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CITY OF HALLANDALE BEACH
City of Choice

# Attachment 1

Technical Memorandum

# City of Hallandale Beach – Conceptual Overview of Reverse Osmosis Addition to the Existing Nanofiltration Facility for Water Supply Planning Purposes

To: William Brant, Director
Public Works/Utilities/Engineering

Date: April 14, 2008

## 1.0 Background

The City of Hallandale Beach (City) is subject to the jurisdiction of the South Florida Water Management District (SFWMD). The SFWMD is one of four Florida water management districts that have concluded traditional water supply sources will not be sufficient to meet the demands of the growing population and needs of the environment, agriculture and industry over the next two decades. As this view has gained prominence in recent years, the Florida Legislature enacted bills in 2002, 2004 and 2005 to more directly address the state's water supply needs by requiring more coordination between local land use planning and water supply planning.

The focus of the initial legislation was to add requirements to Chapter 163, Florida Statutes (FS), for local governments to prepare 10-year water supply facilities work plans and to incorporate the work plans into their comprehensive plans. This legislative change emphasized the need for local comprehensive plans to consider the applicable regional water supply plans prepared by the water management districts. In the case of the SFWMD, the applicable plan is the Lower East Coast Water Supply Plan (LEC Plan), most recently updated in 2005-2006.

In 2005, the Florida Legislature changed Chapters 163 and 373, FS, to improve the coordination of water supply and land use planning. Senate Bills 360 and 444 were designed to strengthen the statutory linkage between the regional water supply plans prepared by the water management districts and comprehensive plans prepared by the local governments, with the goal of ensuring that adequate water supplies and public facilities are available to serve the water supply demands of Florida's growing population.

Local governments subject to a regional water supply plan must prepare a minimum 10-year work plan for building public, private, and regional water supply facilities to serve existing and new development within the local government's jurisdiction. This work plan must be adopted into the comprehensive plan within 18 months after the water management district approves a regional water supply plan or its update. The work plan and the comprehensive plan amendment must address the development of traditional and alternative water supplies (AWS), bulk sales agreements, and conservation and reuse programs that are necessary to serve existing and new development for at least a 10-year planning period.

The referenced legislation and related regulatory correspondence established a series of important dates as summarized below:

1. February 15, 2007 – SFWMD approved the LEC Plan 2005-2006 update.
2. June 22, 2007 – Local governments were notified of AWS projects recommended in the LEC Plan 2005-2006 update.
3. June 22, 2008 – Local governments must notify SFWMD concerning what AWS projects will be implemented.
4. August 15, 2008 – Local governments must adopt a 10-Year Water Supply Facility Work Plan.
5. November 15, annually – Local governments must notify SFWMD concerning progress on project implementation.

## 2.0 Purpose

The purpose of this technical memorandum is to provide a conceptual overview for implementing reverse osmosis into the existing water treatment facilities for the City's use in preparing the 10-Year Water Supply Facility Work Plan as required under Chapter 163, FS. The City will be including the implementation of reverse osmosis at the existing membrane plant as one of several alternative water supply planning options and therefore requires a conceptual cost and operational estimate for implementing this strategy.

The City has determined that several potential alternative water supply options exist and will be developing their 10-Year Water Supply Facility Work Plan that describes these alternatives. Primarily, the City is considering the following alternative water supply methods, in addition to reverse osmosis treatment of the Floridan Aquifer, in their water supply planning effort:

- Water conservation to reduce future demand
- Finished water purchases from alternate suppliers (City of Hollywood and North Miami Beach) to meet future demands
- Relocation of City's wells to the west, potentially within the Town of Pembroke Park, to extend the life of the wells
- Reuse of treated wastewater, potentially through the City of Hollywood's existing facility
- L-8 Reservoir Project[1] to provide an increased Biscayne Aquifer allowance

The City desires to initiate a stepwise approach to their alternative water supply planning effort, implementing the least cost (and most feasible) alternatives first to meet the demand not met for the system. However, many of these options depend upon outside utilities and regulators, and are therefore highly uncertain at this level of planning. The most quantifiable option, at this time, for utilizing an alternative water supply to meet the SFWMD's alternative water requirement is to develop a Floridan Aquifer wellfield and associated reverse osmosis (RO) treatment system to be operated in conjunction with the newly constructed nanofiltration facility and existing water softening plant. For these reasons, the City has requested that Hazen and Sawyer prepare an overview of the implementation strategy and conceptual cost for reverse osmosis addition to the nanofiltration plant.

This TM will present the sizing, cost and implementation strategy for the incorporation of the RO process into the existing nanofiltration facility. The City will then utilize the information within this TM to prepare the 10-Year Water Supply Facility Work Plan to be incorporated into their Comprehensive Plan. Following the 10-Year Water Supply Plan, the City may have other options to consider for meeting their 20-Year Water Supply Plan. Therefore, this TM presents RO implementation guidelines for two planning periods for analysis: ten year (2018) and twenty year (2028). The City should utilize the costs and implementation strategies for the two planning periods in preparation of their 10-Year Water Supply Facility Work Plan as required under Chapter 163 of the Florida Statutes.

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[1] *The L-8 Reservoir Project is potential means of AWS that several municipalities in Southeast Florida are investigating, including Hallandale Beach. The basis for the project involves the construction of a large reservoir in Palm Beach County to divert flow from the C-51 canal which would ordinarily be lost to tide. Water stored in the reservoir would be used to offset the need for water deliveries from the water conservation areas, or the regional system, thereby allowing for increased recharge of surficial aquifers. Participating utilities would, in concept, be granted access to a greater water allowance from the Biscayne Aquifer due to lessened demands from the regional system*

## 3.0 Sizing Criteria

*Note: The City previously planned for the future addition of one nanofiltration skid for additional Biscayne Aquifer treatment and two reverse osmosis skids for drought protection during periods of reduced Biscayne Aquifer usage within the existing membrane building (Note: Coincidental operation of RO skids and all nanofiltration skids was not contemplated in original design). Hence, the original membrane plant design included the necessary infrastructure for adding one nanofiltration feed pump, one nanofiltration skid, two RO feed pumps, two RO skids, three cartridge filters dedicated to the RO system, and associated piping and appurtenances for the additional flow. The sizing criteria presented herein considers the existing infrastructure available.*

### 3.1 Raw Water Requirements

The determination of the number of reverse osmosis skids to be constructed is a function of the raw water demand-not-met, or the alternative water that must be supplied to meet the City's forecasted water demands for the planning period. In 2007, the SFWMD allocated 6.2 mgd of Biscayne Aquifer water to the City, through the Broward County Regional Water Supply (BCRWS) transmission system (Piccollo Wellfield). The SFWMD mandated that additional raw water required to meet future demands must be met through alternative water supplies. The City's planned usage of the Floridan Aquifer meets this requirement.

The City is presently producing approximately 6 mgd of finished water through nanofiltration and lime softening. The City can treat water from their existing wells through lime softening while the BCRWS supply is treated through nanofiltration. The City can continue this scheme until saline intrusion prevents the use of their remaining wells. As the timeframe for the City's loss of wells not predictable, the City must plan alternative water supply to meet the demand-not-met when operation of those wells is no longer allowed. To illustrate this scenario, the raw water demand was projected based on the City's historical per capita usage rate of 165 gallons of finished water per person per day and the County's population projections. Table 1 provides a summary of these projected raw water demands, finished water demands, and City's demand-not met for raw water assuming that the City wells become saline around the year 2013.

**Table 1**
**Summary of Raw Water and Finished Water Requirements**
**Based on Broward County Population Projections**

| | | Average Day | | | Maximum Day | | |
|---|---|---|---|---|---|---|---|
| Year | Total Population[1] | FW mgd | RW[4] mgd | RW Demand-Not-Met[6] mgd | FW[6] mgd | RW [4] mgd | RW Demand-Not-Met[6,7] |
| 2008 | 37014 | 6.11 | 7.33 | | 7.33 | 8.98 | |
| 2009 | 38210 | 6.30 | 7.57 | | 7.57 | 9.24 | |
| 2010 | 39406 | 6.50 | 8.06 | | 7.80 | 9.50 | |
| 2013 | 42160 | 6.96 | 8.70 | 2.5 | 8.35 | 10.43 | 4.2 |
| 2015 | 43996 | 7.26 | 9.07 | 2.9 | 8.71 | 10.89 | 4.7 |
| **2018** | **46694** | **7.70** | **9.63** | **3.4** | **9.25** | **11.56** | **5.4** |
| 2020 | 48493 | 8.00 | 10.00 | 3.8 | 9.60 | 12.00 | 5.8 |
| 2025 | 52149 | 8.60 | 10.76 | 4.6 | 10.33 | 12.91 | 6.7 |
| 2028 | 53452 | 8.82 | 11.02 | 4.8 | 10.58 | 13.21 | 7.0 |

1 *Population based on publication "Broward-by-the-Numbers", March 2007 produced by Broward County Urban Planning and Redevelopment Department Planning Services Division*

2 *Calculated using the historical per capital consumption rate of 165 gallons per person per day*

3 *Calculations assume City well water is treatable (i.e., saline intrusion does not occur) until 2013 (guess-timated)*

4 *Assumed 20% losses overall for membrane treatment (average for NF and RO) and 10% losses for lime softening.*

5 *Assumes City loses City wells to saltwater intrusion in short-term (present demand-not-met is being met by City wells)*

6 *Assumed maximum day demand = 120% times average day demand*

7 *Assumes that NF skids could be operated at 6 mgd each on maximum demand days*

For purposes of water supply planning, the City's raw water demand-not-met for 2018, the 10-year water supply plan, is 3.4 mgd. The City's raw water demand-not-met for 2028, the 20-year water supply plan, is 4.8 mgd.

Figure 1 presents the projected finished water demand (average day) and associated raw water demand along with the permitted raw water flows. The raw water demand-not-met is the area above the permitted capacity and below the projected raw water curve. Since the City desires to first implement conservation prior to implementing RO, the effects of conservation on the raw water demand were reviewed. Table 2 summarizes the impact of enforcing 5% conservation and 10% conservation for the Ten Year Water Supply Plan.

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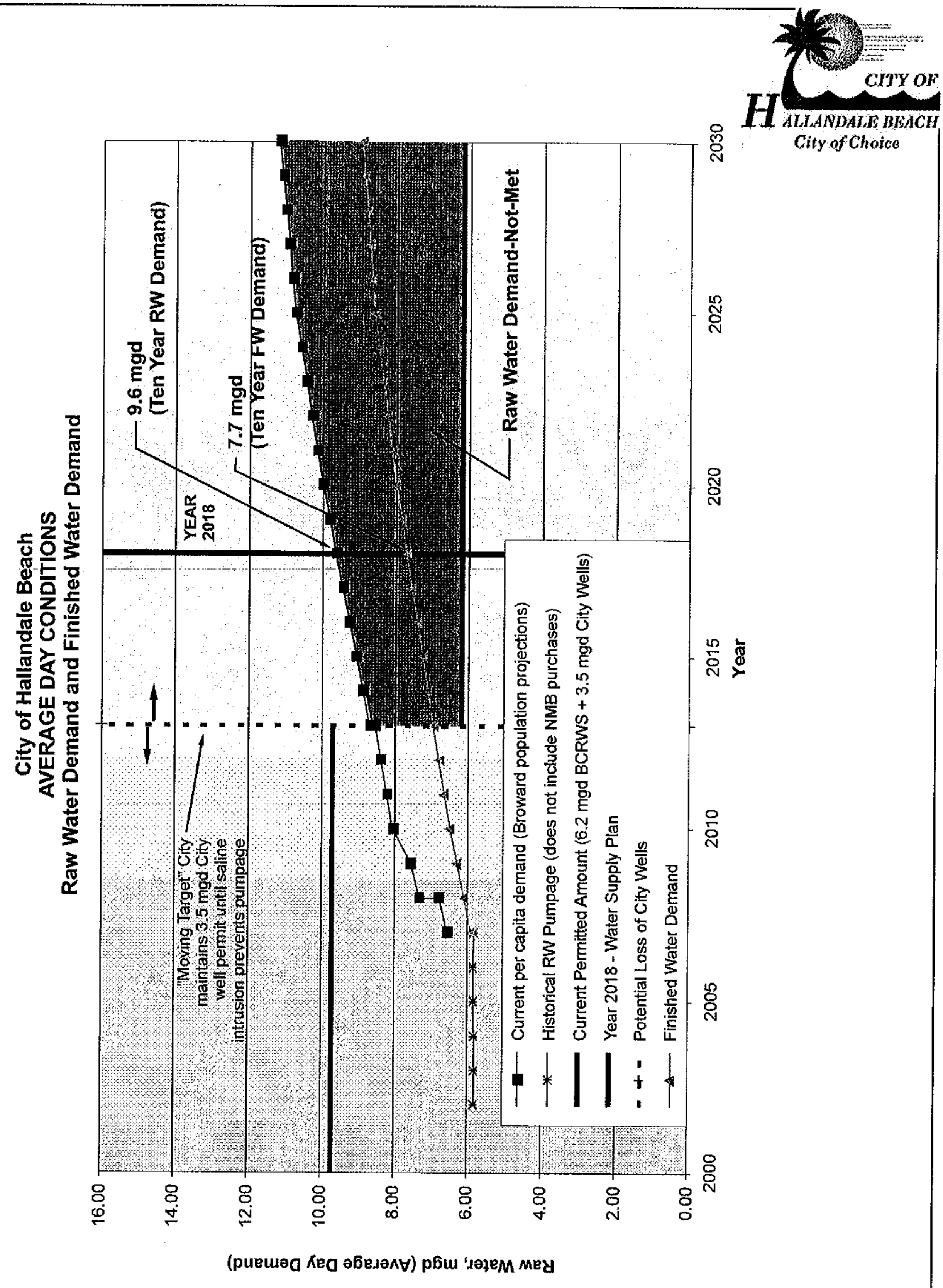


**Figure 1**
Projected Finished Water Demand (Average Day)

**Table 2**
**Summary of Conservation**
**Effects on Raw Water Demand[(1)] (Year 2018)**

| | Average Day RW Demand (mgd) | Average Day RW Demand Not Met | Max Day RW Demand (mgd) | Max Day RW Demand Not Met |
|---|---|---|---|---|
| Baseline (165 pgcd) | 9.6 | 3.4 | 11.6 | 5.4 |
| 5% Conservation (156 pgcd) | 9.2 | 3.0 | 11.0 | 4.8 |
| 10% Conservation (148 gpcd) | 8.6 | 2.4 | 10.4 | 4.2 |

*[(1)]Assumes baseline permit of 6.2 mgd for raw water from BCRWS in the Year 2018.*

Figures 2 and 3 represent the average day raw water demand compared to the permitted raw water flows for two scenarios: 1) The City maintains permit for City wells and 2) Saltwater intrusion occurs and the City maintains the permit for 6.2 mgd from BCRWS only. Similarly, Figures 4 and 5 illustrate the maximum day conditions for these two scenarios. The four figures show the baseline per capita demand projections of 165 gpcd and the projected demands based on 5% and 10% conservation.

Figures 6 and 7 summarize the average day raw water demand-not-met for the two scenarios. Figures 8 and 9 illustrate the maximum day raw water demand-not-met. Although the average day raw water demand-not-met is the critical number for the City's use in preparing the Water Supply Plan, the City must consider sizing their alternative water supply system to meet the maximum day finished water demand associated with the maximum day raw water-demand-not-met. For the Ten Year Water Supply Plan this means that for the identified maximum day raw water demand not-met of 5.4 mgd, the City should prepare for supplying a total of 9.25 mgd finished water (or an additional 3.25 mgd beyond their NF facilities infrastructure).

