Tar River Basin Hydrologic Model Scenarios

Demand Scenarios Modeled

The Tar River Basin Hydrologic Model was used to evaluate three different demand scenarios to evaluate the ability of public water systems that rely on surface water from this basin to meet current and projected water demands.

Surface water conditions and use in 2010 form the foundation of the model. The model was constructed and calibrated to simulate 2010 conditions. This basecase model scenario, also referred to as Simbase, becomes the point of comparison for all other model scenarios evaluated. Comparing results of alternative model scenarios with the 2010 Simbase scenario gives a picture of how surface water flows may change if the assumptions in the alternative scenario are realized. For planning purposes the scenarios are named for the year for which the water system demands were estimated. Modeled water withdrawals were estimated using water demands and other data from local water supply plans and additional information received from water systems and other registered water withdrawals. In this analysis, the results of two other scenarios were compared to the 2010 Simbase scenario to identify possible changes to flow conditions and water availability due to the projected changes in water withdrawals and return flows.

A scenario based on water demands anticipated for the year 2030 was constructed using local water supply plan data and any updated projections received from water systems. While the levels of withdrawals included in this scenario are based on the estimated demands for 2030, this volume of withdrawals could occur before then, or in some year after 2030. The values used in this scenario are based on expectations in 2010 as to what customer demands may be in 2030. Withdrawals are assumed to follow future water use projections provided to the Division by water withdrawers and the water systems that depend on them. Wastewater return flows were estimated based on the proportions of water withdrawals that were returned as treated wastewater in the 2010 Simbase scenario. This scenario is intended to provide information on possible conditions for 20 years in the future.

To get a glimpse of possible conditions for 50 years in the future, a scenario based on anticipated demands in 2060 was also developed. Like the 2030 scenario, water withdrawals are those expected to be needed to meet customers' water demands in the year 2060. Demand projections are based on information supplied to the Division in the local water supply plans and other registered water withdrawals. The projected values are based on current understanding of the number of customers expected to be served and their expected demands for water in 2060.

Water Use and Wastewater Discharge

Table 1 summarizes the estimated withdrawals. Table 2 summarizes the estimated wastewater return flows for the base case of 2010 and the 2030 and 2060 future demand scenarios, for the public water systems withdrawing surface water in this basin. Table 3 lists the modeled transfer flows to and from the Tar Basin. Table 4 lists the estimated wastewater return flows from systems using groundwater or getting water from a source other than one of the modeled surface water withdrawers. All volumes are shown in million gallons per day or mgd.

Table 1: Plan Municipal Demands in millions of gallons per day (MGD)

System Name	PWSS ID	Current Water Treatment Plant Capacity / Contract	2010*	2030*	2060*
Franklinton	02-35-010	1.0	0.32	0.38	0.47
Franklin County Public Utilities [1]	02-35-030	Contract Total: 4.08 (KLRWS 4.0 Franklinton – emergency Louisburg -0.08)	2.44	5.31	11.44
Louisburg	02-35-015	2.0	0.56	0.59	0.90
Rocky Mount	04-64-010	WTP Total : 30 (Tar River Plant - 18) (Sunset Plant - 12)	10.20	12.30	15.15
Enfield	04-42-025	1.0	0.52	0.56	0.56
Tarboro	04-33-010	6.0	2.80	3.60	4.92
Greenville Utilities Commission (GUC)	04-74-010	22.5	11.56	24.36	52.30

[1] Franklin County LWSP 2011 *Estimated demand including transfers to other basins

Table 2: Modeled Demand Dependent Discharge Flows

System Name	Facility	Permit	Discharge Permit Flow (mgd)	Average Discharge (mgd) 2010*	2030*	2060*
Town of Louisburg	Louisburg WWTP	NC0020231	1.37	0.5	0.5	0.8
Town of Tarboro	Tarboro WWTP	NC0020605	5.00	2.3	3.0	4.1
Greenville Utilities Commission	GUC WWTP	NC0023931	17.50	8.9	14.2	33.2
Town of Enfield	Enfield WWTP	NC0025402	1.00	0.7	0.7	0.7
City of Rocky Mount	Tar River Regional WWTP	NC0030317	21.00	9.9	11.9	14.5
Franklin County	Franklin County WWTP	NC0069311	3.00	0.6	1.3	2.7

*Estimated dependent discharge as percent of withdrawals

Table 3: Modeled Transfer Flows (MGD) To and From Tar Basin

Transfer	2010	2030	2060
Kerr RWS*	4.1	6.0	11.2
Halifax*	1.1	0.5	0.6
Wilson to Rocky Mount	Emergency Only	-	-
Greenville IBT (to Greene Co., Farmville, Winterville)	0.2	6.3	10.1

* Tar Model only accounts for amount of transfer that is ultimately discharged as wastewater into the Tar Basin

Table 4: Estimated wastewater return flows (MGD)

Transfer	2010	2030	2060
Bunn	0.1	0.1	0.1
Spring Hope	0.1	0.1	0.2
Hospira	0.7	0.7	0.7
EdgeGen	0.1	0.1	0.1
Pinetops	0.2	0.2	0.2
Macclesfield	0.03	0.04	0.03
Oxford	1.68	1.403	1.68
Warrenton	0.49	0.44	0.49
Littleton	0.07	0.07	0.07
Scotland Neck	1.03	0.5	1.03

Reliability of Supplies

Franklinton County Public Utility

Franklinton County Public Utility has contracts to get water transfer from Kerr Lake in Roanoke River basin through the Kerr Lake Regional Water System, and from Franklinton and Louisburg in Tar River basin for up to 3.43 mgd. Modeling results show a single annual flow pattern when the demands shown for 2060 may not be able to be met for 16 days. However, the future demands exceed the current contract limits.

