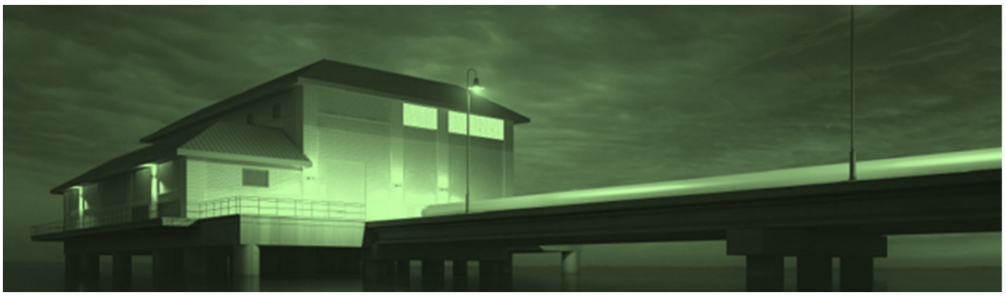
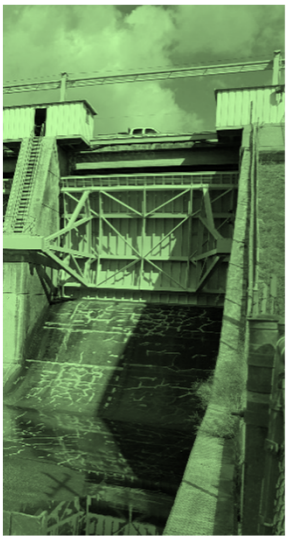
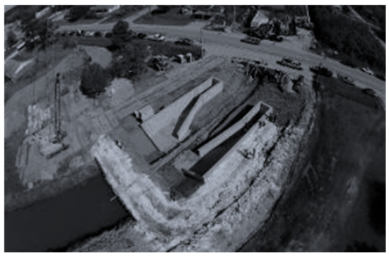
RAW WATER SUPPLY MASTER PLAN
FINAL REPORT







Prepared By
Freese and Nichols Inc.
November, 2018

Final Report for Internal Distribution Only

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ES EXECUTIVE SUMMARY

The mission of the San Jacinto River Authority (SJRA) is to develop, conserve, and protect the water resources of the San Jacinto River Basin. In the future, SJRA will continue to address water supply issues for the region through the development of water supply projects and the responsible stewardship of resources. This Raw Water Supply Master Plan (RWSMP) is intended to serve as a tool in furthering the goals of the authority for the shared benefit of water users within its Service Area.

The RWSMP serves a key objective of SJRA's planning process. Although the Texas Water Development Board (TWDB) funds and administers the Regional and State Water Planning process, it is necessary for each water provider, especially those that supply a significant, regional demand, to conduct its own planning to address factors that are unique to its own operations. By weighing multiple scenarios of climatic and demand growth patterns, SJRA can identify needs and balance associated risks with anticipated costs of projects in order to reach a robust, yet cost-effective plan for its customers.

A detailed examination of the needs and projects is required to adequately assess the demand for water and an economical and environmentally responsible means of meeting future needs. The nature of water supply development necessitates the need for a detailed, comprehensive, long-term approach to planning. One reason for this need is the 10 to 20 years average timeline for development of water supply projects. In addition to the time required to develop viable water supplies, cost is also a significant factor encouraging the adoption of a thorough planning process. The RWSMP structure provides for an opportunity to consider these varied project costs and develop an economically sound plan to avoid water supply deficits. The third reason for a comprehensive plan is the opportunity for stakeholder involvement. The magnitude of water supply projects necessitates a significant amount of stakeholder input and involvement, whether it be from other water providers, agencies, or the general public. The development of a RWSMP provides a framework for these discussions while also serving as a written record of decisions made from plan inception to project delivery.

The development of the RWSMP has been conducted as a cooperative effort among SJRA's operating divisions with the assistance of their consultant, Freese and Nichols, Inc. (FNI). Throughout the process which began in December 2015, SJRA has held staff workshops to receive information and guide the development of the plan. Information was collected by SJRA and FNI and processed to provide data to the process and to further discussions related to long-range water supplies. SJRA also held various stakeholder outreach meetings throughout the project duration to disseminate the information

generated from the study to the stakeholders and facilitate their involvement. *Table ES1* provides a summary of these meetings and the primary topics addressed.

Table ES1: SJRA Workshop Meeting Topics

Meeting Date	SJRA Workshop Topic				
	Demands	Supplies	Strategies	Strategy Portfolios	Implementation Plan
February 26, 2016					
May 19, 2016					
June 21, 2016	Stakeholder Meeting No. 1				
July 12, 2016					
August 31, 2016	Stakeholder Meeting No. 2				
June 27, 2017					
September 21, 2017					
October 10, 2017	Stakeholder Meeting No. 3				
January 12, 2018					
February 16, 2018					
March 13, 2018					

This RWSMP document is intended to be a starting in point in the current iteration of SJRA's long planning history. This document presents a wide range of strategies (water supply projects) and combinations of strategies (portfolios) that may serve as potential water supply options. Due to the dynamic nature of water supply issues, it is recommended that SJRA revisit the recommendations of the RWSMP annually to confirm schedule and suitability of the portfolios of strategies and assumptions presented. Several events may trigger a comprehensive review of the RWSMP including a significant increase in the SJRA Service Area, major shifts in development patterns, or impacts to current water supplies. As time progresses and various obstacles and opportunities arise, the master plan for SJRA's raw water supplies will be adjusted to best suit the contemporary understanding of the constraints.

Projected Water Demands

The SJRA serves customers in two major areas in the San Jacinto River Basin. The Highlands Division has historically served customers in eastern Harris County or the *Highlands Service Area*. The other SJRA divisions (Lake Conroe, GRP, and Woodlands Divisions) serve customers in Montgomery County or the *Montgomery County Service Area*. The RWSMP considers the following demand categories for SJRA in both Service Areas: 1) Industrial demands representing demands of wholesale industrial customers, 2) municipal demands representing demands of wholesale municipal customers and may include demands for industrial and municipal irrigation water use provided by the municipalities and water utilities, and 3)

irrigation demands representing the wholesale irrigation customer demand for agriculture and commercial landscape.

A combination of the projections for the three demand types discussed above were used to develop two demand scenarios for the Highlands Service Area as shown in *Table ES2*. The projections shown in *Figure ES1* represent annual values of these demand scenarios for the Highlands Service Area. The RWSMP is intended to identify water needs at a monthly timestep and reasonable estimates of the demand peaking throughout the year were developed to convert the annualized demand value to a monthly demand. Demand patterns for the Highlands Service Area were analyzed individually for industrial, irrigation, and municipal use and presented in *Figure ES2*.

Table ES2: Highlands Service Area Demand Scenario Descriptions

Scenario		Industrial	Irrigation	Municipal
1	Known Demands	Expanded Contracts	Current Contracts	Current Contracts
2	Known Demands Plus Growth	Expanded Contracts + Region H Growth	Current Contracts	Current Contracts + Region H Growth

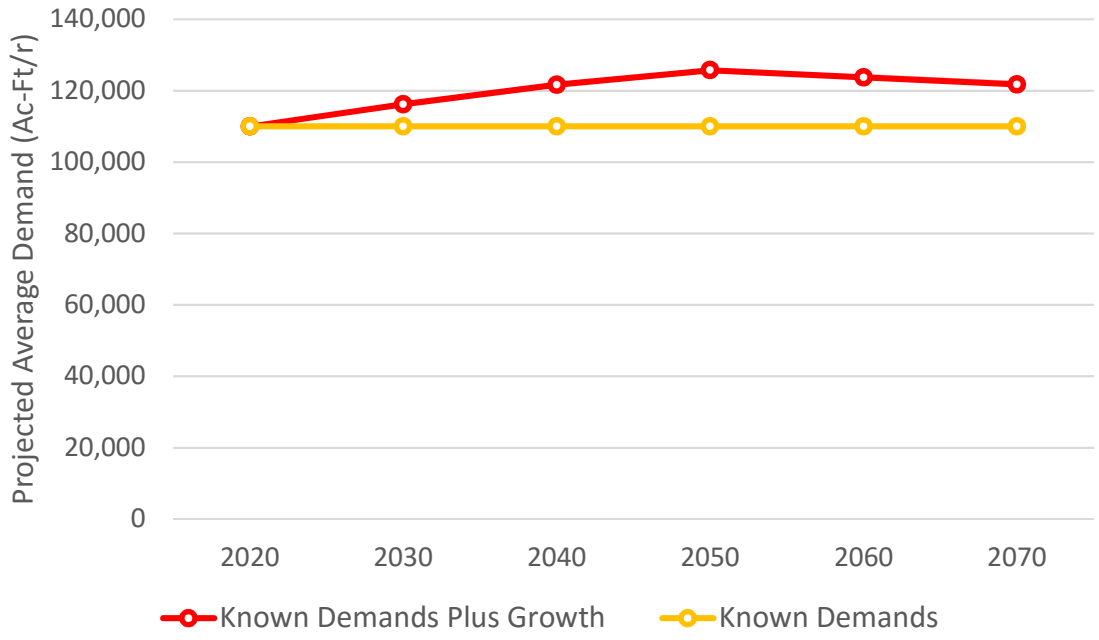

Figure ES1: Highlands Service Area Demand Projections

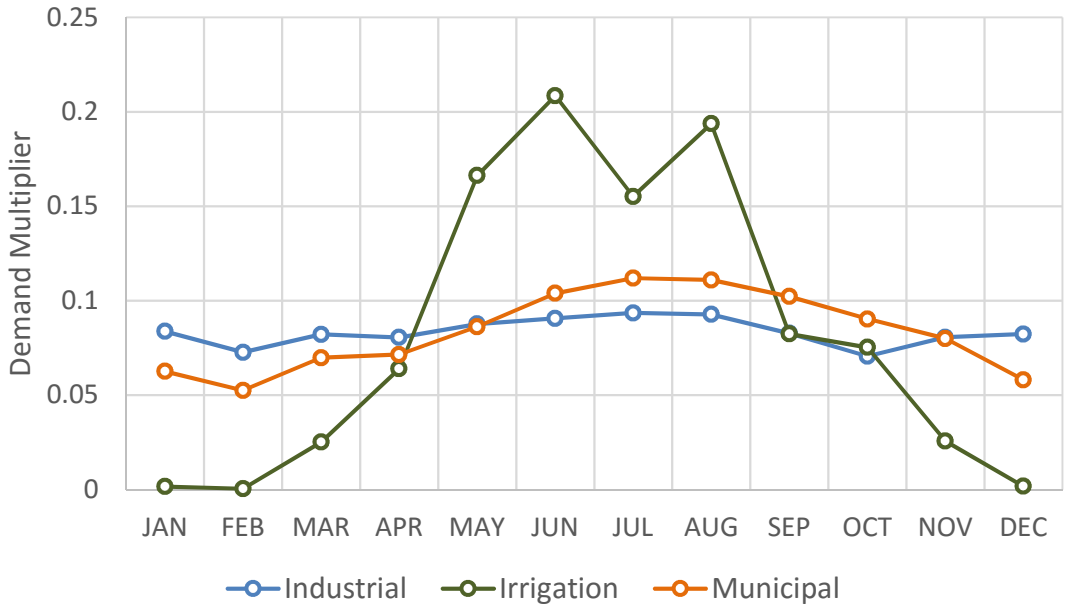

Figure ES2: Highlands Service Area Demand patterns

The water demands for the entirety of Montgomery County were first developed and then water supplies from other sources were accounted for to reduce the projected demand to the anticipated surface water demand that would be met by SJRA. The other supplies included Groundwater from the Gulf Coast Aquifer, water supplied through other Groundwater Reduction Plans (GRPs) in Montgomery County and, exempt pumpage by non-Large Volume Groundwater Users (LVGUs). Three demand scenarios were considered for the Montgomery County Service Area based on the combination of assumptions for industrial, irrigation, and municipal uses. These demand scenarios were primarily impacted by changes to the municipal demand and how conservation was defined in each scenario. The Scenario 1 municipal demands were not adjusted for baseline conservation levels that are typically applied by TWDB in the development of Regional Water Plan (RWP) projections, providing a higher overall projection. Scenario 2 included these baseline conservation savings and Scenario 3 included an advanced conservation approach of a one-percent annual reduction in per-capita water demands over the planning horizon. *Table ES3* below includes a summary of the three demand scenarios for Montgomery County Service Area.

Table ES3: Montgomery county Service Area Demand Scenario Descriptions

Scenario		Industrial	Irrigation	Municipal
1	No Conservation	Expanded Contracts	Current Contracts	Region H Population, Per-capita Demand, and Manufacturing
2	TWDB Baseline Municipal Conservation	Expanded Contracts	Current Contracts	Region H Population, Per-capita Demand, and Manufacturing + Baseline Conservation
3	Advanced Conservation	Expanded Contracts	Current Contracts	Region H Population, Per-capita Demand, and Manufacturing + Advanced Conservation

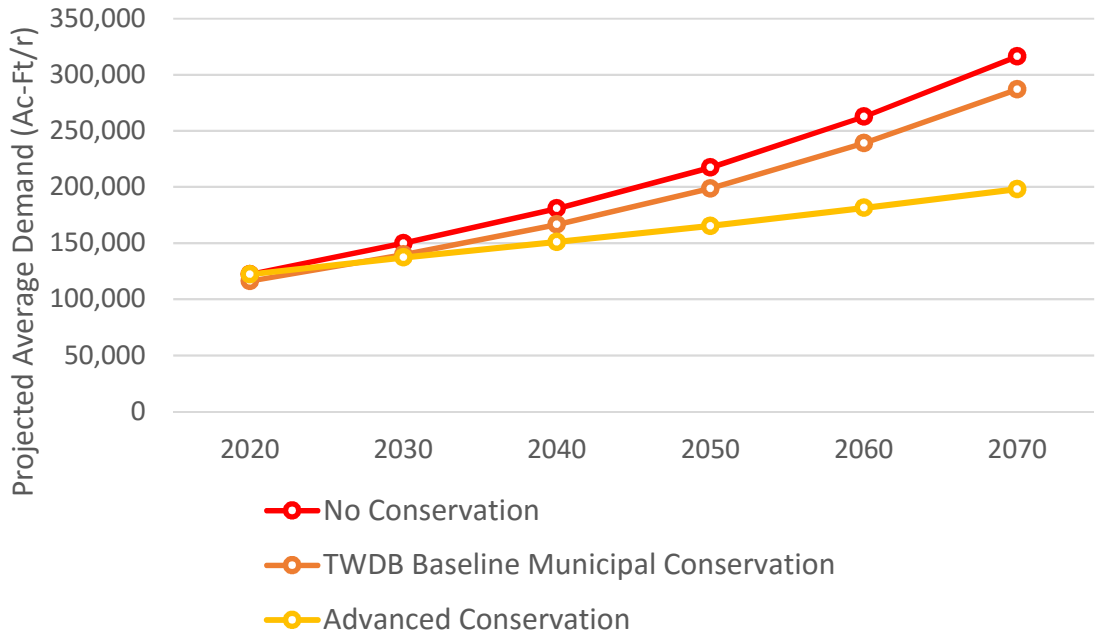

Figure ES3: Montgomery County Demand Projections (SJRA, plus Other Service Areas)

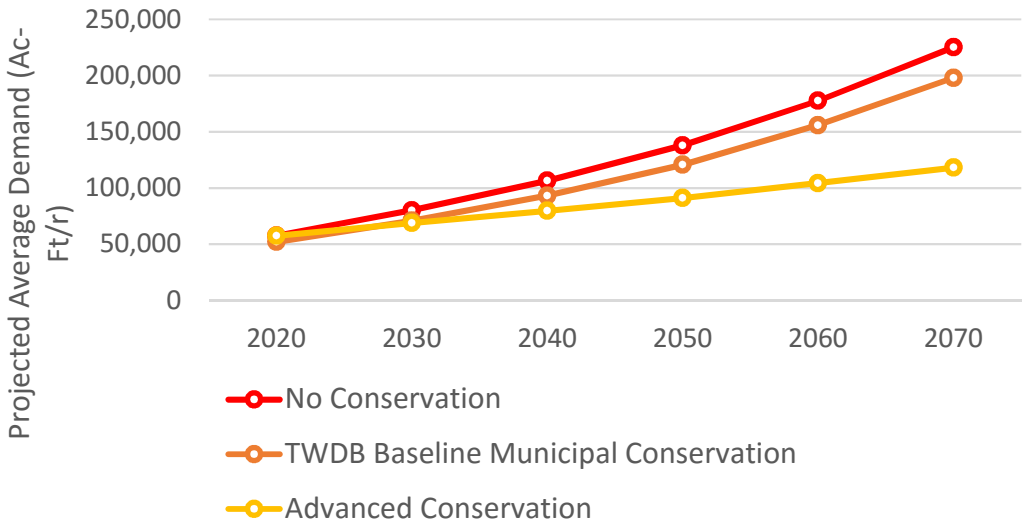

Figure ES4: Montgomery County Service Area Demand Projections (SJRA)

The annual projections for the entirety of Montgomery County are included in *Figure ES3*. The projections shown in *Figure ES4* represent annual values for SJRA's Montgomery County Service Area. However, fluctuations in intra-year water use will produce a higher seasonal demand above this annualized value. Demand patterns indicating reasonable estimates of demand peaking throughout the year were used to establish a likely pattern of use that could be used for further analysis. Demand patterns for the Montgomery County Service Area were analyzed individually for industrial, irrigation, and municipal use, as shown in *Figure ES5*.

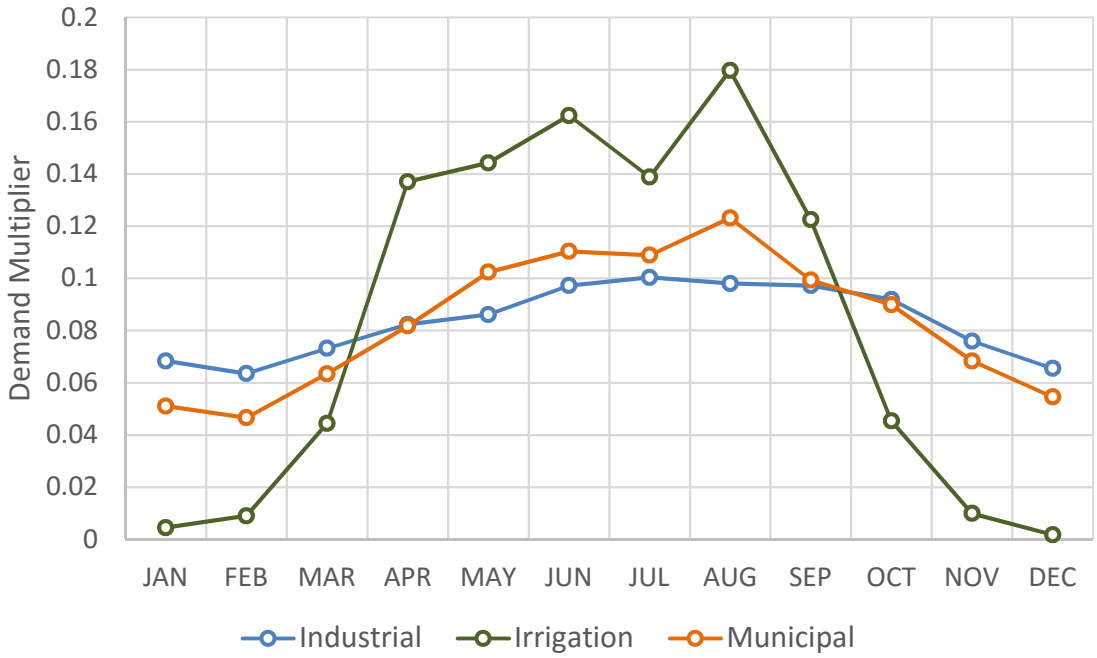

Figure ES5: Montgomery County Service Area Demand Patterns by Water Use

Current Water Supplies

It is important to develop a comprehensive estimate of available water supplies to effectively identify the potential Service Area needs. The SJRA utilizes water supplies from the San Jacinto and Trinity River Basins to serve customers of its four operating divisions. Currently, Lake Conroe is the primary source of supply for Montgomery County and the Lake Conroe, GRP, and Woodlands Divisions, with limited demands being met through the use of reclaimed water from The Woodlands. The Highlands Division relies upon a blend of water diverted from Lake Houston as well as water transferred from the Trinity River Basin. These surface water supplies consist of both run-of-river supplies and reservoir supplies which differ in their reliability under drought-of-record conditions. *Figure ES6* includes a representation of SJRA's Service Areas and their sources of supply.

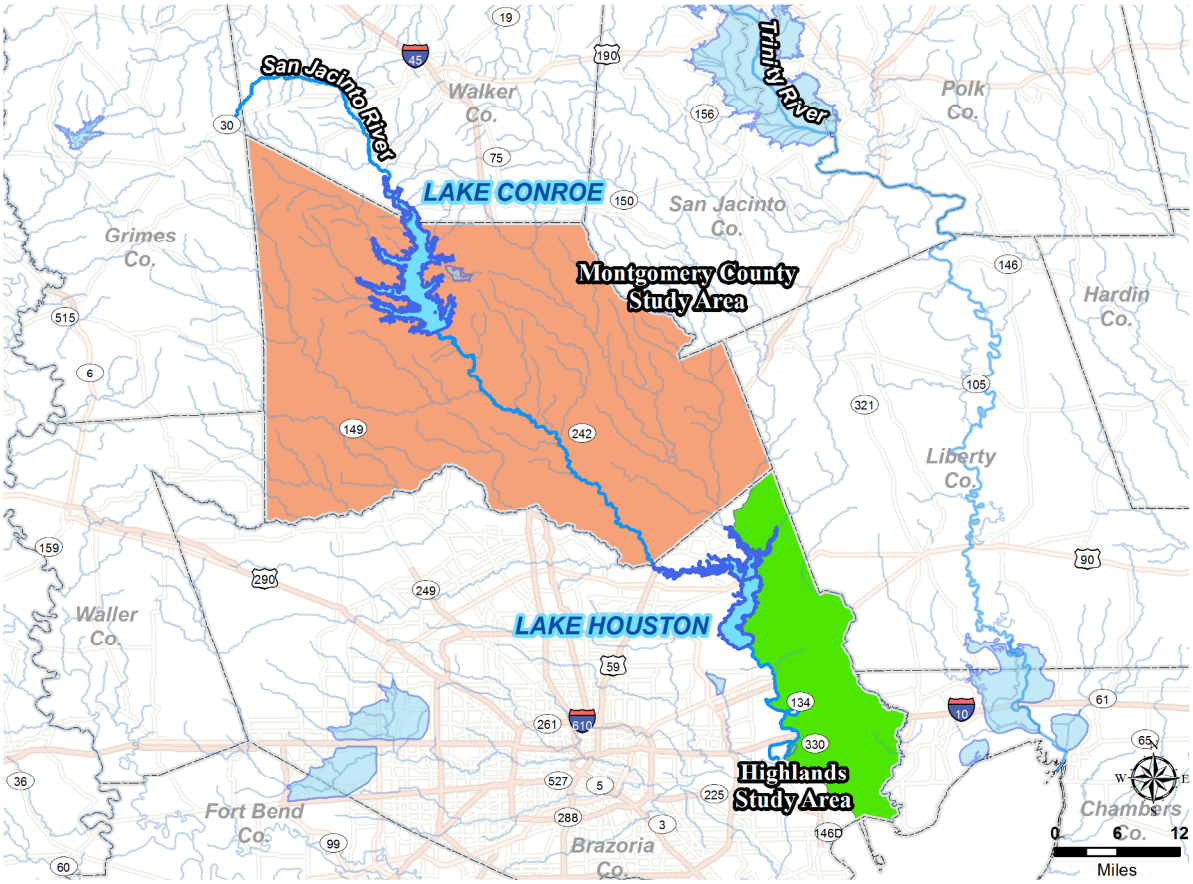

Figure ES6: SJRA Service Areas and Sources of Supply

The Highlands Service Area utilizes a diverse range of supplies to meet customer demands within the area, including run-of-river supplies from the San Jacinto and Trinity River Basins. San Jacinto Basin supplies are diverted at Lake Houston and delivered through the Highlands canal system. Trinity River Basin supplies are diverted at the Trinity River Pump Station operated by the Coastal Water Authority (CWA) and delivered to the Highlands Service Area through the CWA Main Canal where it can be diverted through pump stations to the SJRA Highlands East or South Canals. *Table ES4* summarizes the supplies available to the Highlands Service Area.

Table ES4: Water Supplies Available for Meeting Demands in the Highlands Service Area

Source Name	Water Right Number	Permitted Supply Volume [1] (Acre-Feet per Year)	River Basin
Highlands Permit	WR-4964	55,000	San Jacinto
Lake Houston Additional Authorization (SJRA Portion)	WR-5807	14,100	
Lake Houston Excess Flow Permit (SJRA Portion)	WR-5808	80,000	
Lake Houston Reuse Permit	WR-5809	14,944	
Devers Run-of-River Right	WR-5271	56,000	Trinity
CLCND Run-of-River Right	WR-4279A	30,000	

[1] Supply availability as specified by permit. Actual, firm-yield supplies may vary based on hydrologic conditions.

The firm yield of Highlands Service Area water rights were determined based on the Trinity and San Jacinto River Basin Water Availability Models (WAMs) maintained by TCEQ. These models were modified to include provision for reservoir sedimentation conditions projected for the years 2020, 2040, and 2070. The resulting annual available yields for these rights are shown below in *Table ES5*.

Table ES5: Highlands Projected Annual Water Availability

Period	Highlands[1] (4964)	SJRA (5807)	Excess Flow (5808)	SJRA Reuse (5809)	CLCND (4279A)	Devers[1] (5271)	Highlands TOTAL
2020	55,000	5,300	0	9,344	17,289	56,000	142,933
2040	55,000	3,500	0	9,344	17,289	56,000	141,133
2070	55,000	500	0	9,344	17,289	56,000	138,133

[1] Includes water made firm through contract with COH.

The Montgomery County Service Area is currently served with water solely from Lake Conroe although growing demands will likely require additional sources of supply in the future. Water used from Lake Conroe may be diverted lakeside for meeting raw water demands or diverted from the lake, treated at the SJRA Surface Water Facility (SWF), and distributed to customers of the GRP Division. The SJRA Woodlands Division also produces groundwater for use by the utilities serving The Woodlands. However, groundwater supplies in Woodlands Division and other GRP divisions are not considered within this study, as these supplies have already been subtracted from demands in the Montgomery County Service Area as part of this analysis. The firm yield of Lake Conroe, the primary source of surface water supply in Montgomery County, was determined based on the San Jacinto River Basin WAM maintained by TCEQ.

These models were modified to include provision for reservoir sedimentation conditions projected for the years 2020, 2040, and 2070. The resulting annual available yield and permitted volume for the right is shown below in *Table ES6*. Although this table summarizes annual totals, monthly values were used in the determination of water needs and the remainder of the RWSMP analysis.

The future availability of the existing supplies was determined based on two scenarios; 1) base 2) expected. The decadal base scenario represented the supply availability based on the WAM Run 3 model. These Run3 WAMs reflect the future decadal reservoir sedimentation conditions and do not include the availability of any potential return flows in the river basin. The expected future availability scenario included the supplies based on the WAM Run 3 model adjusted for the impact of known risk variable such as sedimentation, availability of return flows, and potential uncertainty of hydrological conditions.

Table ES6: Montgomery County Permitted Volume and Projected Annual Water Availability

Period	Permitted[1] Supply Volume (Acre-Feet per Year)	Lake Conroe (WR-4963) Base Scenario	Lake Conroe (WR-4963) Expected Scenario
2020	100,000[2]	79,300	86,000
2040		77,794	84,500
2070		75,500	84,000

Projected Water Needs

The critical goal of the RWSMP is to identify the future water needs and to plan effectively to meet those needs. The combination of projected future water demands and current supplies defines the projected water needs. The Regional and State Water Planning processes focus on water demands, supplies, and needs at an annual scale. This approach is appropriate for regional analyses but lacks the detail required for system-scale analysis where sub-annual shortages may manifest in a way that is not always visible at the annual scale. The detailed investigation of water needs requires a methodology for comparing water demands and supply on a sub-annual timestep at a number of localized geographies to identify limitations in supply and infrastructure that may influence the selection of water management strategies in later phases of the RWSMP.

The STELLA model was selected as the basis for development of the needs in the SJRA RWSMP. A STELLA model is capable of not only identifying limitations in water supply and conveyance, but also computing the effective costs of strategies implemented based on operational logic derived by the user. The monthly STELLA model was used to compare monthly water availability and monthly demand information for the

Highlands and Montgomery County Service Areas by considering the linkage of these sources and customers and infrastructure and operational limitations in between. The needs for the Montgomery County Service Area were evaluated for three scenarios (base scenario, expected conditions scenario, and drought contingency scenario) using the two sets of supply availability scenarios and the three sets of demand scenarios identified. Furthermore, the drought contingency scenario takes into account the supply available under expected conditions while adjusting the demand to a include the anticipated drought contingency plan reductions SJRA currently employs. Similarly, the needs for the Highlands Service Area were evaluated for the same three supply scenarios listed above and the two demand scenarios identified. One set of needs for each Service Area, based on the base conditions, was carried forward for the future determination of strategies. The other sets of needs for the expected conditions and the drought contingency scenarios were retained and set aside for further consideration and a future evaluation, if required. This use of the greatest demand scenario and the lower supply projection was selected to provide for a conservative analysis of future water supply.

