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6 Impacts of Regional Water Plan and Consistency with Protection of Water Resources, Agricultural Resources, and Natural Resources

The previous section presented a set of recommended water management strategies for Region C wholesale water providers and water user groups. This section discusses the impacts of the recommended water management strategies on key parameters of water quality, the impacts of moving water from rural and agricultural areas and impacts to third parties. It also discusses how the regional water plan is consistent with the long-term protection of the state's water, agricultural, and natural resources.

Chapter Outline

Section 6.1 – Impacts of Recommended Water Management Strategies on Key Water Quality Parameters

Section 6.2 – Impacts of Recommended Water Management Strategies on Moving Water from Rural and Agricultural Areas and Impacts to Third Parties

Section 6.3 – Invasive and Harmful Species

Section 6.4 – Description of How the Regional Water Plan is Consistent with Long-Term Protection of the State's Water Resources, Agricultural Resources, and Natural Resources

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Appendix A – Consistency with Water Planning Rules

Appendix G – Water Management Strategy Evaluation

Appendix J – Updated Quantitative Analysis of the Proposed Marvin Nichols Reservoir

Appendix K – Key Water Quality Parameters

Appendix L – Socio-Economic Impacts

6.1 Impacts of Recommended Water Management Strategies on Key Water Quality Parameters

For a given water resource, the impact of water management strategies on key water quality parameters is evaluated by comparing current water quality conditions with anticipated water quality conditions when water management strategies are in place. Many of the recommended water management strategies involve diverting water from one water body and transferring this water to another water body. For these strategies, the difference in the quality of the two waters, the quantity of water transferred, and the effectiveness of any mitigation are used to project the impact on the receiving water. Selection of the key water quality parameters used for this comparison is based on the importance of these parameters to the use of the water resource.

The recommended water management strategies can be grouped into the following strategy types:

- **Existing surface water sources**
- **New surface water sources**
- **Existing groundwater sources**
- **New groundwater sources**
- **Direct and Indirect Reuse**
- **Conservation**
- **Desalination**
- **Aquifer Storage and Recovery**

In general, each strategy within a strategy type is anticipated to have a similar qualitative impact on key water quality parameters in the receiving water. Exceptions to this generalization are addressed where appropriate. The strategy type defined as “other” includes strategies that do not involve transfer from one source to another and, therefore, have no impact on water quality in the receiving water. Examples of strategies in this category include increased pipeline capacity to a particular water user group or connection of a water user group to a wholesale provider.

The following sections define the parameters selected as key water quality parameters and present the evaluation of impacts of recommended water management strategies on these key parameters.

6.1.1 Selection of Key Water Quality Parameters

The selection of key water quality parameters involved a two-stage approach. First, a list of candidate water quality parameters was compiled from several sources. Then, key water quality parameters were selected from the list of potential parameters based on the general guidelines described below.

Candidate water quality parameters were identified using the following sources:

- Parameters regulated by the Texas Commission on Environmental Quality (TCEQ) in the Texas Surface Water Quality Standards (TSWQS)[1]
- Parameters considered for the TCEQ Water Quality Inventory in evaluation of whether water body uses are supported, not supported, or have water quality concerns. The designated water body uses included in the Water Quality Inventory are:
  - Aquatic life use
  - Contact recreation use
  - General use
  - Fish consumption use

- Public water supply use
- Parameters that may impact suitability of water for irrigation
- Parameters that may impact treatability of water for municipal or industrial supply

The first two categories above represent environmental water quality parameters, and the last two categories represent water quality as related to water uses.

To develop a manageable and meaningful list of key water quality parameters, the following general guidelines were established for parameter selection:

- Selected parameters should be representative of water quality conditions that may be impacted on a regional scale and that are likely to be impacted by multiple water management strategies within the region. Water quality issues associated with localized conditions (such as elevated levels of a toxic material within one water body) will be addressed as necessary within the environmental impact evaluations of the individual water management strategies for each water user group.
- Sufficient data must be available for a parameter to include it as a key water quality parameter. If meaningful statistical summaries cannot be carried out on the parameter, it should not be designated as a key water quality parameter.

The TCEQ has adopted several changes to the TSWQS since the development of the 2016 Plan. Additional aquatic life criteria were adopted for Acrolein and Carbaryl. There were revisions to 55 existing human health criteria based on updated toxicity information. In addition, human health criteria were proposed for four new parameters: Epichlorohydrin, Ethylene Glycol, Bisphenol A and Methyl tertbutyl ether. These parameters will be addressed as necessary within the environmental impact evaluations of the individual water management strategies for each water user group. In addition, dissolved oxygen (DO) concentrations are protected during wastewater discharge permitting, and any agency that proposes to discharge biochemical oxygen demand (BOD) as part of a water management strategy would have to show that the discharge would meet local DO standards to obtain a discharge permit. Finally, little has changed since the 2016 Plan in terms of parameters that may impact suitability for irrigation, municipal, or industrial purposes.

For the *2021 Region C Water Plan*, the Region C RWPG has added two key water quality parameters to those that were used in the 2006, 2011, and 2016 Plans. Chloride and sulfate were added as key parameters for both surface water and groundwater. These parameters were added because, similar to total dissolved solids (TDS), they are regulated in the TSWQS, there are secondary drinking water standards for both parameters, and there is sufficient data to provide a baseline summary. A detailed discussion of the selection of key water quality parameters and definitions of baseline conditions for these parameters is included in **Appendix K**.

The key water quality parameters selected by the Region C Water Planning Group include:

- Surface Water
  - Ammonia Nitrogen
  - Nitrate Nitrogen
  - Total Phosphorus
  - Chlorophyll-a
  - Total Dissolved Solids (TDS)
  - Chloride (NEW)
  - Sulfate (NEW)
- Groundwater

- Total Dissolved Solids (TDS)
- Chloride (NEW)
- Sulfate (NEW)

6.1.2 Evaluation of Water Quality Impacts

Impacts of recommended water management strategies on key water quality parameters were assessed by comparing the water quality of the source water for a given strategy with that of the receiving water. This comparison included an evaluation of historical median concentrations of key parameters, together with consideration of data quality, relative quantities of water, and planned mitigation measures (e.g., treatment, blending, or other operational strategies that serve to mitigate water quality impacts). Each recommended strategy was assigned one of the following five anticipated impact ratings: low, medium low, medium, medium high, and high. (The quantitative impacts on key water quality parameters are discussed in more detail in **Appendix K**.) No recommended or alternative water management strategy is anticipated to have more than a "medium" impact on key water quality parameters. A "medium" impact is considered to be an impact that results in some changes in water quality but does not result in impairment of the designated uses of the water body. The following sections present a discussion of the anticipated water quality impacts for each strategy type.