Rocky Mount

The City of Rocky Mount, one of the larger systems in the Tar basin, relies solely on surface water withdrawn from Tar River and the Tar River Reservoir. Under the 2010 Simbase scenario the model does not show any supply deficits for Rocky Mount over the range of flows in the 80-year period of record used. However, with the higher demands estimated for 2030 and 2060 scenarios Rocky Mount could face demand shortages during the recurrence of low flow conditions present in the model record. Implementing Rocky Mount's water shortage response plan may reduce the estimated average deficit slightly from 0.35 mgd to 0.3 mgd for 2060 demand scenario. During drought or low flow conditions the City indirectly uses water from naturally fed quarries to supplement river flows. As drought conditions worsen implementation of the water shortage response plan reduces demand gradually and in stage 3 drought conditions, 10cfs of water is pumped from the quarries to the river below the Tar River Reservoir Plant. This additional supply is used at the Sunset Avenue water treatment plant. Rocky Mount's drought stages are determined based on the probability of the reservoir level being below certain levels within the next 12 weeks of forecast horizons. Without efficient monitoring, effective drought response actions, and additional reliable sources, Rocky Mount may still face supply deficits in the future during months when demands are higher than annual average water usage.

According to the 2010 LWSP, Rocky Mount reported a available supply of 30.9mgd of supply, combining 12.9mgd from the Tar River reservoir, based on the 50 year yield estimate, and 18mgd from Tar River based on 20% of the 7Q10 flow in this river reach.

Greenville Utility Commission (GUC)

The demand shortage analysis for Greenville Utility Commission (GUC) shows a potential shortage of up to 0.03mgd for the 2060 demand levels during three annual flow patterns in the model record. The Tar River Hydrologic Model focuses on modeling the use of and impacts to surface water resources. In addition to its Tar River source GUC has a series of groundwater wells that can be used to supplement supplies to meet peak water demands. GUC is actively planning to increase the reliability of water sources to meet future customer demands. GUC received an approved base rate for withdrawals from the groundwater sources regulated by the Central Coastal Plain Capacity Use Area rules. By using their surface water source as the primary water source GUC has been able to bank the unused portion of their approved base rate of withdrawals, and subsequent reductions, to be used to meet more of their peak demands as overall demand increases. GUC also operates an Aquifer Storage and Recovery (ASR) system to cover water demands. The ASR arrangement stores unused treated drinking water in wells for withdrawal, re-treatment and use as needed to meet system demands.

GUC has been banking Cretaceous aquifer water since 2006 when the banking option was approved by DWR. ASR injection process began in 2010 with the completion of the ASR injection capabilities. ASR's projected peak capacity is 1.4mgd. Table 5 below shows the summary of the cretaceous water bank statement sent to GUC in 2013 for conditions in 2012 .

Table 5: Summary of Cretaceous Water Bank use for 2012, millions of gallons per year

Water Bank Years	Approved Base Rate less Reduction	Aquifer Storage Recovery Injection Amount	Transfer Amount	Debit (Annual Water Use)	Credit	Balance
8/1/2004-7/31/2005	439,664,400	0	-	3,093,776	0	0
8/1/2005-7/31/2006	439,664,400	0	-	1,452,137	0	0
8/1/2006-7/31/2007	439,664,400	0	-	957,729	438,706,671	438,706,671
8/1/2007-7/31/2008	439,664,400	0	-	7,623,617	432,040,783	870,747,454
8/1/2008-7/31/2009	329,748,300	0	-	780,045	328,968,255	1,199,715,709
8/1/2009-7/31/2010	329,748,300	0	-	2,744,835	327,003,465	1,526,719,174
8/1/2010-7/31/2011	329,748,300	70,125,280	-6,387,250	1,920,300	321,440,750	1,848,159,924
8/1/2011-7/31/2012	329,748,300	62,415,080	-14,619,250	10,803,200	304,325,850	2,152,485,774
8/1/2012-7/31/2013	329,748,300	-3,843,224	-	3,714,300	326,034,000	2,478,519,774
8/1/2013-7/31/2014	219,832,200	-180,500	-	7,256,900	212,575,300	2,691,095,074
8/1/2014-7/31/2015	219,832,200	-	-	-	-	-

Table 5: Summary of Cretaceous Water Bank use for 2012, millions of gallons per year

Water Bank Years	Approved Base Rate less Reduction	Aquifer Storage Recovery Injection Amount	Transfer Amount	Debit (Annual Water Use)	Credit	Balance
8/1/2015-7/31/2016	219,832,200	-	-	-	-	-
8/1/2016-7/31/2017	219,832,200	-	-	-	-	-
8/1/2017-7/31/2018	219,832,200	-	-	-	-	-
8/1/2018-7/31/2019	109,916,100	-	-	-	-	-