Projected water needs for the Highlands Service Area are shown on an annualized basis in *Table ES7*, below. These needs are of a relatively small magnitude and are driven largely by the limitation on the conveyance of water from the Trinity River Basin through the CWA Main Canal to the Highlands Service Area. Note that these needs are illustrated at the annual level but are based on the detailed, sub-annual analysis within the demand and supply datasets.

Table ES7: Identified Water Needs for Highlands Service Area

Decade	Identified Need (Ac-Ft/Yr)
2020	0
2040	903
2070	2,813

Projected water needs for the Montgomery County Service Area are shown on an annualized basis in *Table ES8* below. The magnitude of these demands is of a much larger magnitude than those identified for the Highlands Service Area and are primarily driven by the growth of total water demand.

Table ES8: Identified Water Needs for Montgomery County Service Area

Decade	Identified Need (Ac-Ft/Yr)
2020	0
2040	50,087
2070	179,113

Water Management Strategy Screening

Water management strategies represent the way in which future supplies may be developed and an initial screening process of these options is a crucial step in the analysis. The process of screening management strategies began with the development of a universe of alternatives that may be considered for future implementation. This process was conducted as a joint effort between SJRA and FNI and relied upon projects identified in planning documents such as the Region H RWP, SJRA-specific studies, and institutional knowledge between the two parties.

Although existing studies and institutional knowledge served as the predominant source of information used to characterize, prioritize, and select water management strategies, SJRA also chose to pursue the detailed study of some selected strategies to better refine project definitions and assess potential. These studies included the following:

- Highlands Service Area
    - Trinity Supplies Transfer to Highlands Service Area
    - Return Flows in Highlands Service Area
- Montgomery County Service Area
    - Lake Livingston to Lake Conroe Transfer
    - Catahoula Aquifer Supplies
    - Return Flows in Montgomery County Service Area
    - Municipal Water Conservation

Each of the potential strategies were evaluated to refine their definition, costs, and evaluation scoring at a planning level. An objective methodology was prepared to score potential strategies so that preferences could be identified among the numerous options presented. Strategies were scored separately for the Highlands and the Montgomery County systems and were ranked based on the scores developed from the product of criteria scores and the weighting factors. Ranks were assigned to the strategies such that the strategy with the highest score was given the lowest rank. *Tables ES9* and *ES10* include the ranked list of strategies for the two Service Areas.

Table ES9: Ranked Strategies for the Highlands Service Area

Rank	Strategy Name	Sub-Type
1	Purchase Surface Water	TRA
2	Lake Livingston Transfer	Livingston to Highlands
3	Trinity Return Flows	
4	Regional Return Flows	Lake Houston
5	Purchase Surface Water	CLCND
6	Purchase Groundwater	Purchase from Eastern Basins
7	Purchase Groundwater	Purchase from Western Basins
8	East Texas Water Transfer	Neches Basin
9	East Texas Water Transfer	Sabine Basin
10	Seawater Desalination	
11	Lake Creek Reservoir	
12	Bedias Reservoir	
13	Brazos River Supplies	

Table ES10: Ranked Strategies for the Montgomery County Service Area

Rank	Strategy	Sub-Type
1	Conservation	TWDB Baseline
2	Catahoula Aquifer Supplies	Developed by SJRA Customers (Blended)
3	Conservation	SJRA Water Conservation Plan
4	Regional Return Flows	Lake Conroe
5	Direct Reuse, Non-Potable	GRP Participants
6	Direct Reuse, Non-Potable	Woodlands
7	Catahoula Aquifer Supplies	Developed by SJRA (Lake Conroe)
8	Catahoula Aquifer Supplies	Developed by SJRA Customers (Treated)
9	Catahoula Aquifer Supplies	Developed by SJRA (Blended)
10	Lake Livingston Transfer	Livingston to Conroe
11	Purchase Surface Water	TRA
12	Aquifer Storage and Recovery	Developed by SJRA Customers
13	Purchase Groundwater	Purchase from Eastern Basins
14	Purchase Groundwater	Purchase from Western Basins
15	Aquifer Storage and Recovery	Developed by SJRA (Mildly Treated)
16	Catahoula Aquifer Supplies	Developed by SJRA (Treated)
17	Aquifer Storage and Recovery	Developed by SJRA (GRP Treated)
18	Lake Creek Scalping	Run-of-River Diversion
19	Regional Return Flows	Lake Houston w/ South Plant
20	Lake Creek Reservoir	
21	Brazos River Supplies	
22	East Texas Water Transfer	Neches Basin
23	East Texas Water Transfer	
24	Increase Lake Conroe Conservation Pool	
25	Lake Creek Scalping	Storage in Lake Conroe
26	Lake Creek Scalping	
27	Bedias Reservoir	
28	Seawater Desalination	

A risk-based analysis for portfolio selection was developed in this study to utilize the risk definition available for the projects in various sources referenced and compare the information using a standardized approach. A risk analysis tool was developed in this study to quantify the risk for each project using a consistent approach.

A detailed approach was developed for defining the risk profile of various strategies being considered as future water supplies to meet the needs in the SJRA Service Areas. To quantify the process, the risk associated with the strategy was divided into five categories. *Table ES11* below lists the five risk categories considered in the risk analysis and a brief description of the categories.

Table ES11: Description of the Risk Categories Used for the Risk Analysis

Number	Risk Category	Description
1	Capital Cost Risk	Risk that the project capital cost may be impacted due to industry fluctuations, rate changes, project definition changes
2	Yield Risk	Risk that the project defined yield may be impacted due to external conditions out of SJRA control, uncertainty, policy changes, political impacts, or would require SJRA to redefine the project
3	Regulatory/Environmental Risk	Risk that a project status may be impacted due to environmental, regulatory, or water quality issues
4	Schedule Risk	Risk that the project schedule, as proposed, will be impacted due to coordination delays, construction delays, policy issues, and material availability
5	Institutional/Legal Risk	Risk that the project may be impacted due to regional cooperation issues, customer coordination issues, public perception issues, legal/contracting issues, and/or any institutional changes at SJRA

Not all risk categories have the same magnitude of impact. Based on the feedback received from SJRA staff, a weighting factor was assigned to each one of the risk categories to characterize the risk of these categories to be more specific to SJRA's supply approach. The risk categories were subdivided into four sub-categories based on the range of the risk. A weighted average is computed for each category and the also for the overall risk of the project.

Based on the needs identified for the Montgomery County Service Area and the yields produced by each of the strategies considered, it was noted that no individual project can meet the future needs for the Montgomery County Service Area. For this reason, a combination of strategies or "portfolios" were developed for the Montgomery County Service Area. Five different themed strategy portfolios were

developed for the Montgomery County Service Area. The portfolios were focused on the following themes: 1) Cost Preferred, 2) Low Perceived Risk, 3) Fast Track/Dry Conditions, 4) Regional Partnership, and 5) Low Regulatory Risk portfolios. The portfolios and strategies were developed based on the current contracted and available groundwater supplies. Currently, discussions are underway with the Lone Star Groundwater Conservation District and other local stakeholders to determine the availability of the additional groundwater in the Gulf Coast aquifer system. Because of the timing of negotiations, the current lack of clarity on the volume, and timing of available additional groundwater, parallel strategy portfolios were developed. One strategy portfolio assumes that additional groundwater will not be available and the other strategy portfolio assumes that additional groundwater will be available.

Similar to the approach developed for the Montgomery County Service Area, three themed portfolios were developed for the Highlands Service Area. They are: 1) Cost Preferred Portfolio, 2) Low Perceived Risk, and 3) Fast Track/Dry Conditions portfolios. Details of these portfolios are discussed in the next section.

Recommended Water Management Strategy Implementation Plan

The final step in the process of preparing a RWSMP is to develop a strategy implementation plan. This implementation plan was developed to guide SJRA in their decision-making process as they consider and plan for future supplies. While any of the portfolios will address the Service Area needs in a systematic manner for the planning horizon, the implementation plan includes multiple potential strategy portfolios and provides a decision tree that helps SJRA decide which portfolio pathway to consider under any given circumstance and how to move forward with the planning process. Separate strategy implementation plans were proposed for the Montgomery County and Highlands Service Areas, as supply planning for these two Service Areas progresses on parallel and distinct tracks.

SJRA has chosen to retain all six portfolios developed for the Montgomery County Service Area and the three portfolios for the Highlands Service Area for future consideration. Of these, the Preferred and Low-Cost portfolios were selected as the recommended pathways for the Montgomery County and the Highlands Service Areas. As it is currently uncertain whether additional groundwater will be available for use, the timing of its availability, and the quantity that may become available, SJRA has chosen to opt for the Preferred portfolio without consideration of additional groundwater supply availability as the recommended path forward. Based on these selections and preferences, a detailed decision tree was prepared to serve as the implementation plan for SJRA's future supply planning process. *Figures ES7 and*

ES8 include the implementation plans for the Montgomery County and Highlands Service Areas, respectively.

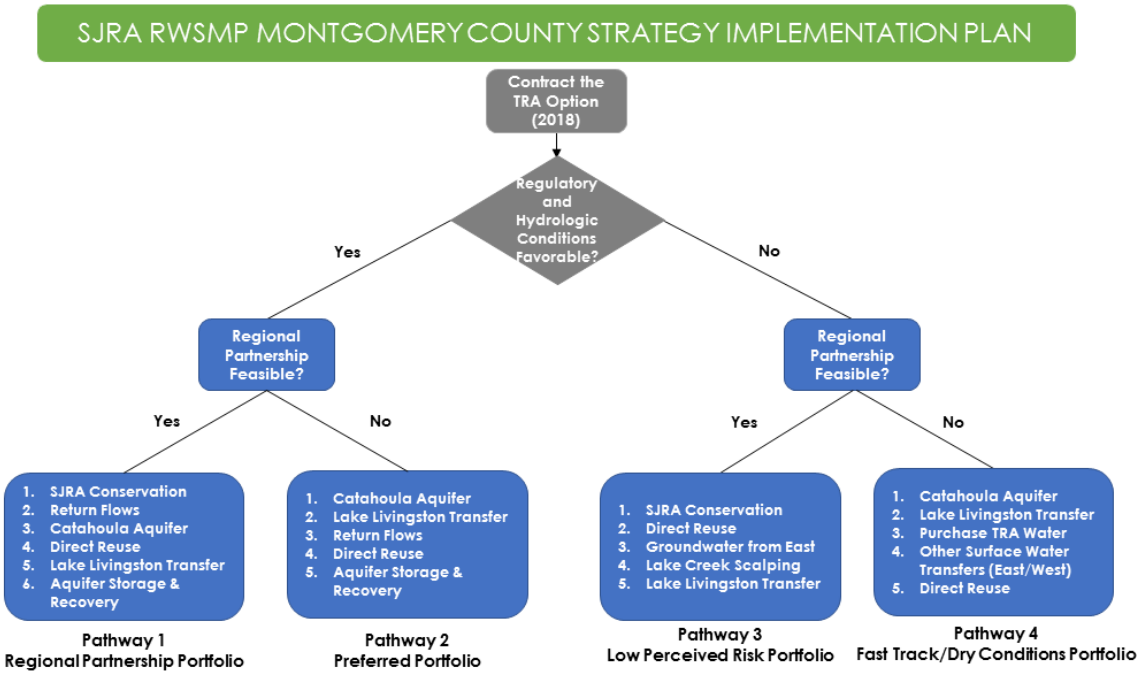

Figure ES7: Strategy Implementation Plan for Montgomery County Service Area

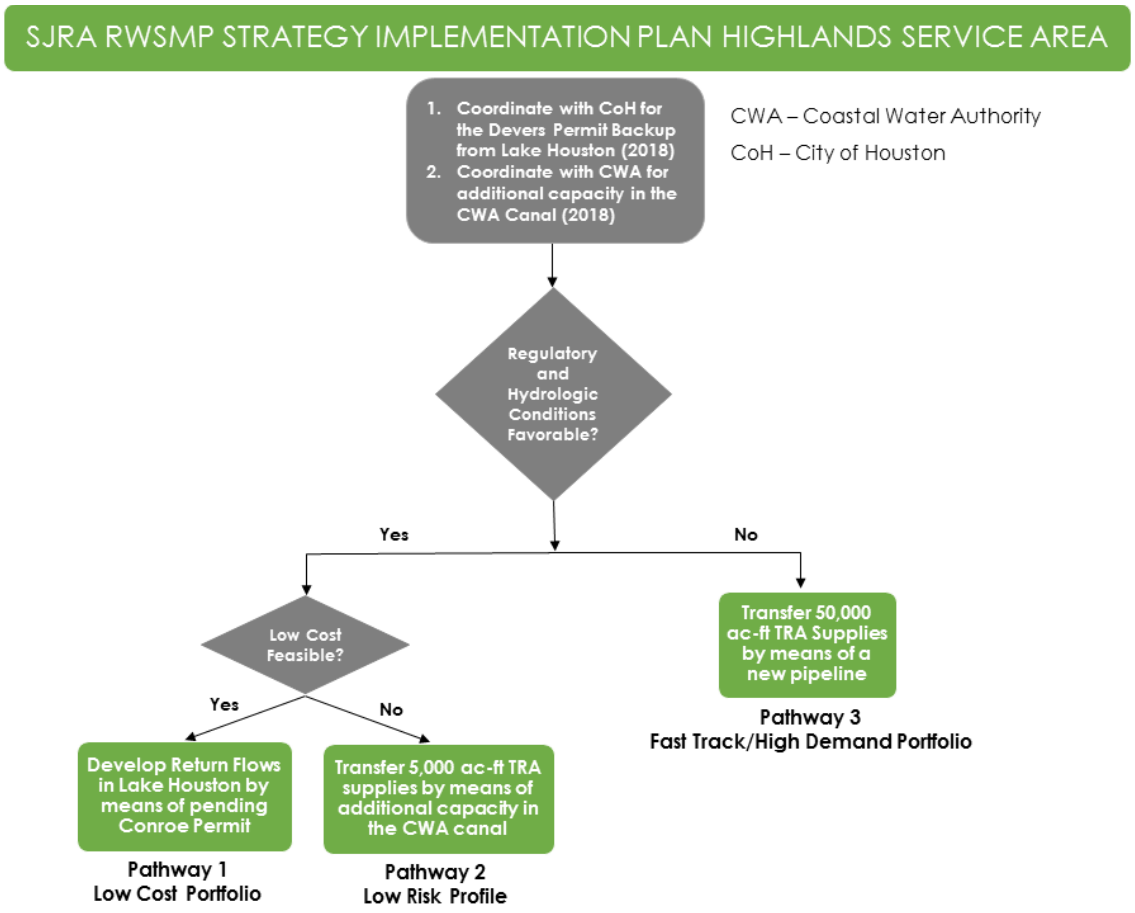

Figure ES8: Strategy Implementation Plan for Highlands Service Area

Strategy implementation schedules were developed and included in this study. They are meant to be planning-level schedules summarizing the overall implementation schedule for the feasibility and planning, design, and construction phases of a given strategy. The schedules were developed to determine the potential timing for when a strategy can be available online to ensure that the strategy is available to be included in any portfolio when it is required to meet the Service Area needs. *Table ES12* includes the illustration of the implementation schedule for SJRA's preferred portfolio to serve the needs in the Montgomery County Service Area.

Table ES12: Strategy Implementation Schedule Illustration for Montgomery County Service Area (Preferred Implementation Pathway)

Number	Strategy Name	Begin Planning By	Begin Design By	Begin Construction By	Project Online By
1	Catahoula Aquifer	2020	2026	2030	2036
2	Lake Livingston Transfer	2023	2029	2035	2040
3	Return Flows	2045	2051	2054	2057
4	Direct Reuse	2050	2053	2056	2060
5	Aquifer Storage & Recovery	2048	2054	2060	2066
1	Catahoula Aquifer	2020	2026	2030	2036

The implementation plan also includes a summary of the best practices, actions to be taken to execute the implementation plan and the scenarios that drive the need for an update of the current implementation plan. The approach for planning future supplies is developed such that it allows for easy incorporation and integration of changes that impact the future water supplies. With the potential future project pathways described in the implementation plan, SJRA can focus on the following actions to effectively execute the implementation plan.

1) Incorporate the results from the implementation plan and the recommended strategies from the preferred pathway into the Capital Improvement Planning (CIP) process, rate studies, and other internal planning processes.
2) Coordinate with the four SJRA water supply divisions to develop a list of specific action items to successfully plan, develop and implement the strategies identified in the implementation plan.
3) Coordinate with other regional entities such as LSGCD, COH, TRA and other entities to initiate the conversations on the various water supply strategies. Specifically,

    - *Coordinate with LSGCD on the development of the Catahoula Aquifer Supplies*
    - *Coordinate with COH on the final agreement of the usage of COH's share of Lake Conroe supplies*
    - *Coordinate with COH on the development of the return flows in the Lake Houston watershed*
    - *Coordinate with COH on the final agreement on the Lake Houston backup of SJRA water rights in Highlands Service Area*
    - *Coordinate with TRA on finalizing the options agreement for the Lake Livingston Water Transfer to Lake Conroe*

- *Coordinate with TRA on potentially using additional TRA supplies to meet the needs in the Highlands Service Area and potential additional future needs in Montgomery County Service Area. The water supply may not be needed for many decades into the future but it would be prudent to establish some understanding on the potential need for the water.*

4) Develop a feasibility study to evaluate the potential transmission corridors for transferring Lake Livingston supplies to Lake Conroe
5) Develop an environmental feasibility study to identify the potential environmental issues associated with the Lake Livingston transfer strategy.
6) Develop a groundwater feasibility study to evaluate the availability and identifying potential locations for developing Catahoula Aquifer supplies.
7) Develop an Aquifer Storage and Recovery feasibility study to evaluate the potential for developing the strategy and the yield produced from the strategy.
8) Develop a feasibility study to determine the potential return flows available and establish contract relationships with the parties owning the return flows.
9) Coordinate with the Region H Regional Water Planning Group to ensure that SJRA's preferred water management strategies and implementation plans are accurately reflected in the upcoming 2021 Region H Regional Water Plan and 2022 State Water Plan.

While it is understood that the strategies included in the implementation plan may remain the same over the planning horizon, it would be prudent to review the assumptions including the supply and demand projections at regular intervals to verify that the implementation plan proposed in this RWSMP is still the preferred pathway. It is recommended that SJRA carefully review and update the RWSMP whenever there is a significant change in anticipated demand and supply conditions. In addition, it is recommended that the implementation plan be revisited annually based on any new information or developments pertaining to the supply strategies considered in the study. Finally, it is recommended that SJRA update the RWSMP at least once every five years in conjunction with the regional water planning process.

1.0 INTRODUCTION

The San Jacinto River Authority (SJRA) is a conservation and reclamation district, body politic and corporate, and a governmental agency of the State of Texas created and operating under the provisions of a series of acts compiled as Vernon's Annotated Texas Civil Statutes, Article 8280-121, enacted pursuant to the provisions of Section 59 of Article XVI of the Texas Constitution, whose area comprises all of the territory within the watershed of the San Jacinto River and its tributaries, except that portion of the watershed lying within the boundaries of Harris County. Such geographical area consists of all of Montgomery County and parts of Waller, Grimes, Walker, San Jacinto, Liberty, and Fort Bend counties.

1.1 MISSION OF THE SAN JACINTO RIVER AUTHORITY

The SJRA was created by special act of the 45th Texas Legislature in 1937 in order to develop, conserve, and protect the water resources of the San Jacinto River Basin. Historic undertakings of the authority in pursuit of water supply development include:

- Acquisition of the Federal Works Agency canal system serving industry,
- Acquisition of additional water rights in Lake Houston following its completion,
- Planning and development of Lake Conroe as a joint water supply between SJRA and the City of Houston (COH),
- Ownership and operation of the water and wastewater systems serving The Woodlands,
- Acquisition of water rights in the Trinity River,
- Sponsorship of the Senate Bill 1 Regional Water Planning process for Region H,
- Development of a reclaimed water right from wastewater return flows from The Woodlands,
- Development of a Groundwater Reduction Plan (GRP) for allowing participating water systems in Montgomery County to meet groundwater reduction requirements, and

- Contracting with the City of Houston for access to the entirety of the Lake Conroe water supply for use within Montgomery County.

In the future, SJRA will continue to address water supply issues for the region through the development of water supply projects and the responsible stewardship of resources. This Raw Water Supply Master Plan (RWSMP) is intended to serve as a tool in furthering the goals of the authority for the shared benefit of water users within its Service Area.

1.2 SAN JACINTO RIVER AUTHORITY OPERATIONS

Water supply operations for the SJRA are divided into four separate operating divisions which include the Highlands Division, Lake Conroe Division, Groundwater Reduction Plan (GRP) Division, and the Woodlands Division. These separate divisions each function with their own dedicated staff, budget, and planning. Several of these divisions rely upon others for all or a portion of their water supplies. All four water supply divisions are guided and supported by the Board of Directors of the SJRA and the General & Administrative (G&A) Division. ***Exhibit 1*** shows an overview of the location of the four operating divisions.

1.2.1 Highlands Division

The Highlands Division is located in eastern Harris County and serves a mixture of industrial, municipal, and agricultural customers with raw water from the San Jacinto River and the Trinity River. San Jacinto River diversions are made at the Lake Houston Dam and transferred via the Main Canal to Highlands Reservoir where the water is conveyed through either the East Canal or South Canal to customers near Mont Belvieu and Baytown, respectively. Diversions are made by a number of customers along the entire length of the canal system both upstream and downstream of Highlands Reservoir. These canals were originally constructed by the Federal Works Agency and were acquired by SJRA in 1945.

The SJRA has also acquired water rights in the Trinity River from the Devers Canal Company and the Chambers-Liberty Counties Navigation District (CLCND). These supplies can be conveyed to the Highlands Service Area through a contractual arrangement with the Coastal Water Authority (CWA) via pump stations on the East and South Canals which lift the water from the CWA Canal into the SJRA system.

The Highlands Division currently serves a larger volume of water to customers than any other division and has been the principal enterprise of SJRA for most of the authority's history. The layout of the Highlands System is shown in ***Exhibit 1***.

1.2.2 Lake Conroe Division

The SJRA Lake Conroe Division is located west of the City of Conroe in Montgomery County where it maintains and operates the Lake Conroe Dam. Construction of this impoundment was initiated as a water supply project in 1969 as a joint project funded by SJRA and the COH, and the reservoir was completed in 1973. The two project sponsors each own a share of the water made available by the reservoir with SJRA owning one-third of the supply. The balance of the water right, owned by COH, has been made available to SJRA through contractual means for use within Montgomery County.

In addition to the maintenance of the dam and spillway structure at Lake Conroe, the division is also responsible for managing water quality issues related to the reservoir, including a comprehensive watershed protection program, and providing for navigation and recreation of the reservoir.

The raw water supply made available by the Lake Conroe Division supplies an industrial customer within Montgomery County as well as lakeside commercial and residential irrigation customers. However, the primary customer of the Lake Conroe Division is the GRP Division which uses raw water from the reservoir for meeting its surface water conversion requirements.

1.2.3 Groundwater Reduction Plan Division

The GRP Division was formed as a direct response to the need to reduce groundwater pumpage as well as to diversify water supplies within Montgomery County. The Lone Star Groundwater Conservation District (LSGCD) requires that Large Volume Groundwater Users (LVGUs) reduce their groundwater production to prevent adverse impacts to the Gulf Coast Aquifer System throughout the county. SJRA developed a GRP to serve regulated LVGUs throughout the county, including the City of Conroe and The Woodlands. This joint approach to conversion is intended to provide a cost-effective means of attaining compliance for all members.

The first phase of the GRP included the development of a surface water intake, treatment plant, and treated water pump station at the Lake Conroe Dam as well as 57 miles of transmission pipelines. Raw water from Lake Conroe, managed by the Lake Conroe Division, is treated at the facility by the GRP Division and provided to connected GRP participants, while some other participants are allowed to continue their level of groundwater use in a balanced manner that achieves groundwater reduction compliance for the comprehensive GRP. The layout of the current GRP Division system is shown in ***Exhibit 1***. Although Lake Conroe serves as the primary water supply to facilitate compliance today, future

strategies employed by the GRP Division may include other water management measures including new raw water source development, reuse, conservation, and the development and use of other unregulated groundwater sources.

1.2.4 Woodlands Division

The Woodlands Division is located in southern Montgomery County and provides water and wastewater service to the population of The Woodlands, which numbers over 100,000 residents. SJRA's operations provide for the production and wholesale distribution of water to the various Municipal Utility Districts that provide retail service to individual customers, as well as the regional collection and treatment of wastewater. The division's infrastructure includes five water plants, 38 wells, and three regional wastewater treatment plants and elevated storage tanks. SJRA has been engaged in this mission through the Woodlands Division since 1975.

The source of water supply for the Woodlands Division has traditionally consisted of groundwater wells producing water from the various formations of the Gulf Coast Aquifer System. However, county-wide management of groundwater resources has necessitated the conversion of supply for the Woodlands Division from a sole source of groundwater to a majority of surface water provided by the GRP Division. Groundwater infrastructure continues to be maintained and is used for meeting peak demands in excess of the available surface water supply.

The operations of the Woodlands Division also provide for additional supplies to customers within The Woodlands and downstream. In 2004, SJRA pursued and obtained a water right permit for the use of return flows originating from Woodlands Division wastewater treatment plants that allow for the bed and banks delivery of the water supply downstream along the San Jacinto River as far as the Lake Houston Dam. Some of this water is used through direct reuse within The Woodlands while the remaining supplies can be used by the Highlands Division and other SJRA customers between the two points.

1.3 THE NEED FOR A RAW WATER SUPPLY MASTER PLAN

The nature of water supply development necessitates the need for a detailed, comprehensive, long-term approach to planning. One reason for this need is the timeline for development of water supply projects. Among the 85 significant, infrastructure-requiring projects in the 2016 Region H Regional Water Plan (RWP), the average project development time is almost nine years with several projects anticipated to have a development timeline of 20 years or more, even under favorable conditions. The RWSMP structure

provides for an opportunity to consider these long-term needs and prepare for appropriate measures to avoid water supply deficits.

In addition to the time required to develop viable water supplies, cost is also a significant factor encouraging the adoption of a thorough planning process. The 2016 Region H RWP projects over $1-billion dollars in capital projects required by SJRA through the year 2070. A detailed examination of water supply needs and potential projects is required to adequately assess the demand for water and an economical and environmentally responsible means of meeting future needs.

The magnitude of anticipated water supply projects necessitates a significant amount of stakeholder input and involvement, whether it be from other water providers, agencies, or the general public. Often, there are combinations of these parties that must be kept informed of decisions being made by a project sponsor, such as SJRA, and these parties should be included in the process. The development of a RWSMP provides a framework for these discussions while also serving as a written record of decisions made from plan inception to project delivery.

Finally, although the Texas Water Development Board (TWDB) funds and administers the Regional and State Water Planning process, it is necessary for each water provider, especially those that supply a significant regional demand, to conduct its own planning to address factors that are unique to its own operations. For instance, where the State Water Plan (SWP) allows for the consideration of only one demand and supply scenario for long-term planning, a water provider may find the need to consider alternative approaches to these projections that significantly impact its ability to provide water. By weighing multiple scenarios of climatic and demand growth patterns, an organization such as SJRA can balance associated risks with anticipated costs of projects in order to reach a robust, yet cost-effective plan for its customers.

1.4 GENERAL APPROACH FOR RAW WATER SUPPLY MASTER PLAN DEVELOPMENT

1.4.1 Definitions and Terms

There are various terms used in this master plan that may mean different things in another context. Included below is a list of frequently used terms in this master plan and the definition for the terms as it relates to this master plan.

Availability – Maximum amount of water that could be produced by a source during a repeat of the drought of record, regardless of whether the supply is physically connected to or accessible.

Drought of Record – The period of record when historical records indicate that natural hydrological conditions would have provided the least amount of water supply.

Existing Water Supply – Maximum amount of water that is physically connected to and legally accessible by a water user group from existing sources under a repeat of drought of record conditions.

Firm Yield – The Texas Commission on Environmental Quality (TCEQ) defines "firm yield" as "that amount of water that the reservoir could have produced annually if it had been in place during the worst drought of record. In performing this simulation, naturalized streamflows will be modified as appropriate to account for the full exercise of upstream senior water rights as well as the passage of sufficient water to satisfy all downstream senior water rights valued at their full authorized amounts and conditions as well as the passage of flows needed to meet all applicable permit conditions relating to instream and freshwater inflow requirements".

Implementation Schedule – A plan summarizing the assortment of strategies that should be developed and the schedule for incorporating them into the SJRA system.

Municipal Water Demand Projection – An estimate of the amount of water projected to be used by a given population in future years. This is determined by multiplying the population for a future year with a representative per capita daily water use from historical period of record.

Non-Municipal Water Demand Projection - Non-municipal demands consist of irrigation, industrial, mining, livestock, and steam electric power demands. Development of non-municipal demand projections incorporates a number of different factors relevant to specific use types, including recent trends, growth projections, special studies, and recommendations from Regional Water Planning Groups.

Portfolio – A combination of strategies to address water supply needs for the RWSMP planning horizon.

Scenario – An alternative future condition for supply availability that is a combination of the known risk variables that define a potential future condition. There can be multiple scenarios developed in this study depending on the combination of the known risk variables considered.

Strategy – A water supply source, via either existing supply or new source. This could be a reservoir, groundwater wells, reuse supply, conservation (demand reduction), desalination, and/or any other potential source. An alternative usage for this term is a project.

Supply Source – A source of supply either developed or to be developed, either currently owned or potentially to be owned by SJRA, originating from surface water sources or groundwater sources or alternatives sources such as reuse, conservation, desalination, or other.

Water Need – A projected water supply shortage based on the difference between projected demands and existing water supplies, incorporating reasonable sedimentation estimates.