Table 6.1 summarizes the range of anticipated water quality impacts within these strategy types.

Table 6.1 Range of Anticipated Impacts on Key Water Quality Parameters by Strategy Type

Strategy Type	Range of Anticipated Impacts on Key Water Quality Parameters	Comments
Existing Surface Water Sources	Low to Medium	Lake Texoma strategies assumed to include mitigation for TDS, chloride and sulfate.
Existing Groundwater Sources	Low to Medium Low	
New Surface Water Sources	Low to Medium	Water quality in new sources difficult to predict.
New Groundwater Sources	Medium Low to Medium	
Direct Reuse	Low/Positive	Potential positive impact resulting from reduced nutrient and TDS loadings to surface waters.
Indirect Reuse	Medium	Assumes mitigation to control impacts on nutrients, TDS, chloride and sulfate, if necessary.
Conservation	Low	
Other	Low	Includes strategies not involving blending of two water sources (e.g. direct pipeline to a treatment plant).

6.1.3 Existing Surface Water Sources

For strategies utilizing existing surface water sources, impacts on key water quality parameters vary depending on a number of factors, including the location of the source and the intended destination of the water transfer. For strategies that involve pumping existing surface water directly to a water treatment plant, no impact on water quality is anticipated (resulting in a rating of "low"). However, when water is pumped from one source to another, the impacts will depend on the existing water quality of the two sources, as well as the quantities to be transferred and any mitigation that may be applied.

Several of the recommended and alternative strategies call for increased use of water from East Texas reservoirs. In general, reservoirs in East Texas have higher concentrations of nutrients (i.e., nitrogen and phosphorus) than many of the Region C reservoirs. The ultimate impact of importing water with higher nutrient concentrations to Region C reservoirs is difficult to predict due to the complex kinetic relationships between nutrients and chlorophyll-a.

Strategies that involve importing water from East Texas reservoirs to Region C reservoirs may result in increases in ammonia, nitrate, total phosphorus, and/or chlorophyll-a, but are not likely to lead to impacts that would impair the designated uses of the Region C water bodies. In general, the dissolved solids (TDS, chloride and sulfate) concentrations in East Texas reservoirs are lower than in Region C reservoirs. Therefore, in nearly all cases, transfer of East Texas water to Region C reservoirs will decrease dissolved solids concentrations in the receiving water bodies. All of the recommended water management strategies involving importation of East Texas water to Region C are anticipated to have a "low" or "medium low" impact on key water quality parameters.

In addition to strategies that include transfers from East Texas reservoirs to Region C reservoirs, several recommended and alternative strategies include intermediate transfers between reservoirs outside of Region C. These include transfers from Wright Patman Lake to Lake Fork Reservoir and Chapman Lake and from Toledo Bend Reservoir to Lake Fork Reservoir, Lake Tawakoni, and Chapman Lake. Although there are some minor variations in water quality among these reservoirs, these strategies are all anticipated to have no more than a "medium-low" impact on the key water quality parameters.

Lake Texoma is included in the recommended and alternative strategies for multiple entities. The water will be transported directly to a water treatment plant, and dissolved solids from Lake Texoma will not directly impact any reservoirs in Region C. However, due to indirect reuse strategies, much of the dissolved solids from Lake Texoma will eventually be discharged to Region C reservoirs. Using TDS as an example, currently, typical TDS concentrations in Lake Texoma are in the 800-1,200 milligram per liter (mg/L) range. Most Trinity River Basin reservoirs in Region C have TDS standards (from the TSWQS) in the 400-500 mg/L range. Therefore, to import a significant quantity of Lake Texoma water into the Trinity River Basin, mitigation will likely be needed in the form of desalination or blending with another lower TDS water (such as an East Texas source) to meet drinking water standards, to prevent significant increases in TDS concentrations in receiving water bodies, and to prevent

violation of the Texas Surface Water Quality Standard for TDS. To project the impact of strategies involving use of Lake Texoma water, it has been assumed that mitigation measures will be used to maintain TDS concentrations in the receiving water body at levels that do not violate the Texas Surface Water Quality Standard for TDS. In addition, for strategies that use desalination treatment as mitigation, disposal of the highly saline reject stream can result in increased TDS concentrations, depending on the method and location of disposal. Based on these issues, the recommended strategy involving importation of Lake Texoma water to Region C is anticipated to have no more than a "medium" impact on key water quality parameters.

6.1.4 New Surface Water Sources

In general, the impact of the development of new surface water sources on key water quality parameters will be similar to that of existing reservoir sources. All of the proposed reservoir sites identified as potential Region C sources are located in the Red, Trinity, Sulphur, or Neches River Basins. As such, the impacts on key water quality parameters of importing water from new reservoirs are likely to be similar to the impacts of importing water from existing East Texas sources to the Trinity River Basin. (The proposed reservoir in the Red River Basin, Bois d'Arc Lake, is on a low-TDS tributary of the Red River.) All strategies involving the importation of water from new reservoirs to Trinity River Basin reservoirs are anticipated to have no more than a "medium" impact on key water quality parameters.

One new surface water strategy involves the transfer of water between reservoirs that are both outside of Region C. That is a recommended strategy for Dallas Water Utilities involving transfer of Lake Columbia water to Lake Palestine. Another recommended strategy for Dallas Water Utilities is to use run-of-river supplies from the Neches River operated as a system with Lake Palestine. Both of these strategies are anticipated to have no more than a "medium" impact on water quality parameters.

6.1.5 Existing Groundwater Sources

Since none of the recommended strategies involving existing groundwater sources include blending of groundwater within a supply reservoir, no significant impacts on key surface water quality parameters are expected. Potential impacts on key water quality parameters resulting from alternative and recommended strategies in this category are anticipated to be "low" or "medium low".

6.1.6 New Groundwater Sources

There are no new major groundwater sources included in the recommended water management strategies for Region C. However, three alternative strategies propose obtaining water from groundwater sources that are new to the region. They are:

- **Carrizo-Wilcox Aquifer groundwater in Anderson County for NTWMD;**
- **Carrizo-Wilcox Aquifer groundwater in Wood, Upshur, and Smith Counties for DWU; and**
- **Carrizo-Wilcox Aquifer groundwater in Anderson and Freestone Counties for TRWD.**

Additional information on these projects is found in **Chapter 5C** of this report.