GUC participates in regional water supply planning with adjacent systems that evolved in response to the CCPCUA rules and the necessity for these systems to find alternate water sources. GUC has existing and future contracts to sell water to the neighboring public water systems of Bethel, Greene County, Stokes Regional Water Corporation, Farmville and Winterville. Nearly one third GUC's demands in 2030 and one fourth of demands in 2060 are contracted to supply areas outside of the Tar River Basin. To meet its estimated future demands GUC will have to increase treatment capacity in the near future. Planning to support the expansion is ongoing and includes relocating the river intake because of concerns about the potential of saltwater intrusion from the estuary at the current intake location

In 2008, GUC initiated a planning study to evaluate the issues associated with flow conditions. The flow study was combined with developing models and methods to assess water quantity as well as water quality and habitat conditions, and to quantify the potential effects of water withdrawals and possible constraints to future water use in the Tar River. One of the study objectives was to characterize risk to public water supply associated with upstream movement of the freshwater/saltwater interface, especially under critical drought condition. Summary of the accomplishments and findings from the Lower Tar–Pamlico River Model developed during this study presented by GUC in April of 2012, indicated that even under severe low flow conditions as experienced in 2007 and 2008, the hydrologic condition relative to the 2050 withdrawal indicates that salinity does not encroach upstream to the GUC WTP intake[2].

GUC's identified list of sources of their long term water supply options includes the Tar River, groundwater, banked groundwater, groundwater/ASR and the Roanoke River, and also brackish water sources from groundwater sources and Pamlico River and acquisitions/mergers with other public suppliers[3].

In some cases the estimated future water system demands may produce wastewater volume greater than current permitted discharges. Table 2 summarizes the estimated wastewater return flows associated with the public water systems modeled. The permitted flow volumes are shown in comparison to the modeled return flows. This shows that the wastewater discharge permits for all systems except for GUC appear to be sufficient to accommodate anticipated wastewater volumes. The long term 2060 predicted discharge for GUC will be more than the 2010 discharge permits.

[2] Technical Memo # 6 – Draft Model Documentation for the Lower Tar – Pamlico River Model.

[3] GUC's report "Long Range Water Supply Options HB606Meeting 9-27-2012.pdf" prepared by HDR

Changes in Water Availability and Reliability

The 2010 Simbase model scenario simulates the current conditions in the Tar River Basin. With the changes in demands and operating conditions for the 2030 and 2060 scenarios, water available at different model nodes will be affected based on the changes in water withdrawals and return flows throughout the basin. This section summarizes the impacts and changes in water availability based on specifics outlined below.

As part of the North Carolina Session Law 2010-143, the hydrologic model* is designed to simulate the flows of each surface water resources within the basin that is identified as a source of water for a withdrawal registered in response to different variables, conditions, and scenarios. The model is specifically designed to predict the places, times, frequencies, and interval at which
1.) Yield may be inadequate to meet **all needs** and
2.) Yield may be inadequate to meet all **essential water uses**.

To answer the yield questions, the model shall determine the yield of reservoirs and yield of the run-of-river intakes.

For modeling and analysis purposes, the following definitions are used:

- **All needs** is the water use that is needed to meet demands when no water use restrictions are being required by a water shortage response plan.
- **Essential water uses** is the water use that is needed to meet demands during the periods when the water shortage response plans are at the most severe mandatory level of restrictions measures.

All needs and **essential water uses** yield adequacy is determined for the water demands by adding and not adding water shortage response plan during simulation and checking for any deficits that occurred during the period of record of hydrology. The adequacy for demand nodes and flow nodes are estimated following the two previously noted criteria.

Water shortage response plans are tied to municipal demand nodes. With proper drought triggers, different drought stages will force the municipal demand nodes to reduce the withdrawal as the various levels of water shortage response are implemented.

Essential Water Use is defined by SL2010-143 as "*the use of water necessary for firefighting, health, and safety; water needed to sustain human and animal life; and water necessary to satisfy federal, State and local laws for the protection of public health, safety, welfare, the environment, and natural resources; and a minimum amount of water necessary to support and sustain the ecomomy of the State, region, or area.*"

*Model includes Ecological flows that were calculated for a required permit. Other ecological flow model scenarios are done on a site specific basis.

Overall Water Availability Summary for all Nodes

Overall yield summary for demand nodes and flow nodes are provided in Table 6 for all needs and Table 7 for essential water uses. The tables also show the criteria used to determine the water availability based on the node type as demand nodes or flow nodes. Nodes with inadequate water are highlighted in pink and with adequate water are in green. Maps for showing all the needs and essential needs for 2030 and 2060 demands are shown in color coded nodes in figures 1-4.

