The 2A system also requires a significant investment in real estate. Alternative 2B adds to the cost of 2A by providing more salinity-reduction treatment, and five DIWs, or one well per area treatment plant.

### 4.2.2 Operation and Maintenance Costs

The methodology for estimating ongoing operations and maintenance (O&M) costs, along with **Table 2.7** summarizing the unit costs, is described in Section 2. As with the estimation of capital costs, the accuracy of the estimate of O&M costs is limited by the information available. Just as the capital cost calculation follows the characteristics of an AACE-I Class 5 estimate, the O&M analysis does as well. Although the limited accuracy of the O&M cost estimates precludes the reliable differentiation between similar alternatives, it is possible to identify meaningful patterns in all twelve alternatives taken as a group.

The alternatives that do not involve any supplemental water treatment have the lowest annual O&M costs. These alternatives, namely 1A through 1D, utilize deep injection wells as a means of effluent disposal. Alternatives 1A, 1C, and 1D have two general categories of O&M costs, first are the costs associated with the pumping of effluent among treatment plant locations, and second are the costs associated with operating and maintaining deep injection wells. Neither of these cost categories are expected to require the addition of a large labor force, but some of the O&M tasks may require the use of intermittent use of specialized contract labor. Alternative 1B has no pumping costs as the DIWs are located on site, but because this alternative uses five DIWs, the well costs are magnified in importance.

Pumping and effluent transmission O&M costs primarily include the electricity required to operate pumps, the cost of periodically repairing and replacing pumping infrastructure, and the costs associated with providing corrective maintenance for transmission line failures. DIW O&M costs include periodic well cleaning, plus monitoring and testing as required by permit.

All twelve of the alternatives involve DIWs and consequently the O&M costs associated with wells are present for all alternatives. They differ in the number of DIWs utilized, ranging from one to five per alternative. In addition to Alternative 1B, Alternative 2B also uses five DIWs to provide onsite effluent disposal. In both of these alternatives there are no pumping and transmission O&M costs, but well maintenance costs are magnified by a factor of five.

Alternatives 2A, 2B, 5, and 6 all provide some level of salinity removal treatment to provide for a public-access non-potable reuse service. These alternatives comprise the middle tier of O&M costs. In addition to the aforementioned DIW costs, these alternatives include significant O&M costs associated with salinity removal treatment. As described in the **Table of Staffing Estimates** (**Appendix G**), the operation of a public-access reuse system will require some expansion of the current staffing at City WWTPs. We expect that at a minimum, the FDEP will require City WWTPs to expand staffing levels so that a licensed operator can be present at all five treatment plants for seven days per week as opposed to the status quo staffing of five days per week.

In addition to new staffing costs, the salinity treatment alternatives (i.e., Alternatives 2A, 2B, 5, and 6) will consume electricity and chemicals in the salinity removal process. The annual cost of electricity and chemical consumption will depend on the specific process technology used and water quality parameters. However, using moderately brackish water and medium pressure reverse osmosis systems for comparison we estimated a unit cost for electricity and chemicals. The treatment technology will also require periodic equipment repair and replacement, which is also a consequential cost.

**Table 4.3: Operation and Maintenance Costs**

| Alternative | Total 30-year O&M Cost |
|---|---|
| **1A** | $12,300,000 |
| **1B** | $17,400,000 |
| **1C** | $14,400,000 |
| **1D** | $15,300,000 |
| **2A** | $81,100,000 |
| **2B** | $94,500,000 |
| **3** | $127,500,000 |
| **4** | $151,900,000 |
| **5** | $58,300,000 |
| **6** | $68,800,000 |
| **7** | $132,200,000 |
| **8** | $144,200,000 |

The treatment processes required for both indirect and direct potable reuse are even more intensive in terms of staffing requirements, electricity and chemical consumption, and repair and replacement costs. Both IPR and DPR require multi-barrier treatment processes, and each barrier typically adds to pumping costs and chemical consumption. Membrane technologies, such as nanofiltration and reverse osmosis, consume copious amounts of electricity because they operate at significant pressures. These technologies also require the consumption of various chemicals to reduce membrane fouling and to regularly clean membranes. Chemicals and electricity are also consumed during pre-treatment, and for advanced disinfection technologies.

Although both IPR and DPR alternatives are expected to have high O&M costs, we expect that the temporary underground storage used by the IPR options will provide some level of natural "treatment" and attenuation of pathogens and other constituents of concern. As a result of this assumption, the unit cost for electricity and chemical consumption was lower in IPR (Alternatives 3 and 7) than DPR (Alternatives 4 and 8). Subsequently, we found the overall O&M costs were expected to be slightly lower for IPR in comparison to DPR.