1.4.2 Planning Process

The development of the RWSMP has been conducted as a cooperative effort among SJRA's operating divisions with the assistance of their consultant, Freese and Nichols, Inc. (FNI). Throughout the process, which began in December 2015, SJRA held staff workshops to receive information and guide the development of the plan. Information was collected by SJRA and FNI and processed to provide data to the process and to facilitate further discussion related to long-range water supplies. *Table 1* provides a summary of these meetings and the primary topics addressed.

Table 1: SJRA Workshop Meeting Topics

Meeting Date	SJRA Workshop Topic				
	Demands	Supplies	Strategies	Strategy Portfolios	Implementation Plan
February 26, 2016					
May 19, 2016					
July 12, 2016					
June 27, 2017					
September 21, 2017					
January 12, 2018					
February 16, 2018					
March 13, 2018					

1.4.3 Cyclical Nature of Planning

This RWSMP document is intended to be a starting in point in the current iteration of SJRA's long planning history. It is not meant to conclude the planning process, even for the given 50-year time-frame it covers. As time progresses and various obstacles and opportunities arise, the master plan for SJRA's raw water supplies will be adjusted to best suit the contemporary understanding of the various factors relevant to the plan.

This document presents a wide range of strategies that may serve as potential water supply options. The project portfolios included in the RWSMP present combinations of these strategies but allow for substitution over time as new information becomes available. Finally, the implementation plan itself is designed with a number of decision points that are intended to vary the prescribed course, as necessary.

Due to the dynamic nature of water supply issues, it is recommended that SJRA will revisit the recommendations of the RWSMP periodically to confirm schedule and suitability of the assumptions presented. It is also helpful to confirm the suitability of the projects included on a five-year basis alongside the development of the Region H RWP to ensure that the most desirable strategies are included in the plan for the sake of regional understanding as well as the availability of funding from TWDB.

Finally, various events may trigger a more comprehensive review of the RWSMP. These events include such items as a significant increase in the SJRA Service Area, major shifts in development patterns, or unexpected impacts to current water supplies and major anticipated demand increases. Of these factors, changes to current water supplies can often create the most dramatic impact to raw water supply needs and require the most immediate action. Recently, the identification of invasive species in Texas lakes has brought about the previously unforeseen need for rapid development of alternative water management strategies and may be a risk factor that could result in a major deviation from the selected implementation plan.

1.5 STAKEHOLDER OUTREACH

The need for stakeholder engagement in the water planning process is evident at all levels from the statewide process conducted by TWDB in developing the SWP to projects conducted by individual water providers and sponsors. SJRA initiated a parallel process to bring stakeholders into its RWSMP planning activities. Four stakeholder meetings were held to review the progress of the RWSMP and encourage feedback on the process. The meetings were divided into topics as shown in *Table 2*.

Table 2: Stakeholder Outreach Meeting Topics

Topic	Stakeholder Outreach Meeting			
	1	2	3	4
Approach				
Demand Scenario Evaluation				
Supply Scenario Evaluation				
Needs Identification				
Water Supply Strategy Screening				
Detailed Strategy Evaluation				
Risk Analysis				
Portfolio Development				
Implementation Plan				

Invited attendees included interested parties from:

- Chevron Phillips Chemical
- City of Conroe
- City of Houston
- City of Magnolia
- Entergy
- Exxon Mobil
- Greater Conroe Economic Development Council
- Harris Galveston Subsidence District
- Lonestar Groundwater Conservation District
- Montgomery County
- North Harris Country Regional Water Authority
- The Woodlands Joint Powers Agency

2.0 EVALUATION OF FUTURE DEMAND SCENARIOS

The SJRA serves customers in two major areas in the San Jacinto River Basin. The Highlands Division has historically served customers in eastern Harris County or which can be considered the Highlands Service Area. The other SJRA water supply divisions (Lake Conroe, GRP, and Woodlands Divisions) serve customers in Montgomery County or what can be considered the Montgomery County Service Area. The variability of demands and the nature of supplies associated with each Service Area necessitate separate methodologies for the evaluation of future demands. This section summarizes the evaluation of future demand scenarios used in directing long-term water supply strategies for SJRA.

The RWSMP considers the following demand categories for SJRA in both Service Areas:

- Industrial – Defined as the demands of wholesale industrial customers served by SJRA. In the Highlands Service Area, these demands are served from the Highlands supply system's raw water canals. In Montgomery County, these demands are served by lakeside diversions. These demands do not include industrial water use served through SJRA's municipal customers.

- Municipal – In the Highlands Service Area, these demands are defined as the demands of wholesale municipal customers who divert raw water from SJRA's canal system. In Montgomery County, demands were developed for the entirety of the county, of which SJRA serves a portion of the total demand through groundwater developed by The Woodlands Division, through surface water treatment and conveyance provided by the GRP Division, and, potentially, through other means that may be developed to provide water to meet the needs of the GRP Division's current contract and future Safe Harbor GRP customers. These demands may also include industrial and irrigation water supplies that are sold by municipalities and water utilities.

- Irrigation - Defined as the demands of wholesale irrigation customers served by SJRA. In the Highlands Service Area, these demands are served from the system's raw water canals. In Montgomery County, these demands are served by lakeside diversions. These demands do not include irrigation water use served through SJRA's municipal customers.

A more detailed discussion of this topic is included in ***Appendix A*** of this report and includes additional alternatives that were considered for future demand projections.

2.1 HIGHLANDS SERVICE AREA

2.1.1 Overview of Demands

The RWSMP considers the following demand categories for the Highlands Service Area:

- Industrial - In the Highlands Service Area, these demands are served from the system's raw water canals.
- Municipal - In the Highlands Service Area, these demands are defined as the demands of wholesale municipal customers who divert raw water from SJRA's canal system.
- Irrigation - In the Highlands Service Area, these demands are associated with agricultural production and are served from the system's raw water canals.
- Early in the twentieth century, Eastern Harris County developed as an agricultural area, primarily for rice farming and ranching, which created significant irrigation demand within this area. During and immediately after World War II, land uses began to convert to industrial facilities and small urban communities for workers in those facilities. Today, only limited irrigation demands remain and these demands are expected to disappear as urban residential demand replaces the few tracts that retain agricultural practices.

2.1.2 Projection Scenarios

Two scenarios were identified for the Highlands Service Area based on a combination of assumptions for industrial, irrigation, and municipal uses. These demand scenarios are described in *Table 3* and illustrated in *Figure 1*.

Table 3: Highlands Service Area Demand Scenario Descriptions

Scenario		Industrial	Irrigation	Municipal
1	Known Demands	Expanded Contracts[1]	Current Contracts	Current Contracts
2	Known Demands Plus Growth	Expanded Contracts + Region H Growth	Current Contracts	Current Contracts + Region H Growth

1 Recently Expanded Contracts for the near future. Do not represent Long-term future expansion.

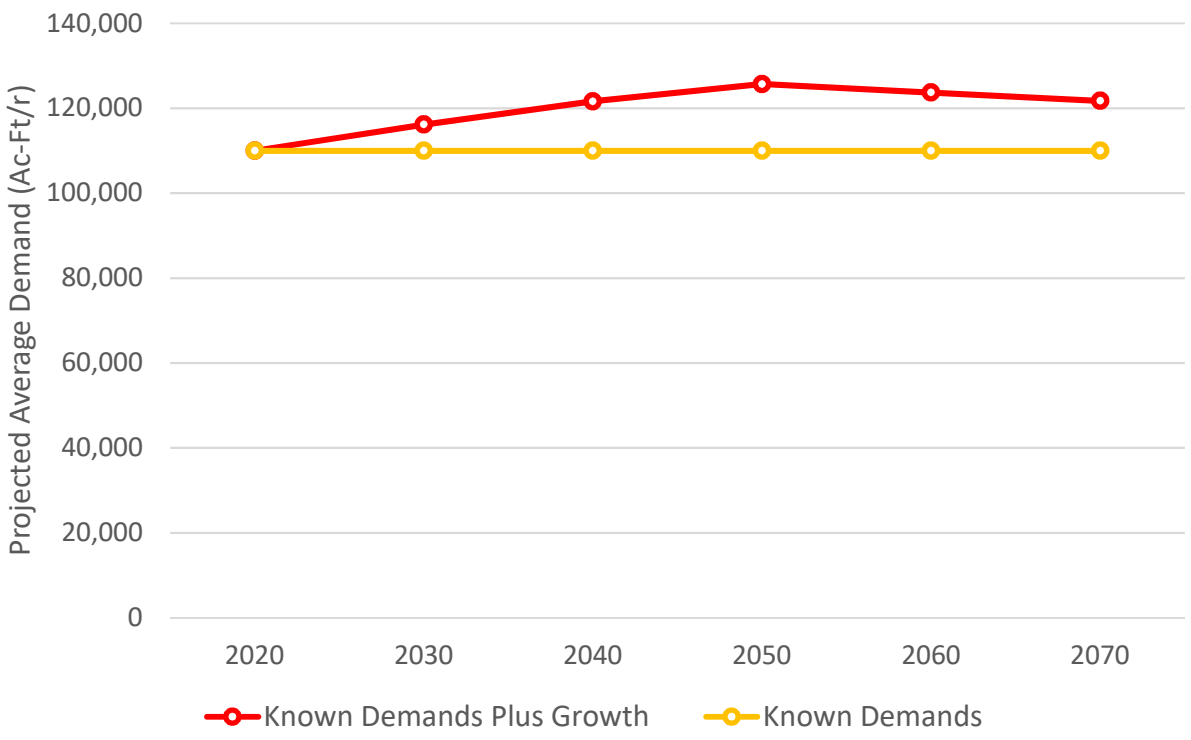

Figure 1: Highlands Service Area Demand Projections

Industrial demands were developed based on current contracts, plus additional needs that have been identified through existing customers. In addition, Scenario 2 also considered the application of the demand curve trend from the 2016 Region H RWP for manufacturing demands in the Trinity-San Jacinto Coastal Basin to add an additional degree of conservatism to the projections. This trend increases demands to the 2050 decade, after which anticipated conservation attenuates the demand growth to the end of the planning horizon. Irrigation demands for both scenarios were based on current contracts. Municipal demands were also based on current contracts, although Scenario 2 considered additional demand based on anticipated growth in County-Other water users within the Trinity-San Jacinto Coastal Basin as depicted in the 2016 Region H RWP.

Scenario 2 demands, including additional, future growth were selected for analysis of the Highlands Service Area in the RWSMP to provide for a conservative (i.e., higher) depiction of future demands.

2.1.3 Demand Patterns

The projections shown in *Figure 1* represent annual values for the Highlands Service Area. However, fluctuations in intra-year water use will produce a higher seasonal demand above this annualized value.

This peak demand will introduce water needs in excess of that demonstrated by the annual aggregate demand. This RWSMP is intended to identify water needs at a monthly timestep and, accordingly, reasonable estimates of demand peaking throughout the year were used to establish a likely pattern of use that could be used for further analysis.

Demand patterns for the Highlands Service Area were analyzed individually for industrial, irrigation, and municipal use. Monthly records of customer diversions were summarized using SJRA data to produce a monthly distribution of demands based on historic water use. These patterns are shown below in *Figure 2*. These patterns were used along with the decadal demand for each water use in each of the two scenarios described above to compute comprehensive patterns that could be used for surface water supply modeling and the operational model described below. This resulted in a combination of 12 (six decades and two scenarios) decade- and projection-specific demand patterns for analysis.

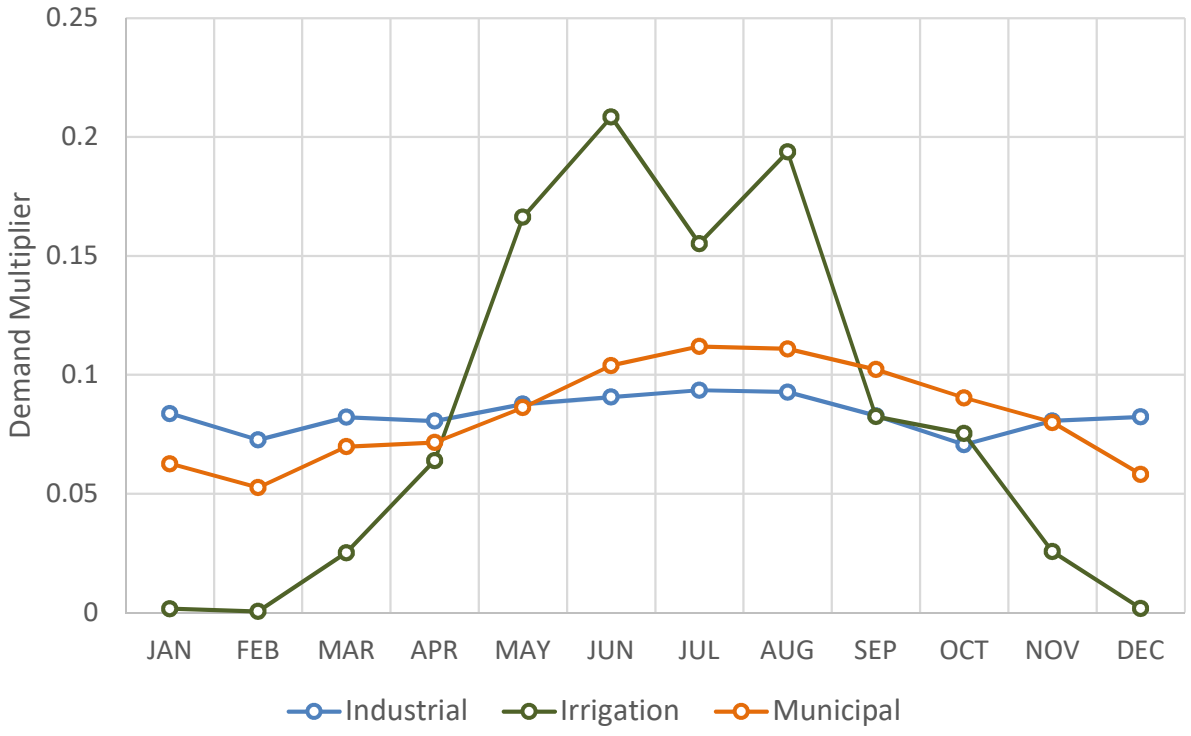

Figure 2: Highlands Service Area Demand Patterns

2.2 MONTGOMERY COUNTY SERVICE AREA

2.2.1 Overview of Demands

The RWSMP considers the following demand categories for the Montgomery County Service Area:

- Industrial – In Montgomery County, these demands are served by lakeside diversions. These demands do not include industrial water use served through SJRA's municipal customers.

- Municipal – In Montgomery County, demands were developed for the entirety of the county, of which SJRA serves a portion of the total demand through groundwater developed by the Woodlands Division, through surface water treatment and conveyance provided by the GRP Division, and, potentially, through other means that may be developed to provide water to meet the needs of the GRP Division's current contract and future Safe Harbor GRP customers. These demands may also include industrial and irrigation water supplies that are sold by municipalities and water utilities to their individual retail customers.

- Irrigation - In Montgomery County, these demands are associated with golf course and residential landscape irrigation which are served by lakeside diversions. These demands do not include irrigation water use served through SJRA's municipal customers or by other privately-owned water sources.

Exhibit 2 illustrates the percent increase in population in the Montgomery County Service Area over the planning horizon ranging from 2020 – 2070. As shown, significant amount of growth is expected to occur in the Service Area in the future decades. Demands for Montgomery County were first developed for the entirety of the county which includes demands served by SJRA as well as other providers including self-supplied groundwater. Demands met by other sources were later removed from this comprehensive analysis to account for groundwater supplies and water supplied through other GRPs in the county. This approach provided both county-wide and SJRA-specific summaries of demands allocated geographically throughout the county based on utility, political, or census boundaries that could be considered in detail throughout the planning process.

2.2.2 Projection Scenarios

Three scenarios were identified for the Montgomery Service Area based on a combination of assumptions for industrial, irrigation, and municipal uses. The future SJRA Service Area in Montgomery County will potentially vary based on the growth of the county and the expansion of the Authority's Service Area to include water demands for future Large Volume Groundwater Users (LVGUs) included in SJRA's Safe Harbor GRP. In order to account for these water demands, the water demands for the entirety of Montgomery County were first developed and then water supplies from other sources were accounted

for to reduce the projected demand to only include the anticipated surface water demand that would be met by SJRA. These alternative supplies include:

- Groundwater from the Gulf Coast Aquifer represented by 70 percent of the Total Qualifying Demand (TQD) of SJRA's GRP,
- Water supplied to users in other GRPs in Montgomery County, and
- Exempt pumpage by non-LVGUs, including domestic and livestock use.

The three scenarios considered for the Montgomery County Service Area are described in *Table 4*. Demands for the entirety of Montgomery County are illustrated in *Figure 3*. Finally, the demands anticipated for SJRA's Service Area within the county are shown in *Figure 4*.

Table 4: Montgomery County Service Area Demand Scenario Descriptions

Scenario		Industrial	Irrigation	Municipal
1	No Conservation	Expanded Contracts[1]	Current Contracts	Region H Population, Per-capita Demand, and Manufacturing
2	TWDB Baseline Municipal Conservation	Expanded Contracts	Current Contracts	Region H Population, Per-capita Demand, and Manufacturing + Baseline Conservation
3	Advanced Conservation	Expanded Contracts	Current Contracts	Region H Population, Per-capita Demand, and Manufacturing + Advanced Conservation

1 Expanded Contracts represent near-term future projections and not based on the long-term demand growth.

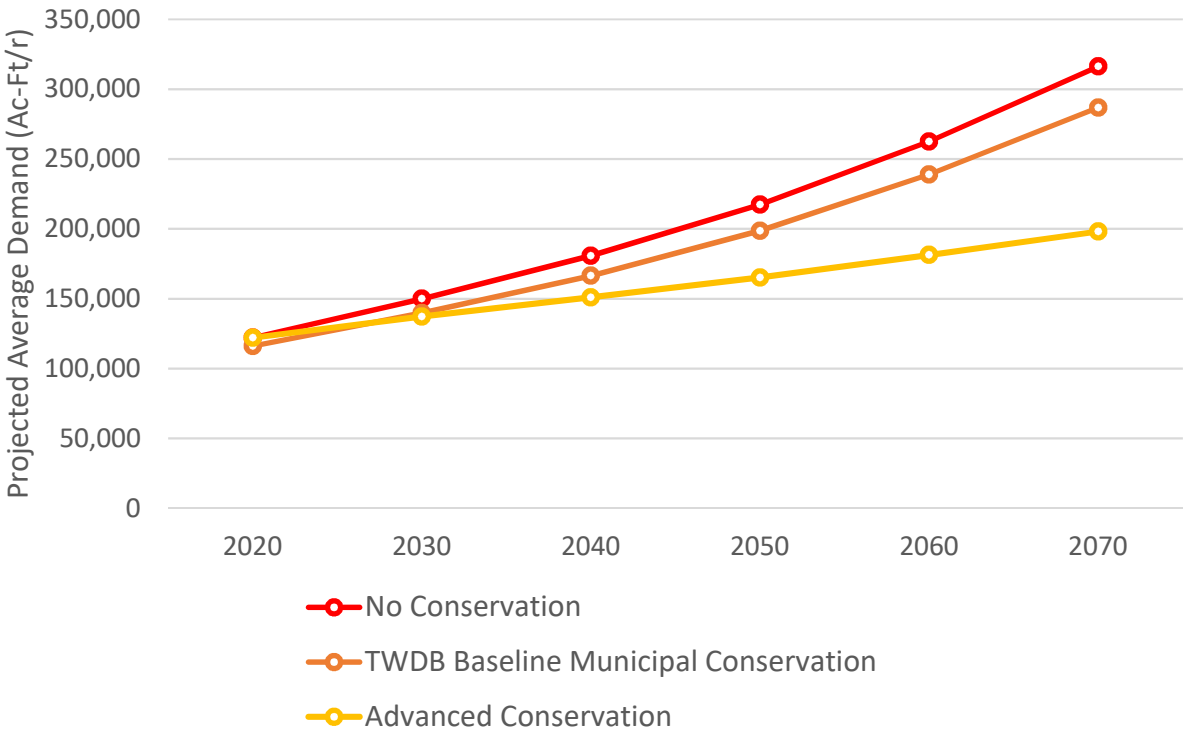

Figure 3: Montgomery County Demand Projections (SJRA, plus Other Service Areas)

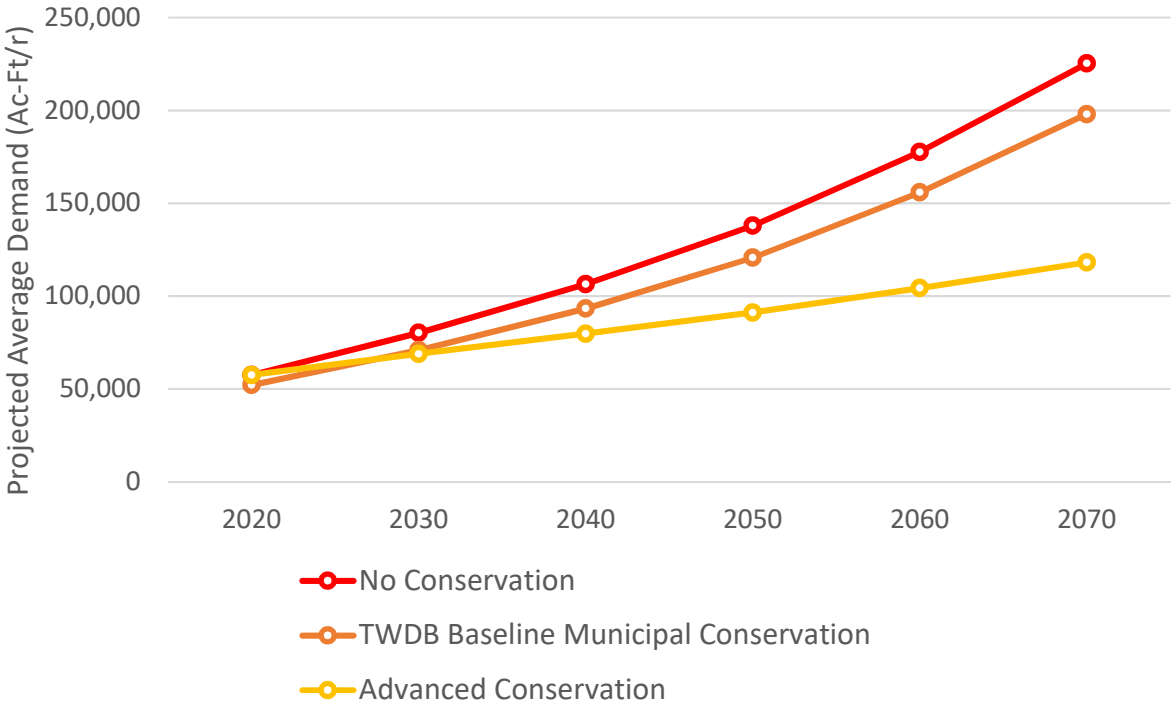

Figure 4: Montgomery County Service Area Demand Projections (SJRA)

All three proposed demand scenarios for the Montgomery County Service Area were developed to include industrial demand projections based on current contracts, plus increases in demand anticipated by SJRA's customers. Similarly, irrigation demands for all scenarios were based on current contract amounts. Municipal demands were based on population projections and baseline per-capita demands included in the 2016 Region H RWP. In addition, manufacturing demands from the 2016 Region H RWP were included as municipal demands as these values are associated with light industry provided for through public water systems. The Scenario 1 municipal demands were not adjusted for baseline conservation levels that are typically applied by TWDB in the development of RWP projections, providing a higher overall projection. Scenario 2 included these baseline conservation savings and Scenario 3 included an additional advanced conservation assumption of a one-percent annual reduction in per-capita water demands over the planning horizon.

Scenario 1 demands were selected for the Montgomery County Service Area due to the more conservative planning condition they depicted. This projection includes no applied water conservation and therefore resulting unit demand reduction over time, although comparisons to Scenarios 2 and 3 demonstrate the great potential for reducing water needs through conservation practices. However, this option allows for the potential to capture savings from water conservation through strategies in later phases of the RWSMP.

2.2.3 Demand Patterns

The projections shown in *Figure 4* represent annual values for the Montgomery County Service Area. However, fluctuations in intra-year water use will produce a higher seasonal demand above this annualized value. This peak demand may introduce water needs in excess of what is demonstrated by the annual aggregate demand. This RWSMP is intended to identify water needs at a monthly timestep and, accordingly, reasonable estimates of demand peaking throughout the year were used to establish a likely pattern of use that could be used for further analysis.

Demand patterns for the Montgomery County Service Area were analyzed individually for industrial, irrigation, and municipal use. Monthly records of customer diversions were summarized using SJRA data to produce a monthly distribution of demands based on historic water use. These patterns are shown below in *Figure 5*. These patterns were used along with the decadal demand for each water use in each of the three scenarios described above to compute comprehensive patterns that could be used for surface water supply modeling and for the operational model described below. In addition, consideration was made to allow for the use of groundwater wells to reduce seasonal peaks during warm periods of the

year, resulting in a flatter curve for municipal use. This analysis resulted in a combination of 18 decade- and projection-specific demand patterns for analysis.

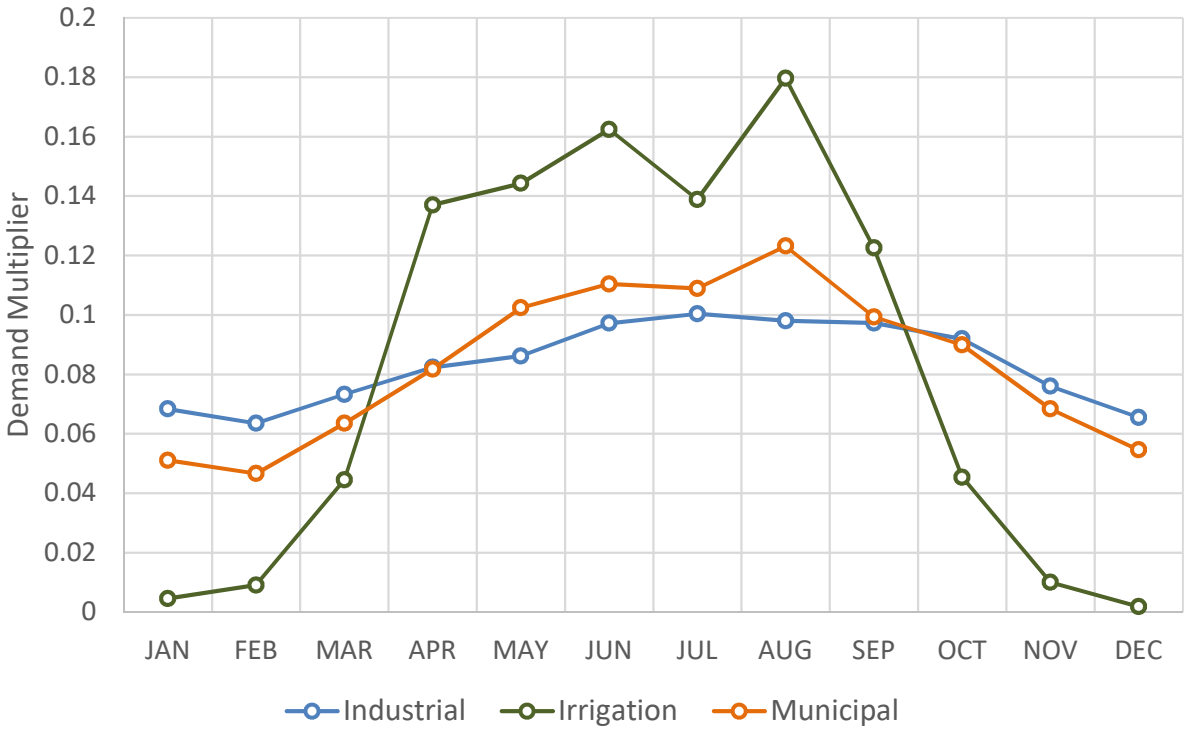

Figure 5: Montgomery County Service Area Demand Patterns by Water Use

3.0 EVALUATION OF WATER SUPPLY SCENARIOS

The SJRA uses water supplies from the San Jacinto and Trinity River Basins to serve customers of its four operating divisions. Currently, Lake Conroe is the primary source of supply for Montgomery County and the Lake Conroe, GRP, and Woodlands Divisions, with limited demands being met through the use of reclaimed water from The Woodlands. The Highlands Division relies upon a blend of water diverted from Lake Houston as well as water transferred from the Trinity River Basin. These surface water supplies consist of both run-of-river (water withdrawn directly from the stream) supplies and reservoir supplies which differ in their reliability under drought-of-record conditions. While run-of-river supplies are subject to water availability as a function of basin hydrology at the time of diversion, reservoir supplies, such as Lake Conroe, may utilize storage to make diversions during periods when streamflows are limited and not available for diversion. This section summarizes the evaluation of future supply scenarios used in directing long-term water supply strategies for SJRA.

Often, long-range water planning generalizes water supplies on an annual basis and seeks to identify deficits between supplies and demands on a similar timescale. This approach can ignore deficits that occur on a sub-annual basis and can therefore under-estimate water needs, especially for run-of-river supplies that do not benefit from storage to aid in extending supplies through a drought of record condition. This RWSMP identifies water needs on a monthly basis. A more detailed discussion of this topic is included in ***Appendix B*** of this report and includes additional alternatives that were considered for supply projections. These include considerations for expected conditions that consider the addition of return flows and hydrologic uncertainty as well as a consideration of potential supplies, as extended through the use of SJRA's drought contingency plan.