## 3.2 Finished Water Considerations

Figure 10 shows the projected finished water demand for average day conditions. Based on the present allocation of 6.2 mgd annual average Biscayne aquifer supply through BCRWS, the nanofiltration facility should meet a baseline demand of 5 mgd. Assuming the City loses their wells to saline intrusion, any demands exceeding this amount will need to be met by an alternative water supply. As Figure 10 shows, the 2018 average day finished water demand is 7.7 mgd. This is a deficit of 2.7 mgd finished water for the ten year planning period.

Figure 11 shows the maximum day finished water demand-not-met. Though the nanofiltration facility will be operated to meet a baseline demand of 5 mgd on an average basis, it will be capable of producing 6 mgd for maximum day requirements. Infrastructure must be installed to allow the City the capability to produce maximum day demand of 9.25 mgd, or an additional 3.25

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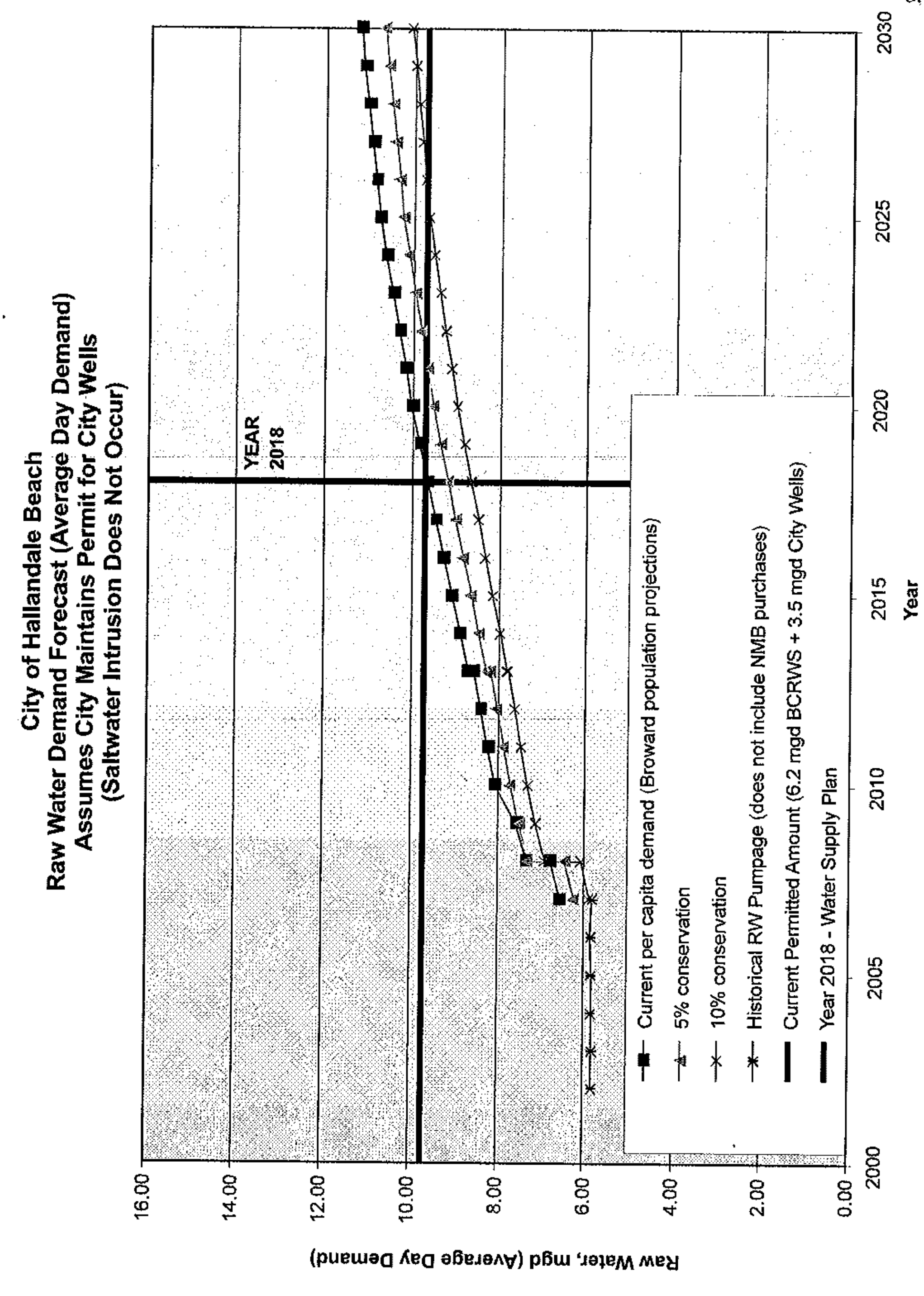


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**Figure 2**
Raw Water Demand Forecast (Average Day)

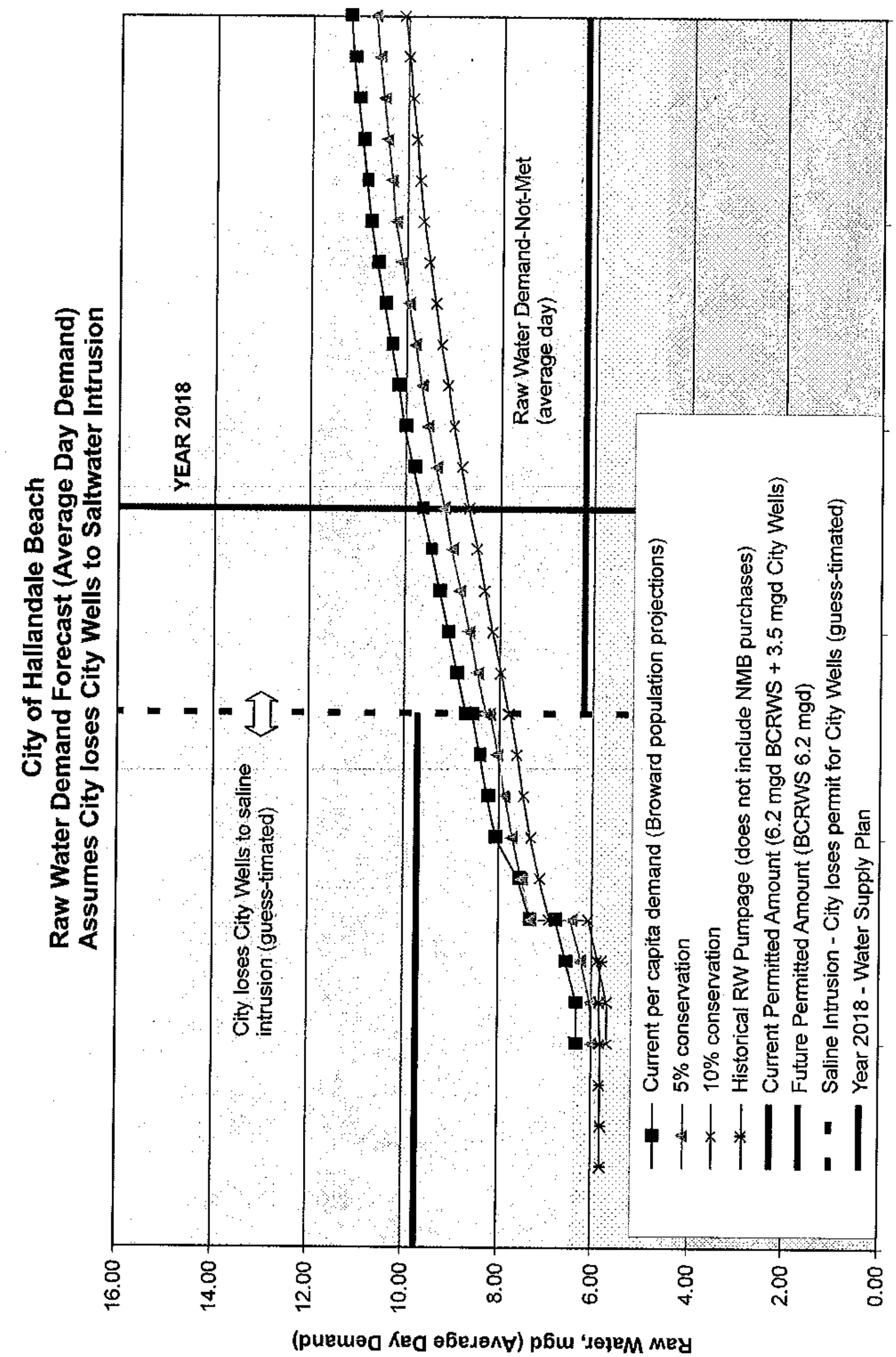


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**Figure 3**
Raw Water Demand Forecast (Average Day)

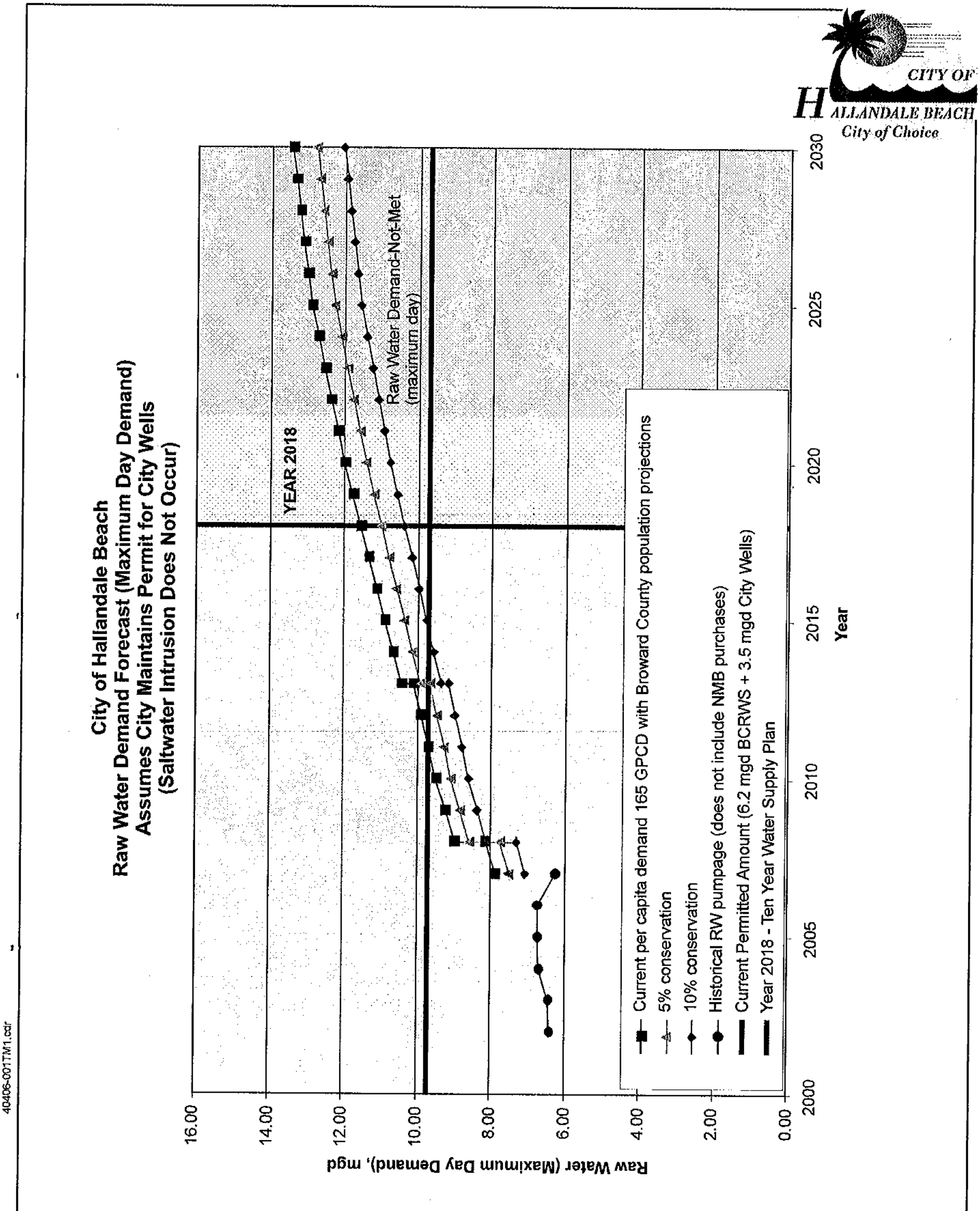


**Figure 4**
Raw Water Demand Forecast (Maximum Day)

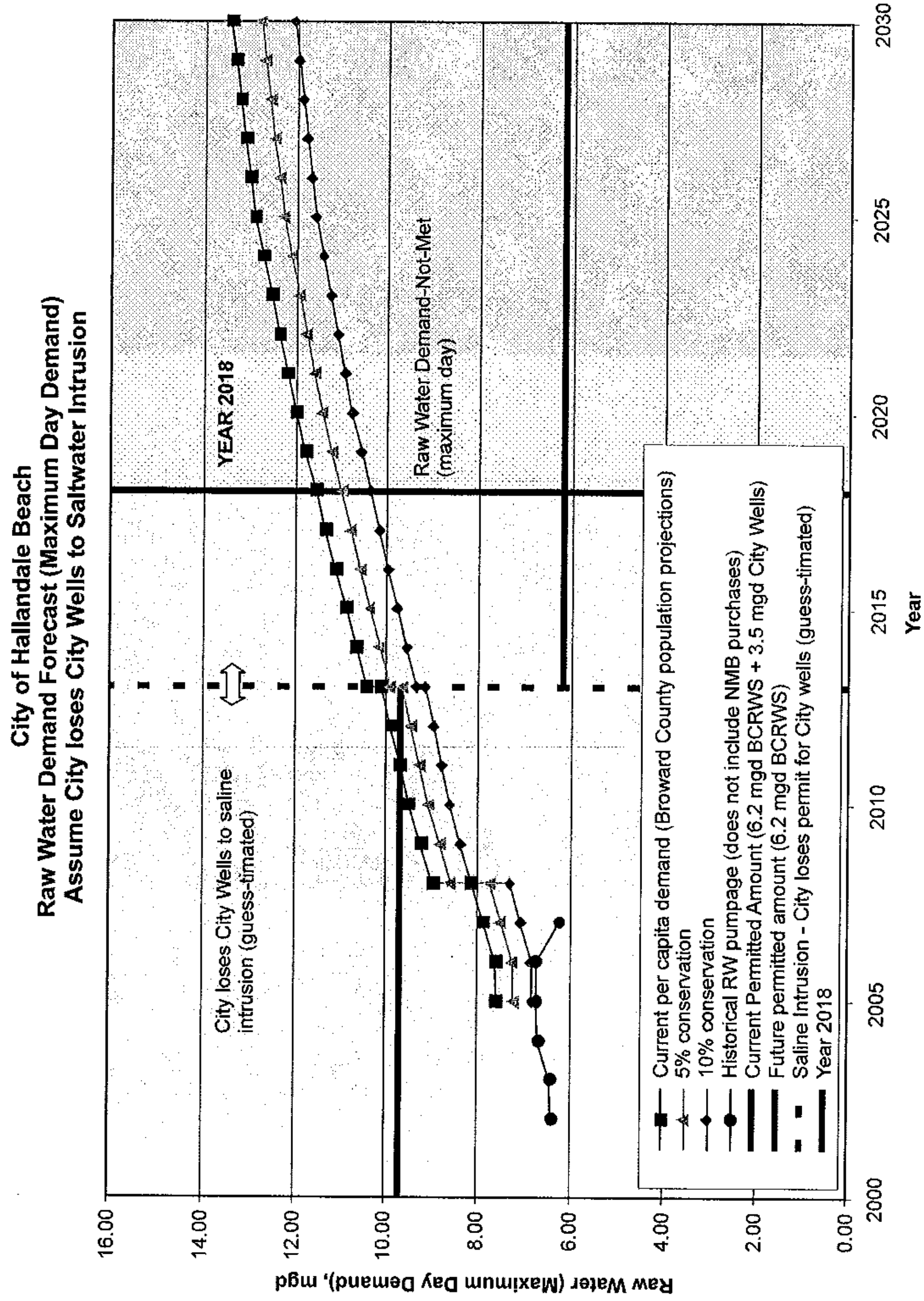


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**Figure 5**

Raw Water Demand Forecast (Maximum Day)