Lake Lavon (North Texas Municipal Water District) is the potential receiving water body for Anderson County groundwater. Anderson County groundwater, drawn from the Carrizo-Wilcox aquifer, has a median TDS concentration that is similar to that in Lake Lavon. Median sulfate and chloride concentration in the groundwater are lower than those in Lake Lavon. As a result, this strategy is anticipated to have a “low” impact on key water quality parameters.

Lake Fork (current supply for DWU and others) is the potential receiving water body for Wood, Upshur, and Smith Counties groundwater. The Carrizo-Wilcox aquifer in these counties has a median TDS concentration that is higher than that in Lake Fork Reservoir and somewhat greater than the surface water quality standard for Lake Fork Reservoir. The TDS concentration in Wood, Upshur, and Smith Counties groundwater relative to the surface water quality standard may limit the use of this resource in Region C. In addition, the median nitrate concentration appears to be high in comparison to the median nitrate concentration in Lake Fork Reservoir. As a result, this strategy is anticipated to have a “medium” impact on key water quality parameters.

TRWD’s potential Carrizo-Wilcox groundwater would be transported to the existing Integrated Pipeline and further transported to TRWD’s service area in Tarrant County. The groundwater can either be delivered directly to a water treatment plant or to Lake Benbrook. Carrizo-Wilcox groundwater from Anderson County has a median TDS concentration that is somewhat greater than that in Lake Benbrook. As a result, this strategy is anticipated to have a “medium low” impact on key water quality parameters.

6.1.7 Direct Reuse

By definition, direct reuse involves the transfer of treated wastewater effluent directly to a point of use and not into another water body. As such, the impact on key water quality parameters for all direct reuse strategies is anticipated to be “low.” In some cases, there may be a positive impact. By reducing the quantity of effluent discharged into a stream or reservoir segment, the nutrient and TDS loads to that segment will also be reduced, thereby potentially improving downstream water quality.

6.1.8 Indirect Reuse

Indirect reuse is a recommended strategy for multiple entities within Region C. This strategy involves the discharge of treated wastewater effluent into a body of water used for water supply. Treated wastewater can contain nutrient and dissolved solids concentrations that are high in comparison to the receiving water. However, for most of the recommended strategies that include indirect reuse, some form of mitigation (e.g., advanced wastewater treatment, constructed wetlands, blending, etc.) is planned to address potential water quality impacts associated with nutrients and dissolved solids. For the purposes of this evaluation, it is assumed that some form of mitigation for potential water quality impacts associated with the key parameters will be implemented, if necessary, such that the designated uses of the water body will not be impaired. For this reason, recommended indirect reuse strategies are anticipated to have no more than a “medium” impact on key water quality parameters.

6.1.9 Conservation

Conservation is a recommended strategy for all municipal water user groups in

Region C, including those without shortages. Water conservation is the development of water resources and practices to reduce the consumption or loss of water, increase the recycling and reuse of water, and improve the efficiency in the use of water. Water conservation plans are designed to implement practices to conserve water and quantitatively project water savings. The water conservation measures recommended in Region C are not expected to affect water quality adversely. The results should generally be beneficial because the demand on surface and groundwater resources will be decreased. Quantifying such positive impacts could be very difficult. **Chapter 5B** contains additional discussion of water conservation.

6.1.10 Summary

The recommended water management strategies in this plan were developed based on the principle that designated water quality and related water uses as shown in the state water quality management plan shall be improved or maintained. Based on the projected impacts of recommended water management strategies on key water quality parameters, some strategies may require mitigation or advanced treatment to obtain the permits necessary for implementation.

6.2 Impacts of Recommended Water Management Strategies on Moving Water from Rural and Agricultural Areas and Impacts to Third Parties

This section discusses the potential impacts of the *2021 Region C Water Plan* on rural and agricultural activities and possible impacts to third party entities, and specifically focuses on the impacts associated with moving water from rural and agricultural areas. This section also discusses the considerations given during the development of the plan to protect rural and agricultural activities.

6.2.1 Impact on Agricultural Resources

The *2021 Region C Water Plan* includes several strategies that move water from rural areas to urban centers. These strategies fall into two general categories:

- New connections to existing water sources: Toledo Bend Reservoir to NTMWD and TRWD, Lake Palestine to DWU, Texoma to NTMWD and GTUA, Oklahoma water to NTMWD, etc.
- New reservoirs: Marvin Nichols, Lake Ralph Hall, Lake Columbia, Lake Tehuacana, and Bois d'Arc Lake

Large groundwater projects also may move large quantities of water from rural to urban areas, but these are not recommended strategies. Alternative strategies of Carrizo-Wilcox groundwater from Anderson, Wood, Upshur, and Smith Counties, are located outside of the Region C planning area.

The impacts from the recommended water management strategies will vary depending on the location of the project, current use of the water, and the quantity of water that is being transferred. The types of impacts that may occur include:

- Transfer of water rights from agricultural use to other uses
- Removal of agriculture through inundation from new reservoirs
- Changes in stream flow immediately downstream of a new reservoir
- Increased water level fluctuations at existing lakes as more water is used

The recommended water plan considered many different factors as strategies were developed and recommended for inclusion. One consideration is the development of a plan that minimizes the potential impacts to rural and agricultural areas through utilization of existing sources with a strong emphasis on conservation and reuse. The existing and recommended 2070 water conservation and reuse strategies, including those that are assumed in the demands, will meet more than one million acre-feet per year of the pre-conservation demand. The emphasis on conservation and reuse reduces the number of strategies and amount of water needed from other sources, including transfers of water from rural and agricultural areas.

Other protections for agricultural and rural uses were incorporated in the process of evaluating and allocating water supplies. Specifically, these include:

- Existing and proposed surface water supplies were evaluated under the prior appropriation doctrine that governs surface water rights and protects senior water rights. In the final *2021 Region C Water Plan*, there are no transfers of irrigation water rights to urban uses.
- The amount of available supplies from existing sources was limited to firm yield. Existing uses from these sources were protected through the allocation process and only the amount of water that is currently permitted (up to the firm yield) was considered for transfer to Region C. Three existing reservoirs (Texoma, Wright Patman and Toledo Bend) are currently seeking or are recommended to seek additional water rights. This additional water would not impact agricultural or rural activities.
- Supplies from new reservoirs considered instream flow releases in accordance with the planning guidelines set forth by the TWDB. These releases protect recreational and non-consumptive water needs downstream of the proposed reservoir sites.