3.1 HIGHLANDS SERVICE AREA

3.1.1 Supplies Available to SJRA

The Highlands Service Area uses a diverse range of supplies to meet customer demands within the area, including run-of-river supplies from the San Jacinto and Trinity River Basins. The supplies from San Jacinto Basin are diverted at Lake Houston and delivered through the Highlands canal system. Trinity River Basin supplies are diverted at the Trinity River Pump Station operated by the Coastal Water Authority (CWA) and delivered to the Highlands Service Area through the CWA Main Canal where it can be diverted through pump stations to the SJRA Highlands East or South Canals. *Table 5* summarizes the supplies available to

the Highlands Service Area. These permits are shown with their corresponding annual diversions. Each permitted diversion is subject to availability based on hydrologic conditions and the annual volume may be reduced by drought conditions.

Table 5: Water Supplies Available for Meeting Demands in the Highlands Service Area

Source Name	Water Right Number	Permitted Supply Volume [1] (Acre-Feet per Year)	River Basin
Highlands Permit	WR-4964	55,000	San Jacinto
Lake Houston Additional Authorization (SJRA Portion)	WR-5807	14,100	
Lake Houston Excess Flow Permit (SJRA Portion)	WR-5808	80,000	
Lake Houston Reuse Permit	WR-5809	14,944	
Devers Run-of-River Right	WR-5271	56,000	Trinity
CLCND Run-of-River Right	WR-4279A	30,000	

[1] Supply availability as specified by permit. Actual, firm-yield supplies may vary based on hydrologic conditions.

All supplies from San Jacinto River Basin are currently diverted at SJRA's Lake Houston Pump Station. However, water rights 4964 and 5809 are not associated with Lake Houston and are not backed up by stored water in the reservoir, by permit. However, SJRA does hold a contract with COH guaranteeing firm supply for water right 4964 which is made 100% reliable through the COH Lake Houston water right. Water rights 5807 and 5808 are held jointly with COH with each party owning equal shares of the additional firm yield identified in Lake Houston and the potential to capture excess flows on an interruptible basis, respectively. Water right 5809 allows for the conveyance of wastewater discharged from wastewater treatment plants (WWTPs) operated by the Woodlands Division through the bed and banks of the San Jacinto River to the Lake Houston Pump Station. A portion of this right may be used within Montgomery County which would preclude an equal portion from being made available to the Highlands Service Area, although this usage has historically been negligible. Water supplies in Lake Conroe are also hydrologically connected to the Highlands System through the San Jacinto River and, theoretically, could be used within the Highlands Service Area, although this has not been assumed in this study due to the high demand for water within Montgomery County, which calls for the maximum use of Lake Conroe within the upper portion of the basin.

SJRA also owns two water rights in the Trinity River Basin. One of these rights, 5271, was purchased from the Devers Canal Company. This right has the benefit of backup from stored water in Lake Livingston through agreement with COH. Another right, 4279A, was purchased from the Chambers-Liberty Counties

Navigation District (CLCND) and does not have the benefit of backup under the same COH agreement. Both of these rights can be used to serve the majority of the Highlands Division's demands on the East and South Canals through the conveyance agreement with CWA. However, this agreement allows for only the transmission of up to 56,000 ac-ft/yr annually, limiting the total volume that can be conveyed currently.

3.1.2 Firm Yield Analysis

The firm yields of water rights in the Highlands Service Area were determined based on the Trinity and San Jacinto River Basin Water Availability Models (WAMs) maintained by TCEQ. These models were modified to include provision for reservoir sedimentation conditions projected for the years 2020, 2040, and 2070. The resulting annual available yields for these rights are shown below in *Table 6*. Although for illustrative purposes, this table summarizes annual totals, monthly values were used in the determination of water needs and the remainder of the RWSMP analysis.

Table 6: Highlands Projected Annual Water Availability

Period	Highlands[1] (4964)	SJRA (5807)	Excess Flow (5808)	SJRA Reuse (5809)	CLCND (4279A)	Devers[1] (5271)	Highlands TOTAL
2020	55,000	5,300	0	9,344	17,289	56,000	142,933
2040	55,000	3,500	0	9,344	17,289	56,000	141,133
2070	55,000	500	0	9,344	17,289	56,000	138,133

[1] Includes water made firm through contract with COH.

3.2 MONTGOMERY COUNTY SERVICE AREA

3.2.1 Supplies Available to SJRA

The Montgomery County Service Area is currently served with water solely from Lake Conroe however, growing demands will likely require additional sources of supply in the future. Water used from Lake Conroe may be diverted lakeside for meeting raw water demands or diverted from the lake and treated at the SJRA Surface Water Facility (SWF), then distributed to customers of the GRP Division. The SJRA Woodlands Division also produces groundwater for use by the utilities serving The Woodlands. However, this supply, as well as other groundwater supplies utilized by GRP Division customers, are not considered part of the RWSMP. Instead, the appropriate level of groundwater pumpage allowed by LSGCD regulation has been subtracted from the water demands developed for this study. *Table 7* summarizes the surface water supplies available to the Montgomery County Service Area.

Table 7: Water Supplies Available for Meeting Demands in the Montgomery County Service Area

Source Name	Water Right Number	Permitted Supply Volume [1] (Acre-Feet per Year)	River Basin
Lake Conroe [2]	WR-4963	100,000	San Jacinto

[1] Supply availability as specified by permit. Actual firm-yield supplies may vary based on hydrologic conditions.
[2] The Lake Conroe water right is split between SJRA and COH in a 1/3 and 2/3 ratio, respectively. SJRA may access water owned by COH through contractual agreement in place between the two parties.

The Lake Conroe water right was developed as a partnership between SJRA and COH. As part of this arrangement, SJRA operates the reservoir and owns one-third of the permitted water supply with COH owning rights to the remaining two thirds. In 2009, SJRA completed a contract with COH to secure the entirety of the Lake Conroe water right for use in Montgomery County. In addition to the Lake Conroe water right, SJRA also owns a reuse water right originating from WWTPs owned and operated by the Woodlands Division. Although a portion of this supply could be used within Montgomery County, this water has historically been utilized within the Highlands Service Area downstream. This RWSMP has followed this approach and considered this supply unavailable for use within Montgomery County.

3.2.2 Firm Yield Analysis

The firm yield of Lake Conroe, the primary source of surface water supply in Montgomery County, was determined based on the San Jacinto River Basin WAM maintained by TCEQ. These models were modified to include provision for reservoir sedimentation conditions projected for the years 2020, 2040, and 2070. The resulting annual available yield for the right is shown below in *Table 8*. Although this table summarizes annual totals, monthly values were used in the determination of water needs and the remainder of the RWSMP analysis.

Table 8: Montgomery County Projected Annual Water Availability

Period	Lake Conroe[1] (4963)	Montgomery County TOTAL
2020	79,300	79,300
2040	77,794	77,794
2070	75,500	75,500

[1] Includes water made available through contract with COH.

4.0 EVALUATION OF PROJECTED WATER NEEDS

The combination of projected future water demands and supplies defines the critical goal of the RWSMP. Future projects and strategies will be required to fill the needs anticipated for SJRA's Service Areas. Water needs were computed separately for both the Highlands and Montgomery County Service Areas through the year 2070 and these estimates were used to guide the selection of management strategies for project portfolios.

4.1 COMPLEX INTERACTION OF SUPPLIES AND DEMANDS

The regional and state water planning processes focus on water demands, supplies, and needs at an annual scale. This approach is appropriate for regional analyses but lacks the detail required for system-scale analysis where sub-annual shortages may manifest in a way that is not always visible at the annual scale. This is particularly important for the SJRA systems that rely on significant water rights that are not backed up by reservoir storage, which can reduce short-term shortages by allowing the "banking" of water for dry periods. Similarly, the operational demands of the infrastructure that daily serve the Highlands Service Area also lends itself to a detailed analysis of how supplies and demands are combined to determine actual projections of need.

4.2 DEVELOPMENT OF A DECISION SUPPORT MODEL FOR MODELING SUPPLIES AND DEMANDS

The detailed investigation of water needs requires a methodology for comparing water demands and supply on a sub-annual timestep at a number of locations to identify limitations in supply and delivery infrastructure that may influence the selection of water management strategies in later phases of the RWSMP. It is necessary to select strategies that provide water to diversion locations that are able to serve the area of need so that the need for additional conveyance or treatment infrastructure may also be determined. Therefore, the creative identification and application of strategies that serve the correct type of water to the location of greatest need is essential to the development of a successful plan. A wide range of applications can be applied to solve this issue, including something as simple as a spreadsheet model that represents the complexities of the supply and demand relationships for the Service Area. However, such a solution can be labor-intensive for more complex systems such as the SJRA Service Areas and not conducive to the flexibility required for testing multiple strategy portfolios.

The STELLA model was selected as the basis for development of the SJRA RWSMP. STELLA is not fundamentally a hydrologic, hydraulic, or operational model. Rather, it is a visual programming language that allows the user to model systems that can be constrained by the user as necessary. Such a model allows the complex combination of many aspects of water supply such as raw water availability, treatment, transmission, and water demands that are all dependent upon their own limitations and characteristics. A STELLA model developed for the SJRA water system is capable of not only identifying limitations in water supply and conveyance, but also estimating the effective costs of strategies implemented based on operational logic derived by the user. A decision support model developed using the STELLA program is amenable to frequent changes in decision variables and provides an easy and user-friendly analysis framework that is adaptable by users at all levels of the organization.

4.2.1 Basic Configuration

The STELLA model for the SJRA RWSMP consists of an interface tab and a model tab. Project-specific decision variables are included in the interface tab so that the users can modify them easily and according to their preference before performing model runs. ***Exhibit 3*** includes an illustration of the interface tab of the STELLA model. The model tab includes the detailed configuration of the monthly, annual, and decadal demand and supply computations as well as the physical representation of the Montgomery County and Highlands Service Areas with various entry points for existing supplies and take-off points for existing and future demands. The model also includes the industrial, irrigation, and municipal demand multipliers developed for this study. One major benefit of the STELLA model is that, instead of comparing supplies and demands on an annual basis, the model allows for a comparison between those on a basis set by the user, such as a monthly basis. In addition to this, the needs determined by means of the STELLA model are spatial in nature and linked to the physical location of the demand and the ability of the existing supply source to meet the demand at its location. ***Exhibit 4*** includes an illustration of the model tab in the SJRA STELLA model.

4.2.2 Enhanced Reservoir Operations

Another benefit of the STELLA model is the opportunity to join TCEQ WAM output to complex demand patterns. By default, the TCEQ WAMs model water availability based on a programmed pattern of water use. In a study such as the RWSMP, demands change dramatically based on the assumptions used for each considered scenario. If diversions made from a reservoir modeled in the WAM are not used to meet demand identified in the study, the supply goes unused and is not available for diversion in later months

when a shortage may occur. Offsetting this typically requires the modification of the WAM water use pattern to match it identically with demand patterns. However, this becomes prohibitive for complex studies with a number of demand scenarios. Here, STELLA can serve as a second "reservoir" for storing unused diversions.

The SJRA STELLA model was designed to capture unused reservoir diversions from Lake Conroe, on a monthly basis, after comparisons were made between monthly supplies and demands. These excess diversions could be stored in a reservoir within the STELLA model where appropriate net evaporation can be computed and assessed against the stored water volumes. This additional storage is discharged once overall storage between the WAM and STELLA reservoirs exceed the conservation pool capacity of Lake Conroe. This stored water can be used to meet demands in later months of insufficient supply. This concept is visually depicted below in *Figure 6*.

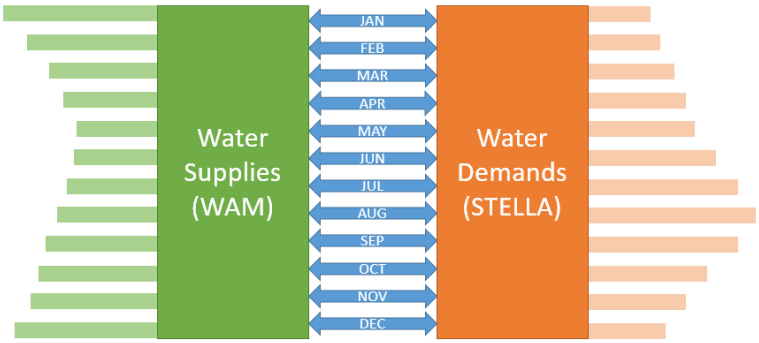

Figure 6: WAM and STELLA Model Interaction

4.3 IDENTIFIED PROJECTED NEEDS

The monthly STELLA model was used to compare monthly water availability and demand information for the Highlands and Montgomery County Service Areas by considering the linkage of these sources and customers and infrastructure and operational limitations in between. The needs for the Montgomery County Service Area were evaluated for three supply scenarios (base scenario, expected conditions scenario, and drought contingency scenario) and the three sets of demand scenarios identified in Section 2.0. Similarly, the needs for the Highlands Service Area were evaluated for the same three supply scenarios listed above and the two demand scenarios identified in Section 2.0. However, upon thorough evaluation of the three sets of needs for the Montgomery County Service Area and two sets of needs for Highlands Service Area, one set of needs for each Service Area was carried forward for the future determination of strategies. The projected needs for both Service Areas were based on the base

conditions of supply availability in the future decades. If different supply and demand scenario combination(s) are desired by SJRA in the future, the analysis can very easily incorporate those changes as needed. These monthly needs were retained for detailed analysis in the management strategy application process but are summarized on an annual basis for this report.

4.3.1 Highlands Service Area

Projected water needs for the Highlands Service Area are shown on an annualized basis in *Table 9*, below. These needs are of a relatively small magnitude and are driven largely by the limitation on the conveyance of water from the Trinity River Basin through the CWA Main Canal to the Highlands Service Area. Further limitations exist due to the interruptible nature of run-of-river supplies utilized by the system although it is recognized that two of the SJRA water rights are backed up through contracts with COH. Therefore, these needs are anticipated to occur sporadically throughout the projected study period due to a combination of seasonal demand peaks and drought impacts on supplies that lack backup through reservoir storage. Further risk of additional water need may come from unforeseen increases in water demand that have not been included in the demand analysis above. Although water needs are shown in *Table 9* for the 2020, 2040, and 2070 periods to correspond with the surface water model results, data was interpolated for every year of the planning horizon for the RWSMP analysis.

Table 9: Identified Water Needs for Highlands Service Area

Decade	Identified Need (Ac-Ft/Yr)
2020	0
2040	903
2070	2,813

4.3.2 Montgomery County Service Area

Projected water needs for the Montgomery County Service Area are shown on an annualized basis in *Table 10*, below. The magnitude of these needs are of a much larger magnitude than those identified for the Highlands Service Area and are primarily driven by the growth of total water demand resulting from the population growth in the region, meaning that these needs have limited seasonal variation and are expected to persist throughout the year once overall water demand exceeds current supply. Although water needs are shown in *Table 10* for the 2020, 2040, and 2070 periods to correspond with the surface water model results, data was interpolated for every year of the planning horizon for the RWSMP analysis.

Table 10: Identified Water Needs for Montgomery County Service Area

Decade	Identified Need (Ac-Ft/Yr)
2020	0
2040	50,087
2070	179,113

5.0 WATER MANAGEMENT STRATEGY SCREENING

The ultimate goal of the RWSMP is to prescribe a means for SJRA to develop future water supplies to meet identified needs. Water management strategies represent the potential source and location of future supplies which may be available for development in the future. Due to the large number of potential options, an initial screening process of these strategies was developed for the RWSMP. This screening process will help prioritize those projects which could continue to planning, design, and implementation phases in the future. Where it may be infeasible to perform detailed studies to evaluate the potential for numerous projects, a combination of information established from other studies, institutional knowledge, and directed studies can provide basis for decision-making in selecting strategies for a long-range plan. The SJRA RWSMP utilized this method in identifying potential water management strategies to meet the needs identified over the planning horizon.

5.1 IDENTIFICATION OF POTENTIAL STRATEGIES

The process of screening management strategies began with the development of a universe of alternatives that may be considered for future implementation. This process was conducted as a joint effort between SJRA and FNI and relied upon projects identified in planning documents such as the Region H regional water plan, SJRA-specific studies, and institutional knowledge between the two parties.

Table 11 summarizes the projects identified for consideration within this RWSMP. ***Exhibit 5*** includes an illustration of all the potential strategies and their approximate, generalized locations. It should be noted that the location identified for most of the strategies is merely an estimation based on available information. The table includes major categories of strategies as well as sub-types identified. Finally, the table indicates the Service Area each strategy was considered for. In each case, a potential strategy may be considered for either one or both of the Highlands or Montgomery County Service Areas. This list of strategies served as a starting point for consideration of projects. The list was further refined with more detailed alternatives for each strategy type, as the study progressed.

The major categories of strategies considered at the onset of the project identification process included:

- Aquifer Storage and Recovery – Use of underground storage to increase the firm yield of interruptible water supplies;

- Bedias Reservoir – Development of a new, major reservoir on Bedias Creek in the Trinity River basin;
- Brazos River Supplies – Pursuit and transfer of water supplies from the Brazos River basin from providers such as Brazos River Authority (BRA);
- Catahoula Aquifer Supplies – Development of alternative groundwater supplies from somewhat brackish groundwater formation that is not currently limited by groundwater regulations;
- Conservation – Reduction of overall water demand through the acceptance of potential baseline water savings and/or the implementation of proactive measures led by SJRA;
- Direct Reuse – Use of treated wastewater effluent to meet non-potable demands;
- East Texas Water Transfer – Transfer of raw water through canal or pipeline conveyance from the Neches or Sabine River Basins under long-term contracts for use;
- Increase Lake Conroe Conservation Pool – Permitting and physical improvements to Lake Conroe to increase conservation pool to extend firm supplies under drought conditions;
- Lake Creek Reservoir – Development of a new major reservoir in the upper portion of the Lake Creek basin;
- Lake Creek Scalping – Development of a project to divert available water supplies from Lake Creek and potentially add storage to produce an additional firm supply of water;
- Lake Livingston Transfer – Transfer of water supplies in the Trinity River basin that SJRA has established a contractual basis to purchase from TRA to either the Montgomery County or Highlands Service Areas;
- Purchase Groundwater – Purchase of groundwater from basins to the east or west of both Service Areas and transfer to the Highlands Service Area;
- Purchase Surface Water – Purchase of additional surface water under long-term contracts from various rights holders in the Trinity River basin;
- Regional Return Flows – Development of indirect reuse permits that include return flows from a number of wastewater systems in the San Jacinto River basin;

- Seawater Desalination – Treatment to remove solids from Galveston Bay water, plus transmission to the Highlands and/or Montgomery County Service Area;
- Trinity Return Flows – Development or purchase of return flows in the Trinity River basin.

Table 11: Potential Water Management Strategies Considered

Name	Sub-Type	Potential Service Area	
		Highlands	Montgomery County
Aquifer Storage and Recovery	Developed by SJRA Customers		•
	Developed by SJRA (GRP Treated)		•
	Developed by SJRA (Mildly Treated)		•
Bedias Reservoir		•	•
Brazos River Supplies		•	•
Catahoula Aquifer Supplies	Developed by SJRA Customers (Treated)		•
	Developed by SJRA Customers (Blended)		•
	Developed by SJRA (Lake Conroe)		•
	Developed by SJRA (Treated)		•
	Developed by SJRA (Blended)		•
Conservation	TWDB Baseline		•
	SJRA Recommendations		•
Direct Reuse	GRP Participants		•
	Woodlands		•
East Texas Water Transfer	Neches Basin	•	•
	Sabine Basin	•	•
Increase Lake Conroe Conservation Pool			•
Lake Creek Reservoir		•	•
Lake Creek Scalping	Run-of-River Diversion		•
	Storage in Lake Conroe		•
	Dedicated Storage		•
Lake Livingston Transfer	Livingston to Conroe		•
	Livingston to Highlands	•	
Purchase Groundwater	Purchase from Eastern Basins	•	
	Purchase from Western Basins	•	
Purchase Surface Water	Trinity River Authority	•	•
	Chamber and Liberty County Navigation District	•	
	City of Houston	•	•
Regional Return Flows	Lake Conroe		•

	Lake Houston	•	
	Lake Houston w/ South Plant		•
Seawater Desalination		•	•
Trinity Return Flows		•	

5.2 DETAILED EVALUATION OF SELECTED STRATEGIES

Although existing studies and institutional knowledge served as the predominant sources of information used to characterize, prioritize, and select water management strategies, SJRA also chose to perform the detailed study of some selected strategies to better refine project definitions and assess potential. These studies included the following:

- Highlands Service Area
    - Trinity Supplies Transfer to Highlands Service Area
    - Return Flows in Highlands Service Area
- Montgomery County Service Area
    - Lake Livingston to Lake Conroe Transfer
    - Catahoula Aquifer Supplies
    - Return Flows in Montgomery County Service Area
    - Municipal Water Conservation

Each of these strategies was evaluated to refine its definition, costs, and evaluation scoring at a planning level. ***Appendix D*** contains a technical memorandum for each of the options listed above, with many of these memoranda containing various alternative applications for the general strategy.

5.3 STRATEGY SCREENING

An objective methodology was prepared to evaluate and rank potential strategies so that preferences could be identified among the numerous options presented. This methodology, described below, was used to prepare a ranked list of strategies from which SJRA could select preferential strategies based, not only upon this ranked score, but also the timing, cost, volume, risk, and other factors associated with a project. This methodology is intended to be one of many tools used in selecting viable candidate strategies for future water supply development.

5.3.1 Methodology

The selection of the most preferable list of strategies was conducted using a screening process developed for the RWSMP study. A list of scoring criteria was developed to quantify the desirability of the strategies as related to defined attributes often characterized as the triple bottom line (Environment, Economics, and Social benefits). Each criterion was scored on a scale ranging from one (less favorable) to four (more favorable). Based on the information available from the Region H regional planning reports and other feasibility study reports, the strategies were assigned a score for each selection criterion. A total of 14 scoring criteria were developed to evaluate the strategies. The list of criteria, scoring range, and the descriptions of the strategies are presented in *Table 12*.

The overall preference of a strategy was determined by the approach discussed below. However, not all criteria impact the quantification of the water management strategies the same way. From the list of the criteria, SJRA determined the importance of each criterion by means of a weighting factor to quantify the importance in driving the overall project score. A weighting factor is simply a factor used to define the importance of the screening criteria. The factor defines how the screening criteria would be weighed in developing the overall strategy score. The weighting factors were assigned a value between one (low importance) and 100 (high importance). The sum of the weighting factors for the screening criteria was set to be a 100. The overall strategy score was determined as the sum product of the score assigned to the criteria and the weighting factor associated with the criteria.

Table 12: List and Description of the Screening Criteria Methodology

Cooperation		Weighting Factor (Low [1] - High [100]):	4
Description: Attributes quality to a project based on the potential for interaction with other entities.			
Scoring:			
Less Favorable **1**	**2**	**3**	**More Favorable** **4**
Significant potential obstacles in working with other stakeholders to develop project	Potentially some obstacles in working with other stakeholders to develop project	Potentially some opportunity to develop project synergistically with other stakeholders	Significant opportunity to develop project synergistically with other stakeholders

Cost	Weighting Factor (Low [1] - High [100]):	40

Description:
Estimated cost of water for a project. This value will be based on preliminary estimates and regional planning-level data.

Scoring:

Less Favorable 1	**2**	**3**	**More Favorable 4**
>$1,000 per ac-ft	$500 to $1,000 per ac-ft	$250 to $500 per ac-ft	<$250 per ac-ft

Diversification	Weighting Factor (Low [1] - High [100]):	2

Description:
Scoring based on how likely a project is to provide diversification to the existing SJRA water supply portfolio.

Scoring:

Less Favorable 1	**2**	**3**	**More Favorable 4**
Supply originates from sources linked to existing SJRA supplies	Supply originates from sources linked to existing SJRA supplies but may be influenced by other factors	Supply developed from sources unrelated to existing SJRA supplies	Supply developed from a variety of water resources outside of current SJRA portfolio

Environmental	Weighting Factor (Low [1] - High [100]):	6

Description:
Describes the extent of environmental impacts required for implementation of the project.

Scoring:

Less Favorable 1	**2**	**3**	**More Favorable 4**
Significant environmental impact is expected; significant environmental studies and mitigation may be required	Some notable environmental impact; uncertain course for studies and mitigation	Some notable environmental impact; routine process for permitting	Minor environmental impact; environmental studies have been completed on similar projects

Funding	Weighting Factor (Low [1] - High [100]):	4

Description:
Related to the ease at which alternative funding may be obtained for the project and if special incentives may be available for project development.

Scoring:

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
No obvious potential opportunities for funding	Common funding mechanisms may be utilized; project will compete equally with other competing projects	Specialized funding mechanisms exist	Project will receive beneficial consideration in a funding program due to type of project or source of water

Land Acquisition	Weighting Factor (Low [1] - High [100]):	4

Description:
Refers to the number of land acres that must be acquired in order to implement the project.

Scoring:

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
Significant land impact (>1,000 ac)	100-1,000 ac	5-100 ac	Minimal land impact (<5 ac)

Legal	Weighting Factor (Low [1] - High [100]):	6

Description:
Defines the level of legal obstacles that must be overcome in implementing the project.

Scoring:

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
Significant permitting required; extensive contracting	Moderate level of permitting and contracting; several unknowns	Moderate level of permitting and contracting; few unknowns	Minimal permitting required; simple contracting

Location	Weighting Factor (Low [1] - High [100]):	6

Description:
Related to the location of the developed supply and proximity to potential demands served.

Scoring:

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
IBT required, long distance from SJRA Service Area	major conveyance required to meet the majority of identified needs	Some conveyance required to meet identified demands	Limited conveyance needs

Magnitude	Weighting Factor (Low [1] - High [100]):	4

Description:
Describes the potential yield of a strategy. Values is based on maximum potential without regard for "right-sizing" to meet identified demands.

Scoring:

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
<5,000 ac-ft per year	5,000 to 25,000 ac-ft per year	25,000 to 50,000 ac-ft/yr	>50,000 ac-ft per year

Other Supplies	Weighting Factor (Low [1] - High [100]):	2

Description:
Defines how the project interacts with other projects or existing supplies in either preventing the development of other alternatives or enhancing the yield of existing or future supplies.

Scoring:

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
Negative impacts to existing and other potential supplies	Negative impacts to other potential projects	Opportunity to enhance other potential projects	Opportunity to enhance existing supplies and other potential supplies

Public	Weighting Factor (Low [1] - High [100]):	6

Description:
Describes public support or potential opposition for a project concept. This is considered from an overall perspective, noting projects are likely to receive both positive and negative support from various sections of the public.

Scoring:

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
No local support; significant opposition	Minimal local support; some opposition	Local support; minimal opposition	Widespread local support; opportunity for ancillary community benefits

Scalability	Weighting Factor (Low [1] - High [100]):	4

Description:
Defines the ability of a project to be implemented by smaller stakeholders in partnership with SJRA.

Scoring:

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
Project requires significant infrastructure and development by a major sponsor	Project may be implemented by a small number of larger entities	Project may be implemented by most existing and potential entities	Project can be implemented by entities of all sizes

Schedule	Weighting Factor (Low [1] - High [100]):	6

Description:
Defines the anticipated schedule for the development of a project. Projects with shorter lead-times are preferred.

Scoring:

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
>30 years	15-30 years	5 to 15 years	0 to 5 years

Yield Risk	Weighting Factor (Low [1] - High [100]):	6
Description: Determined by the risk associated with a potential project's yield being reduced due to regulatory or environmental issues.		
Scoring:		

Less Favorable **1**	**2**	**3**	**More Favorable** **4**
High level of uncertainty that project yield can be developed or will be maintained in the long term. High risk of supply availability	Moderate risk that a project's yield cannot be realized or will diminish over time. Moderate risk of supply availability	Some risk that project yield will not be realized or will be reduce over time. Some risk of supply availability	Virtually no risk of project yield cannot be achieved or will be reduced over time. No potential risk of supply availability

5.3.2 Results

Strategies were scored separately for the Highlands and the Montgomery County Service Areas and were ranked based on the scores developed from the product of criteria scores and associated weighting factors. Ranks were assigned to the strategies such that the strategy with the highest score was given the best rank. For instance, a rank of one meant that the strategy ranked best among the list of the strategies. *Tables 13* and *14* below summarize the final ranking of strategies based on this methodology for the Highlands and Montgomery County Service Areas, respectively. Detailed scores for the strategies and the justification for the scoring are included in ***Appendix C***. It should be noted that this scoring system does not capture all aspects of a project's overall feasibility nor its ability to meet a specific need identified in the RWSMP based on volume, timing, and geographic location.