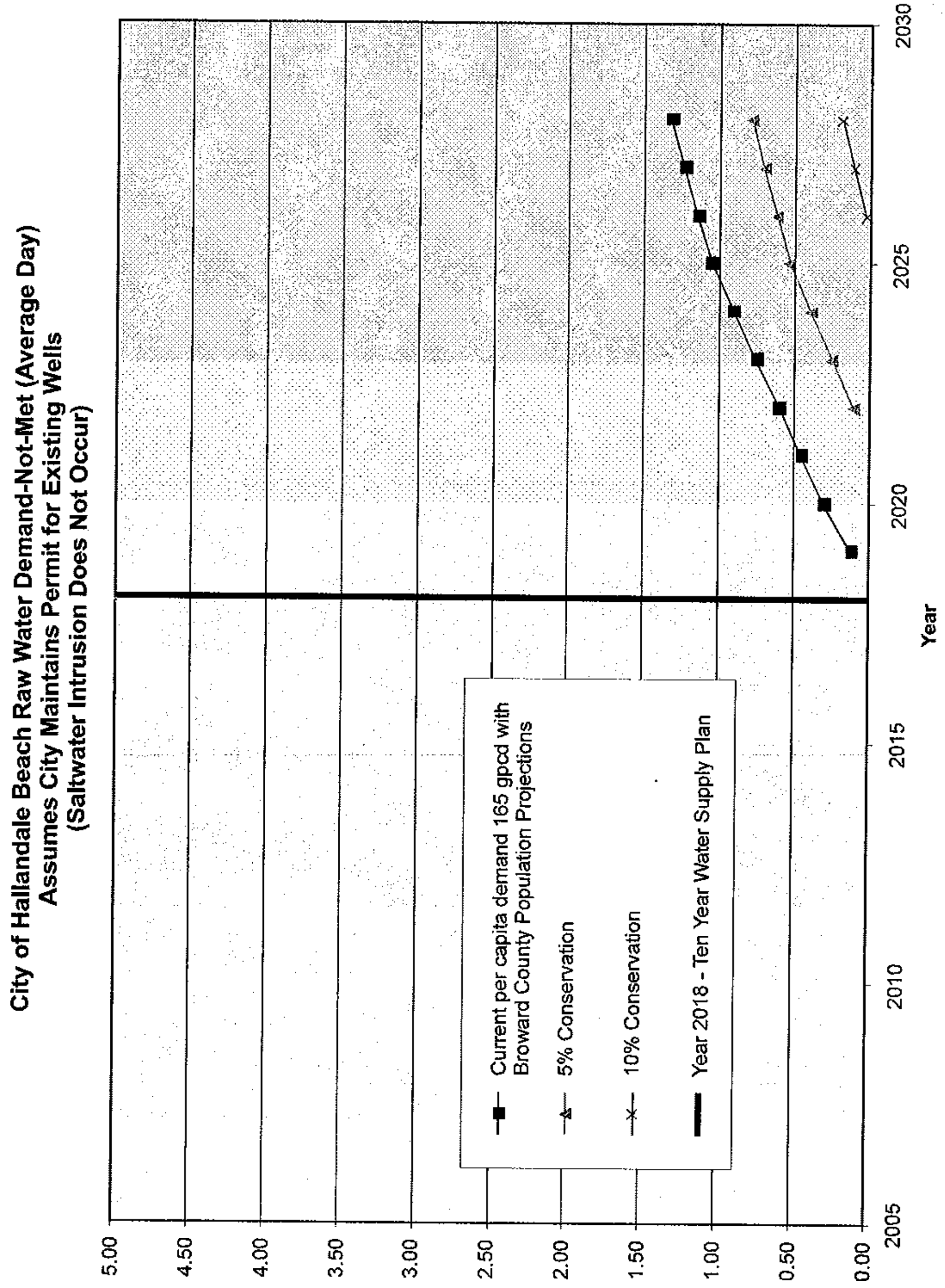


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**Figure 6**
Raw Water Demand-Not-Met (Average Day)

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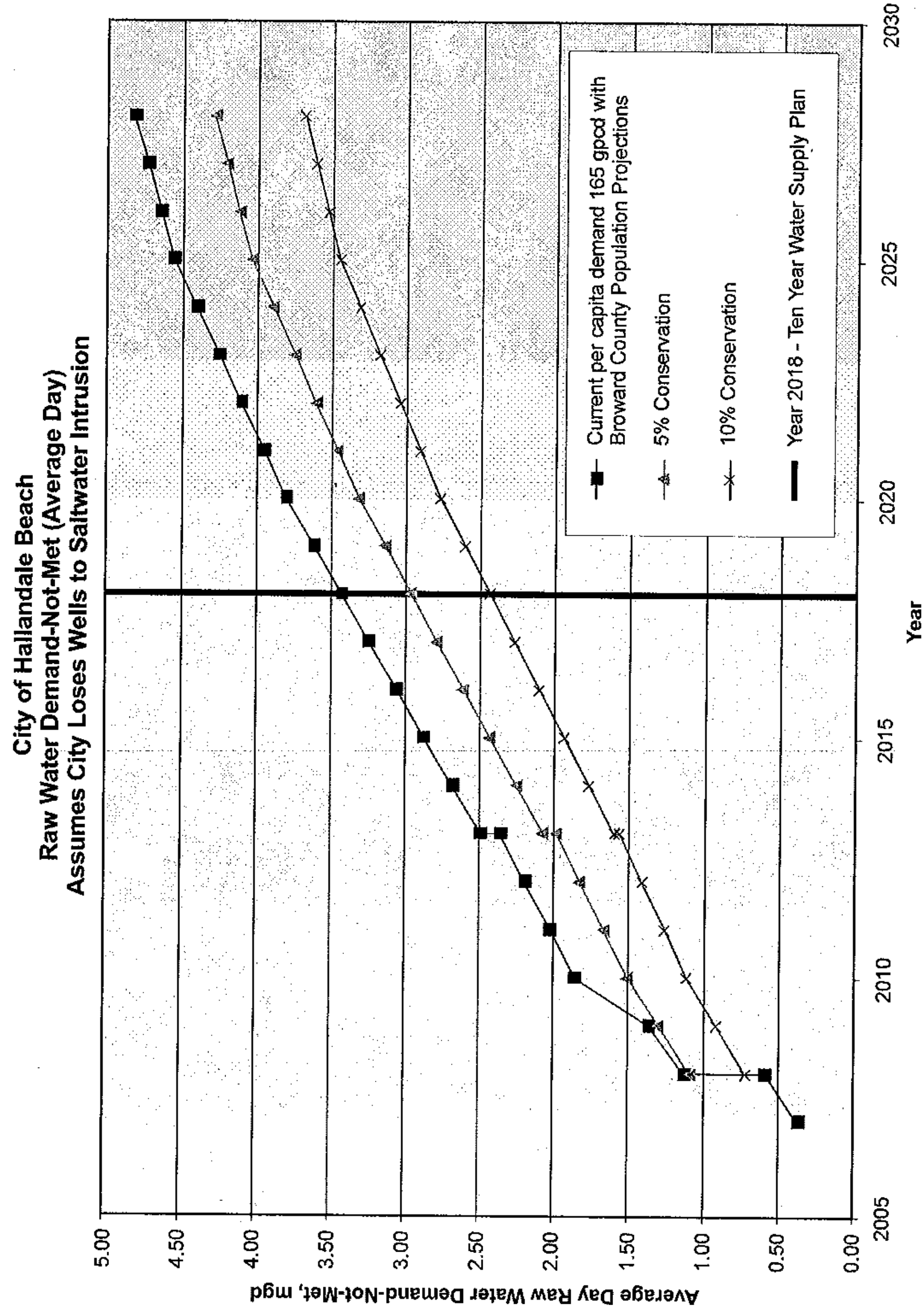


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**Figure 7**
Raw Water Demand-Not-Met (Average Day)

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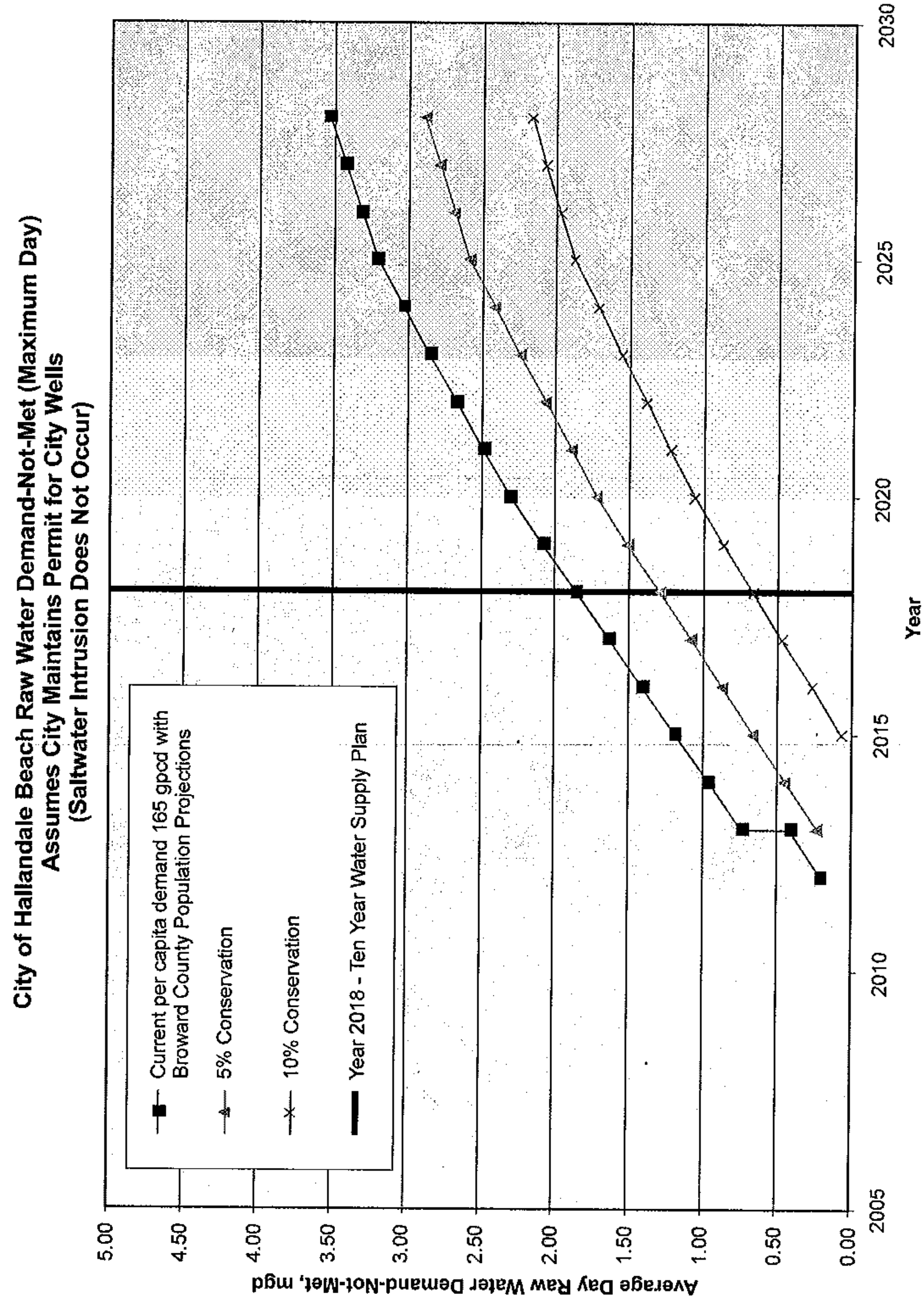


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**Figure 8**
Raw Water Demand-Not-Met (Maximum Day)

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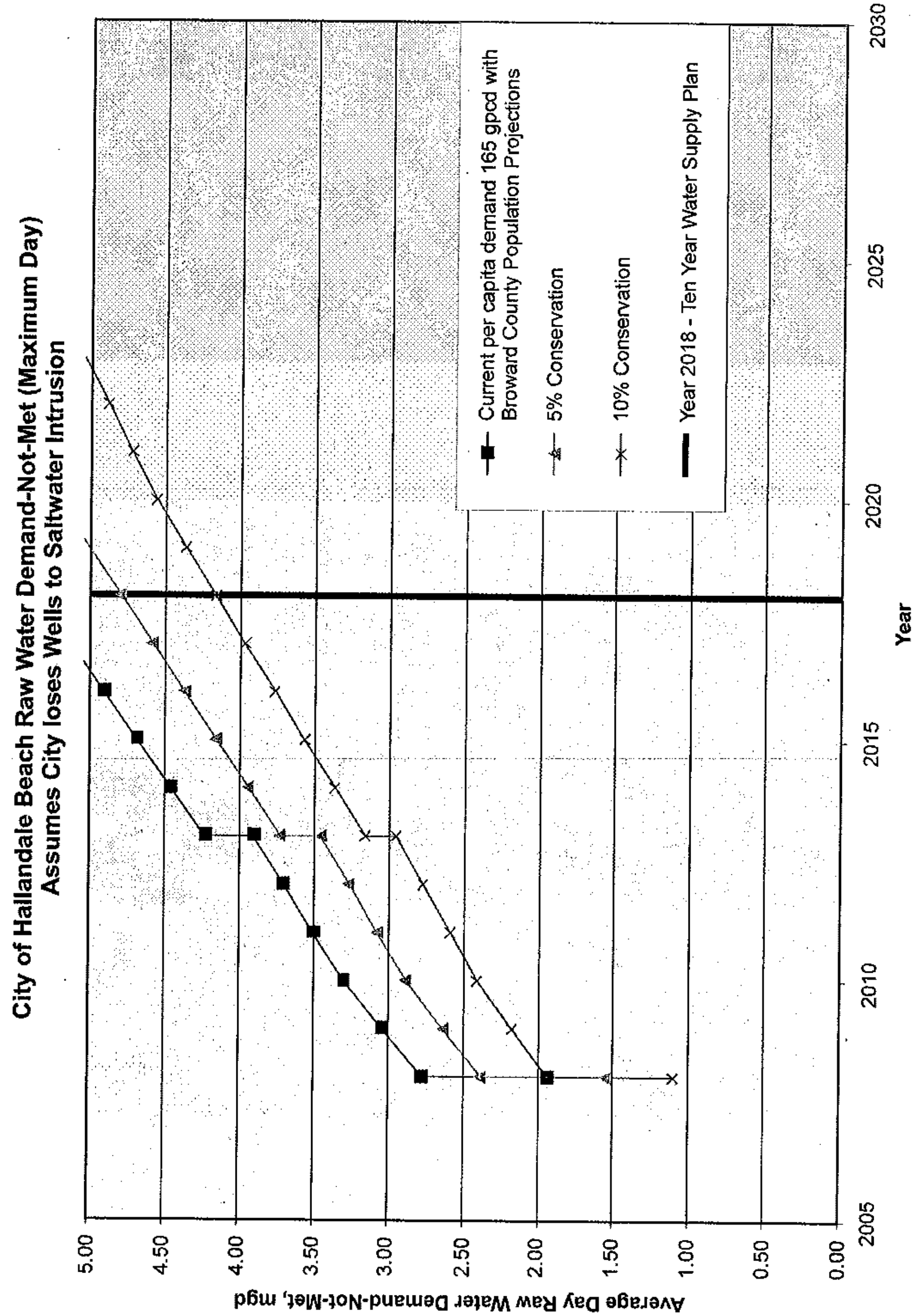