In Region C there is little irrigated agriculture, with irrigated cropland making up less than 2 percent of harvested cropland[(2)]. Most of the irrigation water demand is associated with golf course irrigation in and near urban areas, and much of this water need will be met through reuse. There are no recommended transfers of needed irrigation to other uses and all irrigation and livestock water needs are met through the recommended plan.

The potential impacts to agricultural and rural areas are limited to the loss of land from inundation of new reservoirs. The total acreage that would be flooded if all recommended water management strategies from the *2021 Region C Water Plan* were implemented is almost 131,000 acres, with almost half of that being from the proposed Marvin Nichols Reservoir. More detailed information about the impacts of this reservoir on agricultural land is included in **Appendix J.** Impacts from new reservoirs will be mitigated as part of the permitting process. New reservoirs also can stimulate the rural economy through new recreational business and local improvements. The new reservoirs will provide a new water source for rural activities. Each of the proposed reservoir sites includes water set aside for local water supplies.

6.2.2 Third Party Impacts of Moving Water from Rural and Agricultural Areas

Possible third party impacts include loss of land and timber, impacts to existing recreational business on existing lakes due to lower lake levels, and impacts to

recreational stream activities. Economic studies have been conducted for two of the reservoirs proposed for Region C, and in each case they indicate a significant net economic benefit to the region of origin[3],[4].

6.2.3 Impacts of Recommended Water Management Strategies on Groundwater and Surface Water Inter-relationships

The impacts of recommended water management strategies in Region C on groundwater and surface water relationships are expected to be minimal. For surface water, the supplies used do not exceed the firm yield of the reservoir. For groundwater, the desired future conditions, as adopted by the GMAs, were honored for both currently developed supplies and potential future strategies. By not exceeding the MAG, long-term effects on groundwater and surface water interrelationships were minimized since these complex relationships are considered by the GMA when selecting the DFCs.

6.2.4 Other Factors

The impacts to recreational activities and recreational businesses at existing lakes are expected to be low. While water levels at local and rural lakes may fluctuate more under the recommended plan, these water level changes are within the design constraints of the reservoirs. Five of the major water transmission strategies have water sources that are located in highly prolific rainfall areas. Significant changes in water levels at these sources would be limited to extreme drought conditions. Impacts to recreational stream activities are mitigated through the permitting process and requirements for instream flow releases. New reservoirs offer new recreational opportunities and recreational business growth that could spur the local economies of rural areas.

6.2.5 Interbasin Transfers of Surface Water

Several recommended and alternative water management strategies involve interbasin transfers of surface water to Region C. These strategies propose moving water from the Red, Neches, Sabine, and Sulphur Basins to the Trinity Basin. The needs, as reported in DB22, for each of these basins of origin and the receiving basin (Trinity) are included in **Table 6.2**. By 2040, the needs in the Trinity Basin exceed the needs in each of the basins of origin.

6.3 Invasive and Harmful Species

The appearance of several invasive and/or harmful species (including zebra mussels, giant salvinia, and golden algae) poses a potential threat to water supplies throughout the state of Texas. Monitoring and management by water suppliers in Region C will be necessary in the coming decades. Invasive species will likely be an ongoing area of interest to Region C, as the appearance of additional invasive species in the future remains a possibility. The issue of invasive and harmful species should be considered as plans for interbasin transfers of water supplies are implemented. A more extensive discussion of these invasive species is found in **Chapter 1** of this report.

6.4 Description of How the Regional Water Plan is Consistent with Long-Term Protection of the State's Water Resources, Agricultural Resources, and Natural Resources

The development of viable strategies to meet the demand for water is the primary focus of regional water planning. However, another important goal of water planning is the long-term protection of resources that contribute to water availability and to the quality of life in the state.

The purpose of this section is to describe how the *2021 Region C Water Plan* is consistent with the long-term protection of the state's water resources, agricultural resources, and natural resources. The requirement to evaluate the consistency of the regional water plan with protection of resources is found in 31 TAC Chapter 357.35(c) and 357.41.

Table 6.2 Water Needs by Basin and Region Related to Interbasin Transfers (Acre-Feet per Year)

Basin	Region	2020	2030	2040	2050	2060	2070
Red	A	23,028	29,991	33,283	38,542	43,769	49,653
	B	24,200	26,442	29,501	32,312	35,601	40,877
	C	4,972	5,740	6,308	9,213	16,903	35,876
	D	4,270	4,288	4,290	4,292	4,313	4,358
	G	2,977	3,457	2,719	2,299	2,239	2,677
	O[a]	1,366	1,466	2,139	2,922	3,771	4,671
	Total	**60,813**	**71,384**	**78,240**	**89,580**	**106,596**	**138,112**
Neches	D	54	104	144	190	235	280
	H	8,182	8,464	8,761	9,101	9,477	9,879
	I	128,310	169,099	167,711	172,042	177,872	184,139
	Total	**136,546**	**177,667**	**176,616**	**181,333**	**187,584**	**194,298**
Sabine	C	24	954	1,824	3,687	6,306	8,813
	D	7,754	10,680	13,820	18,232	24,568	33,506
	I	10,919	12,914	15,097	17,847	21,260	21,353
	Total	**18,697**	**24,548**	**30,741**	**39,766**	**52,134**	**63,672**
Sulphur	C	215	229	219	299	504	650
	D	29,784	30,701	31,312	32,164	33,282	34,624
	Total	**29,999**	**30,930**	**31,531**	**32,463**	**33,786**	**35,274**
Trinity	B	545	50	51	136	226	323
	C	58,912	297,441	518,690	751,539	983,723	1,220,076
	D	38	72	123	235	374	582
	G	7,159	8,079	9,194	11,342	14,122	17,224
	H	12,552	13,850	14,140	14,766	15,581	16,449
	I	0	0	0	0	0	146
	Total	**79,206**	**319,492**	**542,198**	**778,018**	**1,014,026**	**1,254,800**

[a]*Region O needs do not include irrigation needs.*

6.4.1 Consistency with the Protection of Water Resources

Five river basins provide surface water for Region C, and six aquifers provide groundwater to the region. The four major river basins within Region C boundaries are the Trinity River Basin, the Red River Basin, the Brazos River Basin, and the Sabine River Basin. Only a small portion of the Sulphur River Basin lies within the Region C boundaries, but this basin provides important surface water supplies for Region C from Chapman Lake. The region's groundwater resources include two major aquifers, the Trinity and Carrizo-Wilcox, and three minor aquifers, the Woodbine, the Nacatoch, and the Queen City. The extents of these aquifers within the region are depicted in **Chapter 1**.