Table 13: Ranked Strategies for the Highlands Service Area

Rank	Strategy Name	Sub-Category
1	Purchase Surface Water	Trinity River Authority
2	Lake Livingston Transfer	Livingston to Highlands
3	Trinity Return Flows	
4	Regional Return Flows	Lake Houston
5	Purchase Surface Water	CLCND/COH
6	Purchase Groundwater	Purchase from Eastern Basins
7	Purchase Groundwater	Purchase from Western Basins
8	East Texas Water Transfer	Neches Basin
9	East Texas Water Transfer	Sabine Basin
10	Seawater Desalination	
11	Lake Creek Reservoir	
12	Bedias Reservoir	
13	Brazos River Supplies	

Table 14: Ranked Strategies for the Montgomery County Service Area

Rank	Strategy	Sub-Category
1	Conservation	TWDB Baseline
2	Catahoula Aquifer Supplies	Developed by SJRA Customers (Blended)
3	Conservation	SJRA Water Conservation Plan
4	Regional Return Flows	Lake Conroe
5	Direct Reuse, Non-Potable	GRP Participants
6	Direct Reuse, Non-Potable	Woodlands
7	Catahoula Aquifer Supplies	Developed by SJRA (Lake Conroe)
8	Catahoula Aquifer Supplies	Developed by SJRA Customers (Treated)
9	Catahoula Aquifer Supplies	Developed by SJRA (Blended)
10	Lake Livingston Transfer	Livingston to Conroe
11	Purchase Surface Water	TRA
12	Aquifer Storage and Recovery	Developed by SJRA Customers
13	Purchase Groundwater	Purchase from Eastern Basins
14	Purchase Groundwater	Purchase from Western Basins
15	Aquifer Storage and Recovery	Developed by SJRA (Mildly Treated)
16	Catahoula Aquifer Supplies	Developed by SJRA (Treated)
17	Aquifer Storage and Recovery	Developed by SJRA (GRP Treated)
18	Lake Creek Scalping	Run-of-River Diversion
19	Regional Return Flows	Lake Houston w/ South Plant
20	Lake Creek Reservoir	
21	Brazos River Supplies	
22	East Texas Water Transfer	Neches Basin
23	East Texas Water Transfer	
24	Increase Lake Conroe Conservation Pool	
25	Lake Creek Scalping	Storage in Lake Conroe
26	Lake Creek Scalping	
27	Bedias Reservoir	
28	Seawater Desalination	

6.0 DEVELOPMENT OF WATER SUPPLY STRATEGY PORTFOLIOS AND RISK ANALYSIS

Based on the needs identified for the Montgomery County Service Area and the yields produced by each of the strategies considered, it was noted that no individual project can meet the future needs for the Montgomery County Service Area. For this reason, a combination of strategies or "portfolios" were developed for the Montgomery County Service Area. Various portfolios were developed, each with a specific objective and purpose. The needs in the Highlands Service Area are of such magnitude that one project may meet the identified future needs. Individual projects were also assembled in the form of portfolios for the Highlands Service Area. Cost, schedule, risk, regulatory issues, environmental issues, and public support were some of the factors considered and included for the specific projects in the portfolios. A risk-based analysis for portfolio selection was developed in this study to utilize the risk definitions available for the projects in various sources referenced and compare the information using a standardized approach. A project was defined as having less or more risk in the sources referenced based on both a qualitative definition of risk (mostly based on subjective opinions) and at other times a quantitative process. For those reasons, a risk analysis tool was developed in this study to quantify the risk for each project using a consistent approach. This methodology is described below.

6.1 RISK ANALYSIS

For any water supply strategy, risk is defined as the variable that makes the project less or more favorable than the way it was conceived. All projects inherently have some risk element and it is important to understand the risk associated with a project before developing it. In order to ideally compare one project against another, it is important to define the risk for all strategies based on a standard approach, determine the risk profile of the strategies based on the approach, and finally, understand the risk associated with the selected strategies.

6.1.1 Methodology

A detailed approach was developed for defining the risk profile of various strategies being considered as future water supplies to meet the needs in the SJRA Service Areas. To quantify the process, the risk associated with each strategy was divided into five categories. *Table 15* below lists the five risk categories considered in the risk analysis and a brief description of the categories.

Table 15: Description of the Risk Categories Used for the Risk Analysis

Number	Risk Category	Description
1	Capital Cost Risk	Risk that the project capital cost may be impacted due to industry fluctuations, rate changes, and/or project definition changes
2	Yield Risk	Risk that the project defined yield may be impacted due to external conditions out of SJRA control, uncertainty, policy changes, political impacts, and/or options that would require SJRA to redefine the project
3	Regulatory/Environmental Risk	Risk that a project status may be impacted due to environmental, regulatory, and/or water quality issues
4	Schedule Risk	Risk that the project schedule, as proposed, will be impacted due to coordination delays, construction delays, policy issues, and/or material availability
5	Institutional/Legal Risk	Risk that the project may be impacted due to regional cooperation issues, customer coordination issues, public perception issues, legal/contracting issues, and/or any institutional changes at SJRA

Not all risk categories have the same magnitude of impact. Depending on the system operations, some risk categories may be more important to an entity than other risk categories. Based on the feedback received from SJRA staff, a weighting factor was assigned to each one of the risk categories to characterize the risk of these categories to be more specific to SJRA's supply approach. It is not sufficient to simply understand whether a strategy poses a risk in a particular category (for example, does a pipeline project pose a schedule risk?). What is also important is to understand the criticality or the nature of the risk. For each of the risk categories, the risk can be varied on a scale as shown in Table 16. The risk categories were subdivided into four sub-categories based on the range of the risk. The subcategories were assigned a risk ranking ranging from 0 – 5. A risk ranking of 0 – 3.5 was considered to be a high-risk project or a low risk resiliency project, a risk ranking of 3.5 – 4 was considered to be a medium or moderate risk project or medium risk resiliency project, and a risk ranking of 4 – 5 was considered to be a low risk project or a high-risk resiliency project. Table 16 below shows the risk categories, the sub categories for each of the risk categories, the weight factors associated with the risk categories and the risk resiliency ranking associated with the sub categories. For each risk category, a project is assigned a percent probability for the potential of falling under the sub-category, the total always adding up to 100. A weighted average is computed for each category and the also for the overall risk of the project.

Table 16: Risk Variables Used for the Risk Analysis

Risk Category	Risk Description	Weight Factor	Risk Resiliency Ranking Factor	Example Project Risk Scoring (%)	Risk Category Score
Capital Cost	As Defined	35	5	60	4.4[1]
	Minor Changes		4	30	
	Significant Changes		2	10	
	Major Changes		1	0	
	Total			100	
Yield	No Risk	35	5	10	1.53
	Some Risk		3.5	15	
	Major Risk		1	50	
	Fatal Flaw		0	25	
	Total			100	
Regulatory / Environmental	No Process	10	5	60	3.8
	Minor Process		3.5	20	
	Major Process		1	10	
	Fatal Flaw		0	10	
	Total			100	
Schedule	No Changes	10	5	60	4.4
	Minor Changes		4	30	
	Significant Changes		2	10	
	Major Changes		1	0	
	Total			100	
Institutional / Legal	No Issues	10	5	15	3.3
	Minor Issues		4	50	
	Significant Issues		2	20	
	Major Issues		1	15	
	Total			100	
TOTAL RISK SCORE		**100**	**3.22[2]**		

1 Weighted Average based on Risk Resiliency Ranking Factors

2 Weighted Average based on Category Risk Scores and Category Weight Factors

6.1.2 Results

Using the approach described in Section 6.1.1, strategy specific risk scores were computed in order to compare strategies based on risk profile. *Tables 17 and 18* below include lists of strategies considered for the Highlands and Montgomery County Service Areas and associated risk scores. In addition to this, a fatal flaw score was computed as the percentage chance that a project may be impacted by a fatal flaw. Not all risk categories include fatal flaws as a potential outcome of the project. That outcome was only limited to two categories: Yield (strategy may result in no yield) and Regulatory/Environmental (strategy

may be aborted due to environmental/regulatory issues). A strategy may seem to be a highly risk resilient project based on the risk score derived from all risk categories but may have a significant chance of resulting in a fatal flaw based on yield and/or regulatory/environmental categories.

Table 17: Summary of Risk Scores for Strategies Considered for Highlands Service Area

Strategy Name	Risk Score	Fatal Flaw (%)
Purchase Surface Water from TRA	4.3	0
Lake Livingston Transfer to Highlands – 1a	4.5	0
Lake Livingston Transfer to Highlands – 1b	3.9	15
Lake Livingston Transfer to Highlands – 1c	4.4	0
Lake Livingston Transfer to Highlands – 2a	4.4	0
Lake Livingston Transfer to Highlands – 2b	3.8	15
Lake Livingston Transfer to Highlands – 2c	4.3	0
Regional Return Flows - Conroe	3.9	15
Regional Return Flows - Montgomery	3.7	15
Regional Return Flows – San Jacinto	3.7	15
Trinity Return Flows	3.6	15
Purchase Surface Water from CLCND	4.3	0
Purchase Groundwater from East	4.2	0
Purchase Groundwater from West	4.2	0
East Texas Water Transfer	3.6	0
Seawater Desalination	4.4	0
Lake Creek Reservoir	3.1	15
Bedias Reservoir	2.4	25
Brazos River Supplies	2.8	15

Table 18: Summary of Risk Scores for the Strategies Considered for Montgomery County Service Area

Strategy Name	Risk Score	Fatal Flaw (%)
Aquifer Storage and Recovery - SJRA	3.2	25
Aquifer Storage and Recovery – Customer Cities	3.2	25
Aquifer Storage and Recovery – Mildly Treated	3.2	25
Bedias Reservoir	2.3	25
Brazos River Supplies	2.9	15
Catahoula Aquifer – Blended with Lake Conroe	3.3	25
Catahoula Aquifer – Treated at SJRA WTP	3.3	25
Catahoula Aquifer – Blended at SJRA WTP	3.5	25
Catahoula Aquifer – Treated at Customer Plants	3.3	25
Catahoula Aquifer – Blended at Customer Plants	3.5	25
Conservation – TWDB Recommendations	4.3	0
Conservation – SJRA Recommendations	4.1	10
Direct Reuse – SJRA GRP Customers	4.3	0
Direct Reuse – Woodlands Customers	4.3	0
East Texas Water Transfer	3.4	15

Strategy Name	Risk Score	Fatal Flaw (%)
Lake Creek Reservoir	3.0	15
Lake Creek Scalping – Run-of-River	4.0	0
Lake Creek Scalping – Transfer to Lake Conroe	4.0	0
Lake Creek Scalping – On Channel Storage	4.0	0
Lake Livingston Transfer – Alternative 1	3.6	15
Lake Livingston Transfer – Alternative 1a	3.6	15
Lake Livingston Transfer – Alternative 2	3.6	15
Lake Livingston Transfer – Alternative 3	3.0	25
Lake Livingston Transfer – Alternative 4	3.8	0
Lake Livingston Transfer – Alternative 5	3.8	0
Groundwater Transfer from East	4.0	0
Groundwater Transfer from West	4.0	0
Increase Lake Conroe Conservation Pool	3.4	15
Surface Water Transfer from TRA	3.7	0
Return Flows – MUDS/Huntsville	3.8	15
Return Flows – Lake Conroe	3.6	15
Return Flows – Lake Creek	3.4	15
Seawater Desalination	3.0	15

Overall, the ranges of the risk scores for the Montgomery County and Highlands Service Areas are as shown below in *Figures 7 and 8* respectively. The risk scores developed here were used to characterize the strategies as having less risk or more risk for the strategy portfolio development.

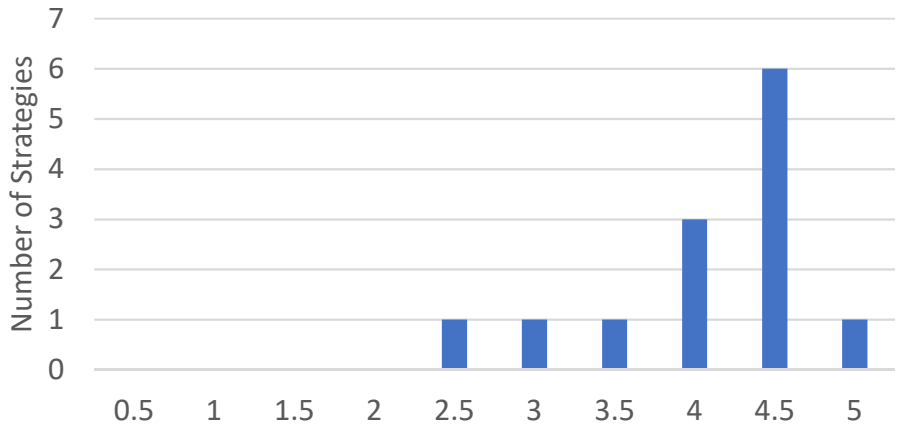

Figure 7: Summary of Risk Scores Distribution in Highlands Service Area

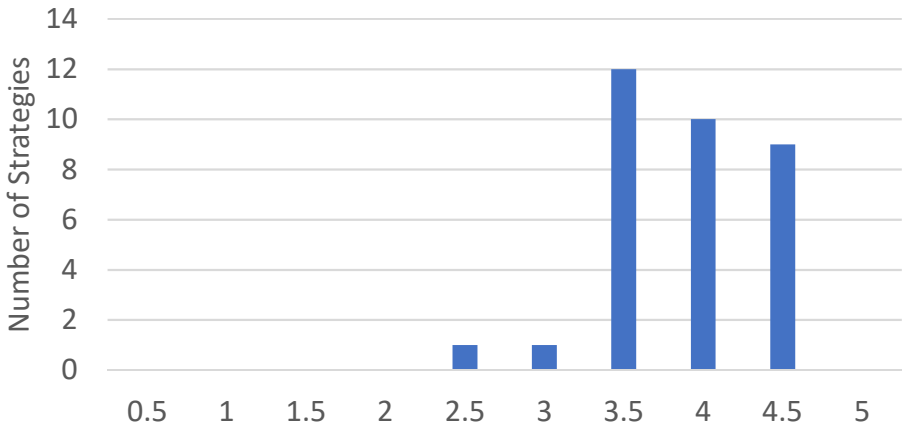

Figure 8: Summary of Risk Scores Distribution in Montgomery County Service Area

6.2 STRATEGY PORTFOLIO DEVELOPMENT

Detailed strategy evaluations and the risk analysis conducted in this study, strategy-specific information collected from several reports, and the strategy screening process provided detailed information for each of the strategies considered in this study. Strategy detail was not just limited to fundamental variables such as cost and schedule, but also included components of the risk associated with each strategy, the environmental and regulatory issues associated with each strategy, as well as legal issues, cooperation, public support, and other characteristics associated with each strategy. The strategies were also ranked based on the screening process described in this report. Ideally, the top most ranked strategy can be selected as the preferred supply option. That may be true for the Highlands Service Area as the needs for this Service Area are very minimal. For the Montgomery County Service Area however, a single strategy would not provide the necessary supply required, as the anticipated needs far exceed the yield for any one of the individual strategies considered. Therefore, a combination of strategies was developed to meet the needs for the Service Areas. These combinations of strategies were termed as "portfolios." The methodology used for developing the strategy portfolios and the final selected portfolios are discussed below.

6.2.1 Methodology

A. Montgomery County Service Area

The approach for developing the portfolios was different for the Montgomery County Service Area, as the needs for this Service Area far exceeded the yield potential of individual strategies. Multiple portfolios

were developed for this Service Area in order to provide SJRA some flexibility in decision-making when selecting future strategies. Each portfolio was based on a specific theme and all projects that fit into the specific theme were considered for the portfolio. The goal of each portfolio was to meet the Service Area demands for the entire planning horizon. All portfolios assumed the exhaustive use of existing supplies (e.g. Lake Conroe) as a fundamental basis for planning. The next requirement was to assume that the baseline TWDB conservation was a given strategy spanning the entire planning horizon. After the inclusion of these two assumptions, strategies were added over time when a shortage manifested within the Service Area. Some basic assumptions were made regarding the yield potential of each strategy, the supply availability for the planning horizon etc. Five different themed strategy portfolios were developed for the Montgomery County Service Area. The portfolios were focused on the following themes: 1) Cost Preferred, 2) Low Perceived Risk, 3) Fast Track/Dry Conditions, 4) Regional Partnership, and 5) Low Regulatory Risk portfolios.

It should be noted that each portfolio consisted of strategies that met the requirements associated with the theme. It does not mean that only one of these portfolios represented the correct sequence of developing projects to meet the Service Area needs. The purpose of the RWSMP is to develop a planning framework that is comprehensive, flexible, and provides multiple options for SJRA's long term planning process. For that purpose, multiple portfolios were developed which are meant to be treated as parallel tracks for meeting the system needs. All of the portfolios are intended to meet the system needs over the planning horizon and each one is chosen for a very specific purpose. Upon further deliberation, an additional "preferred" portfolio was developed. The preferred portfolio represents the preferred list and sequence of strategies that SJRA intends to use to meet the needs of the Montgomery County Service Area based on current information. Instead of choosing a portfolio with one theme, SJRA chose to use the preferred portfolio which combines the benefits from each of the five portfolios discussed above.

Currently, discussions are underway with the Lone Star Groundwater Conservation District and other local stakeholders to determine the availability of additional groundwater in the Gulf Coast aquifer system. Because of the timing of negotiations and the current lack of clarity on the volume and timing of available additional groundwater, parallel strategy portfolios were developed. One strategy portfolio assumes that additional groundwater will not be available, while the other strategy portfolio assumes that additional groundwater will be available. Similarly, themed portfolios were also developed for both the with and without groundwater options.

B. Highlands Service Area

Technically, there is no need to develop multi-strategy portfolios for the Highlands Service Area, as the needs for this Service Area are much less compared to the volume potential of the strategies for this Service Area. However, in keeping with the approach developed for the Montgomery County Service Area, three themed portfolios (consisting of single strategy) were developed for this Service Area. They are: 1) Cost Preferred, 2) Low Perceived Risk, and 3) Fast Track/Dry Conditions portfolios. Details of the portfolios for Highlands and Montgomery County Service Area are discussed in the next section.

6.2.2 Identified Portfolios

This section includes a detailed review of the various portfolios developed for the Montgomery County Service Area and the Highlands Service Area.

A. Montgomery County Service Area

Cost Preferred Portfolio – The Cost Preferred portfolio for the Montgomery County Service Area includes a list of the lower cost strategies stacked up to meet the Service Area needs over the planning horizon. The purpose of developing this portfolio is to provide SJRA a list of strategies that can be implemented if minimizing cost is the primary focus. There may be other technical, operational, and/or regulatory issues associated with developing this portfolio, but those were considered secondary to cost when developing the portfolio schedule. Portfolios are created for both with and without additional groundwater availability. In addition to the baseline TWDB conservation, active SJRA conservation was also included as the preferred first strategy to meet demands. It should be noted that the conservation strategy ramps up from the start of the planning horizon with the maximum conservation savings realized at the end of the planning horizon. Return flows and reuse makeup the next set of strategies, followed by groundwater supplies in the form of Catahoula Aquifer development and aquifer storage and recovery. Finally, even though the transfer of supplies from Lake Livingston is a higher-cost strategy, it is difficult to develop a portfolio for the Montgomery County Service Area without including this strategy. Unlike the other strategies analyzed, the transfer of supplies from Lake Livingston provides a significant volume of water supply on its own. It is assumed that approximately 28,262 ac-ft/yr or additional groundwater would be potentially accessible to SJRA for the with additional groundwater scenario, at a minimum. The list of strategies is the same for the with additional groundwater scenario, except that the schedule for strategies is changed due to the additional groundwater availability. *Table 19* includes a summary of the supply strategies in the Cost Preferred portfolio, developed for with and without additional groundwater

scenarios. *Figures 9 and 10* include graphical illustrations of the Cost Preferred portfolio, for with and without additional groundwater scenarios respectively.

Table 19: Summary of the Cost Preferred Portfolio for Montgomery County Service Area

		Without Groundwater			With Groundwater		
	Cost Preferred Portfolio	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)
	2070 Demand without Conservation	225,321			225,321		
	SUPPLIES						
	Surface Water Supplies (Lake Conroe)	75,500			75,500		
	Additional Groundwater				28,262		
	NEEDS						
	Needs without Conservation	149,821			121,559		
	STRATEGIES						
1	Baseline Conservation	27,267	2020	0	27,267	2020	0
2	SJRA Conservation	18,607	2020	250	18,607	2020	250
3	Return flows	10,846	2038	550	10,846	2049	550
4	Reuse	25,000	2040	450	25,000	2052	450
5	Catahoula Aquifer supplies	10,500	2044	720	10,500	2058	720
6	ASR	25,000	2050	900	25,000	2061	900
7	Lake Livingston Transfer	50,000	2060	843	50,000	2070	843
	Total Strategies	167,220			167,220		
	Needs - Strategies	-17,399			-45,661		

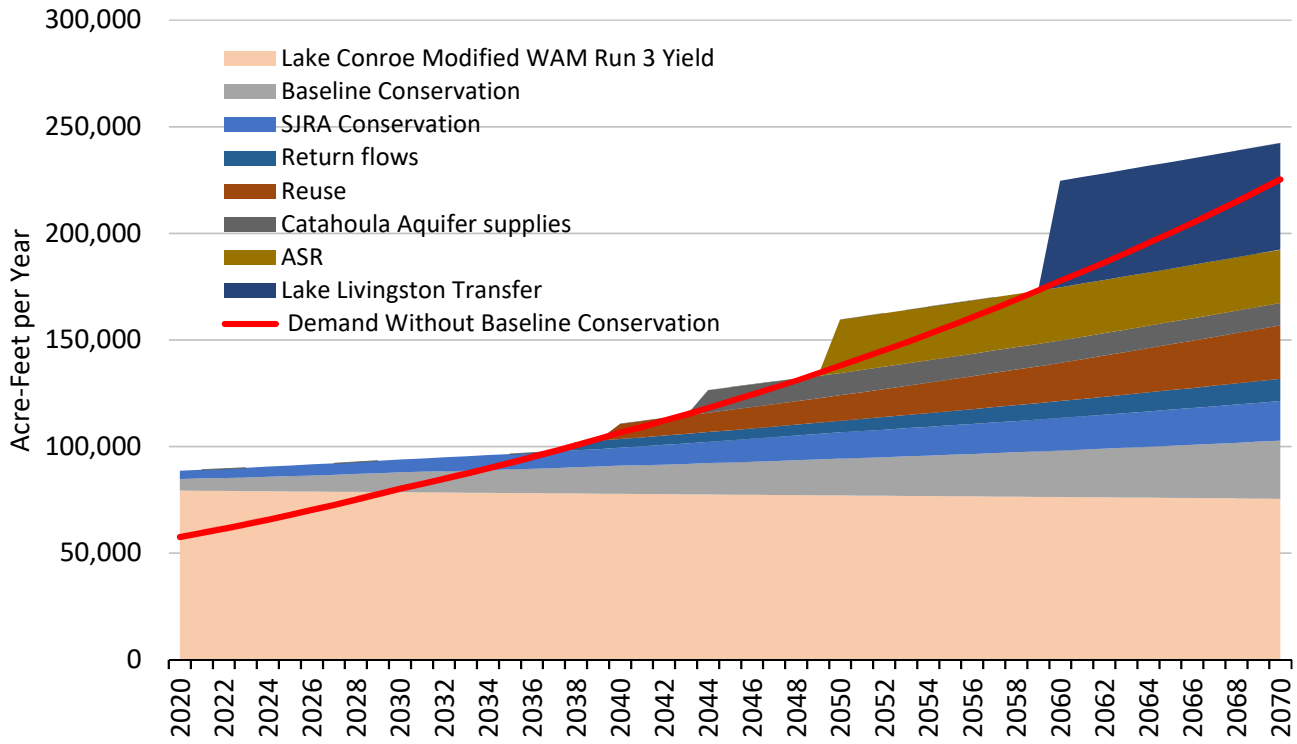

Figure 9: Cost Preferred Portfolio for Montgomery County Service Area – Assuming No Additional Groundwater Availability

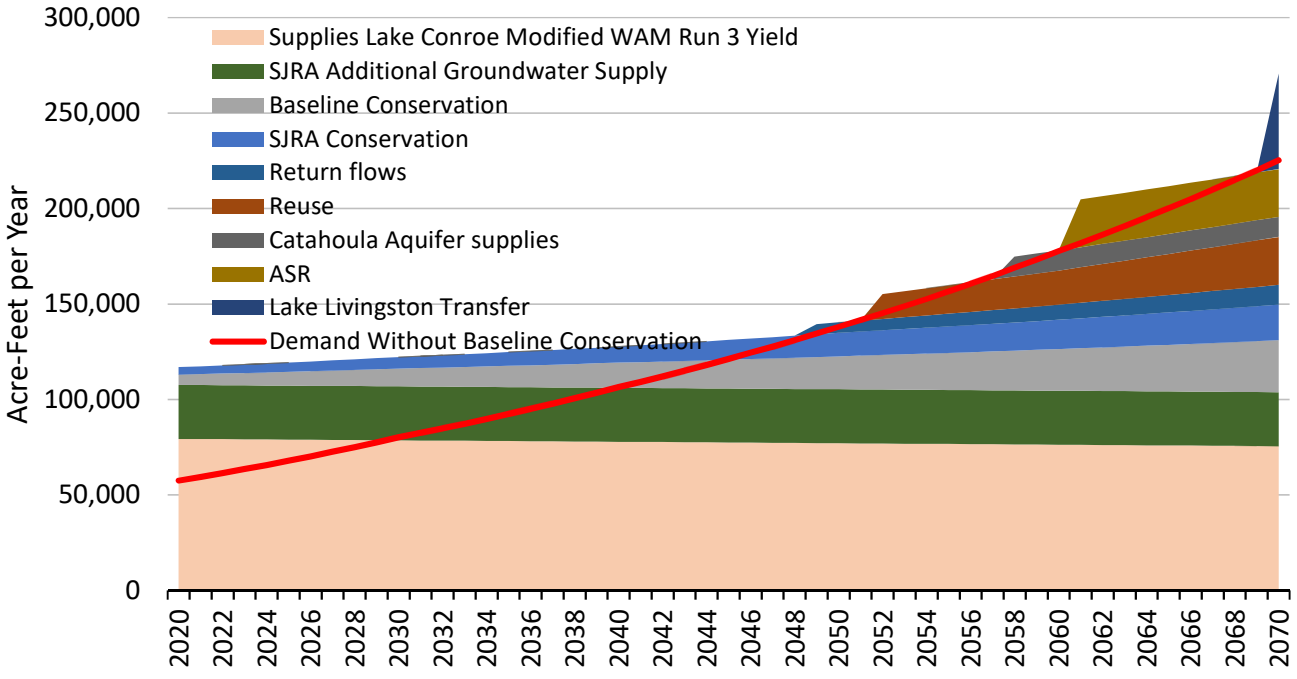

Figure 10: Cost Preferred Portfolio for Montgomery County Service Area – Assuming Additional Groundwater Availability

Low Perceived Risk Portfolio – The Low Perceived Risk portfolio was developed based on the risk scores and ranking established in the risk analysis. The purpose of developing this portfolio is to provide SJRA an alternative portfolio that can be implemented when regulatory and environmental compliance is a cause of significant concern in developing strategies. Cost or schedule, and other factors must still be considered when implementing this portfolio. It should be noted that all the potential strategies considered in this portfolio are required whether or not additional groundwater is available. However, the schedule of these strategies differs based on whether additional groundwater is available, due to difference in total need. *Table 20* includes a summary of the Low Perceived Risk portfolio. *Figures 11 and 12* illustrate the portfolio development for the with and without additional groundwater scenarios, respectively.