**Figure 9**

Raw Water Demand-Not-Met (Maximum Day)

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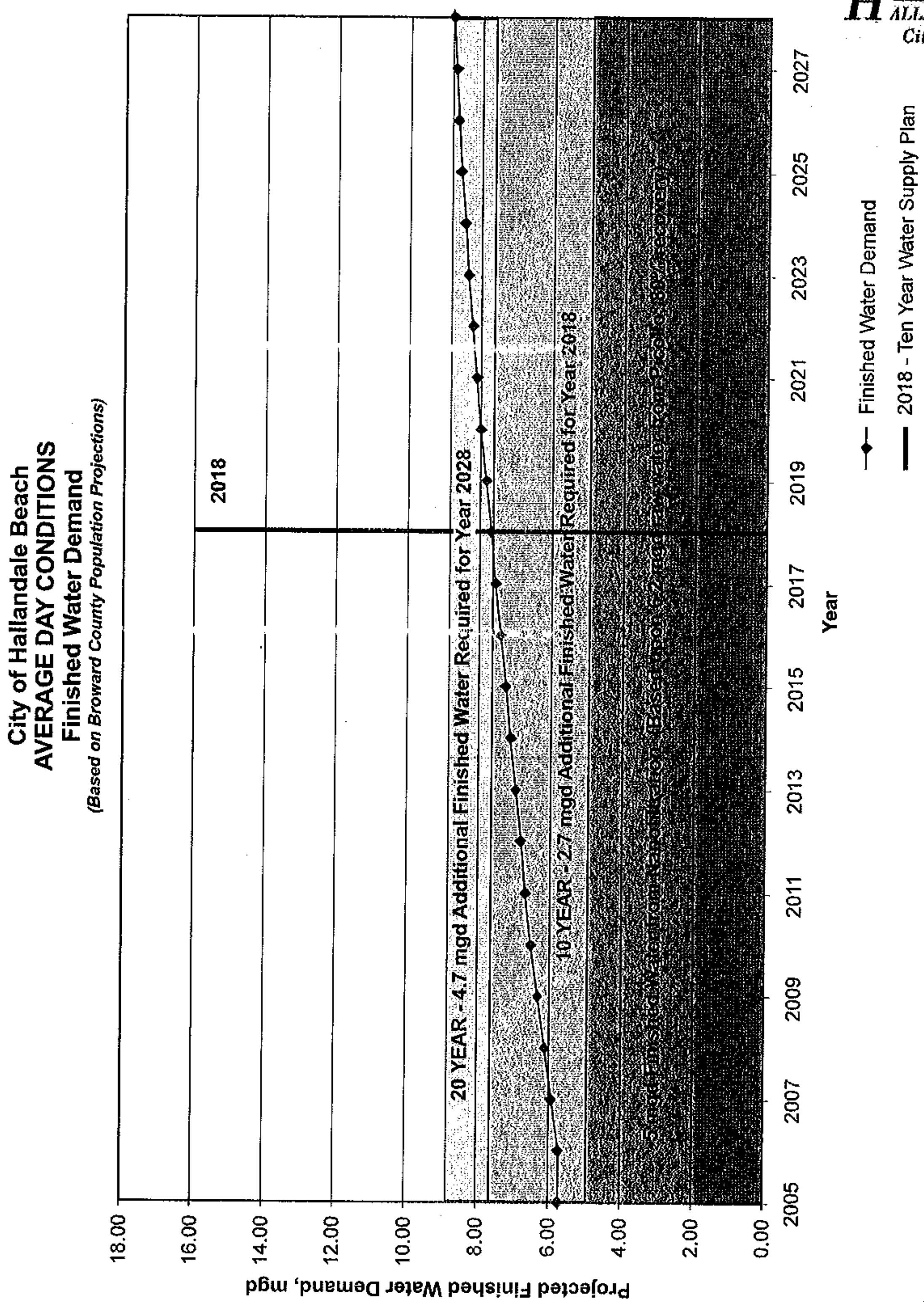


**Figure 10**
Projected Finished Water Demand
(Average Day)

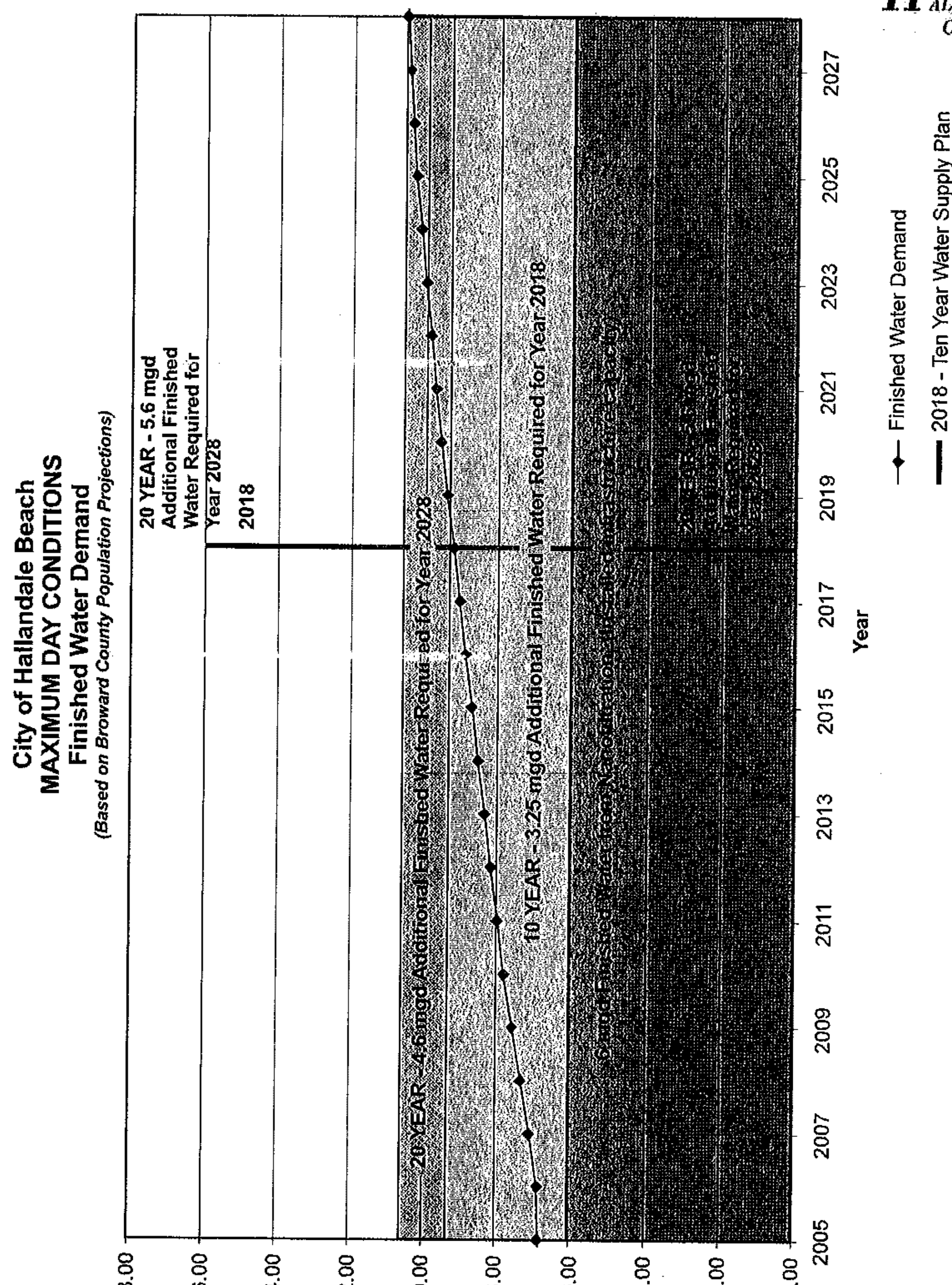


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**Figure 11**
Projected Finished Water Demand
(Maximum Day)

mgd above what the nanofiltration plant is capable of producing now for the 10-year planning period.

Table 3 provides a matrix of options for adding RO capacity to the NF facility. Selecting to limit the addition to two RO skids of 3 mgd each meets all of the criteria except for maximum day demand when one skid if out of service. The City should maintain their existing agreement with North Miami Beach, however, to purchase additional water to meet maximum day demand when one skid or feed pump is out of service. The City should consider, under this scenario, increasing the size of the interconnect and potentially the related distribution piping for higher flowrates that may be required.

**Table 3**
**City Of Hallandale Beach**
**Ten Year Water Supply Plan**
**Overview of Potential Configurations/Options**

| | Configurations for Consideration | Meets Average Day Demand | Meets Maximum Day Demand | Meets Average Day demand with 1 skid Out of Service | Meets Maximum Day Demand with 1 skid out of service | Total Installed Treatment Capacity | Total Treatment Capacity w/ 1 Skid Out of Service | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | Utilize exiting two 3 mgd NF skids<br>Add one 3 mgd RO skid | √ | X | X | X | 9 | 6 | Meets average day demands. Additional finished water would need to be purchased from North Miami Beach to meet maximum day demands and to meet average day demands when skid is out of service |
| 2 | Utilize existing two 3 mgd NF skids<br>Add two 3 mgd RO skids | √ | √ | √ | X | 12 | 9 | Meets maximum day requirement except when one skid (or pump) out of service |
| 3 | Utilize existing two 3 mgd NF skids<br>Add two 3 mgd RO skids<br>Add one 3 mgd NF skid | √ | √ | √ | √ | 15 | 12 | Provides additional infrastructure for plant redundancy |
| 4 | Utilize existing two 3 mgd NF skids<br>Add three 3 mgd RO skids | √ | √ | √ | √ | 15 | 12 | Provides additional infrastructure for plant redundancy |

1. *Average Day Finished Water = 7.70 mgd*
2. *Maximum Day Finished Water = 9.25 mgd*
3. *Configuration 2 will serve as the basis for the cost evaluation presented in this TM*

The City has multiple scenarios to consider to meet the ultimate 20-year planning period. Table 4 provides a matrix of options and criteria used to evaluate those options. For purposes of financial analyses over the 20-year planning period, the installation of one 3 mgd reverse osmosis skid in the space previously allocated for nanofiltration will be considered. This option is likely to be the highest cost alternative and the impact of this alternative will be presented for the City's review and consideration.

**Table 4**
**City of Hallandale Beach**
**Twenty Year Water Supply Plan**
**Overview of Potential Configurations / Options**

| | Configurations for Consideration | Meets Average Day Demand | Meets Maximum Day Demand | Meets Average Day Demand with 1 Skid Out of Service | Meets Max Day Demand with 1 Skid Out of Service | Total Installed Treatment Capacity | Total Treatment Capacity w/ 1 Skid Out of Service | Notes |
|---|---|---|---|---|---|---|---|---|
| 1 | Utilize existing two 3 mgd NF skids<br>Add two 3 mgd RO skids (under 10 yr plan) | √ | √ | √ | X | 12 | 9 | Requires purchases from North Miami Beach to meet maximum day when 1 skid out of service |
| 2 | Utilize existing two 3 mgd NF skids<br>Add two 3 mgd RO skids (under 10 yr plan)<br>Add one 3 mgd RO skid | √ | √ | √ | √ | 15 | 12 | |
| 3 | Utilize existing two 3 mgd NF skids<br>Add two 3 mgd RO skids (under 10 yr plan)<br>Add one 3 mgd NF skid | √ | √ | √ | √ | 15 | 12 | Requires additional withdrawals from the Biscayne Aquifer permittable in future |
| 4 | Utilize existing two 3 mgd NF skids<br>Add two 3 mgd RO skids (under 10 yr plan)<br>Utilize lime softening | √ | √ | √ | √ | 15 | 12 | Requires that lime softening plant remain operational<br>Requires additional withdrawals from the Biscayne Aquifer permittable in future |

*1. Average Day Finished Water = 8.8 mgd*
*2. Maximum Day Finished Water = 10.6 mgd*

## 4.0 Conceptual Water Supply and Distribution System

In order to supply water for reverse osmosis treatment for the ten year water supply plan, the City would need to drill and develop wells to the Floridan Aquifer and construct pumping systems and conveyance pipelines to transmit the raw water to the water treatment plant for RO treatment. A typical production capacity for Floridan Aquifer wells in this region is approximately 2 mgd, though modeling and pilot testing should be performed to confirm this yield prior to design of the wellfield. Therefore, to supply adequate raw water (8 mgd) to produce 6 mgd through two 3 mgd RO skids at 75 - 80% recovery, four wells of 2 mgd each will be required. A redundancy of 20% is recommended for raw water supply, or one additional well such that if one well is out of service, the raw water requirement for treatment can still be met. Thus, the ten year water supply plan should include the drilling, developing, and equipping of five wells. If a third RO skid is added to the plant under the twenty year supply plan, two additional raw water wells would be required.

Though modeling and testing of these wells should be performed to estimate drawdown and spacing requirements prior to design, it is assumed for planning purposes that these wells should be at least approximately 1000 feet apart. In order to prepare a preliminary cost opinion for the raw water supply and conveyance portion of this project, the wells were preliminary sited in the area around the plant. The conceptual wellfield is bordered by I-95 to the west, Pembroke Road to the north, Dixie Highway to the east, and Hallandale Beach Boulevard to the south. This configuration minimizes the effects of constructing the conveyance system through major thoroughfares and utility corridors since much of this area is zoned as medium residential and low-medium residential.

In order to minimize raw water conveyance costs, the wells were preliminarily sited as close to the water treatment plant as possible. One well is assumed to be drilled onsite at the water treatment plant while the remaining wells are assumed to be constructed on city-owned property near the water treatment plant. Figure 12 shows the approximate locations of these wells and the pipe layouts for the ten year water supply plan. It should be noted that these sites are preliminary and have not been investigated or discussed with city personnel for feasibility; the locations were selected solely to estimate potential cost for construction.

Table 5 provides a description of each of the well locations.