The Trinity River Basin provides the largest amount of water supply in Region C. Surface reservoirs in the Trinity Basin in Region C with conservation storage over 50,000 acre-feet include:

- **Bridgeport Reservoir**
- **Eagle Mountain Reservoir**
- **Benbrook Lake**
- **Joe Pool Lake**
- **Grapevine Lake**
- **Ray Roberts Lake**
- **Lewisville Lake**
- **Lavon Lake**
- **Lake Ray Hubbard**
- **Bardwell Lake**
- **Navarro Mills Lake**
- **Richland-Chambers Reservoir**
- **Cedar Creek Reservoir**
- **Lake Fairfield**

Other major reservoirs supplying surface water to Region C include the following:

- Lake Texoma in the Red River Basin
- Only a small portion of the Sabine River Basin lies within Region C; however, Region C receives water from two major water supply reservoirs located in Region D and the Sabine Basin (Lake Tawakoni and Lake Fork Reservoir).
- Only small portions of the Brazos River Basin lie within Region C, and no Brazos River Basin reservoirs with conservation storage over 50,000 acre-feet are located in Region C.
- Chapman Lake is located in the Sulphur River Basin in Region D.
- Lake Palestine is permitted for use in Region C, but is located in the Neches River Basin in Region I.

Of the groundwater resources in Region C, the Trinity aquifer provides about 67 percent of the region's groundwater, and about 17 percent comes from the Woodbine aquifer. The remainder of the groundwater is from the Carrizo-Wilcox (10 percent), and 6 percent is from minor and undesignated aquifers.

To be consistent with the long-term protection of water resources, the plan must recommend strategies that minimize threats to the region's sources of water over the planning period. The water management strategies identified in **Chapter 5** were evaluated for threats to water resources. The state-developed surface Water Availability Models (WAMs) and Groundwater Availability Models (GAMs) were used to evaluate surface water and groundwater supplies, respectively. The results from these models were used to determine the amount of water supply that could be allocated while still protecting the sustainability of the water resources. The recommended strategies represent a comprehensive plan for meeting the needs of the region while effectively minimizing threats to water resources.

Descriptions of the major strategies and the ways in which they minimize threats include the following:

- **Water Conservation.** Strategies for water conservation have been recommended that will significantly reduce the demand for water, thereby reducing the impact on the region's groundwater and surface water sources. Not including reuse, water conservation practices are expected to reduce the municipal water use in Region C by 192,405 acre-feet per year by 2070 and reduce non-municipal water use by 4,276 acre-feet per year by 2070, reducing impacts on both groundwater and surface water resources (Table 5B.11).
- **Reuse Projects.** Existing and recommended reuse projects in Region C account for a total water

supply of 413,729 acre-feet per year as of 2070 (Table 5B.8). The majority of the recommended reuse is for municipal use. A portion of the reuse water is for golf course and general irrigation in municipal areas and for steam electric power generation. These strategies will provide an economical and environmentally desirable source of water for Region C and delay the need for development of new water supplies.

- **Conservation and Reuse.** The existing and recommended 2070 water conservation and reuse strategies, including those that are assumed in the demands, will meet more than 1.35 million acre-feet per year (or 42.9 percent) of the pre-conservation demand.
- **Full Utilization of Existing Surface Supplies Committed to Region C.** A number of recommended strategies for Region C are intended to make full use of existing supplies. Most reservoirs in Region C will be utilized at or near their firm yield capacities but not beyond, thus protecting these reservoirs and allowing the continued water supplies throughout a drought similar to the drought of record. In addition, by fully utilizing the existing water supplies, water providers will delay the need for new supplies.
- **Investigation of Existing Supplies Not Committed to Region C.** As part of this planning process, the Region C Water Planning Group investigated the cost and availability of existing water supplies that might be made available to Region C. Cost-effective existing supplies are included in the *2021 Region C Water Plan*.
- **Optimal Use of Groundwater.** This strategy is recommended for entities with limited alternative sources and sufficient groundwater supplies to meet their needs. Groundwater availability reported in the plan maintains the long-term sustainability of the aquifer and is based on aquifer recharge.
- **New Surface Reservoirs.** A number of new surface reservoirs have been recommended as water management strategies. They include: Bois d'Arc Lake in 2020, Lake Ralph Hall in 2030, Tehuacana Reservoir in 2040, Marvin Nichols Reservoir in 2050, and Lake Columbia in 2070. These reservoirs will have significant impacts on the land, homes, and habitat that will be inundated and on the existing stream segments which will be altered. As part of reservoir development, the Corps of Engineers will determine the quantity of land that should be set aside to mitigate for impacts to aquatic and wildlife habitats. Landowners within the reservoir sites will be compensated for their land. These new reservoirs will make releases for environmental water needs in accordance with environmental regulations and permit conditions, which will help sustain aquatic and wildlife habitat downstream from the reservoir. Water right permits for these reservoirs will be granted based on results from the WAMs which will ensure that these new water rights do not interfere with existing prior water rights, thus protecting existing water resources of the state.

6.4.2 Consistency with Protection of Agricultural Resources

Many areas of Region C are heavily urbanized, and the region has comparatively little irrigated agriculture. In

the year 2016, 4 percent of the region's total water use was for irrigation and livestock and most of the irrigation shown in that table was used for golf course irrigation rather than agricultural irrigation.

None of the recommended water management strategies involve transferring water rights from agricultural use to another use. Thus, the Region C plan protects current agricultural water use.

The proposed reservoirs in the *2021 Region C Water Plan* will inundate some agricultural areas, but agricultural use in the reservoir sites is limited. The proposed reservoirs located in Region C include Bois d'Arc Lake, Lake Ralph Hall and Lake Tehuacana. Very little agricultural activity exists in the area of these proposed reservoirs. During the permitting process, site specific analyses would address this topic in more detail.

The proposed Marvin Nichols Reservoir in the Region C Plan is located outside of Region C. The area of the proposed Marvin Nichols Reservoir site has some agricultural activity, including cattle raising and timber.

This area is also known to have some hunting leases for game animals. A quantitative analysis of the impacts of the proposed Marvin Nichols Reservoir on agricultural and natural resources is included in **Appendix J**.

The proposed Lake Columbia in the Region C Plan is located outside of Region C. The area of the proposed Lake Columbia site has 11,330 acres. Very little agricultural activity exists in this area and site specific analyses will be conducted during the permitting process.