Table 20: Summary of the Low Perceived Risk Portfolio for Montgomery County Service Area

		Without Groundwater			With Groundwater		
	Low Perceived Risk Portfolio	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)
	2070 Demand without Conservation	225,321			225,321		
	SUPPLIES						
	Surface Water Supplies (Lake Conroe)	75,500			75,500		
	Additional Groundwater				28,262		
	NEEDS						
	Needs without Conservation	149,821			121,559		
	STRATEGIES						
1	Baseline Conservation	27,267	2020	0	27,267	2020	0
2	SJRA Conservation	18,607	2020	250	18,607	2020	250
3	Reuse	25,000	2037	450	25,000	2050	450
4	Groundwater Transfers	30,000	2041	1,550	30,000	2055	1,550
5	Scalping	8,000	2055	2,290	8,000	2065	2,290
6	Lake Livingston Transfer	50,000	2058	843	50,000	2067	843
	Total Strategies	158,874			158,874		
	Needs - Strategies	-9,053			-37,315		

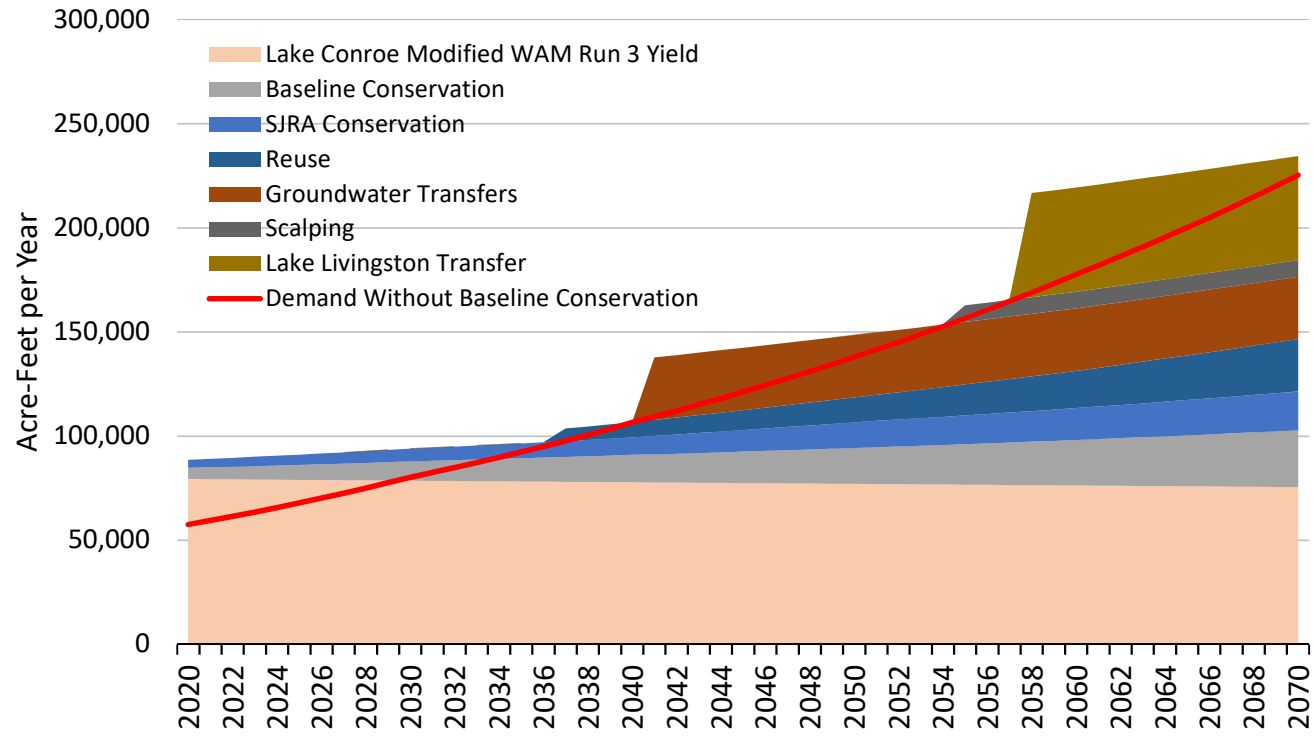

Figure 11: Low Perceived Risk Portfolio for Montgomery County Service Area – Assuming No Additional Groundwater Availability

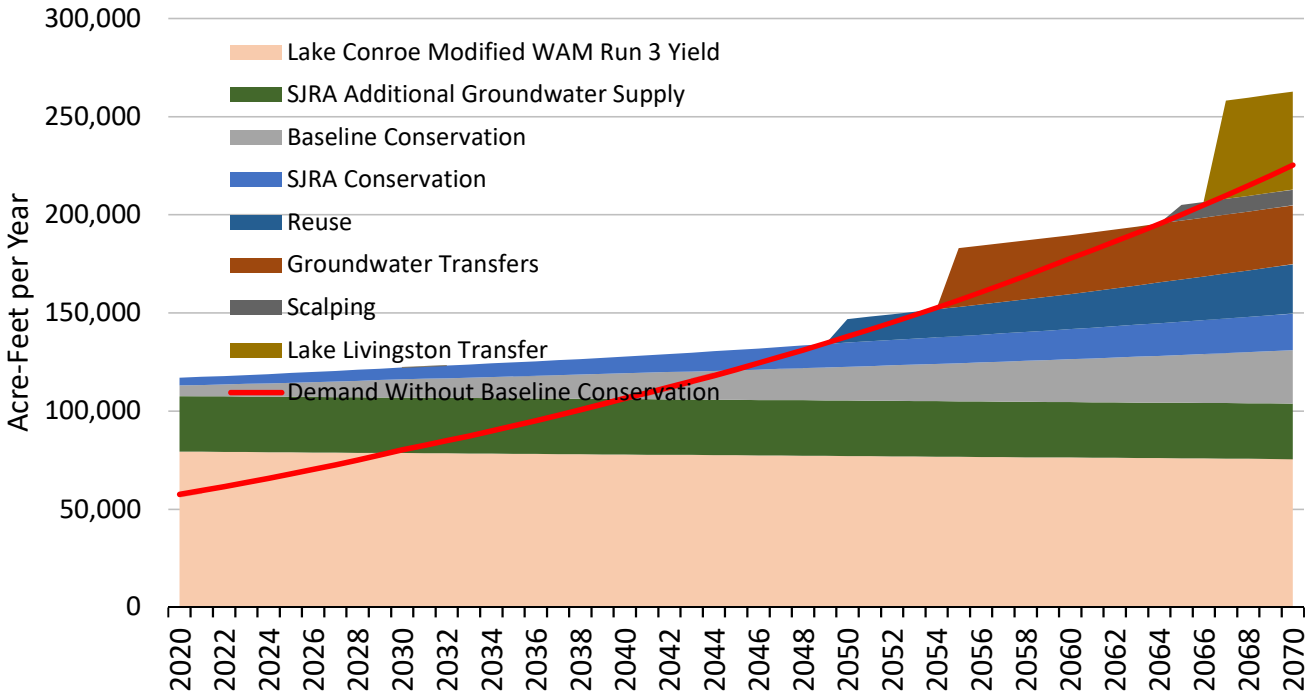

Figure 12: Low Perceived Risk Portfolio for Montgomery County Service Area – Assuming Additional Groundwater Availability

Fast Track/Dry Conditions Portfolio – This portfolio was developed with the intention to provide SJRA with strategies to implement when weather conditions or any other natural or man-made cause forces the development and implementation of strategies on an expedited schedule. The strategies listed in *Table 21* are selected for their ability to deliver sufficient yield to meet SJRA needs on a fast schedule. It is SJRA's discretion to determine the definition of a dry condition or the trigger for requiring fast track implementation. Any sudden, unforeseen impact to existing supplies that renders existing supplies unusable or a surge of growth in the SJRA's Service Area could be triggers for this portfolio.

It should be noted that the yield volumes assumed to be purchased from Trinity River Authority (TRA) and the Brazos basin are purely based on speculation. The availability for these strategies has not been discussed with the two entities. Portfolios were developed for both with and without additional groundwater scenarios, and it can be noted that SJRA does not need to implement the reuse strategy if the additional groundwater supply is available to them. *Figures 13 and 14* include an illustration of the portfolios for the with and without groundwater scenarios, respectively.

Table 21: Summary of the Fast Track/Dry Conditions Portfolio for Montgomery County Service Area

		Without Groundwater			With Groundwater		
	Fast Track/Dry Conditions Portfolio	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)
	2070 Demand without Conservation	225,321			225,321		
	SUPPLIES						
	Surface Water Supplies (Lake Conroe)	75,500			75,500		
	Additional Groundwater				28,262		
	NEEDS						
	Needs without Conservation	149,821			121,559		
	STRATEGIES						
1	Baseline Conservation	27,267	2020	0	27,267	2020	0
2	Catahoula Aquifer Supplies	10,500	2033	720	10,500	2046	720
3	Lake Livingston Transfer	50,000	2039	843	50,000	2049	843
4	Purchase TRA Water	25,000	2056	1,150	25,000	2063	1,150
5	Purchase Brazos Supplies	25,000	2063	865	25,000	2069	865
6	Reuse	25,000	2068	450			
	Total Strategies	162,767			137,767		
	Needs - Strategies	-12,946			-16,208		

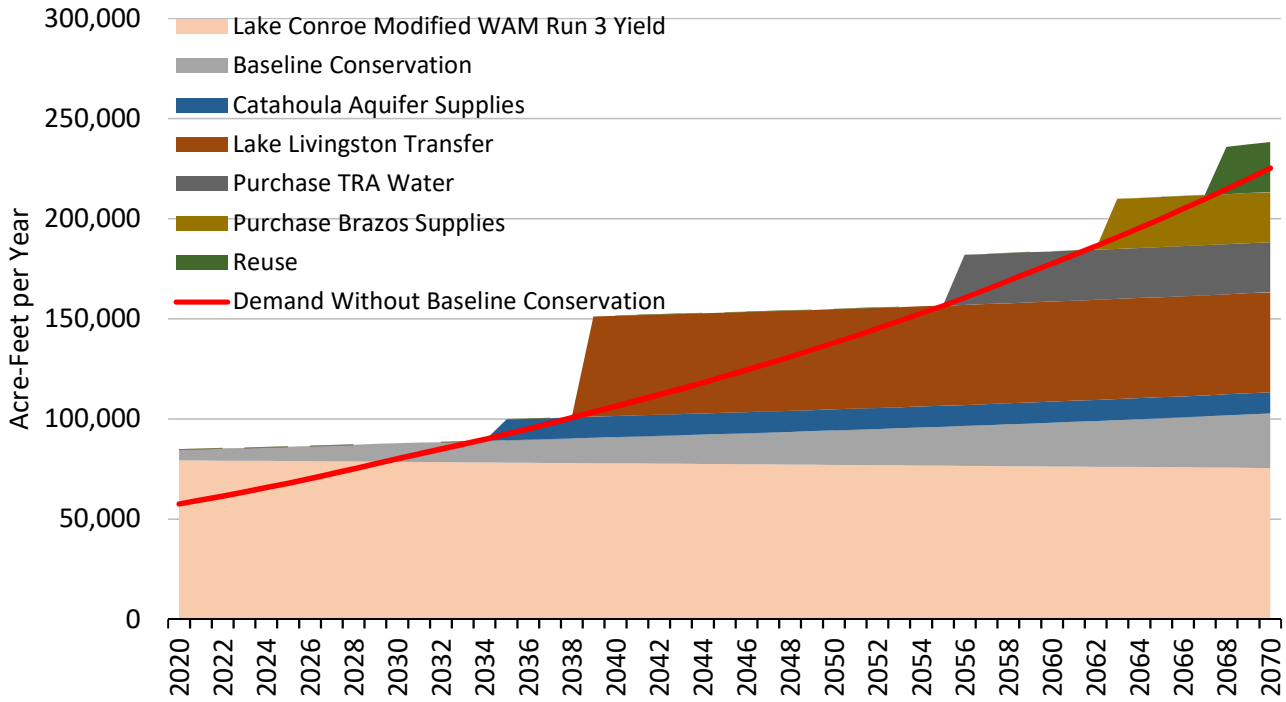

Figure 13: Fast Track/Dry Conditions Portfolio for Montgomery County Service Area – Assuming No Additional Groundwater Availability

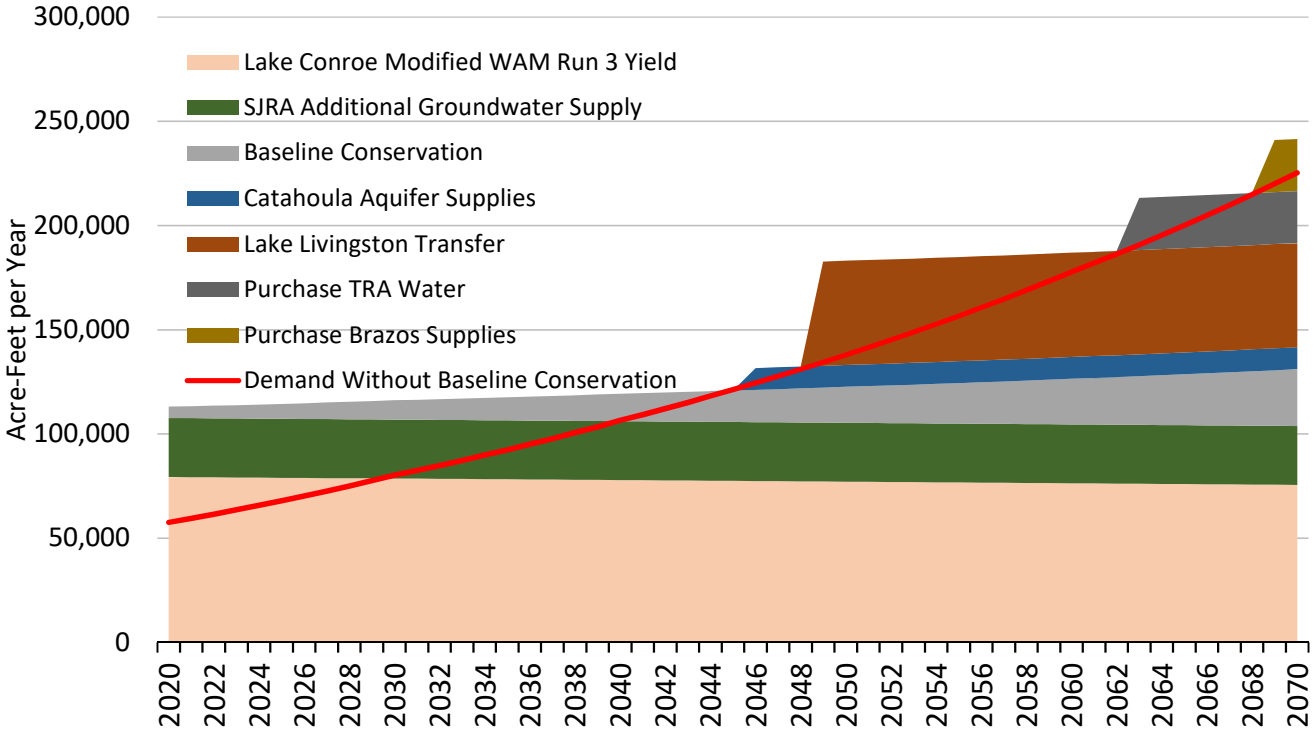

Figure 14: Fast Track/Dry Conditions Portfolio for Montgomery County Service Area – Assuming Additional Groundwater Availability

Regional Partnership Portfolio – A Regional Partnership portfolio was developed including the strategies that would make most sense when developed on a regional scale, in cooperation with other water providers in the region. The purpose of developing this strategy is to provide SJRA a path to consider, if there is a desire for prioritizing regional cooperation in developing water supplies. It should be noted that the Lake Livingston transfer was included in the portfolio, even though it is not perceived as a regional strategy, because it was required to meet the Service Area needs. *Table 22* includes a summary of the strategy portfolio for the two scenarios of without and with additional groundwater. *Figures 15 and 16* include the illustration of the portfolio for the two potential scenarios.

Strategies such as Catahoula Aquifer development or aquifer storage and recovery or return flows can be developed either as entity-specific strategies or region-wide strategies. In case of this portfolio, it was assumed that these strategies would be developed as region-wide strategies.

Table 22: Summary of the Regional Partnership Portfolio for Montgomery County Service Area

		Without Groundwater			With Groundwater		
	Regional Partnership Portfolio	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)
	2070 Demand without Conservation	225,321			225,321		
	SUPPLIES						
	Supplies (Lake Conroe)	75,500			75,500		
	Additional Groundwater				28,262		
	NEEDS						
	Needs without Conservation	149,821			121,559		
	STRATEGIES						
1	Baseline Conservation	27,267	2020	0	27,267	2020	0
2	SJRA Conservation	18,607	2020	250	18,607	2045	250
3	Return Flows	10,846	2037	550	10,846	2048	550
4	Catahoula Aquifer Supplies	10,500	2040	720	10,500	2051	720
5	Reuse	25,000	2045	450	25,000	2056	450
6	Lake Livingston Transfer	50,000	2049	843	50,000	2065	843
7	ASR	25,000	2,065				
	Total Strategies	167,220			142,220		
	Needs - Strategies	-17,399			-20,661		

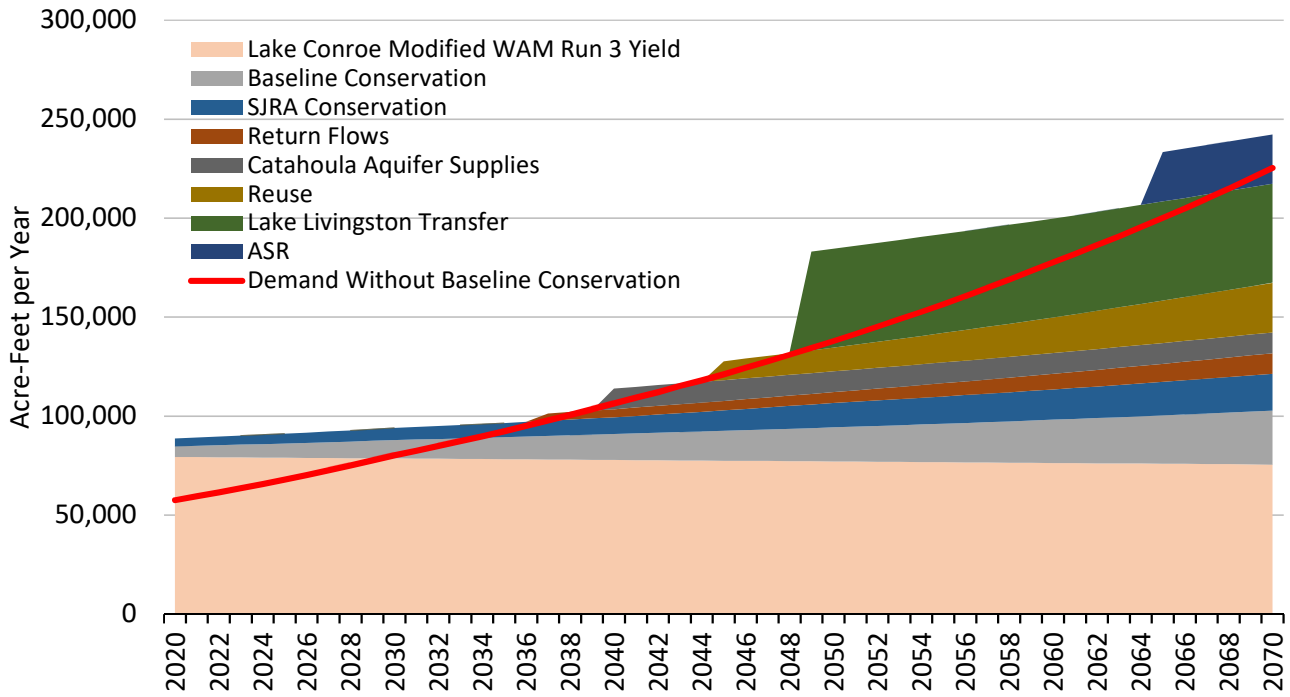

Figure 15: Regional Partnership Portfolio for Montgomery County Service Area – Assuming No Additional Groundwater Availability

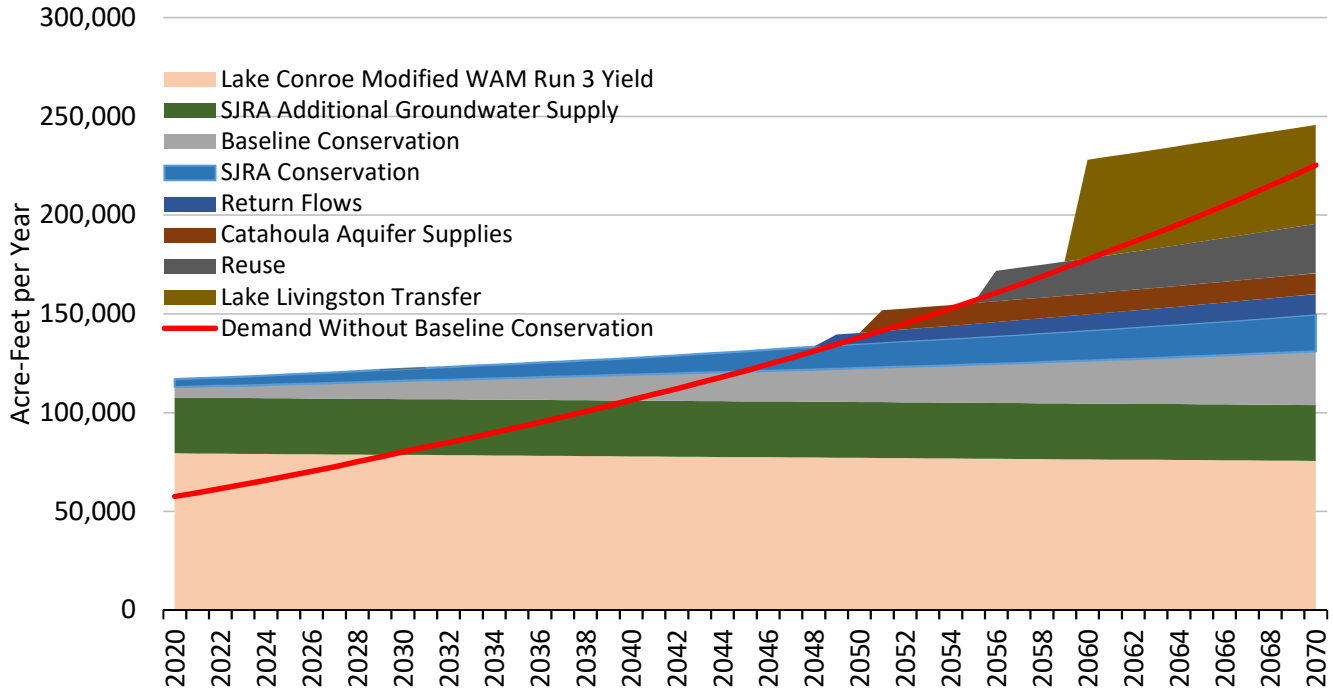

Figure 16: Regional Partnership Portfolio for Montgomery County Service Area – Assuming Additional Groundwater Availability

Low Regulatory Risk Portfolio – A Low Regulatory Risk portfolio includes all the potential strategies that can be implemented when the environmental and regulatory framework is favorable and supportive of developing the strategies. Ideally, all strategies selected for future consideration are sustainable in terms of their impact and implementation, but the list of strategies considered in this portfolio are intended to be more easily developed. *Table 23* includes a summary of the portfolio development and the illustrations are included in *Figures 17 and 18*.

Table 23: Summary of the Low Regulatory Risk Portfolio for Montgomery County Service Area

		Without Groundwater			With Groundwater		
	Low Regulatory Risk Portfolio	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)
	2070 Demand without Conservation	225,321			225,321		
	SUPPLIES						
	Supplies (Lake Conroe)	75,500			75,500		
	Additional Groundwater				28,262		
	NEEDS						
	Needs without Conservation	149,821			121,559		
	STRATEGIES						
1	Baseline Conservation	27,267	2020	0	27,267	2020	0
2	SJRA Conservation	18,607	2020	250	18,607	2020	250
3	Reuse	25,000	2037	450	25,000	2049	450
4	Catahoula Aquifer Supplies	10,500	2042	720	10,500	2054	720
5	ASR	25,000	2048	900	25,000	2058	900
6	Return Flows	10,846	2057	550	10,846	2066	550
7	Lake Livingston Transfer	50,000	2060	843	50,000	2070	843
	Total Strategies	167,220			167,220		
	Needs - Strategies	-17,399			-45,661		

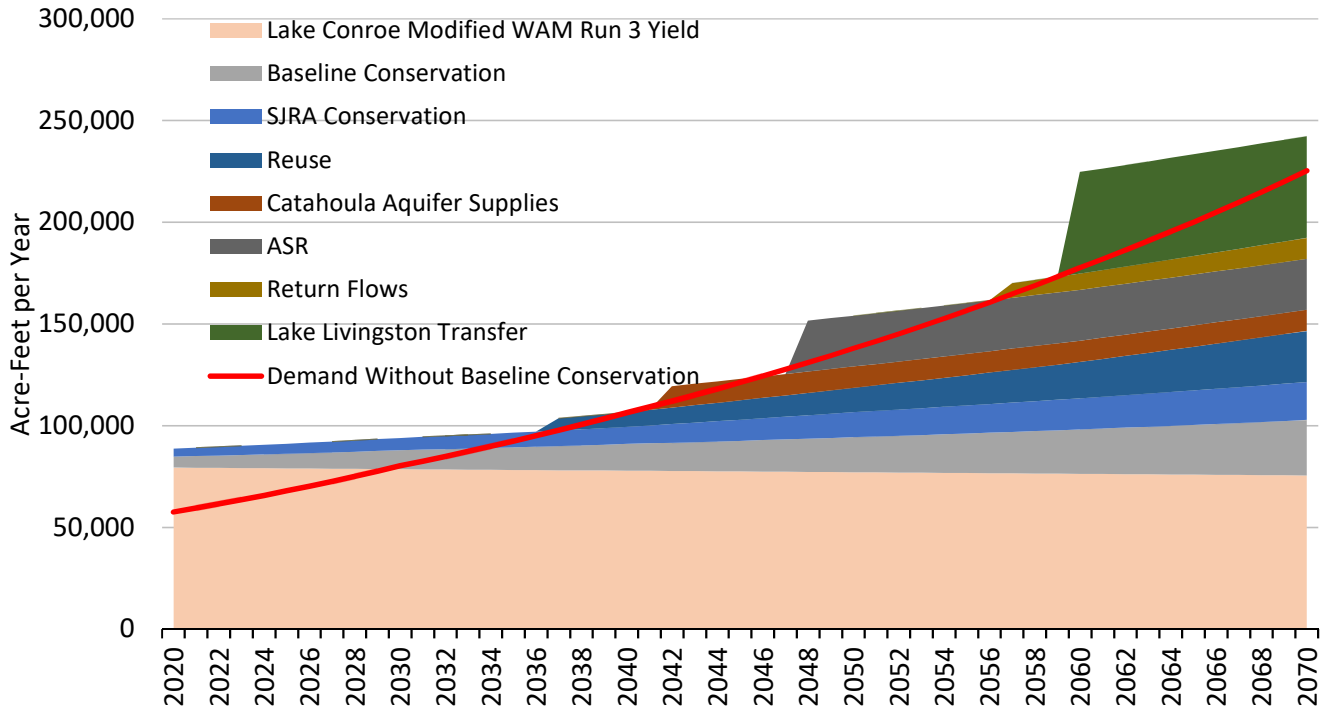

Figure 17: Low Regulatory Risk Portfolio for Montgomery County Service Area – Assuming No Additional Groundwater Availability

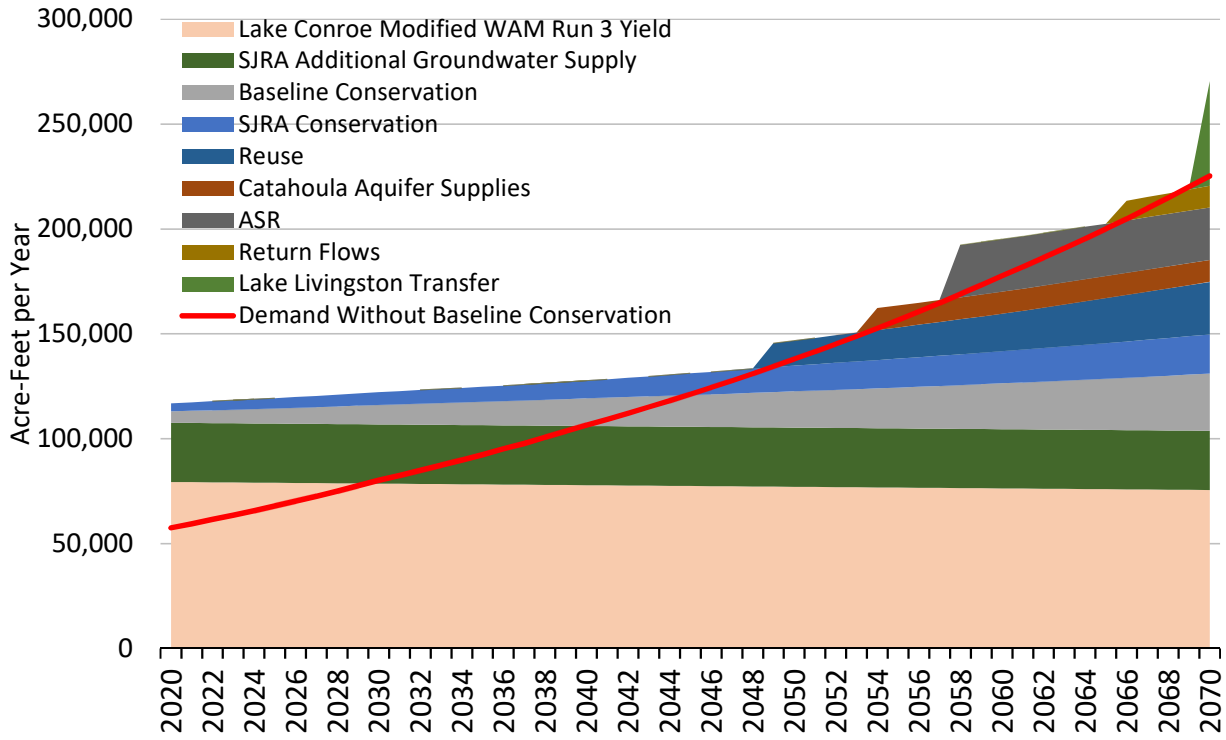

Figure 18: Low Regulatory Risk Portfolio for Montgomery County Service Area – Assuming Additional Groundwater Availability

Preferred Portfolio – In addition to all the different portfolios described above, a preferred portfolio was developed that is a combination of the five portfolios described above. The preferred portfolio includes strategies that were considered most feasible for implementation given that SJRA has already begun some preliminary feasibility evaluation. It should be noted that the preference to this portfolio does not render the other portfolios less important. SJRA will be re-evaluating and re-assessing the portfolio selection frequently, including and at any time there is a change in a variable impacting their supplies or demands. In that sense, SJRA will keep all portfolios in consideration with the focus on the preferred portfolio.

Table 24 includes a summary of the strategies considered for the preferred portfolio, and *Figures 19 and 20* include the illustrate portfolio development for the without and with groundwater scenarios, respectively. The reasons for the development and preference of the preferred portfolio and the approach for integrating this into the planning process are discussed in Section 7.0.