Table 6: Overall Water Availability Summary for **All Needs** (Water Shortage Response Plan off)

Model Scenario				2030	2060	
Model Node	Model Arc	Node Type	Criteria	Water Availability	Water Availability	River Reaches
074	072.074	Demand Node	Demand not met	Adequate	Adequate	Franklinton Demand
076	075.076	Demand Node	Demand not met	Adequate	Adequate	Franklin Co Demand
086	084.086	Demand Node	Demand not met	Adequate	Adequate	Louisburg Demand
146	120.146	Demand Node	Demand not met	Inadequate*	Inadequate*	Rocky Mt Demand
226	220.226	Demand Node	Demand not met	Adequate	Adequate	Enfield Demand
296	250.296	Demand Node	Demand not met	Adequate	Adequate	Tarboro Demand
392	391.392	Demand Node	Demand not met	Adequate	Adequate	GUC Demand
394	391.394	Demand Node	Demand not met	Adequate	Adequate	Farmville IBT
396	391.396	Demand Node	Demand not met	Adequate	Inadequate	Greene IBT
398	391.398	Demand Node	Demand not met	Adequate	Adequate	Winterville IBT
*Rocky Mount's inadequate supply is a result of model input vs. actuality of a shortage						

Table 7: Overall Water Availability Summary for **Essential Needs** (Water Shortage Response Plan On)

Model Scenario				2030	2060	
Model Node	Model Arc	Node Type	Criteria	Water Availability	Water Availability	River Reaches
074	072.074	Demand Node	Demand not met	Adequate	Adequate	Franklinton Demand
076	075.076	Demand Node	Demand not met	Adequate	Adequate	Franklin Co Demand
086	084.086	Demand Node	Demand not met	Adequate	Adequate	Louisburg Demand
146	120.146	Demand Node	Demand not met	Adequate	Inadequate*	Rocky Mt Demand
226	220.226	Demand Node	Demand not met	Inadequate	Adequate	Enfield Demand
296	250.296	Demand Node	Demand not met	Adequate	Adequate	Tarboro Demand
392	391.392	Demand Node	Demand not met	Adequate	Adequate	GUC Demand
394	391.394	Demand Node	Demand not met	Adequate	Adequate	Farmville IBT
396	391.396	Demand Node	Demand not met	Adequate	Inadequate	Greene IBT
398	391.398	Demand Node	Demand not met	Adequate	Inadequate	Winterville IBT
*Rocky Mount's inadequate supply is a result of model input vs. actuality of a shortage						

The following two tables present the results for the demands nodes for **all needs** and **essential water uses** deficit or adequacy in detail. The tables present the deficit characteristics as magnitude as percent of demand, duration as the longest number of consecutive days of deficit and frequency as the number of annual flow conditions in the 80 years of flow records modeled when a deficit may occur. The tables summarize conditions that may occur if all the assumptions included in the model, especially demand estimates, hold true.

Table 8 summarized the impacts of future water demands for the municipal withdrawal nodes in the model. This set of runs is performed ***without*** the water shortage response plans. This set of runs is performed without consideration of the water shortage response plan (i.e., evaluation of **all needs**). Predicted deficits are highlighted pink for any significant decimal point percent of average deficits over the period of records demands. In this table, Rocky Mount (Node 146) is estimated to have some demand deficits with longest deficits for 132 days and 193 days for 2030 and 2060 demand scenarios respectively. The model calculates changes in surface water conditions by evaluating the effects of each scenario's demands against 80 sets of annual flow records. The supply deficit analysis for Rocky Mount indicates that there is the potential for surface water supply deficits during the recurrence of flow condition experienced in 50 of those 80 years with demand not met for at least one day. Similarly Greenville IBT (Node 396) has small deficits for only a few sets of flow conditions. Any deficit less than 0.1 percent are shown as zero in the table and are not pink highlighted, but the number of days are highlighted in light yellow. Nodes with adequate water to withdraw are shown as normal fonts without highlights.

Table 8: Yield Summary for Available supply **Without** water shortage response plans

Model* Scenario		2010				2030				2060			
Model Node	Water Systems	Avg Demand (mgd)	Avg Deficit (% of Demand)	Longest Deficit (Days)	No of Years Demand Not Met Out of 80	Avg Demand (mgd)	Avg Deficit (% of Demand)	Longest Deficit (Days)	No of Years Demand Not Met Out of 80	Avg Demand (mgd)	Avg Deficit (% of Demand)	Longest Deficit (Days)	No of Years Demand Not Met Out of 80
74	Franklinton	0.3	0.0%	0	0	0.4	0.0%	0	0	0.5	0.0%	15	1
76	Franklin County	2.4	0.0%	0	0	5.3	0.0%	0	0	11.4	0.0%	16	1
86	Louisburg	0.6	0.0%	7	1	0.6	0.0%	13	2	0.9	0.0%	13	2
146	Rocky Mount*	10.2	0.0%	4	1	12.3	**0.7%**	**132**	**50**	15.2	**2.3%**	**193**	**50**
226	Enfield	0.5	0.0%	0	0	0.6	0.0%	0	0	0.6	0.0%	0	0
296	Tarboro	2.8	0.0%	0	0	3.6	0.0%	0	0	4.9	0.0%	0	0
392	GUC	11.4	0.0%	0	0	18.1	0.0%	10	1	42.2	0.0%	12	3
394	Farmville IBT	0.0	0.0%	0	0	1.7	0.0%	11	1	3.1	0.0%	21	3
396	Greenville IBT	0.0	0.0%	0	0	2.7	0.0%	10	1	4.5	**0.2%**	**25**	**3**
398	Winterville IBT	0.2	0.0%	0	0	1.8	0.0%	11	1	2.5	0.0%	15	3
Total Model Demand		28.4				47.1				85.8			