6.4.3 Consistency with Protection of Natural Resources

Region C contains many natural resources that must be considered in water planning. Natural resources include threatened or endangered species; local, state and federal parks and public land; and energy/mineral reserves.

The Region C plan is consistent with the long-term protection of these resources. A brief discussion of consistency of the plan with protection of natural resources follows.

Threatened/Endangered Species. A list of threatened or endangered species located within Region C is contained in two tables in **Chapter 1**. Federally and state listed species are summarized utilizing data from the Texas Parks and Wildlife Department's listing[5] and from the U.S. Fish and Wildlife Service [6].

All recommended strategies in Region C have been chosen with the possible effects on these threatened and endangered species in mind. For example, strategies that are likely to disturb threatened or endangered species habitat include mitigation allowances that set aside additional land for that habitat.

Wetland Habitats. The Region C plan includes some projects that would have impacts to existing wetland habitats. The Marvin Nichols Reservoir project would inundate a portion of the state's Priority 1 bottomland hardwoods. These wetlands are considered high value to key waterfowl species and would require comparable mitigation. As discussed in **Section 6.4.1**, state and federal agencies will determine the quantity of land that should be set aside to mitigate for impacts to aquatic and wildlife habitats during reservoir development. The quantity and quality of the mitigation lands will be designed to achieve no net loss of

wetlands functions and values. In addition, the development of a lake will create new wetland and aquatic habitats.

Parks and Public Lands. The Texas Parks and Wildlife Department operates several state parks in Region C listed below [7]:

- Bonham State Park in Fannin County
- Cedar Hill State Park in Dallas County
- Eisenhower State Park in Grayson County
- Fairfield Lake State Park in Freestone County
- Lake Mineral Wells State Park in Parker County
- Fort Richardson & Lost Creek Reservoir State Park in Jack County
- Purtis Creek State Park partially in Henderson County
- Caddo National Grasslands Wildlife Management Area in Fannin County
- Ray Roberts State Park in Cooke, Denton, and Grayson Counties
- Richland Creek Wildlife Management Area in Freestone and Navarro Counties
- Ray Roberts Lake Wildlife Management Area in Cooke, Denton, and Grayson Counties
- Cedar Creek Islands Wildlife Management Area in Henderson County

Federal government natural resource holdings in Region C include the following:

- Parks and other land around all of the Corps of Engineers lakes in the region (Texoma, Ray Roberts, Lewisville, Lavon, Grapevine, Benbrook, Joe Pool, Bardwell, and Navarro Mills)
- Hagerman National Wildlife Refuge on the shore of Lake Texoma in Grayson County
- Lyndon B. Johnson National Grasslands in Wise County
- The Caddo National Grasslands in Fannin County

In addition, there are a number of city parks, recreational facilities, and public lands located throughout the region. Increased utilization of some reservoirs may lower the lake levels during a severe drought. This may affect the parks and public lands surrounding these reservoirs, but the strategies recommended in the Region C plan will have no additional impact on these water resources beyond what has already been allowed for in their water right permits. None of the recommended water management strategies evaluated for the Region C plan are expected to adversely impact parks or public lands.

Energy Reserves. Oil and natural gas fields are important natural resources in portions of Region C. Most of the oil production is in Jack, Wise, Cooke, Navarro, and Grayson Counties [8], and most of the natural gas production is in Freestone, Parker, Denton, Tarrant, and Wise Counties [9]. Gas production in the Barnett Shale has rapidly increased in the past decade due in large part to improvements in hydraulic fracture stimulation technologies [10]. This use of water in gas production has significantly increased the mining use in Region C. None of the recommended water management strategies are expected to impact oil or gas production in the region. The proposed Tehuacana Reservoir location in Freestone County is underlain, in parts, by lignite coal deposits. In 1982, the US Army Corps of Engineers conducted a feasibility report on the recovery of these resources [11].

This report concluded that there was economic impetus to mine this deposit to 150 feet. However, the economic environment for the mining and use of coal for power generation has changed substantially since 1982. One major assumption in the report is that the coal could be used at the Luminant's Big Brown Plant near Fairfield, which is only a short distance from the potential mine location near Tehuacana. However, in 2011, Luminant ceased coal production at their three current lignite mines and no longer uses lignite coal at the Big Brown Plant due to the EPA Cross-State Air Pollution Rule [12]. Furthermore, in 2014 the EPA proposed a new Clean Power Plan Rule [13], which if it passes, may make coal fired power generation even less attractive. While it is impossible to predict future market changes and conditions, given the current regulatory environment and the trend of closing lignite mines, it is unlikely that the construction of the Tehuacana Reservoir will result in adverse impacts on the coal industry.

6.4.4 Consistency with Protection of Navigation

No commercial navigation activities occur in Region C at this time. For the two river segments identified by the Corps of Engineers as "navigable waters" (Trinity River downstream of Fort Worth and the Red River downstream of Warren's Bend in Cooke County), there are no known plans to initiate navigation activities. This plan has no impact to navigation in Region C.

The Region C recommended strategies also do not impact navigation activities in other regions. Analysis of the proposed reuse projects found that there are limited impacts to stream flows from reuse projects, thus protecting potential downstream navigation activities. The recommended reservoirs located in adjacent regions include sufficient releases that would protect instream uses and downstream navigation activities.

6.5 Impacts of Not Meeting Municipal Water Needs

6.5.1 Unmet Needs in Region C

There is one municipal WUG and seven non-municipal WUGs with unmet needs in Region C. The WUGs with unmet needs are

- Hickory Creek SUD
- Ellis County Irrigation,
- Fannin County Irrigation
- Fannin County Mining,
- Freestone County Mining,
- Freestone County Steam Electric Power,
- Kaufman County Mining, and
- Navarro County Mining.

The unmet need for Hickory Creek SUD is due to limitations of the MAG in Hunt County. Since the SUD's water source is not within a groundwater conservation district, the SUD intends to further develop its groundwater to meet the projected water needs.

For both Ellis and Fannin County Irrigation, the current use is groundwater, and the anticipated future use is also groundwater. However, there is not enough MAG supply to allocate to these WUGs as a WMS to fully meet their needs.

For Freestone County Mining, the need is unmet because the demand is a function of how the TWDB classifies the mining operation, not an "actual" demand. The demand is from the de-watering of lignite mines from shallow aquifers. It is the amount of water produced by dewatering rather than a true demand, and no supply is needed.