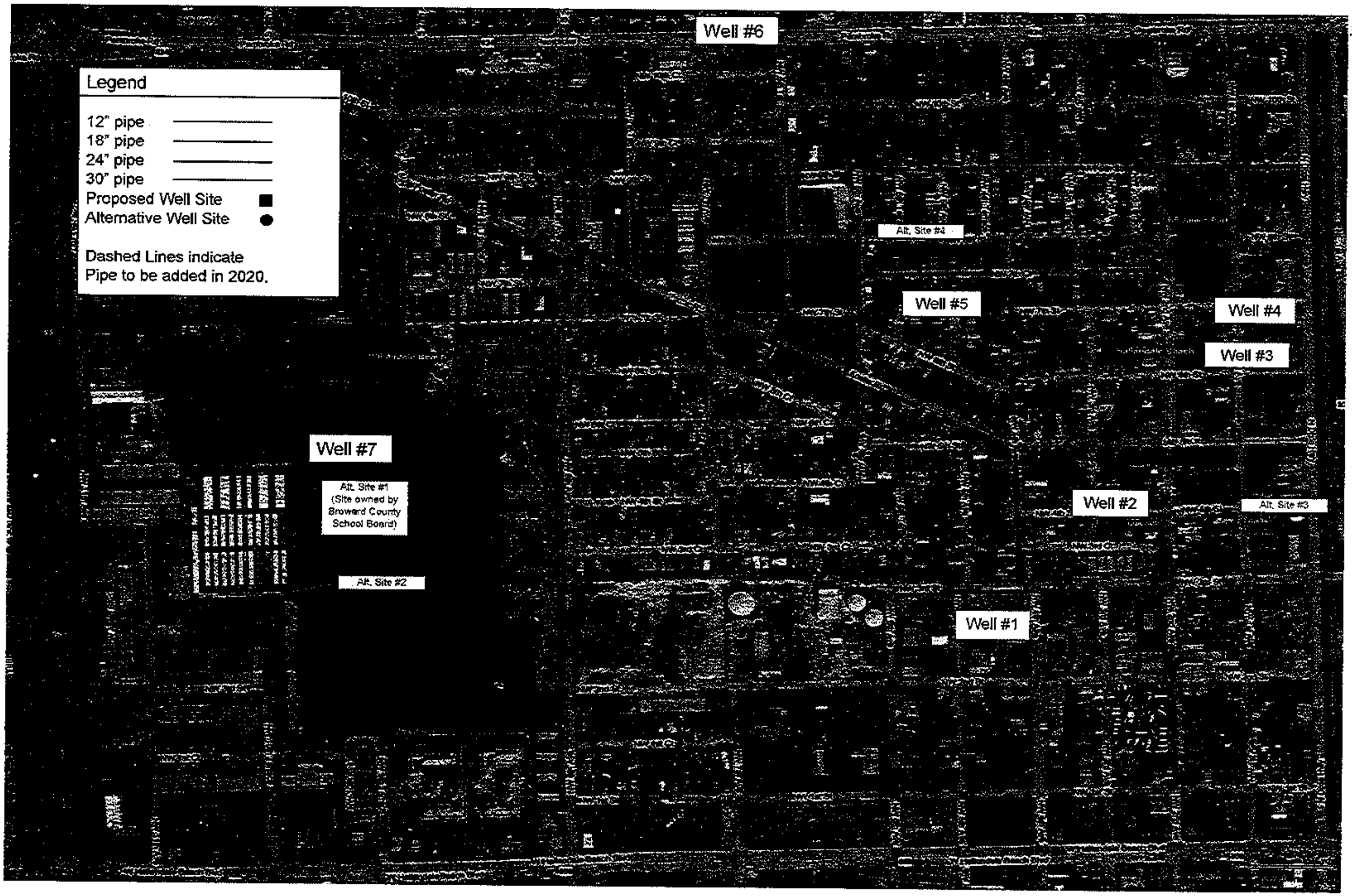


**Figure 12**
Conceptual Floridan Aquifer Wellfield

**Table 5**
**Well Site Description for the Ten Year Water Supply Plan**

| Well Designation | Description of Site |
|---|---|
| Well #1 | On-site of the Hallandale Beach Water Treatment Plant |
| Well #2 | Two adjoining parcels owned by City of Hallandale Beach (Folio # 514222040411 and 514222040460. Combined area is approx. 16,800 sq. ft. |
| Well #3 | Seven adjoining parcels owned by City of Hallandale Beach. Combined area of parcels is approx. 81,500 sq. ft. |
| Well #4 | B.F. James Park – owned by City of Hallandale Beach |
| Well #5 | Foster Park – owned by City of Hallandale Beach |

Each well site will require an area of approximately 3000 square feet for construction. A conceptual layout for a typical wellhead is shown in Figure 13. Though a construction easement of approximately 3000 square feet will be needed to construct the well, each well head will require a fenced area of approximately 700 square feet.

Additionally, easements will need to be obtained to construct the raw water conveyance pipelines. Pipe diameters were selected by limiting the flow velocity to approximately four feet per second. The pipeline extending to Well #5 however, should be 24" in diameter, large enough to accommodate the flows from two additional production wells to be added as part of the twenty year water supply requirement, if needed. The additional two wells for the twenty year water supply plan (designated as Well #6 and Well #7) are also shown in Figure 12.

Table 6 provides a description of each of these well locations for the twenty year water supply plan.

**Table 6**
**Well Site Descriptions for the 2020 Additions**

| Well Designation | Description of Site |
|---|---|
| Well #6 | Oreste Blake Johnson Park – owned by City of Hallandale Beach |
| Well #7 | Two adjoining parcels owned by City of Hallandale Beach (Folio # 514221010180 and 514221010182) located east of Hallandale High |

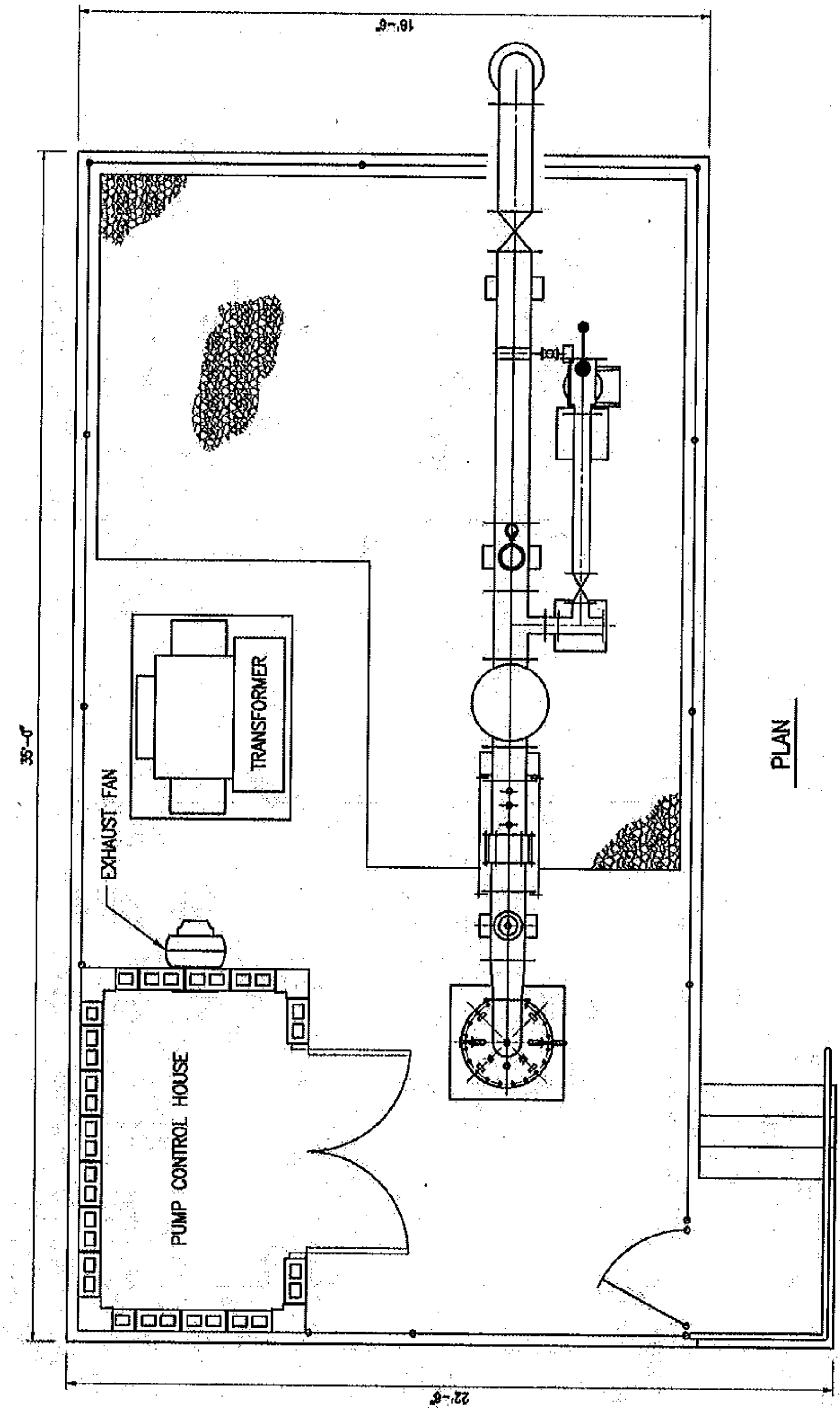


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**Figure 13**
Wellhead Plan

## 5.0 Conceptual RO Skid Addition and Membrane Plant Modifications

As presented previously, the existing membrane building houses two nanofiltration skids and has space available for two RO skids plus one additional nanofiltration or RO skid. The 10-year water supply planning effort includes the addition of two RO skids. The addition of these skids will require related feed pumps, energy recovery turbines, process piping, pretreatment chemical feed systems, cartridge filtration, cleaning system connections, concentrate booster pump additions, and an additional degasifier with dedicated odor control. Additionally, the increase in plant production may require transfer pump additions or changeouts and high service pumping improvements. Also, to stabilize the aggressive membrane softened water, hydrated lime and/or recarbonation facilities may be required.

A second deep injection well is recommended for the disposal of concentrate from the RO skids. The existing well has adequate capacity for the disposal of the concentrate from two RO skids; however it does not have adequate capacity to dispose of the startup flow (permeate plus concentrate) of one RO skid when disposing of concentrate from two nanofiltration skids already in service. Additionally, the City's present backup plan for concentrate disposal during mechanical integrity test (MIT) of the well every 2½ years, is to dispose of the concentrate from one skid to sanitary sewer. Since more than one skid will be in service and the sanitary sewer capacity is limited to one skid's concentrate flow, a redundant well is required to provide adequate disposal capacity.

The original electrical design for the membrane plant included provisions to facilitate the future potential addition of reverse osmosis treatment capacity. However, miscellaneous electrical modifications and upgrades will be required to accommodate the 6.0 mgd reverse osmosis expansion. These electrical modifications will include modifications to the electrical system at the membrane building, backup power system, and postreatment facilities including transfer and high service pumping. A second emergency generator would be provided to provide backup power for the facilities associated with the RO expansion. Additional fuel storage is also recommended.

The addition of the two RO skids will require expansion of the existing plant control system hardware and software. Programmable logical controllers (PLC) or remote input/output (I/O) control panels will be required for new unit processes or systems. Additional I/O and communication modules will be added to existing control panels as required. The existing HMI and OIT applications will be expanded as required.

A process flow diagram showing these proposed facilities is presented in Figure 14. A site plan showing the location of the proposed improvements and upgrades is presented in Figure 15. The RO skids and associated piping, feed pumps, pretreatment, and ancillary equipment will be located inside the membrane building. Scale inhibitor (for RO) bulk storage would be located near the membrane building. The postreatment degasifier will be located on top of the existing