Staffing regulations have yet to be finalized in Florida for both indirect and direct potable reuse projects. However, we expect that regulators will require a minimum of continuous operator staffing (i.e., 24 hours per day and 7 days per week) at any IPR or DPR treatment plant. As summarized in the **Table of Staffing Estimates** (**Appendix G**), we expect that the IPR and DPR alternatives (i.e., Alternatives 3, 4, 7, and 8) will require the largest expansions in staffing. The bulk of the new staffing needs for these alternatives will be for licensed operators and plant maintenance staff.

### 4.2.3 Revenues

As explained in Section 2.3.1, the unit rates for revenues generated from water sales were based on the published FKAA retail rate. This analysis used three separate rates to make revenue projections; the highest rate was for potable water sales at $8.00 per 1,000 gallons, residential non-potable water was priced at $4.00 per 1,000 gallons, and the price to bulk customers for non-potable water was set lowest at $2.00 per 1,000 gallons.

For both potable and non-potable reuse water we assumed that demand would be sufficient to purchase all of the product supplied. The spreadsheet model calculated expected revenues over a 30-year period, and revenues are expected to increase as effluent flow projections increase. The changes in flow and revenue were estimated by decade, with a separate average flow and revenue estimate for each of the three decades in question.

The quantity of reuse water available was generally determined by the sum of the average daily flow of treated wastewater effluent minus "losses" of water that are expected to occur during any additional treatment required to meet final product standards. In general, the lost water was assumed to be approximately 25 percent of the average daily flow.

As previously discussed, Alternatives 1A through 1D do not provide any additional treatment and there is no expectation that these alternatives would generate revenue. However, the remaining eight alternatives all utilize some type of additional treatment with the goal of providing a beneficial use for the effluent water.

The estimated 30-year revenues are provided in **Table 4.4**.

**Table 4.4: Revenues**

| Alternative | 30-year Estimated Revenues |
|---|---|
| 1A | $-0 |
| 1B | $-0 |
| 1C | $-0 |
| 1D | $-0 |
| 2A | $49,700,000 |
| 2B | $46,300,000 |
| 3 | $92,600,000 |
| 4 | $92,600,000 |
| 5 | $16,700,000 |
| 6 | $13,000,000 |
| 7 | $56,700,000 |
| 8 | $56,700,000 |

The highest revenue expectations are from the potable water sales anticipated in Alternatives 3 and 4. Note that the quantity of water sold, and therefore the revenue, is expected to be the same for both Alternatives 3 and 4, although in reality there would be some difference in yield between the indirect and direct treatment processes. The same assumption was made for Alternatives 7 and 8.

At an estimated $92.6 million over 30 years, the revenue from Alternatives 3 and 4 would offset a significant portion of the expected capital and O&M costs. However, the revenue from potable water sales is not expected to meet or exceed annual O&M costs for either Alternative 3 or 4. But the two alternatives do have the highest revenues when measured as a percentage of the O&M costs.

As previously discussed, Alternative 3, the indirect potable reuse option, has lower expected annual O&M costs than Alternative 4, the direct potable reuse option. Since revenue expectations are the same for both options, Alternative 3 has the highest estimated revenue in terms of percentage of O&M costs at roughly 73 percent. The next highest revenues as percent of O&M costs are Alternatives 4 and 2A, which are both nearly tied at 61 percent. All other options have revenue projections below 50 percent of O&M costs.

The highest revenues from reuse for irrigation are expected from Alternatives 2A and 2B. However, expected revenues for these two alternatives are not expected to meet a large percentage of the combined capital and O&M costs.

Aside from Alternatives 1A-1D, the lowest expectations for revenue generation come from Alternatives 5 and 6. This follows mainly because of the low price of bulk non-potable sales.

### 4.2.4 30-Year Life Cycle Cost

The purpose of a life cycle cost (LCC) analysis is to combine all present and future project cost and revenue streams into one representative "present value" that can be used for a comparative assessment of different conceptual alternatives. Life cycle cost analysis is often used in engineering design to evaluate opportunities to save on long-term O&M costs by investing in better equipment such as more efficient motors or more durable parts. In theory, from a cost-based perspective only, the alternative with the lowest life cycle cost will be the most preferable option. In practice, non-cost considerations must be evaluated as well to determine the best course of action.