Pink Highlighted= - Inadequate; Yellow Highlighted = Adequate with manageable deficits
Note: average deficit <0.1% of demand is shown as 0.0 % * *Rocky Mount's inadequate supply is a result of model input vs. actuality of a shortage

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Table 9 summarizes the **essential water uses *with*** water shortage response plans or drought implemented. This set of deficits is calculated over the reduced demand based on the drought stage demand reduction protocol and not the annual average demand. The results show that Rocky Mount with WSRP will face some reduced percent of average deficit with reduced number of longest deficit days which is still significantly high for 2060 demands. At the same time 2030 demand shows some improvements. However, Enfield triggered deficits for 2030 demand, but not for 2060 demand. Greenville remains the same as an impacted node and this cluster adds Winterville, as an impacted node (Node 398) for the 2060 demand.

Table 9: Yield Summary for Available supply **With** water shortage response plans

Model* Scenario		2010				2030				2060			
Model Node	Water Systems	Avg Demand (mgd)	Avg Deficit (% of Demand)	Longest Deficit (Days)	No of Years Demand Not Met Out of 80	Avg Demand (mgd)	Avg Deficit (% of Demand)	Longest Deficit (Days)	No of Years Demand Not Met Out of 80	Avg Demand (mgd)	Avg Deficit (% of Demand)	Longest Deficit (Days)	No of Years Demand Not Met Out of 80
74	Franklinton	0.3	0.00%	0	0	0.4	0.0%	0	0	0.5	0.05%	15	3
76	Franklin County	2.4	0.00%	0	0	5.3	0.0%	0	0	11.4	0.00%	16	1
86	Louisburg	0.6	0.00%	7	1	0.6	0.0%	13	2	0.9	0.00%	13	2
146	Rocky Mount*	10.2	0.00%	0	0	12.3	0.0%	96	45	15.1	**2.00%**	**112**	**45**
226	Enfield	0.5	-0.08%	21	74	0.5	**0.2%**	**61**	**78**	0.5	-0.02%	17	63
296	Tarboro	2.8	0.00%	0	0	3.6	0.0%	0	0	4.9	0.00%	0	0
392	GUC	11.4	0.00%	0	0	18.1	0.0%	0	0	42.2	0.02%	21	3
394	Farmville IBT	0.0	0.00%	0	0	1.7	0.0%	0	0	3.1	0.00%	25	3
396	Greenville IBT	0.0	0.00%	0	0	2.7	0.0%	0	0	4.5	**0.22%**	**25**	**3**
398	Winterville IBT	0.2	0.00%	0	0	1.8	0.0%	0	0	2.5	**0.40%**	**27**	**7**
Total Model Demand		28.4				47.0				85.7			

Pink Highlighted= Inadequate; Yellow Highlighted = Adequate with manageable deficits
Note: average deficit <0.1% of demand is shown as 0.0 % * *Rocky Mount's inadequate supply is a result of model input vs. actuality of a shortage

*The hydrologic model is based on assumptions and therefore model results are conditional and may not be relied upon as unfailingly accurate. The yellow highlighted cells in the chart represent de minimis deficits which are therefore likely to be insignificant. The pink cells represent deficits that are likely significant assuming conditions built into the model do not change, but may still require follow up to qualify their significance.