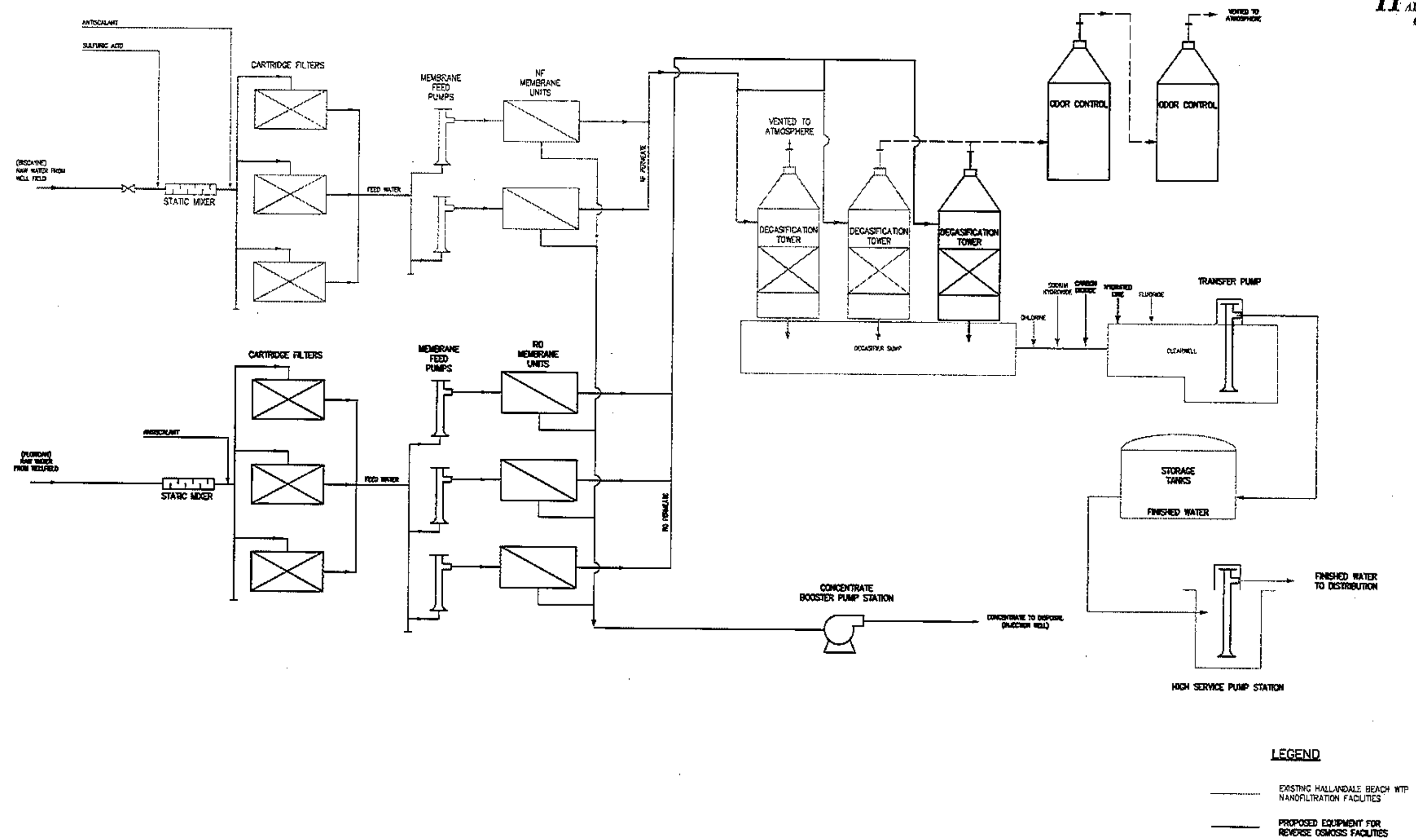


**Figure 14**
Process Flow Diagram

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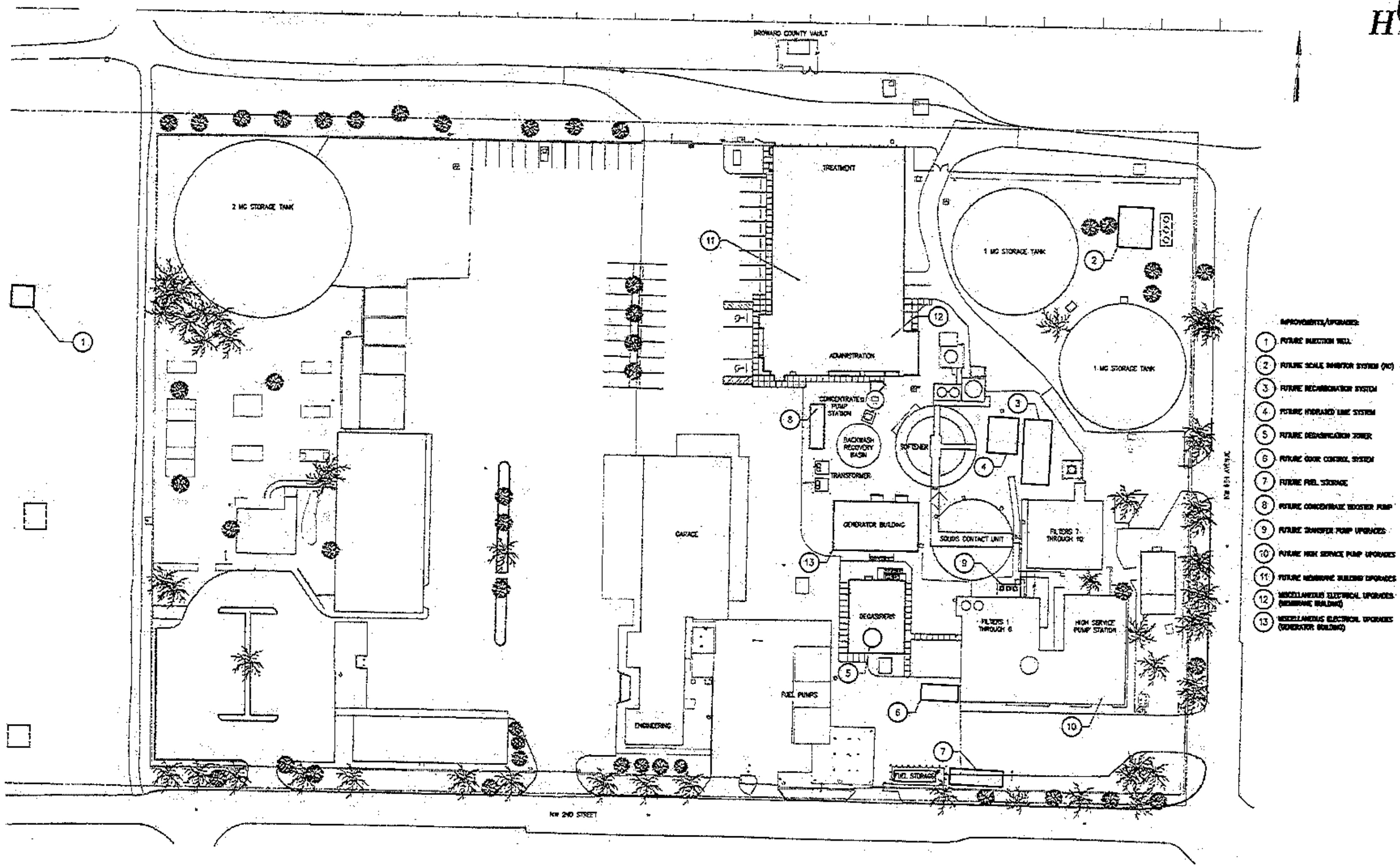


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**Figure 15**
Expansion Recommendations to the Membrane Building and Overall Site Plan

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postreatment facility, next to the two degasifiers dedicated to the nanofiltration skids. The degasifier for RO will require odor control, which could be ducted from the third degasifier over to the south side of the existing chlorine building. The odor control system will require sodium hydroxide storage and feed as well as sodium hypochlorite, which should both be located near the addition point. Future facilities for hydrated lime and/or recarbonation could be located in the vicinity of the existing lime softening facility.

The process equipment required within the membrane building is shown in Figure 16. The RO skids, feed pumps, energy recovery turbines/interstage boost pumps, and the cartridge filters will be located to the west side of the process trench.

For purposes of developing conceptual costs, conservative projections of reverse osmosis skid performance were calculated. These projections assumed Floridan Aquifer water quality with a total dissolved solids concentration of approximately 7800 mg/L. The assumed raw water quality and the resulting membrane skid performance and skid sizing is shown in Table 7 below. These projections were developed using a modeling software program by Dow Filmtec; other manufacturers of reverse osmosis elements exist with similar results.

**Table 7**
**Projected Reverse Osmosis Membrane Performance**

| **Projected Skid Configuration** | **Dow Filmtec** |
|---|---|
| Membrane Element Model Number | BW30-400 |
| Membrane Surface Area per Element (sq.ft.) | 400 |
| Elements per Pressure Vessel (#) | 6 |
| 1st Stage Pressure Vessels (#) | 60 |
| 2nd Stage Pressure Vessels (#) | 30 |
| 1st Stage Elements Total (#) | 360 |
| 2nd Stage Elements Total (#) | 180 |
| Total Membrane Elements (#) | 540 |
| Average Flux Rate (gfd) | 14 |
| Feed Pressure (psi)1 | 305 |
| Permeate Recovery Rate (%) | 75 |
| Fouling Factor | 0.85 |
| Sulfuric Acid (100 percent) Dose | None |
| **Assumed Floridan Raw Water Quality** | |
| TDS (mg/L) | 7,790 |
| Calcium (mg/L) | 244 |
| Magnesium (mg/L) | 324 |
| Sodium (mg/L) | 2,190 |
| Barium (mg/L) | 0.44 |
| Strontium (mg/L) | 12 |
| Ammonium (mg/L) | 1.50 |
| Bicarbonate (mg/L) | 170 |

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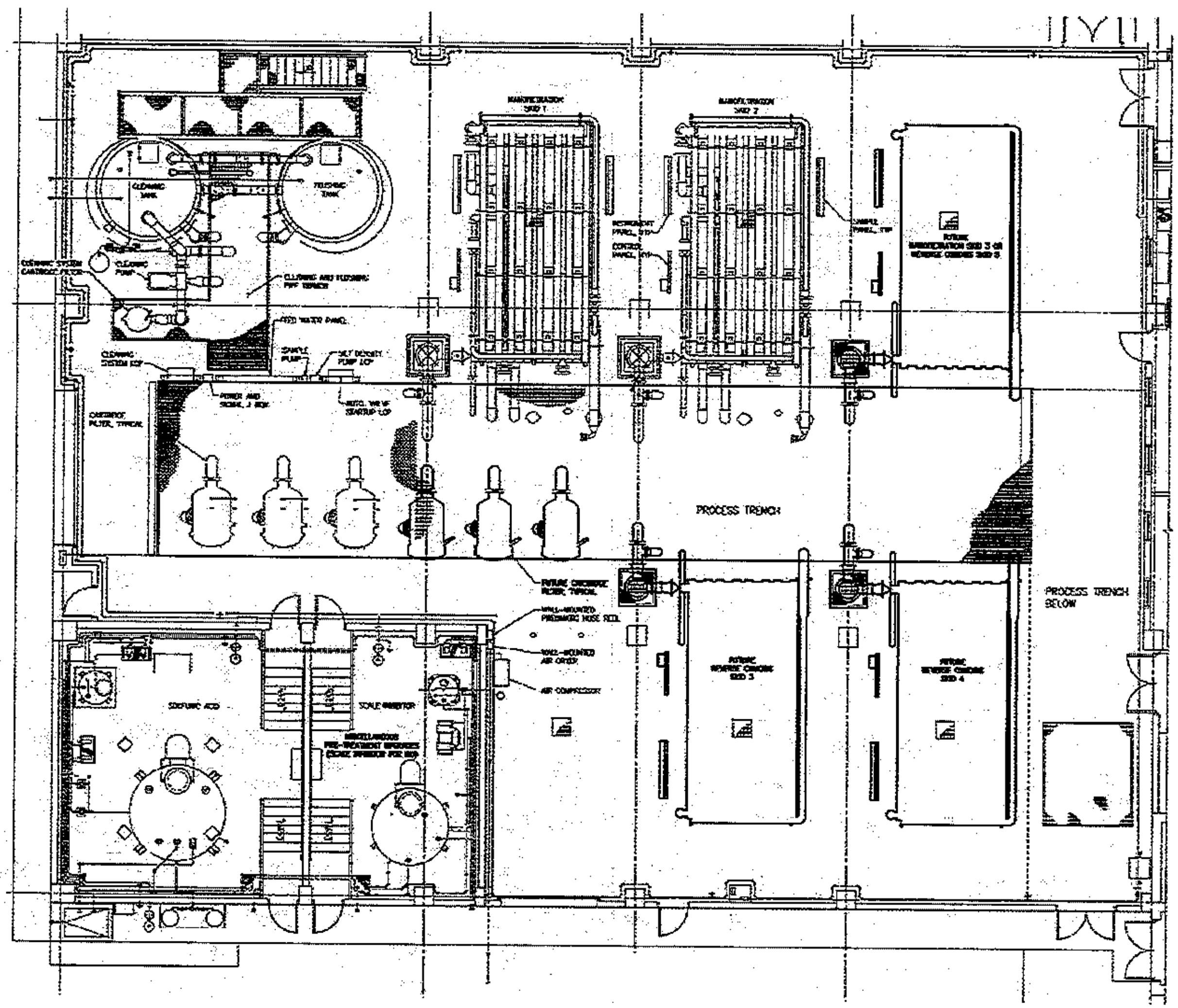


**Figure 16**
Miscellaneous Upgrades Inside the Membrane Building

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**Table 7**
**Projected Reverse Osmosis Membrane Performance**

| Projected Skid Configuration | Dow Filmtec |
|---|---|
| Sulfate (mg/L) | 630 |
| Chloride (mg/L) | 4,200 |
| Fluoride (mg/L) | 1.1 |
| pH | 7.9 |
| **Permeate Water Quality** | |
| TDS (mg/L) | 123 |
| Calcium (mg/L) | 2.21 |
| Magnesium (mg/L) | 2.98 |
| Sodium (mg/L) | 40.4 |
| Total Hardness (mg/L as $CaCO_3$) | 17.7 |
| Barium (mg/L) | 0.00 |
| Strontium (mg/L) | 0.11 |
| Ammonium (mg/L) | 0.03 |
| Bicarbonate (mg/L) | 3.47 |
| Sulfate (mg/L) | 4.00 |
| Chloride (mg/L) | 70.0 |
| Fluoride (mg/L) | 0.03 |
| Total Alkalinity (mg/L as $CaCO_3$) | 2.84 |
| pH | 6.21 |
| **Concentrate Water Quality** | |
| TDS (mg/L) | 30,773 |
| Calcium (mg/L) | 971 |
| Magnesium (mg/L) | 1286 |
| Sodium (mg/L) | 8,645 |
| Barium (mg/L) | 1.75 |
| Strontium (mg/L) | 47.0 |
| Ammonium (mg/L) | 5.90 |
| Bicarbonate (mg/L) | 643 |
| Sulfate (mg/L) | 2,508 |
| Chloride (mg/L) | 16,581 |
| Fluoride (mg/L) | 4.32 |
| pH | 7.6 |

*Notes:*
[1] *Includes 20 psi total permeate backpressure assumption.*

The projections yield a membrane array size of 60 first stage pressure vessels by 30 second stage pressure vessels, with six RO elements installed in each pressure vessel. The required feed pressure of 305 psi will require a 500 hp feed pump plus an energy recovery turbine/interstage booster pump, to reduce the overall electrical power requirements by about 20%.

These sizing assumptions, and those listed below, form the basis for the conceptual cost preparation:

**Table 8**
**Conceptual Overview of Major Elements**
**Required for 6 mgd RO Addition**

| Process Element | Requirement |
|---|---|
| Raw Water Pipeline | 600 ft on-site |
| Conditioned Water Pipeline | 30 feet in trench |
| Pretreatment System | 2 cartridge filters |
| Sulfuric Acid | Metering pumps only |
| Antiscalant | Storage and feed |
| Feed Pumps | Two 500 hp |
| Energy Recovery Turbines/ Interstage Boost Pump | 1 per skid |
| RO Skids | 60 first stage pressure vessels, 30 second stage; 6 elements each |
| Permeate Pipeline | 360 feet |
| Postreatment | 1 degasifier with odor control and associated chemical systems |
| Stabilization | Recarbonation facility and hydrated lime addition |
| Concentrate Pipeline | 600 feet |
| Concentrate Booster Pump | One additional |
| Concentrate disposal | Injection well |
| Transfer Pumps | Two additional pumps |
| High Service Pumps | As identified in Water Model Update Report |
| Emergency generator | One 2000 kw |
| Fuel Storage | One additional tank |

Modifications to the facility to incorporate a fifth skid for the 20-year water supply plan would include one additional cartridge filter for pretreatment, RO (or NF) skid addition, feed pump and energy recovery turbine/interstage boost pump addition and associated piping and ancillary system modifications. Additional postreatment modifications may also be required for stabilization (e.g. hydrated lime, recarbonation).

## 6.0 Preliminary Opinion of Conceptual Cost

For planning and evaluation purposes, the conceptual construction cost estimate is presented in Table 9 below for the raw water supply and conveyance system for the ten year water supply plan.

**Table 9**
**Engineer's Preliminary Opinion of Probable Project Cost**
**City of Hallandale Beach Floridan Aquifer Supply Wells**
**Ten Year Water Supply Plan**

| Item | Quantity | Unit | Installed Unit Cost | Total (Rounded) |
|---|---|---|---|---|
| **FAS Production Wells** | | | | |
| Site Preparation | 1 | lump sum | $30,000 | $30,000 |
| FAS Production Well Drilling and Developing | 5 | each | $1,500,000 | $7,500,000 |
| Wellhead access roads | 150 | feet | $150 / foot | $20,000 |
| Pumps and appurtenances | 5 | each | $120,000 | $600,000 |
| Wellhead mechanical (piping, valves, etc.) | 5 | each | $100,000 | $500,000 |
| Wellhead structural (includes well site fence) | 5 | each | $60,000 | $300,000 |
| Well site landscaping | 5 | each | $25,000 | $120,000 |
| Wellfield electrical | 1 | lump sum | $2,800,000 | $2,800,000 |
| Wellfield instrumentation and controls | 1 | lump sum | $800,000 | $800,000 |
| **Raw Water Transmission System** | | | | |
| 12-in HDPE Pipe (with road restoration) | 1900 | LF | $125 | $240,000 |
| 18-in HDPE Pipe (with road restoration) | 500 | LF | $175 | $90,000 |
| 24-in HDPE Pipe (with road restoration) | 900 | LF | $250 | $230,000 |
| 30-in HDPE Pipe (with road restoration) | 1300 | LF | $310 | $400,000 |
| Valves and valve boxes | 1 | lump sum | $285,000 | $290,000 |
| **Construction Cost Subtotal** | | | | **$13,920,000** |
| Contingency (estimated at 30 percent of subtotal)1 | | | | $1,930,000 |
| Subtotal with contingency | | | | $15,850,000 |
| Planning/Testing/Design/Engineering Services (estimated at 20 percent of subtotal ) | | | | $3,170,000 |
| **Engineer's Preliminary Opinion of Probable Project Cost (2008 Dollars)** | | | | **$19,020,000** |

[1] *The subtotal used to estimate the contingency does not include the drilling costs since the well drilling cost is a negotiated item based on recent well drillings.*

The conceptual cost estimate for the water treatment plant modifications is presented in Table 10 below.