**Table 4.5 30-year Life Cycle Costs**

| Alternative | 30-year Life Cycle Costs |
|---|---|
| **1A** | $56,000,000 |
| **1B** | $184,000,000 |
| **1C** | $95,000,000 |
| **1D** | $59,000,000 |
| **2A** | $248,000,000 |
| **2B** | $349,000,000 |
| **3** | $174,000,000 |
| **4** | $171,000,000 |
| **5** | $160,000,000 |
| **6** | $198,000,000 |
| **7** | $264,000,000 |
| **8** | $247,000,000 |

For this assessment, the twelve alternatives have generally followed similar patterns for all three "cost" categories, meaning capital, O&M, and revenue. The capital costs generally increase along with the level of complexity associated with each alternative. Likewise, O&M costs also increase as the level of treatment complexity expands from no treatment (Alternatives 1A-1D), up to salinity removal (Alternatives 2A, 2B, 5, and 6), and finally the treatment required to generate safe potable water in the IPR and DPR processes. Revenues also follow the same pattern. Effluent disposal alternatives generate no revenue, non-potable public access alternatives provide some revenue, and finally the potable reuse alternatives are expected to provide the highest value product and consequently the highest revenues.

The 30-year life cycle costs calculated in this analysis also follow the same pattern for the twelve alternatives. The top tier of alternatives, meaning the lowest 30-year LCC, were 1A, 1D, and 1C. These three alternatives also have the lowest capital costs and lowest O&M costs.

None of the twelve alternatives are expected to have revenues that completely offset or exceed the estimated annual O&M costs. From a cost perspective only, the alternatives with the higher capital costs did not lead to the lowest LCC.

The second tier of alternatives for life cycle cost include: 1B, 3, 4, 5, and 6. This group was also the middle tier for capital costs. However, the expectations for the highest revenues allow Alternatives 3 and 4 (IPR and DPR) to be competitive with the non-potable bulk reuse options, Alternatives 5 and 6.

The highest LCC tier includes Alternatives 8, 2A, 2B, and 7.

## 4.3 Combination of Non-Cost and Cost Evaluation

The non-cost scoring and cost estimates were combined into an overall evaluation score for each alternative by assessing a weighting to each and normalizing each into a portion of that score. The non-cost criteria have been weighted as 50% of the overall score. The remain 50% is allocated to the 30-year life cycle cost.

### 4.3.1 Non-Cost Normalized Score

The non-cost scoring can be normalized by dividing the scores by the highest score. The normalized cost can then be multiplied by the 50-point weighting. **Table 4.6** lists the non-cost normalized score.

**Table 4.6: Non-Cost normalized Score**

| Alternative | Non-Cost Score | Normalized Score | Normalized Score X 50 |
|---|---|---|---|
| **1A** | 105.00 | 0.955 | 47.7 |
| **1B** | 105.00 | 0.955 | 47.7 |
| **1C** | 92.50 | 0.841 | 42.0 |
| **1D** | 110.00 | 1.000 | 50.0 |
| **2A** | 40.00 | 0.364 | 18.2 |
| **2B** | 42.50 | 0.386 | 19.3 |
| **3** | 81.67 | 0.742 | 37.1 |
| **4** | 102.50 | 0.932 | 46.6 |
| **5** | 79.17 | 0.720 | 36.0 |
| **6** | 78.33 | 0.712 | 35.6 |
| **7** | 66.67 | 0.606 | 30.3 |
| **8** | 72.50 | 0.659 | 33.0 |

### 4.3.2 30-Year Life Cycle Cost Scores

The 30-year life cycle score can be normalized by dividing each alternative's 30-year life cycle cost by the highest cost. Since we want the higher cost alternatives to be evaluated as a lower score, we can subtract the normalized cost from 1, and then multiply it by the 50-point weighting. **Table 4.7** lists the LCC normalized scores.

**Table 4.7: Total Project 30-Year Life Cycle Cost Normalized Score**

| Alternative | Total 30-Year Life Cycle Cost | Normalized Cost | Normalized Score (1-Normalized Cost) | Normalized Score X 50 |
|---|---|---|---|---|
| **1A** | $56,000,000 | 0.160 | 0.840 | 42.0 |
| **1B** | $184,000,000 | 0.527 | 0.473 | 23.6 |
| **1C** | $95,000,000 | 0.272 | 0.728 | 36.4 |
| **1D** | $59,000,000 | 0.169 | 0.831 | 41.5 |
| **2A** | $248,000,000 | 0.711 | 0.289 | 14.5 |
| **2B** | $349,000,000 | 1.000 | 0.000 | 0.0 |
| **3** | $174,000,000 | 0.499 | 0.501 | 25.1 |
| **4** | $171,000,000 | 0.490 | 0.510 | 25.5 |
| **5** | $160,000,000 | 0.458 | 0.542 | 27.1 |
| **6** | $198,000,000 | 0.567 | 0.433 | 21.6 |
| **7** | $264,000,000 | 0.756 | 0.244 | 12.2 |
| **8** | $247,000,000 | 0.708 | 0.292 | 14.6 |

### 4.3.3 Total Scores

The total score for each alternative can be calculated as a sum of the normalized scores as shown in **Table 4.8** and **Figure 4.2**.