Table 24: Summary of the Preferred Portfolio for Montgomery County Service Area

		Without Groundwater			With Groundwater		
	Preferred Portfolio	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)	Volume (Ac-Ft/Yr)	Strategy Schedule	Strategy Cost ($ per Ac-Ft)
	2070 Demand without Conservation	225,321			225,321		
	SUPPLIES						
	Surface Water Supplies (Lake Conroe)	75,500			75,500		
	Additional Groundwater				28,262		
	NEEDS						
	Needs without Conservation	149,821			121,559		
	STRATEGIES						
1	Baseline Conservation	27,267	2020	0	27,267	2020	0
2	Catahoula Aquifer Supplies	10,500	2035	720	10,500	2046	720
3	Lake Livingston Transfer	50,000	2039	843	50,000	2049	843
4	Return Flows	10,846	2056	550	10,846	2063	550
5	Reuse	25,000	2058	450	25,000	205	450
6	ASR	27,000	2063	900			
	Total Strategies	150,613			123,613		
	Needs - Strategies	-792			-2,054		

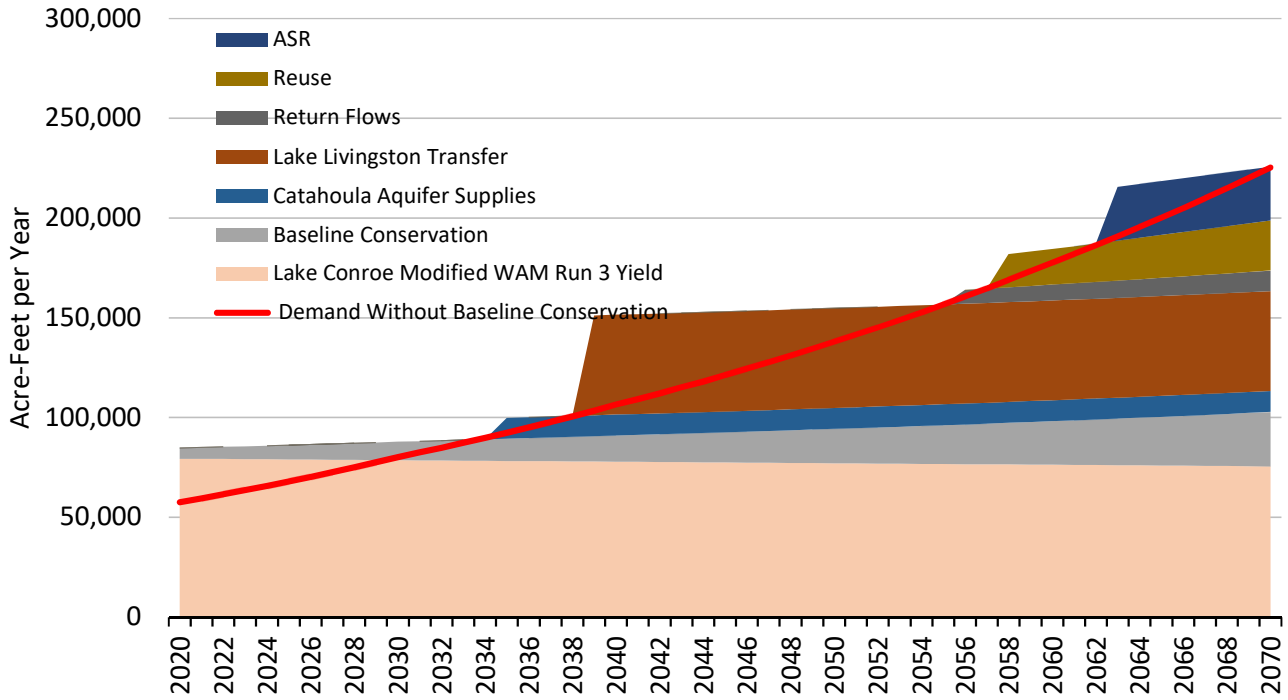

Figure 19: Preferred Portfolio for Montgomery County Service Area – Assuming No Additional Groundwater Availability

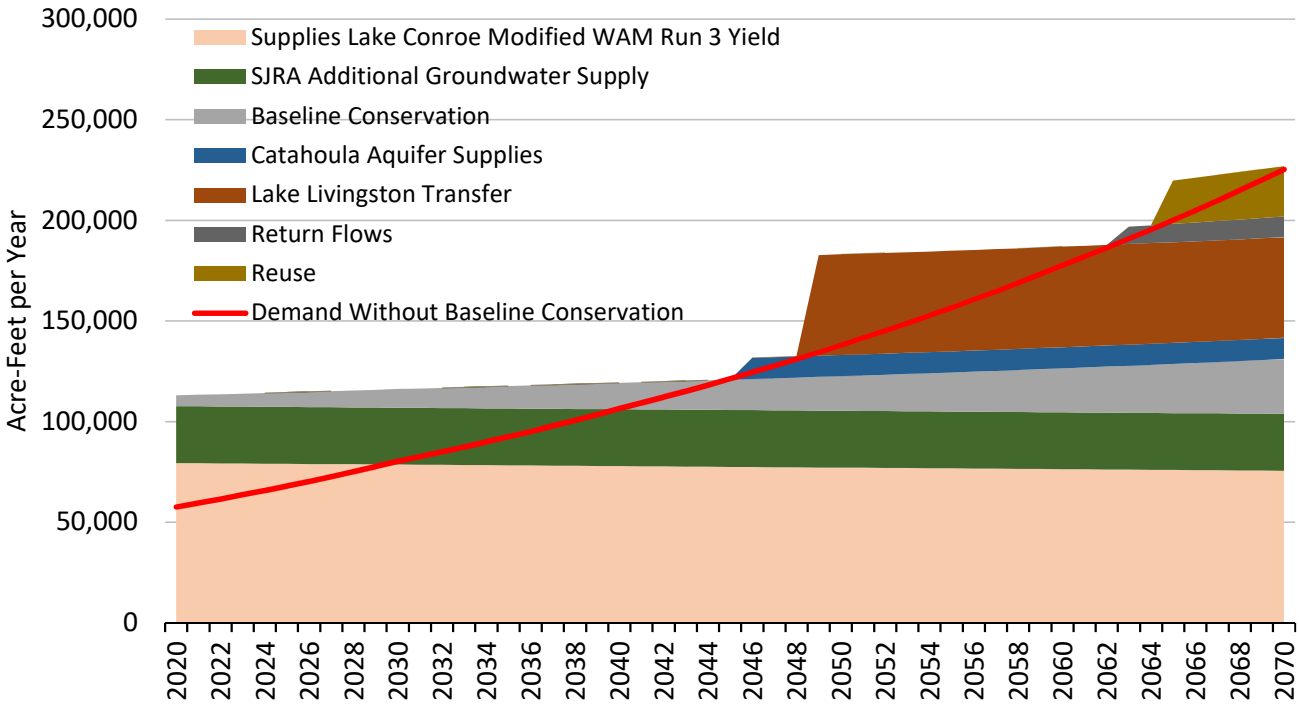

Figure 20: Preferred Portfolio for Montgomery County Service Area – Assuming Additional Groundwater Availability

B. Highlands Service Area

Three single-strategy portfolios were developed for the Highlands Service Area as the needs in this Service Area are minimal compared to the existing available supplies. Current supplies are projected to be sufficient for a significant portion of the planning horizon without the need to develop any additional supplies in the Highlands Service Area and by efficiently and optimally managing existing supplies. However, the portfolios were developed to provide SJRA with options, if and when there is a need for developing additional supplies. The three portfolios are discussed below.

Low Risk Portfolio – The strategy that offers the least risk potential for meeting the Highlands Service Area needs is the option of transferring TRA supplies from the Trinity Basin to the CWA canal. The summary of the Low Risk strategy portfolio is illustrated in *Figure 21*. Based on the timing of the shortages, it is estimated that the transfer of TRA supplies may be implemented in the late 2050s. It should be noted that any TRA supplies used in the Highlands Service Area will not be available for use in the Montgomery County Service Area.

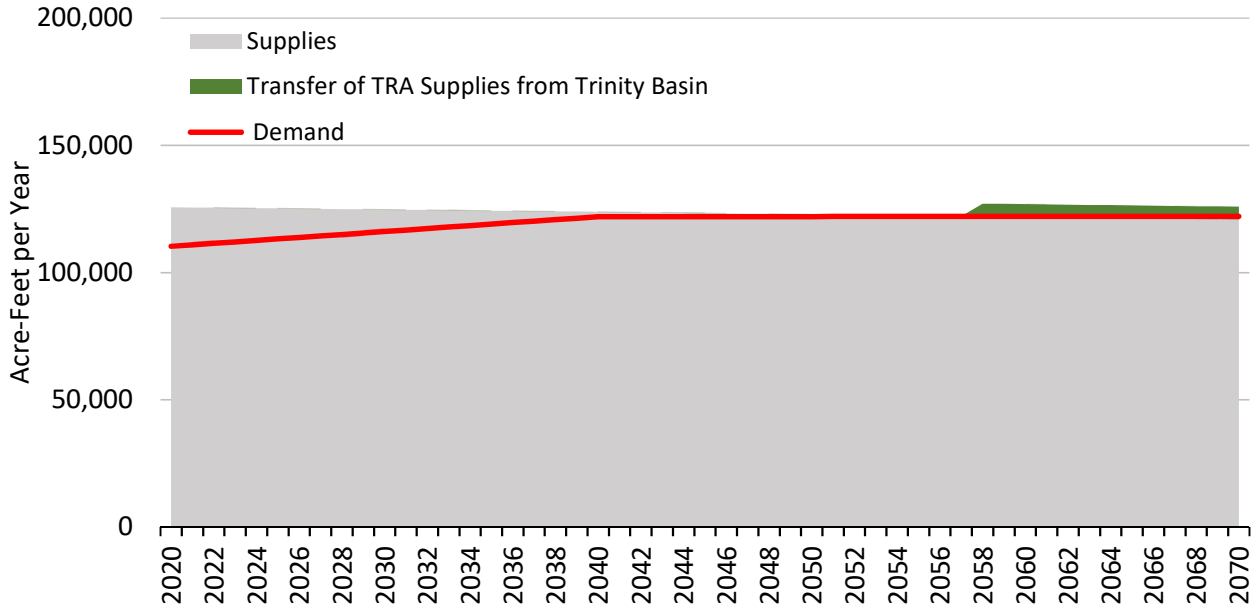

Figure 21: Low Risk Portfolio for the Highlands Service Area

Low Cost Portfolio – The lowest cost strategy to meet the needs in the Highlands Service Area would be to develop the return flows available in the watersheds flowing into Lake Houston. There is a significant amount of return flow potential in the Lake Houston watershed, and the return flows would develop to their full potential in future decades, around the same time when a potential strategy may be needed to

address the anticipated Highlands Service Area shortages. The strategy is a low-cost strategy as it is only required that SJRA permit for the return flows to be able to use these supplies in the future. *Figure 22* includes an illustration of the timing and the volume potential of the Low Cost portfolio.

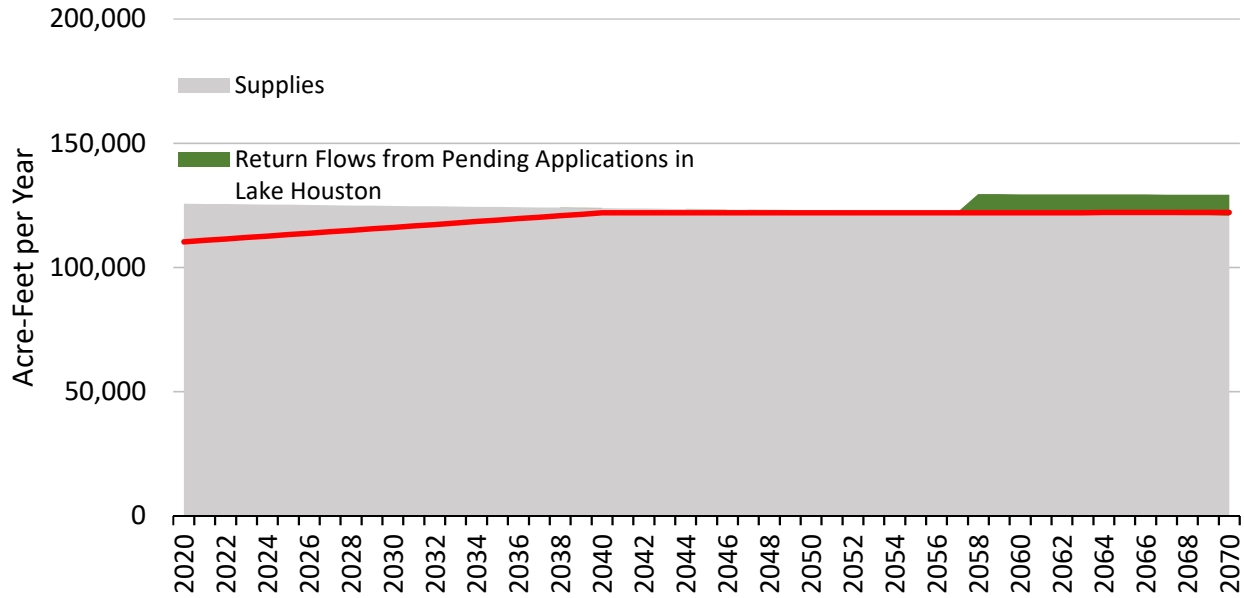

Figure 22: Low Cost Portfolio for the Highlands Service Area

Fast Track/High Demand Portfolio – All six portfolios developed for the Montgomery County Service Area and the two developed for the Highlands Service Area were planned for meeting the system needs considered for the study. This Fast Track portfolio for the Highlands Service Area was developed to address the potential of a sudden increase in demand as a result of a new industrial or municipal demand. This demand was not considered in the demand projections estimated for this study and the demand considered for this portfolio is strictly a hypothetical scenario. It was assumed for this portfolio that an approximate amount of 50,000 ac-ft/yr of demand would need to be met by 2040. The strategy to address this fast track demand scenario is to contract with TRA for additional supplies and transfer that water to the Highlands canal system by means of a hypothetical future pipeline parallel to the CWA canal. Alternately, the supplies can be transferred by contracting for additional supplies in the CWA canal.

7.0 DEVELOPMENT OF A STRATEGY IMPLEMENTATION PLAN

The process for the RWSMP involved a step-by-step methodical approach of estimating available supplies, projecting demands, and identifying Service Area needs. The process then focused on developing a universal list of potential strategies and screening those strategies based on a standardized approach. Since no individual strategy was found to be capable of meeting the entire SJRA Service Area needs, the screened strategies were used to prepare multiple portfolios. The fundamental principle for the entire process has been to build flexibility into the overall implementation strategy for the plan. The RWSMP approach considered multiple alternatives for each evaluation and at every step of the process. While a preferred option for each Service Area was chosen from the multiple alternatives evaluated, all alternatives were retained for the future consideration. The final step in the process of preparing a RWSMP is to develop a strategy implementation plan. This implementation plan was developed to guide SJRA in their decision-making process as they consider and plan for future supplies. A comprehensive list of portfolios was discussed in the previous section. While any of the portfolios will address the Service Area needs in a systematic manner for the planning horizon, the implementation plan includes multiple potential strategy portfolios and provides a decision tree that helps SJRA decide which portfolio pathway to consider under any given circumstance and how to move forward with the planning process. Separate strategy implementation plans were proposed for the Montgomery County and Highlands Service Areas, as supply planning for these two Service Areas progresses on parallel and distinct tracks.

7.1 SELECTED PORTFOLIOS

SJRA has chosen to retain all six portfolios developed for the Montgomery County Service Area and the three portfolios for the Highlands Service Area for future consideration. Of these, the Preferred and Low-Cost portfolios were selected as the recommended pathways for the Montgomery County and Highlands Service Areas respectively. As it is currently uncertain whether additional groundwater will be available for use, the timing of its availability, and the quantity that may become available, SJRA has chosen to opt for the Preferred portfolio for the Montgomery County Service Area without consideration of additional groundwater supply availability as the recommended path forward. Based on these selections and preferences, a detailed decision tree was prepared to serve as the implementation plan for SJRA's future supply planning process. ***Exhibits 6 and 7*** include the strategies considered in the Preferred portfolios for both Montgomery County and Highlands Service Areas.

7.2 CRITICAL DECISION POINTS AND IMPLEMENTATION DECISION TREE

Exhibits 8 and 9 include the implementation plans for the Montgomery County and Highlands Service Areas, respectively. For the Montgomery County Service Area, SJRA would begin their decision-making process by finalizing the negotiations related to the TRA options agreement for Lake Livingston supplies. The Lake Livingston transfer strategy is a default strategy that was included in all of the portfolios for Montgomery County Service Area. This strategy, on its own, provides a significant volume of water and goes a long way towards meeting the significant demands in the Montgomery County Service Area. If the Lake Livingston transfer strategy was not considered as part of the implementation plan, SJRA would have to replace it with multiple smaller projects with uncertain future yield and feasibility. Therefore, the first recommendation from the RWSMP analysis is for SJRA to firm up the negotiations with TRA on the options agreement for the Lake Livingston transfer strategy. Another recommendation is to consider the TWDB baseline conservation as a default baseline strategy. SJRA will realize the benefits of water savings from this strategy without any additional effort or investment. Therefore, the study accounted for the savings from this conservation strategy as a default strategy. At this point, SJRA can select any of the multiple portfolios as potential future pathways. The implementation plan provides a decision tree that guides SJRA's decision-making process. The implementation plan includes a few decision triggers to help SJRA arrive at the preferred or recommended pathway. The first decision trigger is to determine if regulatory and/or hydrologic conditions are favorable. If they are favorable, the decision tree is diverted to the pathways including the Regional Partnership and Preferred portfolios. At this point, another decision trigger is to consider if a regional partnership is feasible. If so, the Regional Partnership portfolio is selected as the recommended pathway otherwise the Preferred portfolio is selected as the recommended pathway.

Alternately, if the regulatory and hydrologic conditions are unfavorable, then the decision tree is diverted to the Low Perceived Risk and the Fast Track/Dry Conditions portfolios. While both of these pathways are good alternatives to consider under complicated regulatory environment and potential dry hydrological conditions, the Low Perceived Risk portfolio is preferred if a regional partnership is desired and the Fast Track/Dry Conditions portfolio is preferred if regional partnership is not feasible. It should be noted that for each potential future pathway, the implementation plan provides the portfolios developed for with and without additional groundwater availability scenarios. It is unclear what the final outcome of the decision-making process for additional groundwater availability will be, so SJRA chose to proceed with both options (with and without additional groundwater availability) as equally likely future pathways. As

more information is available, the decision tree will be refined accordingly. While SJRA considers all the four pathways on the decision tree as feasible pathways for future water supply development, their current recommended pathway is identified as pathway No. 2 on the decision tree without additional groundwater availability (Preferred portfolio). Until future evaluations recommend a different pathway, SJRA's planning process will focus on implementing the strategies identified on pathway No. 2. The decision tree also identifies the timeline at which each of the strategies will be online and providing supply to the SJRA Service Areas.

Exhibit 9 includes an illustration of the implementation plan for the Highlands Service Area. In order for SJRA to successfully develop and utilize their existing water right permits, they would have to coordinate with the City of Houston to finalize the CoH backup from Lake Houston to the Devers permit (COA-5271). In addition to this, SJRA will also have to potentially coordinate with CoH and Coastal Water Authority (CWA) for additional capacity in the CWA canal. This additional capacity can be in the range of 5,000 ac-ft/yr to 50,000 ac-ft/yr depending on whether the Highlands needs are based on project demands or the Fast Track/High Demand scenarios. A decision trigger to determine hydrological and regulatory feasibility puts the decision tree on two parallel tracks. If the regulatory and hydrologic conditions are favorable, then SJRA has to choose between the return flows strategy and the transfer of TRA supplies (approximately 5,000 ac-ft/yr) through the CWA canal. If the hydrologic and regulatory conditions are not favorable or if there is a sudden increase in the Service Area demand, then SJRA will have to consider the alternate pathway of developing the infrastructure to transfer up to 50,000 ac-ft/yr of TRA supplies either through the CWA canal or a new conveyance.

For the projects to be available on the timelines identified on the pathways, each strategy needs to go through a preliminary planning and feasibility phase, a design phase, and a construction phase. The time required to develop the projects through planning, design, and construction phases was taken into account when estimating the timeline of the strategy availabilities. In addition to this, the unit costs (not shown on the implementation plans but developed as part of the analysis) are based on August 2017 dollars and are subject to change as the planning process progresses into future decades. Detailed implementation schedules were prepared for all the portfolios to develop a better understanding of the overall schedule for developing each one of the portfolios and the schedule for developing the individual projects within the portfolios.

7.3 IMPLEMENTATION SCHEDULES

The strategy implementation schedules included in this report are meant to be planning-level schedules summarizing the overall implementation schedule for the feasibility and planning, design, and construction phases of a given strategy within a portfolio. The schedules were developed to determine the potential timing for when a strategy's water supply can be available or "online" to ensure that the strategy is available to be included in any portfolio when it is required to meet the Service Area needs. The implementation schedules discussed in this report should not be confused with a detailed implementation schedule prepared for any project during the feasibility/planning or design phases. Preliminary planning level assumptions were made to estimate the amount of time required to complete the feasibility/planning, design, and construction tasks for each project. The actual timing may vary significantly based on strategy specific issues that drive the project schedules. ***Exhibit 10*** includes an illustration of the estimated implementation schedule for SJRA's preferred portfolio without additional groundwater to serve the needs in the Montgomery County Service Area. The conservation strategy is always assumed to be online although the savings are realized gradually over the planning horizon. In order for Catahoula Aquifer supplies and Lake Livingston Transfer supplies to be available by 2036 and 2040 respectively, SJRA will have to begin the feasibility and planning level studies for the strategies by 2020.

Exhibits 11 and 12 include the implementation schedules for all four pathways of the Montgomery County Service Area implementation plan including without and with additional groundwater scenarios, respectively.

8.0 FUTURE EFFORTS

8.1 ACTIONS TO EXECUTE THE IMPLEMENTATION PLAN

With the potential future project pathways described in the implementation plan, SJRA can focus on the following actions to effectively execute the implementation plan.

1) Incorporate the results from the implementation plan and the recommended strategies from the preferred pathway for each Service Area into the Capital Improvement Planning (CIP) process, rate studies, and other internal planning processes.
2) Coordinate with the four SJRA water supply divisions to develop a list of specific action items to successfully plan, develop and implement the strategies identified in the implementation plan.
3) Coordinate with other regional entities such as LSGCD, COH, TRA and other entities to initiate the required conversations on the various water supply strategies. Specifically,

    - *Coordinate with LSGCD on the development of Catahoula Aquifer Supplies*
    - *Coordinate with COH on the final agreement of the usage of COH's share of Lake Conroe supplies*
    - *Coordinate with COH on the development of the return flows in the Lake Houston watershed*
    - *Coordinate with COH on the final agreement on the Lake Houston backup of SJRA water rights in Highlands Service Area*
    - *Coordinate with TRA on finalizing the option agreement for the Lake Livingston Water Transfer to Lake Conroe*
    - *Coordinate with CWA for additional conveyance capacity in the Canal*
    - *Coordinate with TRA on potentially using additional TRA supplies to meet the needs in the Highlands Service Area and potential additional future needs in the Montgomery County Service Area. The water supply may not be needed for many decades into the future, but it would be prudent to establish some understanding on the potential need for the water.*

4) Develop a feasibility study to evaluate the potential transmission corridors for transferring Lake Livingston supplies to Lake Conroe
5) Develop an environmental feasibility study to identify the potential environmental issues associated with the Lake Livingston transfer strategy.

6) Develop a groundwater feasibility study to evaluate availability and potential locations for developing Catahoula Aquifer supplies.

7) Develop an Aquifer Storage and Recovery feasibility study to evaluate the potential for developing the strategy and the potential yield from the strategy.

8) Develop a feasibility study to determine potential return flows available for both Service Areas and establish contract relationships with the parties owning the return flows.

9) Coordinate with the Region H Regional Water Planning Group to ensure that SJRA's preferred water management strategies and implementation plans are accurately reflected in the upcoming 2021 Region H Regional Water Plan and 2022 State Water Plan.

8.2 REGULAR UPDATE TO RAW WATER SUPPLY MASTER PLAN AND SCHEDULE

The implementation plan is developed in such a way as to take into account all the various feasible possibilities for demand growth, supply availability, needs manifestation, and future water supply development. Based on the current mindset, and the information available at this time, an implementation plan has been developed to guide SJRA's planning process in the future. While it is understood that the strategies included in the implementation plan may remain the same over the planning horizon, it would be prudent to review all assumptions made, including the supply and demand projections, at regular intervals to verify that the implementation plan proposed in this RWSMP is still the preferred pathway. It is recommended that SJRA carefully review and update the RWSMP any time there is a significant change in demand and/or supply information. In addition, it is recommended that the implementation plan be revisited annually based on any new information or developments pertaining to the supply strategies considered in the study. Finally, it is recommended that SJRA update the RWSMP at least once every five years in conjunction with the regional water planning process.

SJRA Service Area Overview

SJRA RAW WATER SUPPLY MASTER PLAN

Lake Conroe Division Location

GRP Division Location

Woodlands Division Location

Highlands Division Location

LAKE LIVINGSTON

LAKE CONROE

LAKE HOUSTON

San Jacinto River

Trinity River

Brazos River

Walker

Polk

San Jacinto

Hardin

Grimes

Montgomery

Liberty

Waller

Harris

Chambers

Brazoria

Highlands Distribution System

GRP Distribution System

Woodlands Distribution System

Highlands Service Area

Montgomery County Service Area

Woodlands Service Area

Elevated Storage Tanks

Counties

N

W

E

S

0 8 16

Miles

EXHIBIT 1

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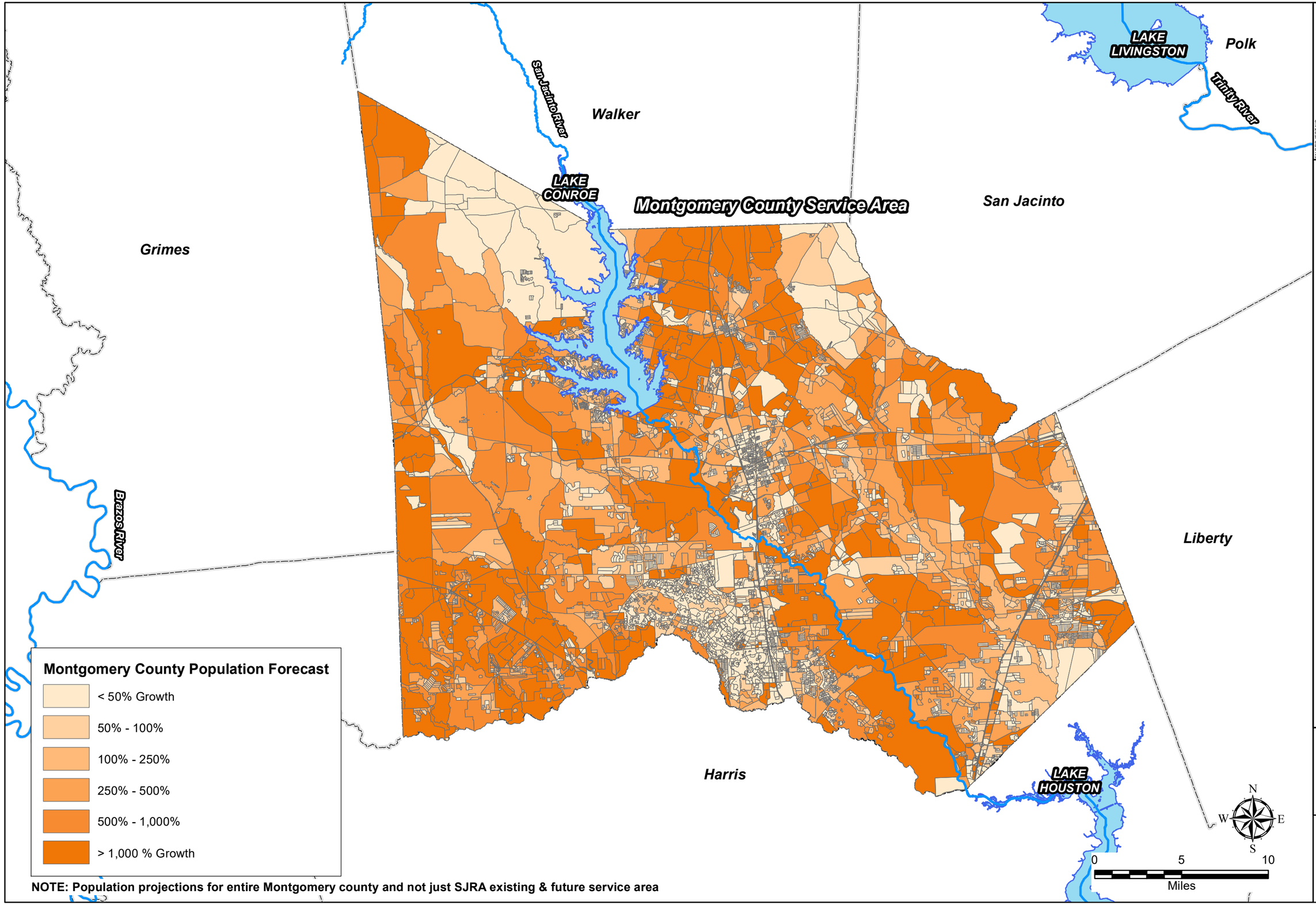

NOTE: Population projections for entire Montgomery county and not just SJRA existing & future service area

2070 Population Growth (Forecasted as Percent Increase based on 2010 Census)

SJRA RAW WATER SUPPLY MASTER PLAN

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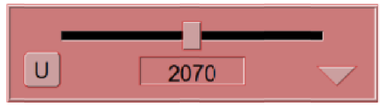
BASIC ASSUMPTIONS

Back

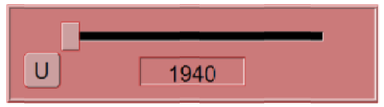
SUPPLY ASSUMPTIONS

DEMAND ASSUMPTIONS

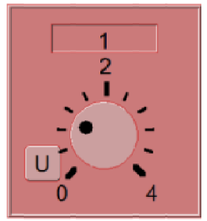
Year



Hydrology Year

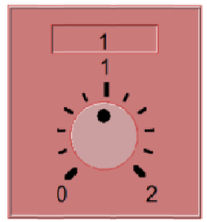


Trigger Supply Scenario



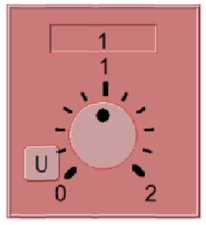
0 - BASE
1 - SEDIMENTATION
2 - RETURN FLOWS
3 - UNCERTAINTY
4 - RF+UC+SD

Trigger Mont Dem Scen



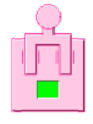
0 - DEMAND SCENARIO 4
1 - DEMAND SCENARIO 6
2 - DEMAND SCENARIO 8