**Table 10**
**Engineer's Preliminary Opinion of Probable Project Cost – City of Hallandale Beach**
**6 MGD RO Addition**
**Ten Year Water Supply Plan**

| Item | Quantity | Unit | Installed Unit Cost | Total |
|---|---|---|---|---|
| **Water Pretreatment** | | | | |
| Cartridge Filtration | 2 | each | $150,000 | $300,000 |
| Sulfuric Acid System | 1 | lump sum | $60,000 | $60,000 |
| Scale Inhibitor System | 1 | lump sum | $140,000 | $140,000 |
| **Water Treatment** | | | | |
| RO Skids | 2 | each | $1,100,000 | $2,200,000 |
| RO Feed Pumps | 2 | each | $300,000 | $600,000 |
| Energy Recovery | 2 | each | $60,000 | $120,000 |
| Cleaning/Flushing System (piping) | 1 | lump sum | $50,000 | $50,000 |
| **Postreatment/Pumping** | | | | |
| Sodium Hydroxide (pH adjustment) | 1 | lump sum | $90,000 | $90,000 |
| Sodium Hydroxide & Sodium Hypochlorite (odor control) | 1 | lump sum | $200,000 | $200,000 |
| Degasification System | 1 | lump sum | $300,000 | $300,000 |
| Odor Control System | 1 | lump sum | $500,000 | $500,000 |
| Recarbonation System and Hydrated Lime Systems | 1 | lump sum | $500,000 | $500,000 |
| Fluoride | 1 | lump sum | $50,000 | $50,000 |
| Transfer Pumps | 2 | each | $110,000 | $220,000 |
| High Service Pumps[1] | 1 | lump sum | $3,350,000 | $3,350,000 |
| **Concentrate Disposal** | | | | |
| Concentrate Booster Pump | 1 | each | $60,000 | $60,000 |
| Injection Well[2] | 1 | lump sum | $7,000,000 | $7,000,000 |
| **Pipelines (pipe/valves/fittings/etc)** | 1 | lump sum | | $500,000 |
| **Electrical** | 1 | lump sum | | $2,000,000 |
| **Instrumentation and Control** | 1 | lump sum | | $800,000 |
| **Building Modifications and Site Work** | 1 | lump sum | | $200,000 |
| **General Requirements** | 1 | lump sum | | $1,000,000 |
| **Construction Cost Subtotal** | 1 | lump sum | | **$20,240,000** |
| Estimating Contingency (estimated at 30 percent of subtotal)[4] | | | | $3,930,000 |
| Subtotal with contingency | | | | $24,170,000 |
| Testing/Design/Engineering/Oversight Services (estimated at 20 percent of subtotal with contingency) | | | | $4,830,000 |
| **Engineer's Preliminary Opinion of Probable Project Cost (2008 Dollars)** | | | | **$29,000,000** |

*Notes:*

1. *High service pump costs were identified in the water/wastewater model updates report, 2007. These costs were not included in the previous conceptual cost estimate provided to the City in January 2007.*
2. *The injection well cost is based on recent negotiated costs for a 24" diameter well.*
3. *The electrical costs include the addition of one 2 MW emergency generator.*
4. *The subtotal used to estimate the contingency does not include the Injection Well cost since the well drilling cost is a negotiated item based on recent well drillings.*

A summary of the conceptual costs for the ten-year water supply plan for reverse osmosis addition and raw water supply provisions is shown in Table 11 below.

**Table 11**
**City of Hallandale Beach - 6 MGD RO Expansion**
**Ten Year Water Supply Plan**
**(Addition of two RO Skids)**

| | |
|---|---|
| Water Supply and Conveyance | $13,920,000 |
| Water Pretreatment | $20,240,000 |
| Construction Cost Subtotal | $34,160,000 |
| Estimating Contingency (estimated at 30 percent of subtotal)[1] | $5,860,000 |
| Subtotal with contingency | $40,020,000 |
| Testing/Design/Engineering/Oversight Services (estimated at 20 percent of subtotal with contingency ) | $8,000,000 |
| **Engineer's Preliminary Opinion of Probable Project Cost (2008 Dollars)** | **$48,020,000** |

1 *The subtotal used to estimate the contingency does not include the well drilling costs (raw water nor injection well) since the well drilling costs are a negotiated item based on recent well drillings.*

The City has expressed interest in considering the addition of one RO skid with two Floridian Aquifer wells as a lower cost option. This option would save approximately $10 - 12 million dollars, offsetting that dollar amount to a future date for skid and well construction.

Similarly, if one additional RO (or NF) skid is required for the twenty year water supply plan, the additional capital expenditure is approximately $12 million, as shown in Table 12 below.

**Table 12**
**City of Hallandale Beach - 6 MGD WTP RO Expansion**
**Twenty Year Water Supply Plan**
**(Addition of third 3 mgd Reverse Osmosis Skid to Existing NF/RO Facility)**

| | |
|---|---|
| Water Supply and Conveyance | $5,000,000 |
| Water Pretreatment | $3,520,000 |
| Construction Cost Subtotal | $8,520,000 |
| Estimating Contingency (estimated at 30 percent of subtotal)[1] | $1,660,000 |
| Subtotal with contingency | $10,180,000 |
| Testing/Design/Engineering/Oversight Services (estimated at 20 percent of subtotal with contingency ) | $2,040,000 |
| **Engineer's Preliminary Opinion of Probable Project Cost (2008 Dollars)** | **$12,220,000** |

[1] *The subtotal used to estimate the contingency does not include the well drilling costs since the well drilling costs are a negotiated item based on recent well drillings.*

The anticipated operation and maintenance cost for a membrane plant of this size is approximately $1.25 per 1000 gallons of finished water. This cost includes the following:

- Power
- Chemicals
- Replacement Parts and Materials
  - Membrane Replacement
  - Cartridge Filter Replacement
- Operation Labor
- Maintenance Labor
- Administration/Regulatory Compliance

The operation and maintenance costs were estimated based on data presented in the report titled Water Supply Cost Estimation Study, published by the SFWMD in February 2007. The report was prepared by Camp Dresser and McKee.

## 7.0 Conceptual Implementation Schedule

Figure 17 provides a preliminary implementation schedule for the addition of RO treatment to the Hallandale Beach membrane plant. Including planning, testing, design, construction, and startup, the project delivery will require approximately five years.

The City may consider pursuing the RO addition in phases while they evaluate other alternatives for alternative water supply. The first phase shown on the schedule provides for concurrent well development with preparation of a Basis of Design Report (BODR) for the RO skid addition. This initial phase includes groundwater modeling to determine design parameters for the wellfield. It would also include the design, drilling and developing of at least one full size well initially so that membrane pilot testing can be performed prior to the design of the facility. However, the City may desire to drill two wells initially so that they may also examine potential drawdown effects of the wells to determine ultimate well spacing and sizing guidelines. This phase is a critical phase because data will be determined during the development of these wells that will ultimately affect the sizing and pricing of the facilities.

The second phase includes pilot testing of RO elements directly using a Floridan Aquifer well for supply. This phase includes the development of the pilot study plan, the execution of the pilot study, and the interpretation of pilot study results for process mechanical design of the facility.

The third phase includes the design, permitting, bidding or negotiating, construction, development, and equipping of the remaining Floridan Aquifer wells. This phase also includes the design, permitting, bidding, and construction of the wellfield conveyance pipeline and appurtenances. The design and construction of the injection well could also be included in this phase to be in concordance with the design and construction of the raw water wells.

The fourth phase includes the design, permitting, bidding, construction, and startup of the RO facilities. The design of the RO facilities will utilize data obtained during the Phase 2 RO element testing.

The City desires to implement water conservation and water purchases from other facilities first prior to initiating the Floridian Aquifer development and RO skid addition. This may help to offset the implementation of RO facilities. However, the City should consider that the implementation of RO may require a total of up to five years. If the City elected to initiate the project in Spring 2008, then the project completion date could be early to mid-2013. Other approaches to minimize project schedule may be available; however, the schedule presented herein is appropriate for maximizing data collection and incorporation into design.

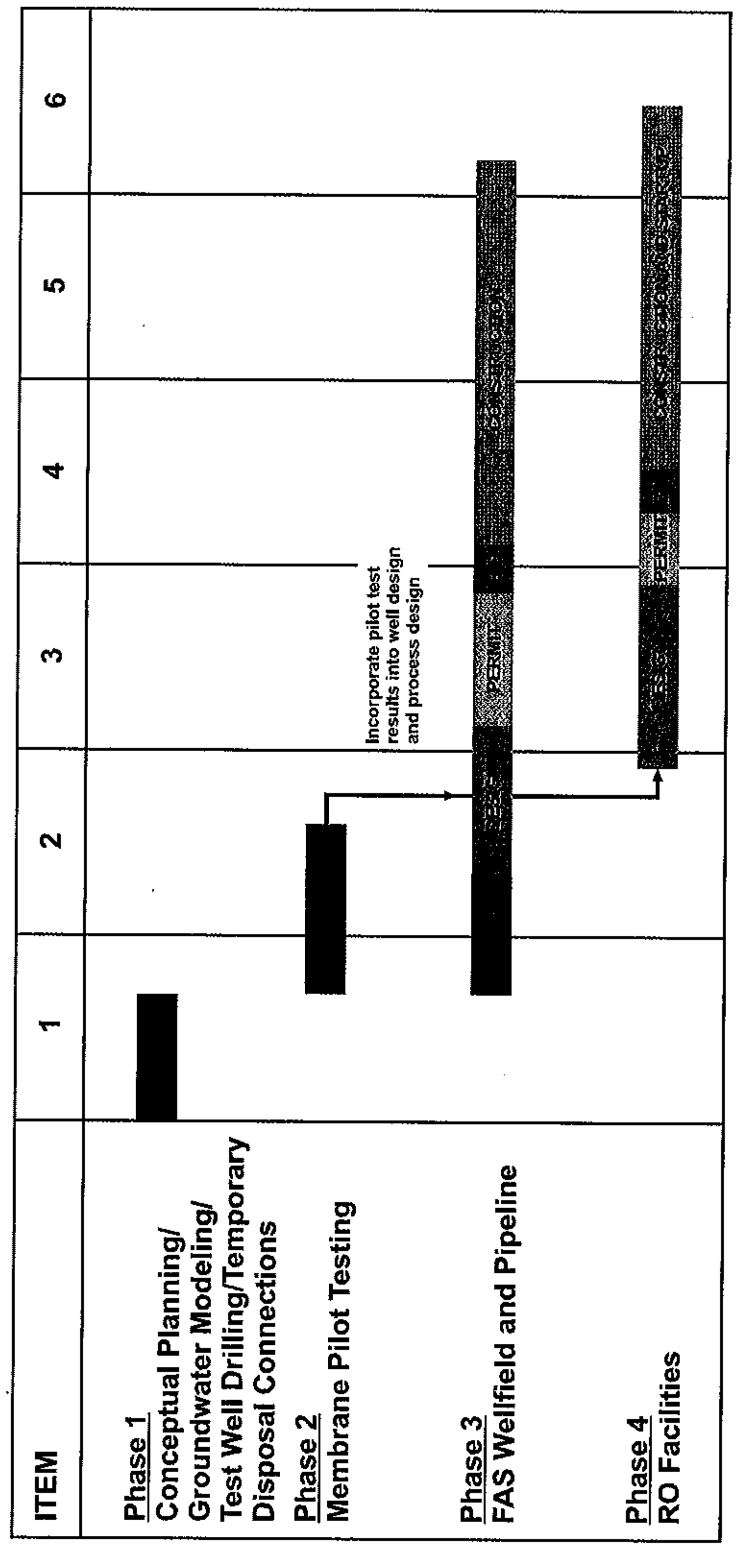


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**Figure 17**
Preliminary Implementation Schedule

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# Appendix A

40406-001B001.CDR

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City of Hallandale Beach

Forecasted Average Finished Water Demand and Average Raw Water Demand

| Year | Population | Average Day FW Demand | | | | Average Day RW Demand | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A -Water Model Report | B - @165 gpcd (FW) | C - 5% conservation | D - 10% conservation | Historical | A -Water Model Report | B - @165 gpcd (FW) | C - 5% conservation | D - 10% conservation |
| 2000 | 34282 | | 5.66 | 5.38 | 5.07 | | | 6.29 | 5.98 | 5.64 |
| 2001 | 34339 | | 5.67 | 5.39 | 5.08 | | | | | |
| 2002 | 34395 | | 5.68 | 5.40 | 5.09 | 5.82 | | 6.31 | 6.00 | 5.66 |
| 2003 | 34452 | | 5.68 | 5.41 | 5.10 | 5.82 | | 6.32 | 6.01 | 5.67 |
| 2004 | 34509 | | 5.69 | 5.42 | 5.11 | 5.83 | | 6.33 | 6.02 | 5.67 |
| 2005 | 34565 | 6.20 | 5.70 | 5.43 | 5.12 | 5.84 | 6.46 | 6.34 | 6.03 | 5.68 |
| 2006 | 34622 | 6.53 | 5.71 | 5.44 | 5.12 | 5.85 | 6.81 | 6.35 | 6.04 | 5.69 |
| 2007 | 35818 | 6.86 | 5.91 | 5.62 | 5.30 | 5.82 | 7.15 | 6.57 | 6.25 | 5.89 |
| 2008 | 37014 | 7.19 | 6.11 | 5.81 | 5.48 | | 7.49 | 6.79 | 6.46 | 6.09 |
| 2008 | 37014 | 7.19 | 6.11 | 5.81 | 5.48 | | 8.63 | 7.33 | 7.29 | 6.92 |
| 2009 | 38210 | 7.88 | 6.30 | 6.00 | 5.66 | | 9.46 | 7.57 | 7.50 | 7.12 |
| 2010 | 39406 | 8.57 | 6.50 | 6.19 | 5.83 | | 10.28 | 8.06 | 7.71 | 7.31 |
| 2011 | 40324 | 8.91 | 6.65 | 6.33 | 5.97 | | 10.69 | 8.23 | 7.87 | 7.46 |
| 2012 | 41242 | 9.26 | 6.80 | 6.47 | 6.10 | | 11.11 | 8.39 | 8.03 | 7.62 |
| 2013 | 42160 | 9.60 | 6.96 | 6.62 | 6.24 | | 11.52 | 8.56 | 8.19 | 7.77 |
| 2013 | 42160 | 9.60 | 6.96 | 6.62 | 6.24 | | 11.52 | 8.70 | 8.27 | 7.80 |
| 2014 | 43078 | 9.94 | 7.11 | 6.76 | 6.38 | | 11.93 | 8.88 | 8.45 | 7.97 |
| 2015 | 43996 | 10.29 | 7.26 | 6.91 | 6.51 | | 12.34 | 9.07 | 8.63 | 8.14 |
| 2016 | 44895 | 10.38 | 7.41 | 7.05 | 6.64 | | 12.45 | 9.26 | 8.81 | 8.31 |
| 2017 | 45795 | 10.47 | 7.56 | 7.19 | 6.78 | | 12.56 | 9.45 | 8.99 | 8.47 |
| 2018 | 46694 | 10.56 | 7.70 | 7.33 | 6.91 | | 12.67 | 9.63 | 9.16 | 8.64 |
| 2019 | 47594 | 10.65 | 7.85 | 7.47 | 7.04 | | 12.77 | 9.82 | 9.34 | 8.80 |
| 2020 | 48493 | 10.74 | 8.00 | 7.61 | 7.18 | | 12.88 | 10.00 | 9.52 | 8.97 |
| 2021 | 49224 | 10.87 | 8.12 | 7.73 | 7.29 | | 13.04 | 10.15 | 9.66 | 9.11 |
| 2022 | 49955 | 11.00 | 8.24 | 7.84 | 7.39 | | 13.20 | 10.30 | 9.80 | 9.24 |
| 2023 | 50687 | 11.13 | 8.36 | 7.96 | 7.50 | | 13.36 | 10.45 | 9.95 | 9.38 |
| 2024 | 51418 | 11.26 | 8.48 | 8.07 | 7.61 | | 13.52 | 10.60 | 10.09 | 9.51 |
| 2025 | 52149 | 11.40 | 8.60 | 8.19 | 7.72 | | 13.68 | 10.76 | 10.23 | 9.65 |
| 2026 | 52583 | 11.54 | 8.68 | 8.26 | 7.78 | | 13.84 | 10.85 | 10.32 | 9.73 |
| 2027 | 53018 | 11.68 | 8.75 | 8.32 | 7.85 | | 14.01 | 10.93 | 10.40 | 9.81 |
| 2028 | 53452 | 11.82 | 8.82 | 8.39 | 7.91 | | 14.19 | 11.02 | 10.49 | 9.89 |
| 2029 | 53887 | | 8.89 | 8.46 | 7.98 | | | 11.11 | 10.58 | 9.97 |
| 2030 | 54321 | | 8.96 | 8.53 | 8.04 | | | 11.20 | 10.66 | 10.05 |