For Freestone County Steam Electric Power, the demand projections include use from an unidentified new facility based on state and federal reports (See **Appendix C**

for Steam Electric Power Memo). It is unclear where the facility would get its supply. In addition, in the previous plan, 6 MGD of this need was met by a WMS of TRA reuse water. In this plan, however, TRA has identified other users for its reuse supply and none is available for Freestone County SEP.

For Kaufman and Navarro County Mining, the current use is groundwater and the anticipated future use is also groundwater. However, there is no MAG supply to allocate to these WUGs as a WMS.

For Fannin County Mining, the current use is run-of-river water. There is no additional firm supply of run-of-river and no additional MAG groundwater supply to allocate to this use. Additionally, the new surface water in Fannin County is not authorized for mining use.

6.5.2 Socioeconomic Impacts

If no additional water supplies are developed, Region C will face substantial shortages in water supply over the next 50 years. The Texas Water Development Board (TWDB) provides technical assistance to regional water planning groups in the development of specific information on the socio-economic impacts of failing to meet projected water needs. This information is presented in **Appendix L**. A summary of the TWDB's socio-economic report is presented in this section. The TWDB analysis of socio-economic impacts is based on information on potential Region C shortages provided to the TWDB by Region C through TWDB's online database (DB22). TWDB based the socio-economic analysis on the information in DB22 as of September 2019. In November 2019, Region C made adjustments to some of the data in DB22 which slightly changed the overall shortages. These changes represent a 1.5 percent decrease in 2070 water needs. The socio-economic analysis was not updated to incorporate this new data. The minimal change in shortages would mostly likely have minimal effect on the outcome of the socio-economic analysis. Therefore, the results presented in this section remain a valid representation of the effects of not meeting all water needs.

Table 6.3, Figure 6.1 and **Figure 6.2** summarize the TWDB's analysis of the impacts of a severe drought occurring in a single year at each decadal period in Region C. It was assumed that all of the projected shortage was attributed to drought. Under these assumptions, the TWDB's findings can be summarized as follows:

- With the projected shortages, the region's projected 2070 population would be reduced by 86,839.
- Without any additional supplies, the projected water needs would reduce the region's projected 2070 employment by almost 473,000 jobs.
- By not meeting water needs in Region C, the annual combined lost income in 2070 is estimated at $48.1 billion.
- The lost water utility revenues (municipal sector only) in 2070 are $4.6 billion.

The projected impact on population and jobs over the planning period is shown on **Figure 6.1.** The impacts to income by use category are shown on **Figure 6.2.** It is important to note that this socio-economic impact analysis only considers a severe drought occurring in a single year. A drought several years long would have an even greater impact on the region.

6.6 Consistency with State Water Planning Guidelines

To be considered consistent with long-term protection of the state's water, agricultural,

and natural resources, the Region C plan must be determined to be in compliance with the following regulations:

- **31 TAC Chapter 357.35**
- **31 TAC Chapter 357.40**
- **31 TAC Chapter 357.41**
- **31 TAC Chapter 358.3**

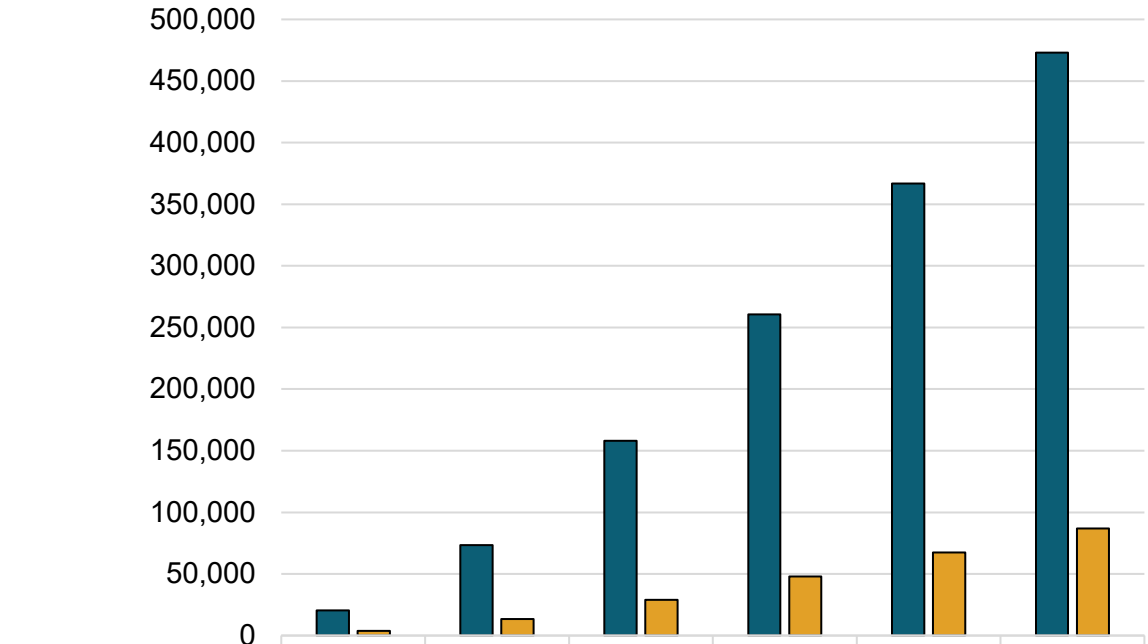
The information, data, evaluation, and recommendations included in the Region C plan collectively comply with these regulations. To assist with demonstrating compliance, Region C has developed a matrix addressing the specific recommendations contained in the above referenced regulations. The matrix is a checklist highlighting each pertinent paragraph of the regulations. The content of the *2021 Region C Water Plan* has been evaluated against this matrix.

Appendix A contains a completed matrix.