Trigger High Dem Scen



0 - LOWER ADF DEMAND SCENARIO
1 -UPPER ADF DEMAND SCENARIO

Trigger Drought Cont



Up=Drought Trigger On
Down=Drought Trigger Off

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SJRA RAW WATER SUPPLY MASTER PLAN

SJRA STELLA Model Interface

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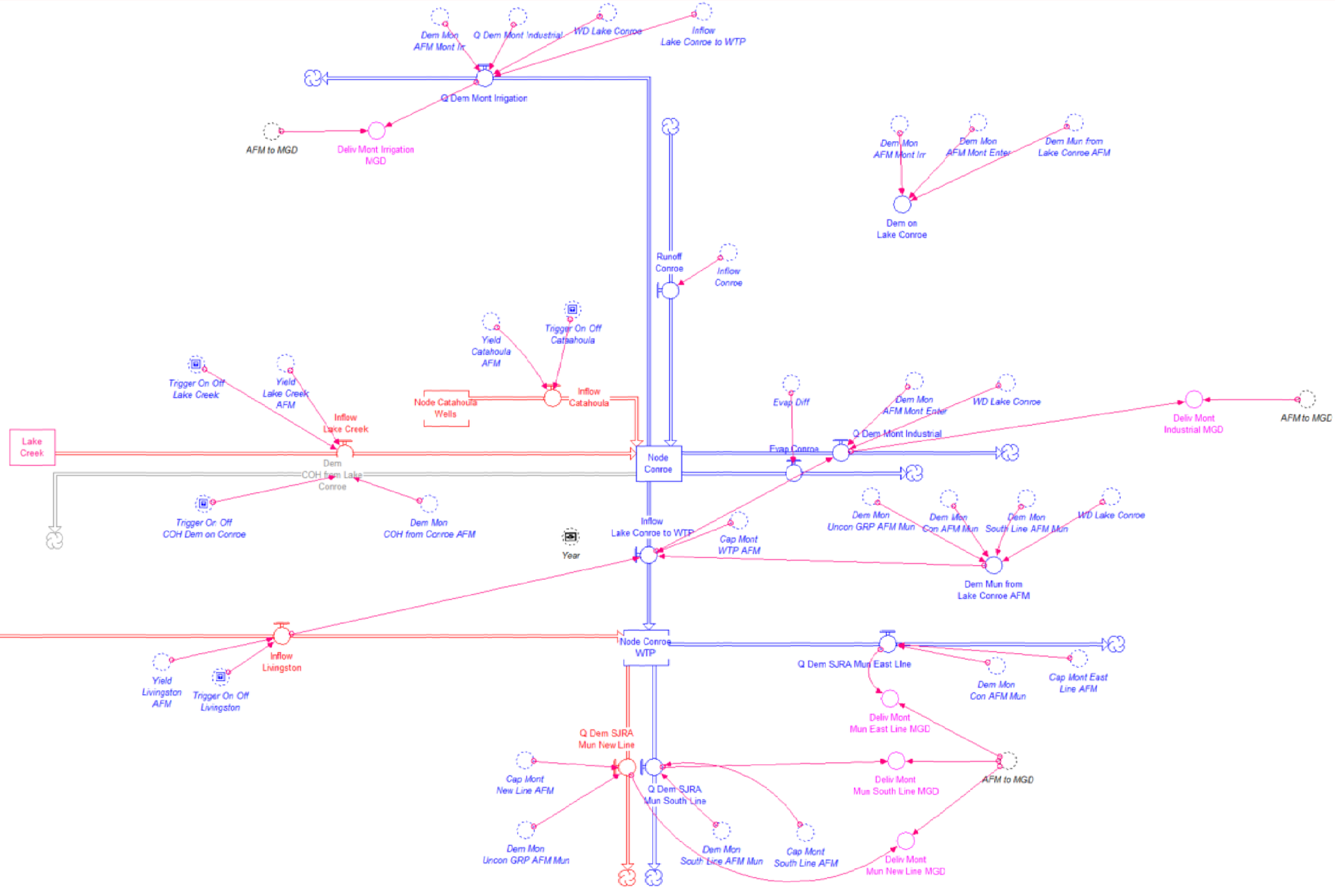
LAKE CONROE SYSTEM



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FILENAME Exhibit_4_SJRA_STELLAModel
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SJRA RAW WATER SUPPLY MASTER PLAN

SJRA STELLA Model

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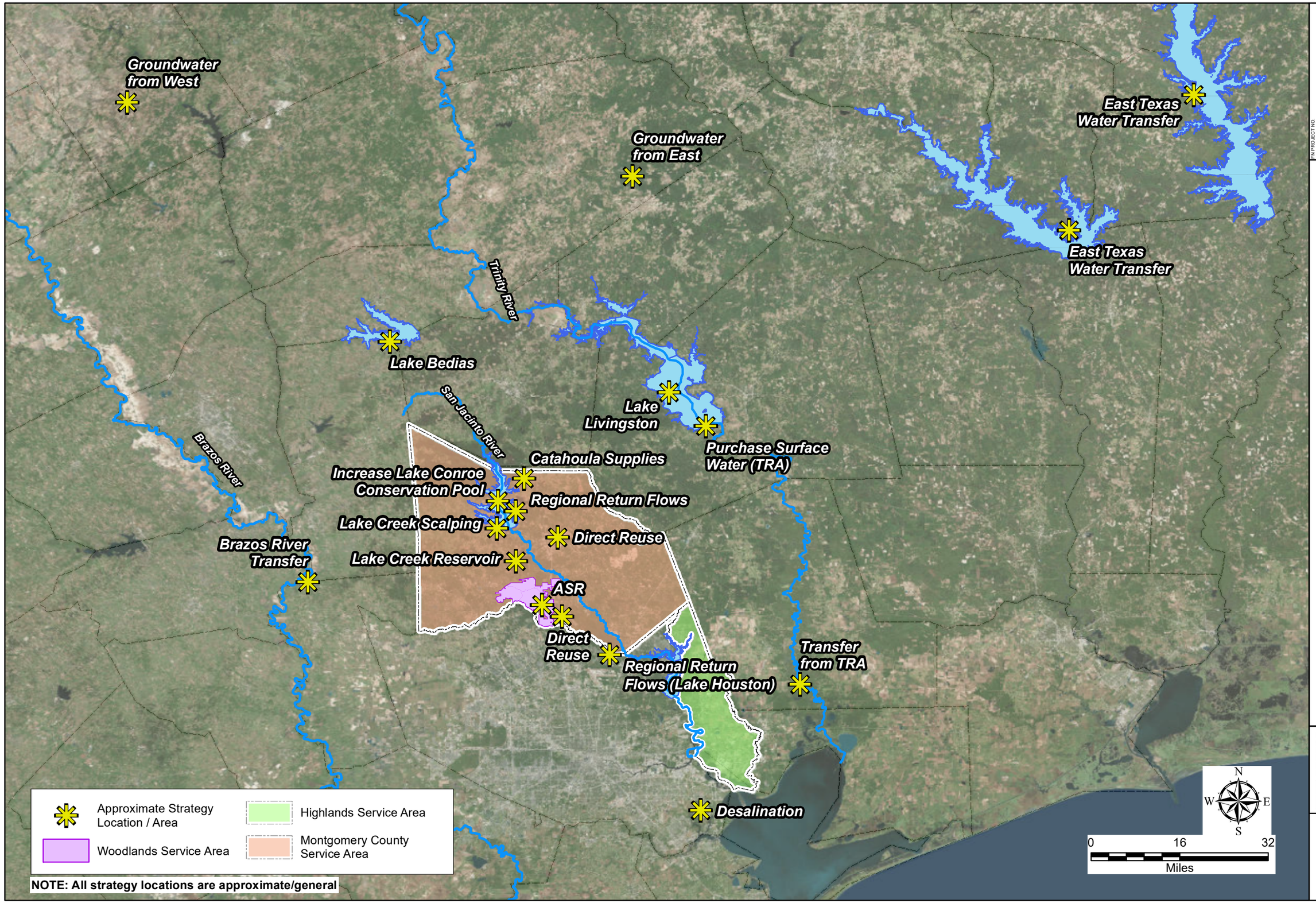

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DATE CREATED 9/4/2018

DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central

FILENAME Exhibit_5_WaterSupplyStrategiesMap

PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Potential Water Supply Strategies Location Map

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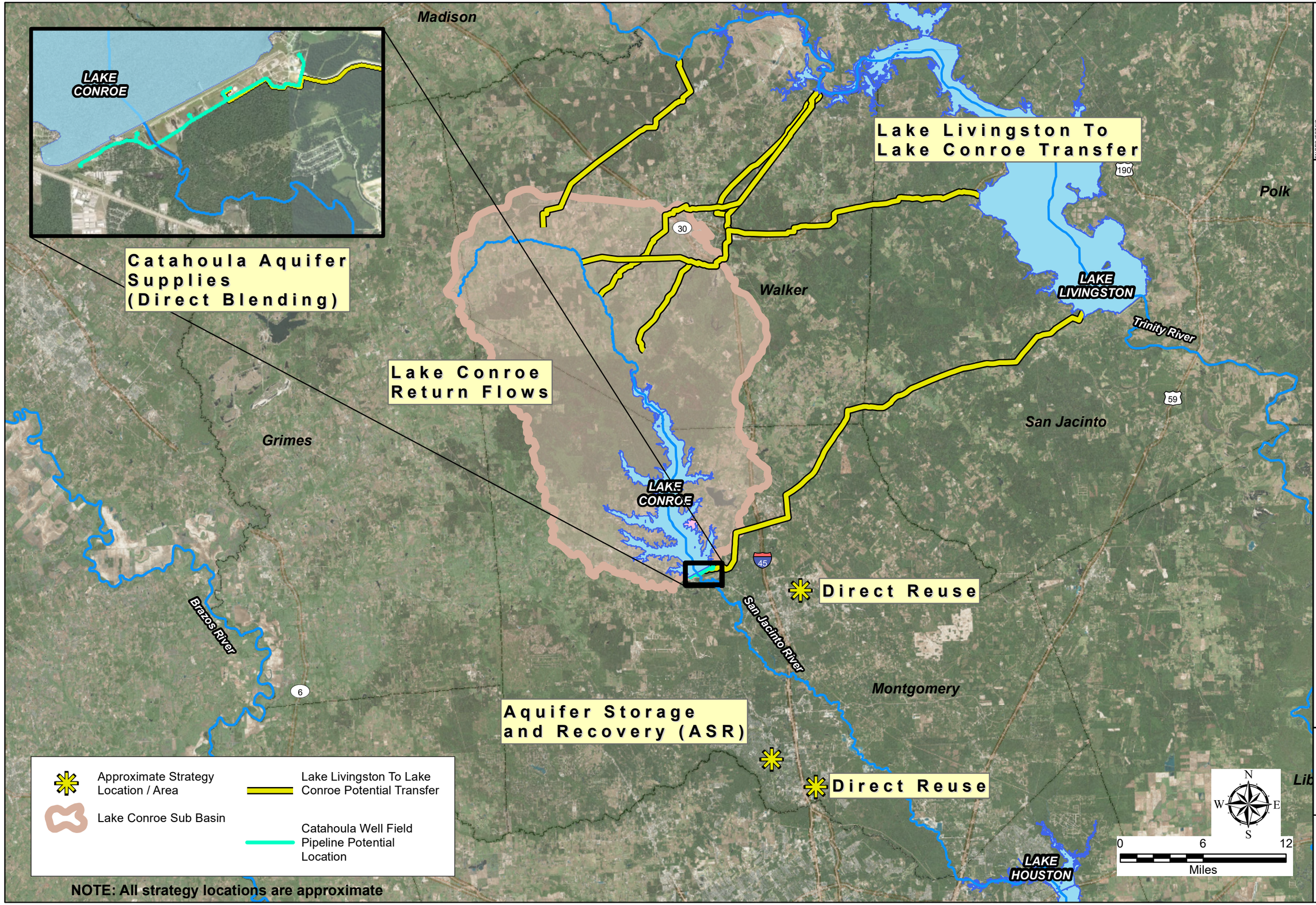

FN PROJECT NO. SJR16616
DATE CREATED 9/4/2018
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILENAME Exhibit_6_MontgomeryStrategyMap
PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Montgomery County Service Area

Potential Strategies for Montgomery County Service Area

FREESE AND NICHOLS, INC.
10497 TOWN AND COUNTRY WAY, SUITE 600
HOUSTON, TEXAS 77024
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Madison
Trinity
Walker
Polk
LAKE LIVINGSTON
San Jacinto River
Grimes
San Jacinto
Trinity River
LAKE CONROE
Hardin
Montgomery
Liberty
Lake Houston Return Flows
Surface Water From TRA
Jefferson
LAKE HOUSTON
Waller
Harris
HIGHLANDS LAKE
Chambers
Brazos River
Fort Bend
Brazoria
Galveston

Highlands Distribution System
TRA To Highlands Potential Location
Lake Houston Drainage Sub Basin

N
W
E
S
0
10
20
Miles

SJRA RAW WATER SUPPLY MASTER PLAN

Highlands Service Area

Potential Strategies to Meet Highlands Service Area Needs

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HOUSTON, TEXAS 77024
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7

FN PROJECT NO.	SJR15616
DATE CREATED	9/4/2018
DATUM & COORDINATE SYSTEM	NAD83 State Plane (feet) Texas South Central
FILENAME	Exhibit_7_WaterSupplyStrategiesMap_Highlands
PREPARED BY	DML

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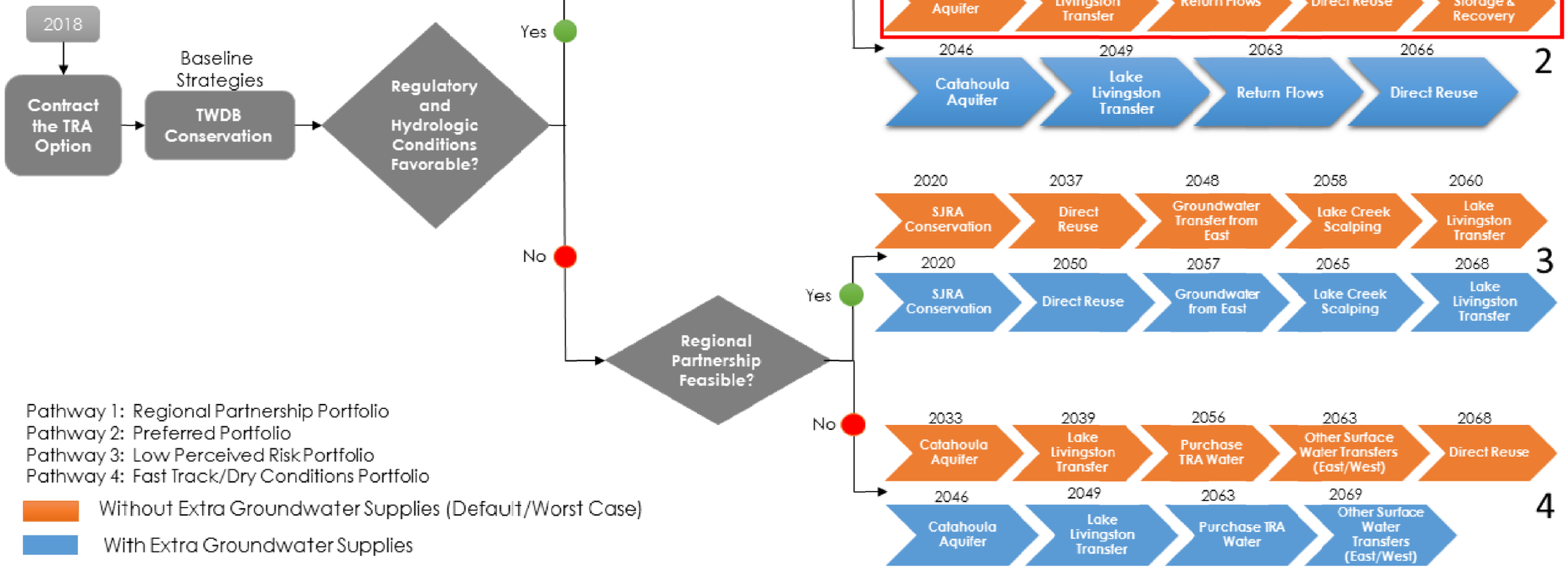
SJRA RAW WATER SUPPLY MASTER PLAN
STRATEGY IMPLEMENTATION PLAN
MONTGOMERY COUNTY



Pathway 1: Regional Partnership Portfolio
Pathway 2: Preferred Portfolio
Pathway 3: Low Perceived Risk Portfolio
Pathway 4: Fast Track/Dry Conditions Portfolio

Without Extra Groundwater Supplies (Default/Worst Case)

With Extra Groundwater Supplies

FN PROJECT NO. SJR15616
DATE CREATED 4/13/2018
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILENAME Exhibit_8_Implementation Plan-MontgomeryCountyServiceArea
PREPARED BY DMK

SJRA RAW WATER SUPPLY MASTER PLAN

Implementation Plan for Montgomery County Service Area

FREESE AND NICHOLS, INC.
10497 TOWN AND COUNTRY WAY, SUITE 600
HOUSTON, TEXAS 77024
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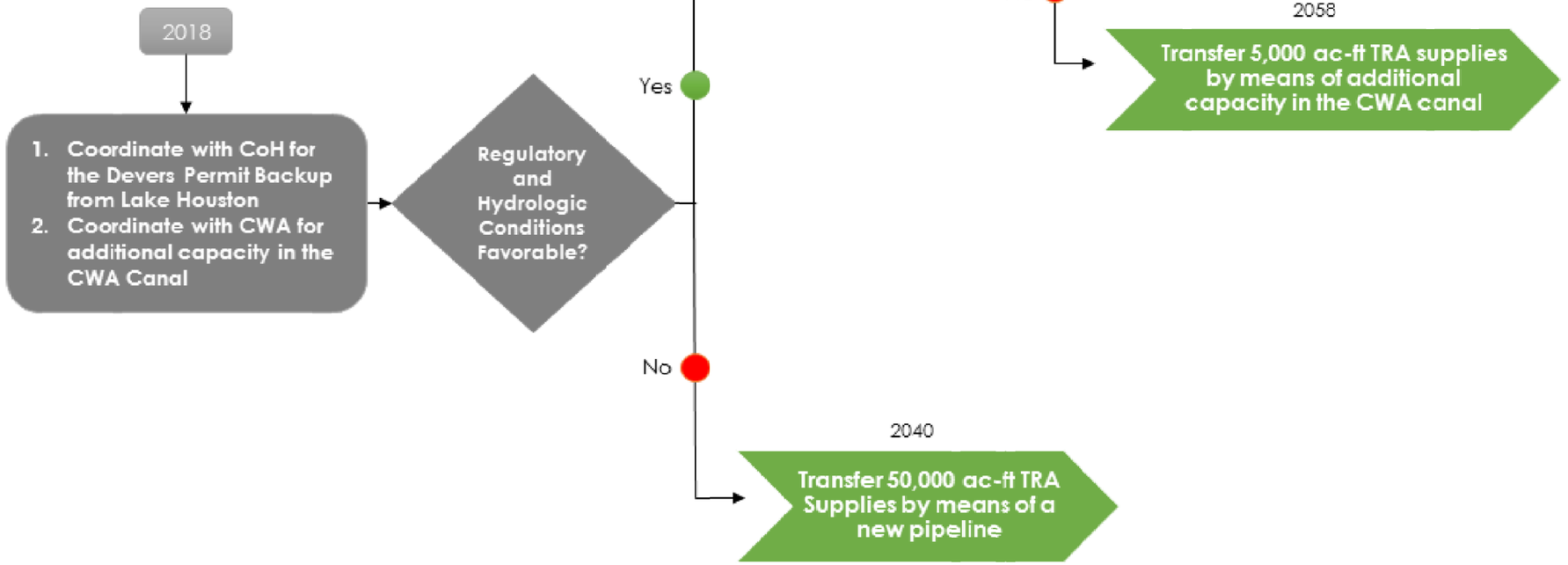
EXHIBIT
8

SJRA RAW WATER SUPPLY MASTER PLAN
STRATEGY IMPLEMENTATION PLAN
HIGHLANDS SERVICE AREA



CoH – City of Houston
CWA – Coastal Water Authority

FN PROJECT NO. SJR15616
DATE CREATED 4/13/2018
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILENAME Exhibit_9_Implementation Plan-Highlands
PREPARED BY DMK

SJRA RAW WATER SUPPLY MASTER PLAN

Implementation Plan for Montgomery County Service Area

FREESE AND NICHOLS, INC.
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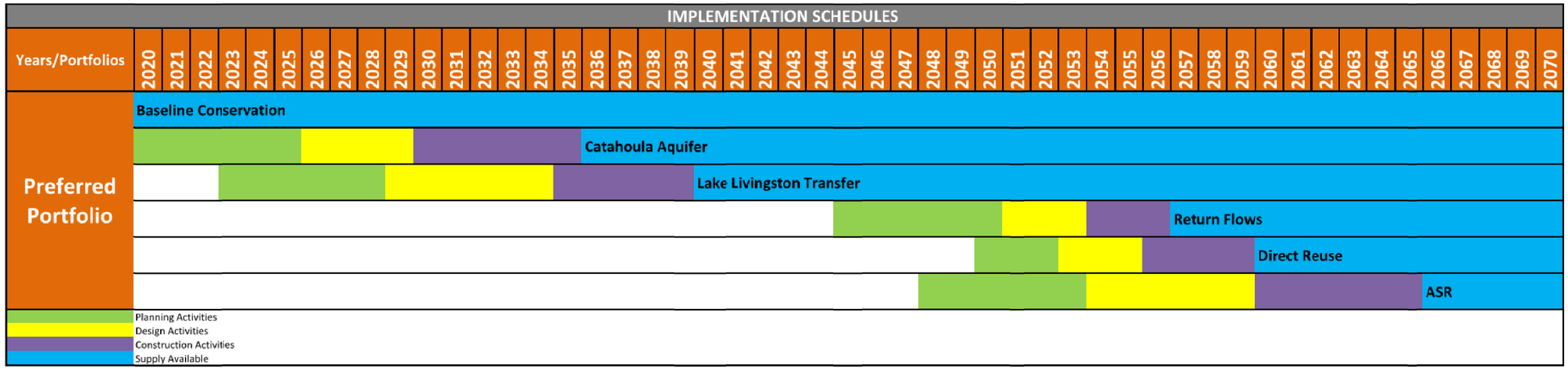

FN PROJECT NO. SJR15616

DATE CREATED 4/13/2018

DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central

FILENAME Exhibit_10_Preferred Portfolio-Montgomery

PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Preferred Portfolio Implementation Schedule for the Montgomery County Service Area

FREESE AND NICHOLS, INC.
10497 TOWN AND COUNTRY WAY, SUITE 600
HOUSTON, TEXAS 77024
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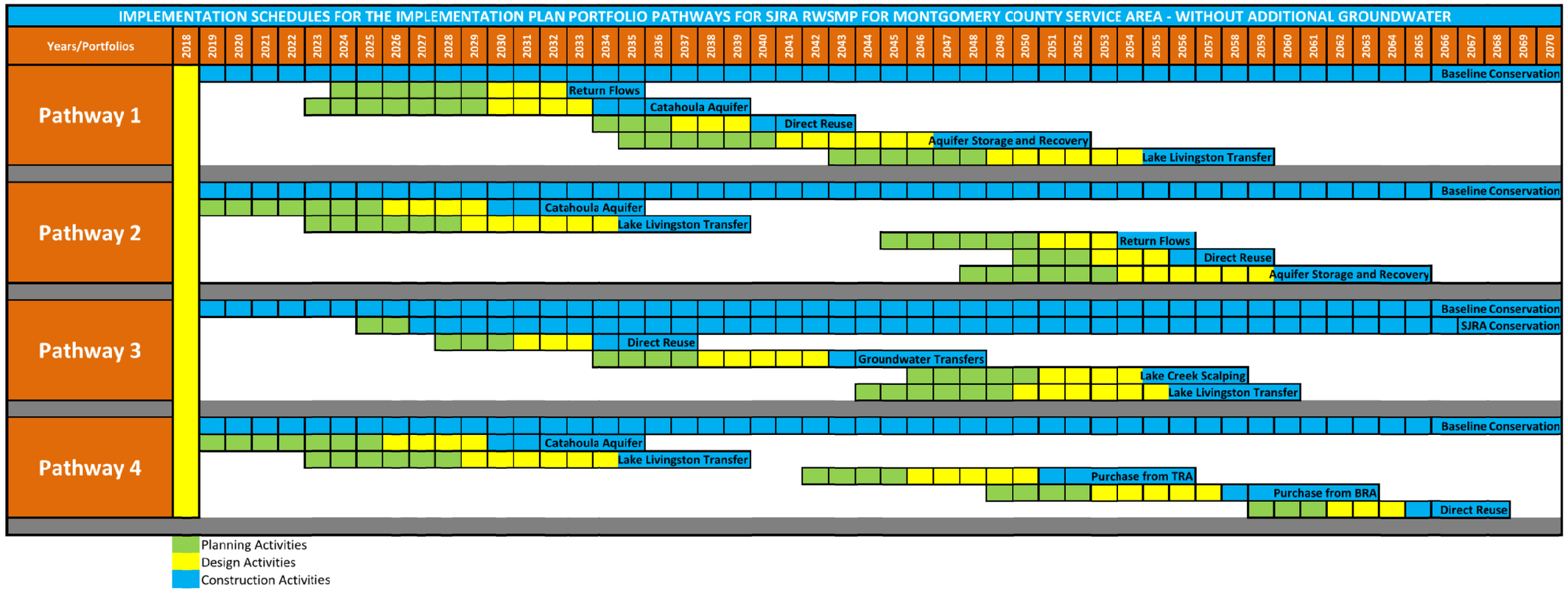

F/N PROJECT NO. SJR16616
DATE CREATED 4/13/2018
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILENAME Exhibit_11_Without Additional Groundwater
PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Implementation Schedules for Montgomery County Service Area (Without Additional Groundwater)

FREESE AND NICHOLS, INC.
10497 TOWN AND COUNTRY WAY, SUITE 600
HOUSTON, TEXAS 77024
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F: (713) 600-6801

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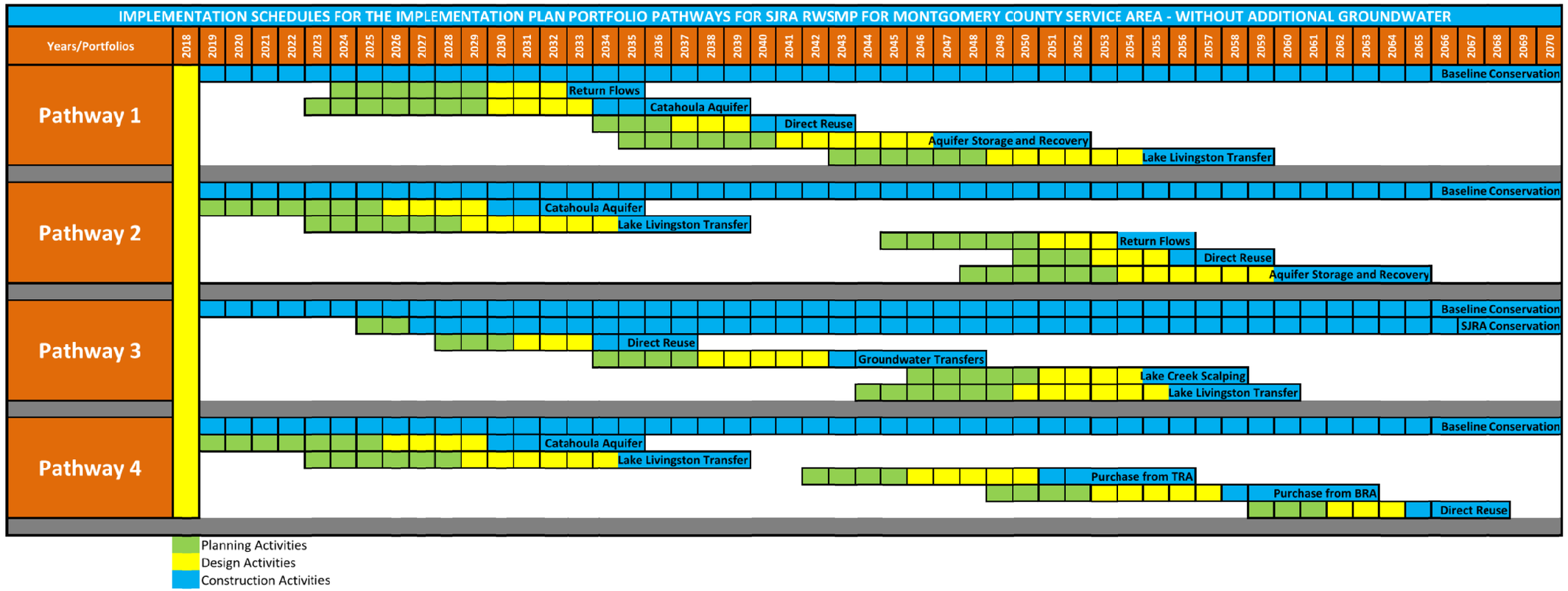
11



F/N PROJECT NO. SJR15616
DATE CREATED 4/13/2018
DATUM & COORDINATE SYSTEM NAD83 State Plane (feet) Texas South Central
FILENAME Exhibit_12_With Additional Groundwater
PREPARED BY DML

SJRA RAW WATER SUPPLY MASTER PLAN

Implementation Schedules for Montgomery County Service Area (With Additional Groundwater)

FREESE AND NICHOLS, INC.
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HOUSTON, TEXAS 77024
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F: (713) 600-6801

EXHIBIT

12

APPENDICES