**City of Hallandale Beach**

**Forecasted Maximum Day Finished Water Demand and Maximum Day Raw Water Demand**

| Year | Population (Broward County) | Maximum Day FW Demand | | | | | Maximum Day RW Demand | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A -Water Model Report | B - @165 gpcd (FW) *1.2 | C - 5% conservation | D - 10% conservation | Historical | A -Water Model Report | B - @165 gpcd (FW) | C - 5% conservation | D - 10% conservation |
| 2000 | 34282 | | 6.79 | 6.46 | 6.09 | | | 7.54 | 7.18 | 6.76 |
| 2001 | 34339 | | 6.80 | 6.47 | 6.10 | | | | | |
| 2002 | 34395 | | 6.81 | 6.48 | 6.11 | 6.40 | | 7.57 | 7.20 | 6.79 |
| 2003 | 34452 | | 6.82 | 6.49 | 6.12 | 6.44 | | 7.58 | 7.21 | 6.80 |
| 2004 | 34509 | | 6.83 | 6.50 | 6.13 | 6.69 | | 7.59 | 7.22 | 6.81 |
| 2005 | 34565 | 7.44 | 6.84 | 6.51 | 6.14 | 6.73 | 7.76 | 7.60 | 7.24 | 6.82 |
| 2006 | 34622 | 7.84 | 6.86 | 6.52 | 6.15 | 6.74 | 8.17 | 7.62 | 7.25 | 6.83 |
| 2007 | 35818 | 8.24 | 7.09 | 6.75 | 6.36 | 6.26 | 8.58 | 7.88 | 7.50 | 7.07 |
| 2008 | 37014 | 8.63 | 7.33 | 6.97 | 6.57 | | 8.99 | 8.14 | 7.75 | 7.30 |
| 2008 | 37014 | 8.63 | 7.33 | 6.97 | 6.57 | | 10.49 | 8.98 | 8.58 | 8.14 |
| 2009 | 38210 | 9.46 | 7.57 | 7.20 | 6.79 | | 11.35 | 9.24 | 8.83 | 8.37 |
| 2010 | 39406 | 10.28 | 7.80 | 7.42 | 7.00 | | 12.21 | 9.50 | 9.08 | 8.61 |
| 2011 | 40324 | 10.69 | 7.98 | 7.60 | 7.16 | | 12.64 | 9.70 | 9.27 | 8.79 |
| 2012 | 41242 | 11.11 | 8.17 | 7.77 | 7.32 | | 13.07 | 9.91 | 9.47 | 8.97 |
| 2013 | 42160 | 11.52 | 8.35 | 7.94 | 7.49 | | 13.50 | 10.11 | 9.66 | 9.15 |
| 2013 | 42160 | 11.52 | 8.35 | 7.94 | 7.49 | | 14.40 | 10.43 | 9.93 | 9.36 |
| 2014 | 43078 | 11.93 | 8.53 | 8.12 | 7.65 | | 14.91 | 10.66 | 10.14 | 9.56 |
| 2015 | 43996 | 12.34 | 8.71 | 8.29 | 7.81 | | 15.43 | 10.89 | 10.36 | 9.77 |
| 2016 | 44895 | 12.45 | 8.89 | 8.46 | 7.97 | | 15.56 | 11.11 | 10.57 | 9.97 |
| 2017 | 45795 | 12.56 | 9.07 | 8.63 | 8.13 | | 15.70 | 11.33 | 10.78 | 10.17 |
| 2018 | 46694 | 12.67 | 9.25 | 8.80 | 8.29 | | 15.83 | 11.56 | 11.00 | 10.37 |
| 2019 | 47594 | 12.77 | 9.42 | 8.97 | 8.45 | | 15.97 | 11.78 | 11.21 | 10.57 |
| 2020 | 48493 | 12.88 | 9.60 | 9.14 | 8.61 | | 16.10 | 12.00 | 11.42 | 10.77 |
| 2021 | 49224 | 13.04 | 9.75 | 9.27 | 8.74 | | 16.30 | 12.18 | 11.59 | 10.93 |
| 2022 | 49955 | 13.20 | 9.89 | 9.41 | 8.87 | | 16.50 | 12.36 | 11.76 | 11.09 |
| 2023 | 50687 | 13.36 | 10.04 | 9.55 | 9.00 | | 16.70 | 12.54 | 11.94 | 11.25 |
| 2024 | 51418 | 13.52 | 10.18 | 9.69 | 9.13 | | 16.90 | 12.73 | 12.11 | 11.41 |
| 2025 | 52149 | 13.68 | 10.33 | 9.82 | 9.26 | | 17.09 | 12.91 | 12.28 | 11.58 |
| 2026 | 52583 | 13.84 | 10.41 | 9.91 | 9.34 | | 17.30 | 13.01 | 12.38 | 11.67 |
| 2027 | 53018 | 14.01 | 10.50 | 9.99 | 9.42 | | 17.52 | 13.12 | 12.49 | 11.77 |
| 2028 | 53452 | 14.19 | 10.58 | 10.07 | 9.49 | | 17.73 | 13.23 | 12.59 | 11.87 |
| 2029 | 53887 | | 10.67 | 10.15 | 9.57 | | | 13.34 | 12.69 | 11.96 |
| 2030 | 54321 | | 10.76 | 10.23 | 9.65 | | | 13.44 | 12.79 | 12.06 |

## City of Hallandale Beach

### RW Demand-not-met for Average Day Demands (City maintains permit for City Wells)

**9.7** mgd permit (BCRWS & City Wells)

| Year | A - Water Model Report | B - @165 gpcd (FW) | C - 5% conservation | D - 10% conservation |
|---|---|---|---|---|
| 2000 | | | | |
| 2001 | | | | |
| 2002 | | | | |
| 2003 | | | | |
| 2004 | | | | |
| 2005 | | | | |
| 2006 | | | | |
| 2007 | | | | |
| 2008 | | | | |
| 2008 | | | | |
| 2009 | | | | |
| 2010 | 0.58 | | | |
| 2011 | 0.99 | | | |
| 2012 | 1.41 | | | |
| 2013 | 1.82 | | | |
| 2014 | 2.23 | | | |
| 2015 | 2.64 | | | |
| 2016 | 2.75 | | | |
| 2017 | 2.86 | | | |
| **2018** | **2.97** | | | |
| 2019 | 3.07 | 0.12 | | |
| 2020 | 3.18 | 0.30 | | |
| 2021 | 3.34 | 0.45 | | |
| 2022 | 3.50 | 0.60 | 0.10 | |
| 2023 | 3.66 | 0.75 | 0.25 | |
| 2024 | 3.82 | 0.90 | 0.39 | |
| 2025 | 3.98 | 1.06 | 0.53 | |
| 2026 | 4.14 | 1.15 | 0.62 | 0.03 |
| 2027 | 4.31 | 1.23 | 0.70 | 0.11 |
| 2028 | 4.49 | 1.32 | 0.79 | 0.19 |

## City of Hallandale Beach

### RW Demand-not-met for Average Day Demands (City loses Wells to Saltwater Intrusion)

**6.2** mgd permit (BCRWS only)

| Year | A -Water Model Report | B - @165 gpcd (FW) | C - 5% conservation | D - 10% conservation |
|---|---|---|---|---|
| 2000 | | | | |
| 2001 | | | | |
| 2002 | | | | |
| 2003 | | | | |
| 2004 | | | | |
| 2005 | | | | |
| 2006 | 0.61 | | | |
| 2007 | 0.95 | 0.37 | | |
| 2008 | 2.43 | 1.13 | 1.09 | 0.72 |
| 2009 | 3.26 | 1.37 | 1.30 | 0.92 |
| 2010 | 4.08 | 1.86 | 1.51 | 1.11 |
| 2011 | 4.49 | 2.03 | 1.67 | 1.26 |
| 2012 | 4.91 | 2.19 | 1.83 | 1.42 |
| 2013 | 5.32 | 2.50 | 2.07 | 1.60 |
| 2014 | 5.73 | 2.68 | 2.25 | 1.77 |
| 2015 | 6.14 | 2.87 | 2.43 | 1.94 |
| 2016 | 6.25 | 3.06 | 2.61 | 2.11 |
| 2017 | 6.36 | 3.25 | 2.79 | 2.27 |
| **2018** | **6.47** | **3.43** | **2.96** | **2.44** |
| 2019 | 6.57 | 3.62 | 3.14 | 2.60 |
| 2020 | 6.68 | 3.80 | 3.32 | 2.77 |
| 2021 | 6.84 | 3.95 | 3.46 | 2.91 |
| 2022 | 7.00 | 4.10 | 3.60 | 3.04 |
| 2023 | 7.16 | 4.25 | 3.75 | 3.18 |
| 2024 | 7.32 | 4.40 | 3.89 | 3.31 |
| 2025 | 7.48 | 4.56 | 4.03 | 3.45 |
| 2026 | 7.64 | 4.65 | 4.12 | 3.53 |
| 2027 | 7.81 | 4.73 | 4.20 | 3.61 |
| 2028 | 7.99 | 4.82 | 4.29 | 3.69 |

## City of Hallandale Beach

**RW Demand-not-met for Maximum Day Demands (City maintains permit for City Wells)**

**9.7** mgd permit (BCRWS & City Wells)

| Year | A - Water Model Report | B - @165 gpcd (FW) | C - 5% conservation | D - 10% conservation |
|---|---|---|---|---|
| 2000 | | | | |
| 2001 | | | | |
| 2002 | | | | |
| 2003 | | | | |
| 2004 | | | | |
| 2005 | | | | |
| 2006 | | | | |
| 2007 | | | | |
| 2008 | 0.79 | | | |
| 2009 | 1.65 | | | |
| 2010 | 2.51 | | | |
| 2011 | 2.94 | | | |
| 2012 | 3.37 | 0.21 | | |
| 2013 | 4.70 | 0.73 | 0.23 | |
| 2014 | 5.21 | 0.96 | 0.44 | |
| 2015 | 5.73 | 1.19 | 0.66 | 0.07 |
| 2016 | 5.86 | 1.41 | 0.87 | 0.27 |
| 2017 | 6.00 | 1.63 | 1.08 | 0.47 |
| **2018** | **6.13** | **1.86** | **1.30** | **0.67** |
| 2019 | 6.27 | 2.08 | 1.51 | 0.87 |
| 2020 | 6.40 | 2.30 | 1.72 | 1.07 |
| 2021 | 6.60 | 2.48 | 1.89 | 1.23 |
| 2022 | 6.80 | 2.66 | 2.06 | 1.39 |
| 2023 | 7.00 | 2.84 | 2.24 | 1.55 |
| 2024 | 7.20 | 3.03 | 2.41 | 1.71 |
| 2025 | 7.39 | 3.21 | 2.58 | 1.88 |
| 2026 | 7.60 | 3.31 | 2.68 | 1.97 |
| 2027 | 7.82 | 3.42 | 2.79 | 2.07 |
| 2028 | 8.03 | 3.53 | 2.89 | 2.17 |

## City of Hallandale Beach

### RW Demand-not-met for Maximum Day Demands (City loses Wells to Saltwater Intrusion)

**6.2** mgd permit (BCRWS only)

| Year | A - Water Model Report | B - @165 gpcd (FW) | C - 5% conservation | D - 10% conservation |
|---|---|---|---|---|
| 2000 | | | | |
| 2001 | | | | |
| 2002 | | 1.37 | 1.00 | 0.59 |
| 2003 | | 1.38 | 1.01 | 0.60 |
| 2004 | | 1.39 | 1.02 | 0.61 |
| 2005 | 1.56 | 1.40 | 1.04 | 0.62 |
| 2006 | 1.97 | 1.42 | 1.05 | 0.63 |
| 2007 | 2.38 | 1.68 | 1.30 | 0.87 |
| 2008 | 4.29 | 2.78 | 2.38 | 1.94 |
| 2009 | 5.15 | 3.04 | 2.63 | 2.17 |
| 2010 | 6.01 | 3.30 | 2.88 | 2.41 |
| 2011 | 6.44 | 3.50 | 3.07 | 2.59 |
| 2012 | 6.87 | 3.71 | 3.27 | 2.77 |
| 2013 | 8.20 | 4.23 | 3.73 | 3.16 |
| 2014 | 8.71 | 4.46 | 3.94 | 3.36 |
| 2015 | 9.23 | 4.69 | 4.16 | 3.57 |
| 2016 | 9.36 | 4.91 | 4.37 | 3.77 |
| 2017 | 9.50 | 5.13 | 4.58 | 3.97 |
| **2018** | **9.63** | **5.36** | **4.80** | **4.17** |
| 2019 | 9.77 | 5.58 | 5.01 | 4.37 |
| 2020 | 9.90 | 5.80 | 5.22 | 4.57 |
| 2021 | 10.10 | 5.98 | 5.39 | 4.73 |
| 2022 | 10.30 | 6.16 | 5.56 | 4.89 |
| 2023 | 10.50 | 6.34 | 5.74 | 5.05 |
| 2024 | 10.70 | 6.53 | 5.91 | 5.21 |
| 2025 | 10.89 | 6.71 | 6.08 | 5.38 |
| 2026 | 11.10 | 6.81 | 6.18 | 5.47 |
| 2027 | 11.32 | 6.92 | 6.29 | 5.57 |
| 2028 | 11.53 | 7.03 | 6.39 | 5.67 |

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