**Table 4.8: Summary of Alternative Scoring**

| Alternative | Alternative Scoring | | Total Alternative Score | Alternative Rank |
|---|---|---|---|---|
| | Non-Cost Score | Cost Score | | |
| **1A** | 47.7 | 42.0 | 89.7 | 2 |
| **1B** | 47.7 | 23.6 | 71.4 | 5 |
| **1C** | 42.0 | 36.4 | 78.4 | 3 |
| **1D** | 50.0 | 41.5 | 91.5 | 1 |
| **2A** | 18.2 | 14.5 | 32.7 | 11 |
| **2B** | 19.3 | 0.0 | 19.3 | 12 |
| **3** | 37.1 | 25.1 | 62.2 | 7 |
| **4** | 46.6 | 25.5 | 72.1 | 4 |
| **5** | 36.0 | 27.1 | 63.1 | 6 |
| **6** | 35.6 | 21.6 | 57.2 | 8 |
| **7** | 30.3 | 12.2 | 42.5 | 10 |
| **8** | 33.0 | 14.6 | 47.6 | 9 |

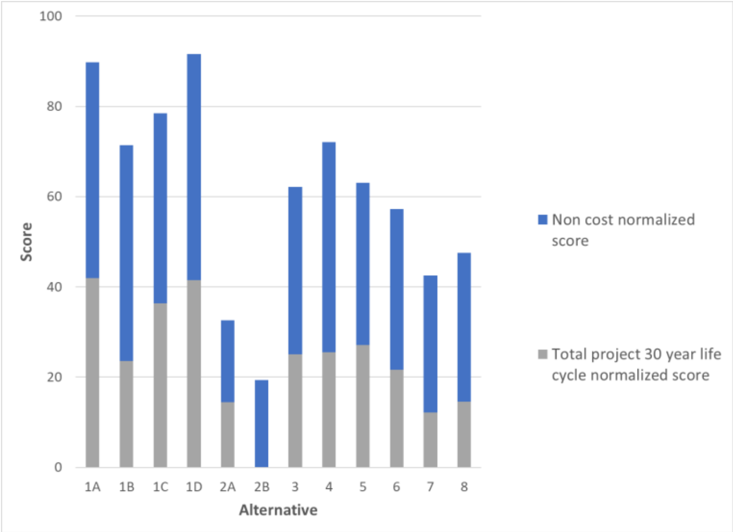



**Figure 4.2: Graph of Normalized Total Scores by Component**

Using the methodology described above, Alternative 1D (a single deep well located at Crawl Key) is the highest ranked alternative, followed closely by Alternative 1A (a single deep well located at the Area 6 WWTP site), then Alternative 1C (two deep injection wells one each at or near the Area 3 and Area 6 facilities) and Alternatives 4 (direct potable reuse ). The lowest scoring alternatives are 2B and 2A (development of a reclaim system throughout the City). In the middle of the scoring are the remaining alternatives 5, 3, 6 and 8.

# 5 Conclusions

As described in Section 1, the primary goal of this project is to eliminate the current approach for disposal of treated wastewater effluent through shallow well injection, and each of the twelve (12) alternatives presented herein will accomplish this primary goal. Secondary to that goal, is the expectation, at all levels of government, that wastewater effluent will play an increasingly important role as an available water resource (i.e., a beneficial use) in the future. We evaluated both goals in this analysis. Summaries of the Alternatives including their evaluation results are in **Appendix H.**

In addition, the non-cost and cost criteria each focused on identifying which of the proposed alternatives have the best chance of being implemented. The conclusions generated by this analysis can be organized according to those three ideas, namely:

1. Effective disposal of excess treated wastewater effluent by eliminating the use of shallow wells.
2. Beneficial uses of treated wastewater effluent.
3. Ability to implement alternative wastewater effluent projects.

<u>Effective Disposal</u>

After investigating the use of deep injection wells in south Florida, and with the specialized experience of our hydrogeologist team member, ASRus, we concluded that **one DIW could be sufficient** to effectively dispose of all the wastewater effluent generated by the City of Marathon. We expect that a single properly designed, constructed, and operated DIW would have the capacity to dispose of the City's wastewater effluent even under the highest projected flow (current and projected future) conditions.