Figure 1: Map for Adequate Yield Summary for All needs 2030 Demand

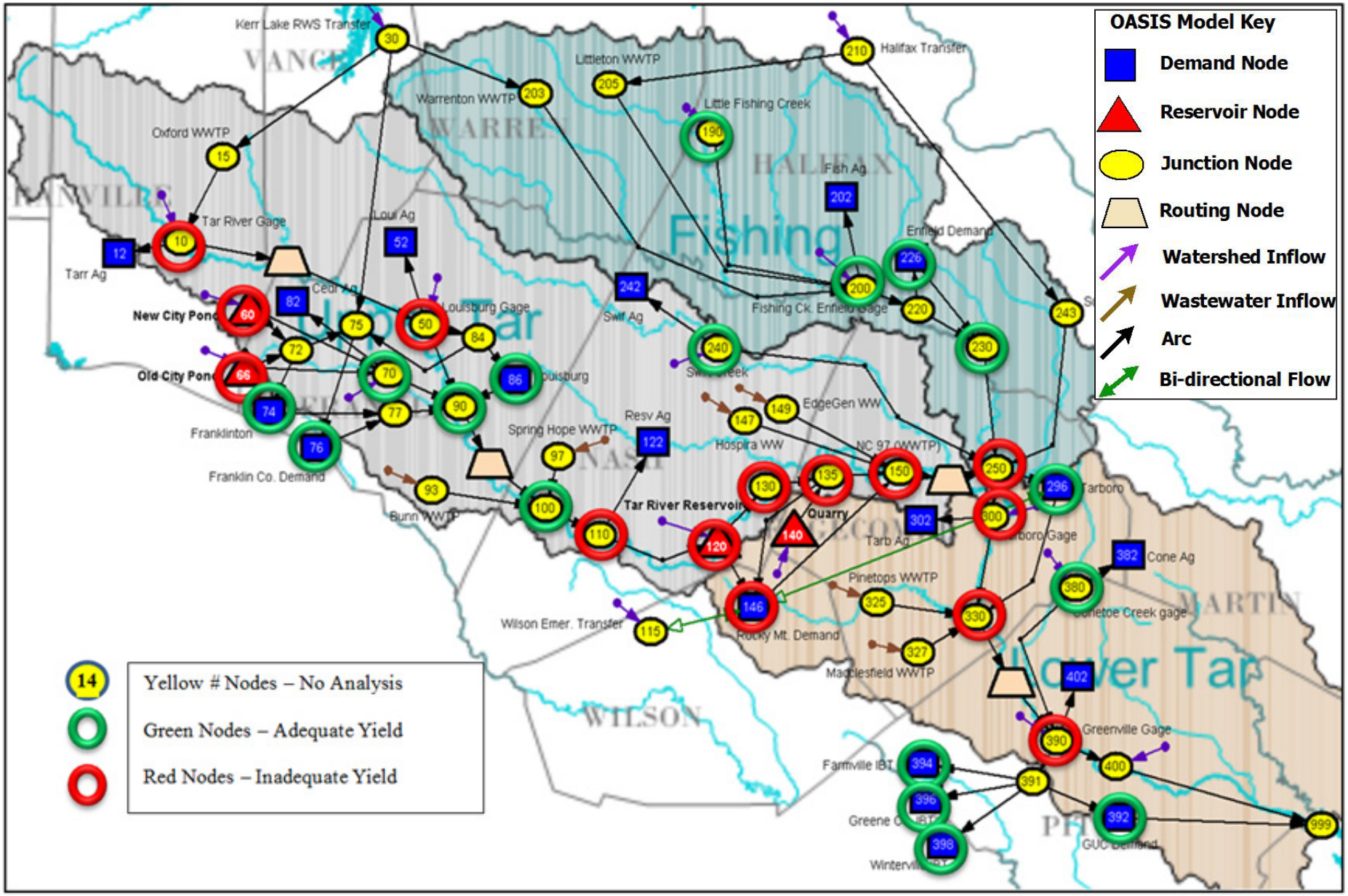

Figure 2: Map for Adequate Yield Summary for Essential needs 2030 Demand

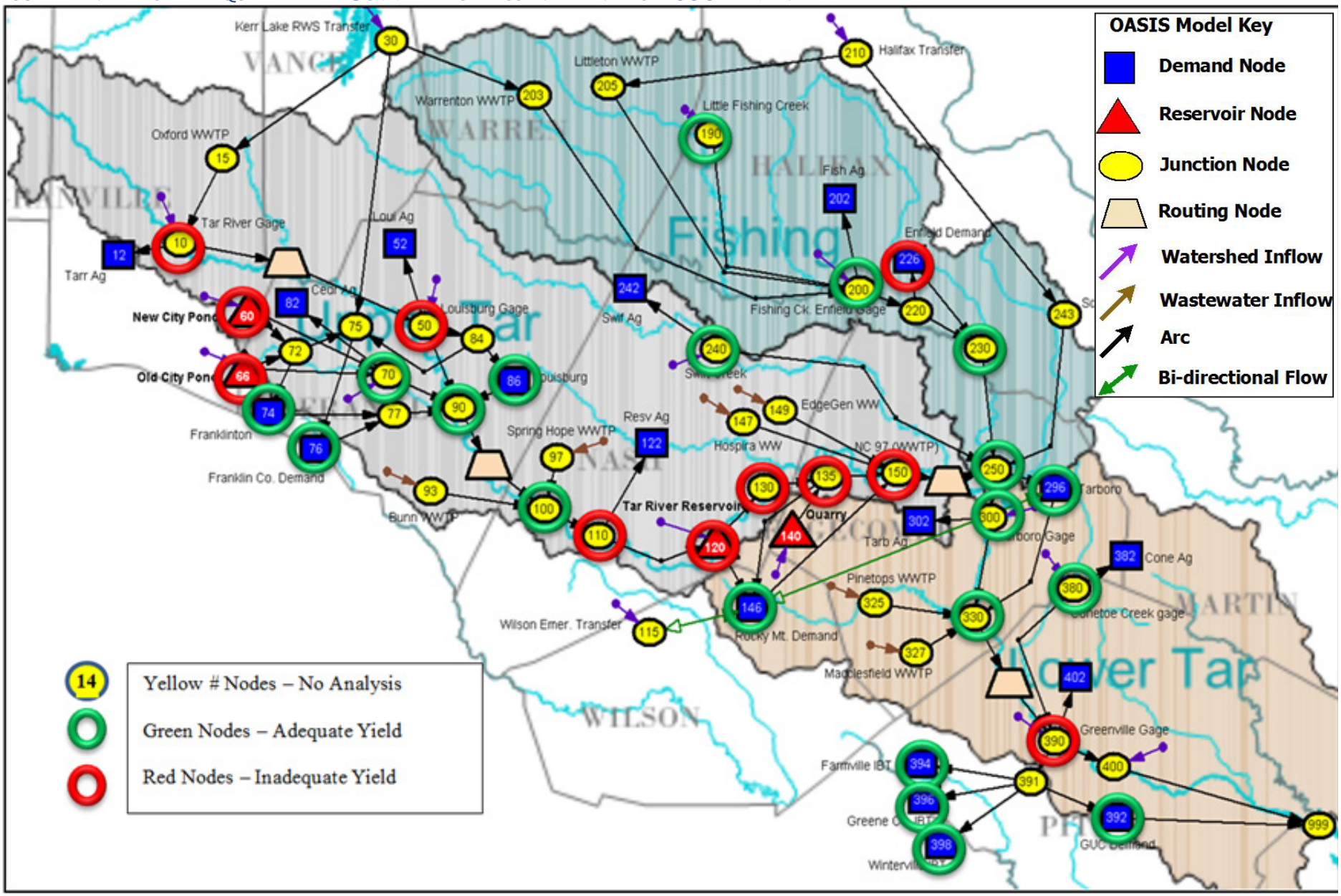

Figure 3: Map for Adequate Yield Summary for All needs 2060 Demand

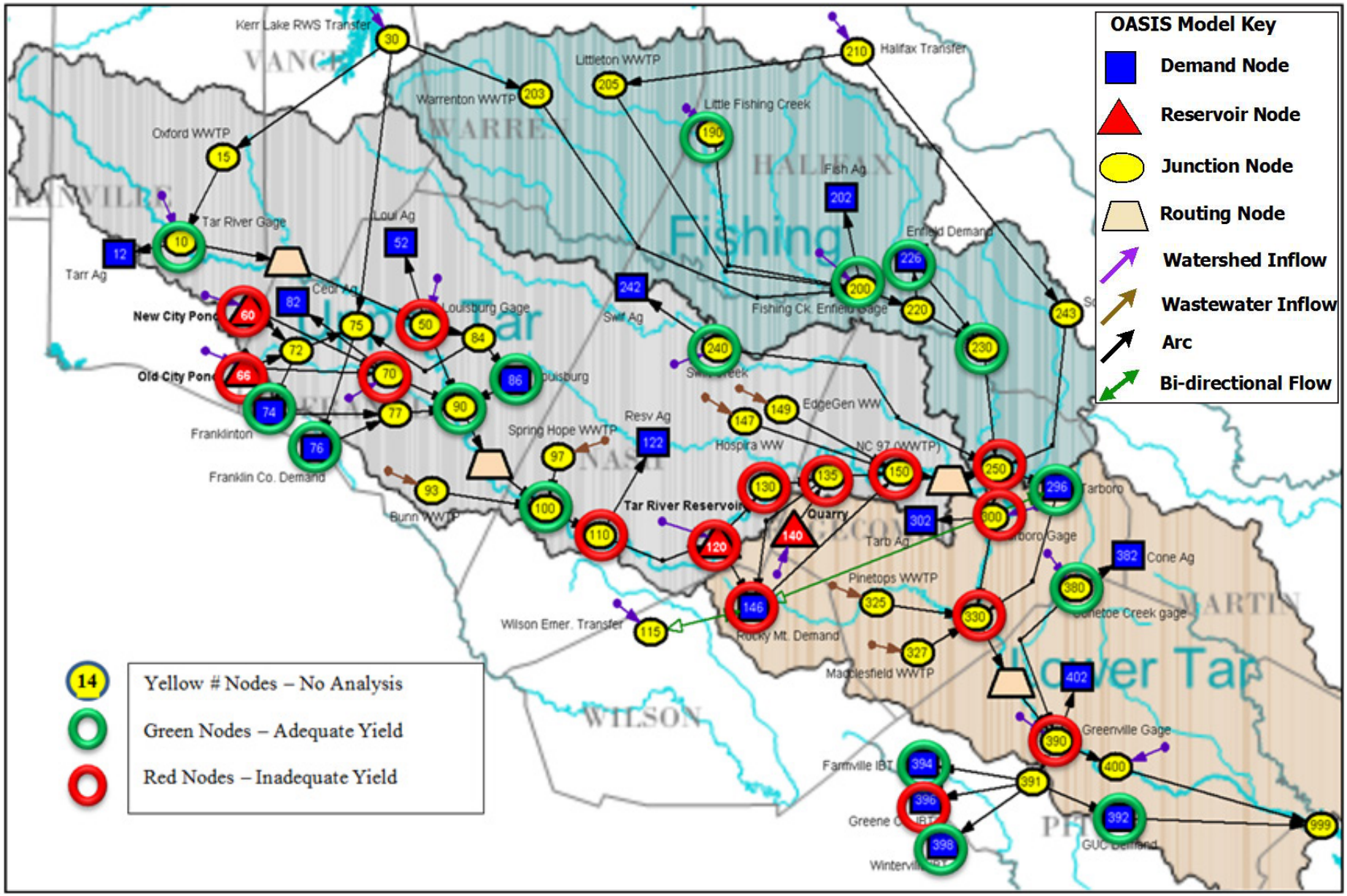

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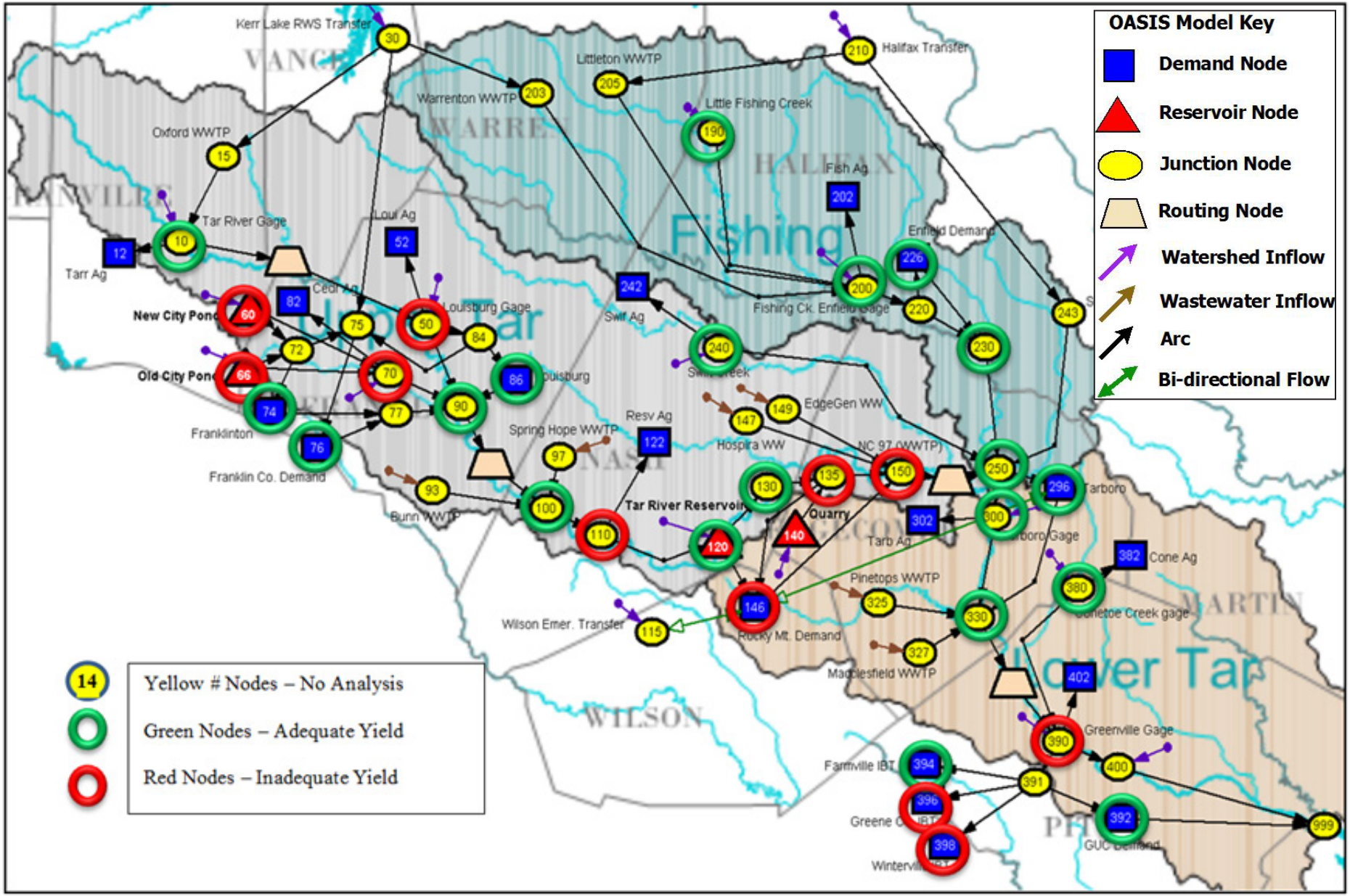
Figure 4: Map for Adequate Yield Summary for Essential needs 2060 Demand



Model Schematic Definitions

1. Demand Nodes (blue square): Demand nodes are nodes to which water is delivered. Delivery to a demand node is a basic, built-in operating goal. The delivery may meet, but never exceed, a specified target value referred to simply as the demand. The deficit between delivery and demand is called shortage.

2. Reservoir Nodes (red triangle): Reservoir nodes are nodes at which water can be stored. OASIS computes the storage at the end of every time step, which is the storage at the beginning of the next time step. Maintaining storage at a reservoir node is a basic, built-in operating goal. OASIS has built-in features to model many types of rules associated with a reservoir node.

3. Junction Nodes (yellow ellipse): Junction nodes are the simplest type of nodes. Unlike demand or reservoir nodes, junction nodes are not automatically associated with any special operating rules. Therefore, there are no special input tables for junction nodes.

4. Routing Node (beige trapezoid): An innovative feature that simulates the routing of water by solving a linear program. Operating rules are expressed as operating goals or operating constraints.

5. Watershed Inflow (purple arrow): These denote water inflow such as streams and river tributaries entering into the system.

6. Wastewater Inflow (brown arrow): Captures inflow from a Wastewater Treatment Plant (WWTP) that gets water from a groundwater system or water sources outside of the model.

7. Arc (black arrow): Arcs represent conveyance from one node to another. In OASIS, every node must have at least one arc connecting to it.

8. Bi-directional Flow (green, two-ended arrow): Water can move in two directions