Table 6.3 Socio-Economic Impacts in Region C of Not Meeting Projected Demands

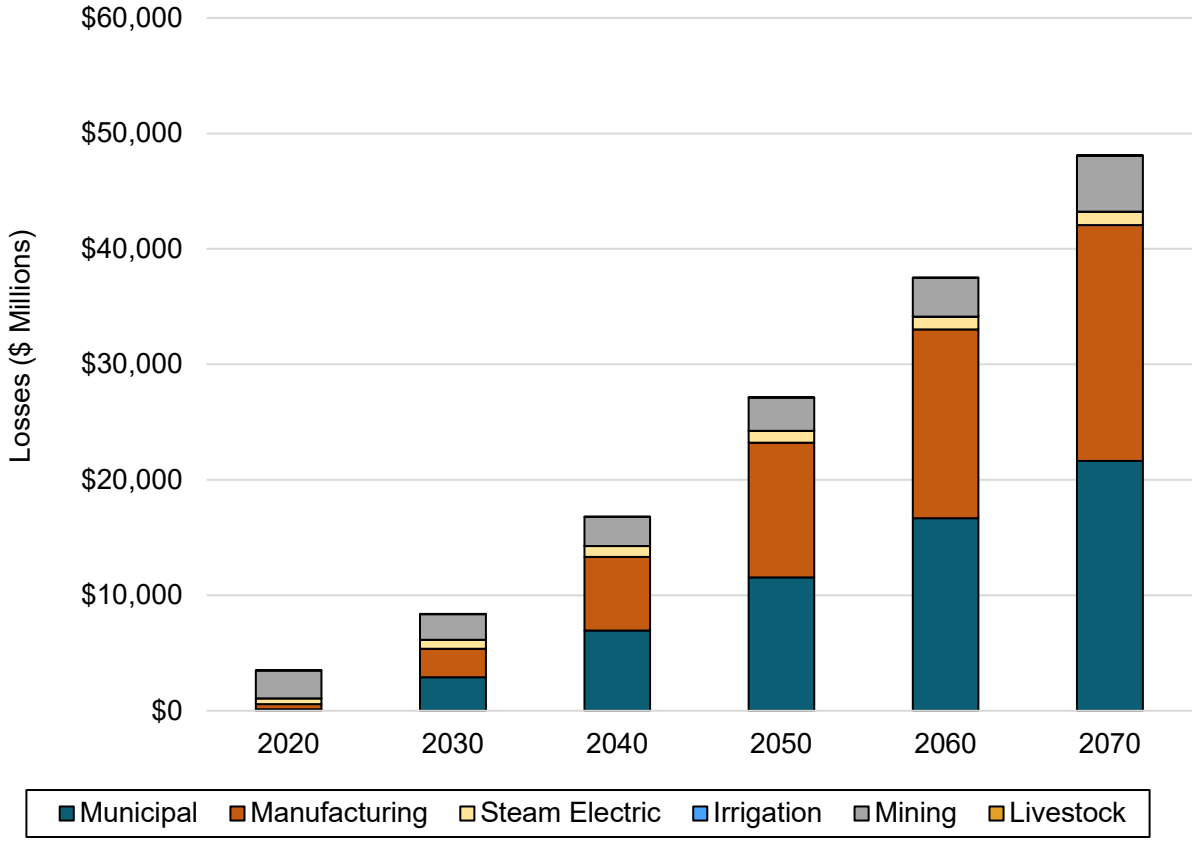
Year	Income ($ Millions)	Tax Losses on Production and Imports ($ Millions)	Jobs Lost	Population Losses
2020	$3,505	$279	20,437	3,752
2030	$8,361	$582	73,315	13,461
2040	$16,791	$1,123	158,102	29,027
2050	$27,127	$1,777	260,573	47,841
2060	$37,499	$2,461	366,762	67,338
2070	$48,071	$3,221	472,979	86,839

Figure 6.1 Population and Job Losses Associated with Not Meeting Projected Demands



	2020	2030	2040	2050	2060	2070
Jobs Lost	20,437	73,315	158,102	260,573	366,762	472,979
Population Losses	3,752	13,461	29,027	47,841	67,338	86,839

Figure 6.2 Projected Loss of Income with Not Meeting Projected Demands



6.7 Chapter 6 List of References

(1) Texas Administrative Code, Title 30, Chapter 307, [Online], Available URL: http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/307%60.pdf, January 2010.

(2) U.S. Department of Agriculture: 2007 Census of Agricultural, Volume 1, Chapter 2: Texas County Level Data, Table 1, [Online], Available URL: http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp, February 2010.

(3) Weinstein, B. L. and T. L. Clower: The Economic, Fiscal, and Developmental Impacts of the Proposed Marvin Nichols Reservoir Project, prepared for the Sulphur River Basin Authority, Denton, March 2003.

(4) Clower, T. L. and B. L. Weinstein: The Economic, Fiscal, and Developmental Impacts of the Proposed Lower Bois d'Arc Reservoir Project, prepared for the North Texas Municipal Water District, Denton, September 2004.

(5) Texas Parks and Wildlife Department, Wildlife Division, Diversity and Habitat Assessment Programs: County Lists of Texas' Special Species. Region C Counties, January 20, 2009.

(6) U.S. Fish and Wildlife Service: Listed Species Information Center, [Online], Available URL: http://www.fws.gov/southwest/es/EndangeredSpecies/lists/ListSpecies.cfm, January 2008.

(7) Texas Parks and Wildlife Department: State Parks and Destinations, [Online], Available URL : http://www.tpwd.state.tx.us/ , February, 2010.

(8) Texas Railroad Commission: Well Distribution by County, Oil Well Counts, Austin, [Online], Available URL : http://www.rrc.state.tx.us/data/wells/wellcount/oilwellct_0210.pdf , February 2010.

(9) Texas Railroad Commission: Well Distribution by County, Gas Well Counts, Austin, [Online], Available URL: http://www.rrc.state.tx.us/data/wells/wellcount/gaswellct_0210.pdf , February 2010.

(10) R.W. Harden & Associates, Inc, Freese & Nichols, Inc, Bureau of Economic Geology: Northern Trinity/Woodbine GAM, Assessment of Groundwater Use in the Northern Trinity Aquifer Due to Urban Growth and Barnett Shale Development, Austin, January 2007.

(11) U.S. Army Corps of Engineers, Feasibility Report Lignite Resource Recovery Richland and Tehuacana Lake Sites Freestone and Navarro Counties, Texas, Fort Worth District, August 1982.

(12) Nelson, Gabriel: Texas Utility to Ide Boilers, Cole Mines in Response to New EPA Rule, New York Times [Online], Available URL:

http://www.nytimes.com/gwire/2011/09/12/12greenwire-texas-utility-to-idle-boilers-coal-mines-in-re-68196.html, September 2011.

(13) Environmental Protection Agency, Clean Power Plan Proposed Rule [Online] Available URL: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule, June 2014.

(14) Texas Water Development Board: Chapter 357, Regional Water Planning Guidelines, Austin, October 1999, amended February 18, 2008.

(15) Texas Water Development Board: Chapter 358, State Water Planning Guidelines, Austin, October 1999, amended December 6, 2004.