*Each of the twelve alternatives that we analyzed included at least one DIW*, with many alternatives designed to utilize multiple DIWs. In all alternatives shallow wells would be retained for backup use only. The investigation of multiple wells was justified for three possible situations:

1. In the event that a single well would not have sufficient capacity to match the expectations for wastewater effluent flow.
2. For economic reasons, assuming that it would be less expensive to build multiple DIWs than it would be to convey effluent between locations.
3. For the situation where effluent transmission pipes could not be installed between locations. We found that all three of those contingencies would be unlikely.

Many of the existing DIWs currently in use in south Florida have a disposal capacity of several million gallons per day, which is well over the expectations for future flows of the City's treated effluent. We expect that the surplus capacity of a single DIW could allow the well to be used for both effluent disposal and the disposal of "concentrate" from a new drinking water facility. The capacity of the DIW would provide drinking water treatment plant designers with some flexibility, allowing for a wide range of treatment plant sizes and operational conditions. For example, one DIW located at Crawl Key would have the ability to dispose of the City's effluent even under conditions where a drinking water treatment plant is not yet operating.

Beneficial Use

Although Alternatives 1A, 1B and 1C do not provide beneficial use, Alternatives 2 through 8 do provide beneficial use of treated wastewater effluent in differing amounts as presented herein. The selection of any of the Alternatives 1A through 1D does not preclude the implementation of a future project to provide beneficial use of treated effluent. The selection of Alternatives 1A, 1B or 1C could be considered as a preliminary phase in one of the beneficial use alternatives described in this analysis. Similarly, Alternative 1D could be considered as the first phase of any of the Crawl Key alternatives (and provide for a future beneficial reuse), including 3, 4, 7, and 8. All of the alternatives utilize one or more DIWs for disposal of excess treated wastewater effluent when demands for beneficial use are less than available treated wastewater (such as is the case for many reclaim water systems during wet season, or if a drinking water treatment facility is not yet operating, or has been taken offline for maintenance).

Regarding the alternatives that provide non-potable public access reuse water for residential customers, several important caveats must be considered. The successful implementation of a residential reclaimed water program relies on customer acceptance followed by development of customer demand. Even under the best circumstances, such as in communities with a higher demand of potable water for residential or commercial landscaping, it can take time to build demand for reclaimed water for the same outdoor uses. In a community such as the City of Marathon, where customers have already tried to establish landscaping that does not consume much water, e.g., using Florida-Friendly plants, and where lot spaces are small, it may be very difficult to build a significant demand for reclaimed water. Our analysis assumed 100 percent demand for residential reclaimed water, and even under that condition the revenue projection was well below annual O&M costs.

Once a capital-intensive residential reclaimed distribution network is established, options for other beneficial uses of treated effluent would be unlikely given the public and or bulk user expectation of reclaim service. Accordingly, an investment in residential reclaim would most likely preclude any future possibility of using treated effluent for higher value alternatives such as potable reuse.

The potable reuse alternatives, primarily Alternatives 3 and 4, and to a lesser extent Alternatives 7 and 8, would require significant public outreach and acceptance of the new drinking water source. As previously discussed, a DIW located at Crawl Key could be used for disposal of treated wastewater, and future drinking water treatment concentrate. Potable reuse would improve overall system reliability from both a geographic perspective and diversity of source water supply.

Implementation

None of the twelve alternatives that we analyzed will be easy to implement quickly. The more complex the alternative the more time we expect it will take to fund, design, permit, construct, commission and operate, with even the more simple options requiring at least 4 years and the more complex requiring 8 or more years.

We expect that the conditions and assumptions used in this analysis may change considerably in the next few years. The regulatory situation, particularly those that will apply to direct potable reuse of treated wastewater effluent, economic climate, and environmental conditions may all change significantly in the future. **A multi-phased approach** may be the best option for meeting effluent disposal goals as quickly as possible, while still maintaining some flexibility to respond to changing future conditions.

At this time, FKAA is not considering potable reuse as a future water source; therefore, alternatives 3, 4, 7, and 8 are not presently feasible options. In the future, after the regulations are in place and successful installations have been built, the public is expected to become more accepting of reuse water as a safe and suitable alternative drinking water supply. Drinking water treatment technologies have been evolving over the past few decades, where capital and operating costs per unit of potable water produced have dropped. In conjunction with the current stress on sustainable supply in south Florida aquifers, this may be an opportunity to plan for future potable reuse projects.