2009

Red River Basin

Characterization Report

Louisiana State Reservoir Priority
and Development Program

moffatt & nichol

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2009

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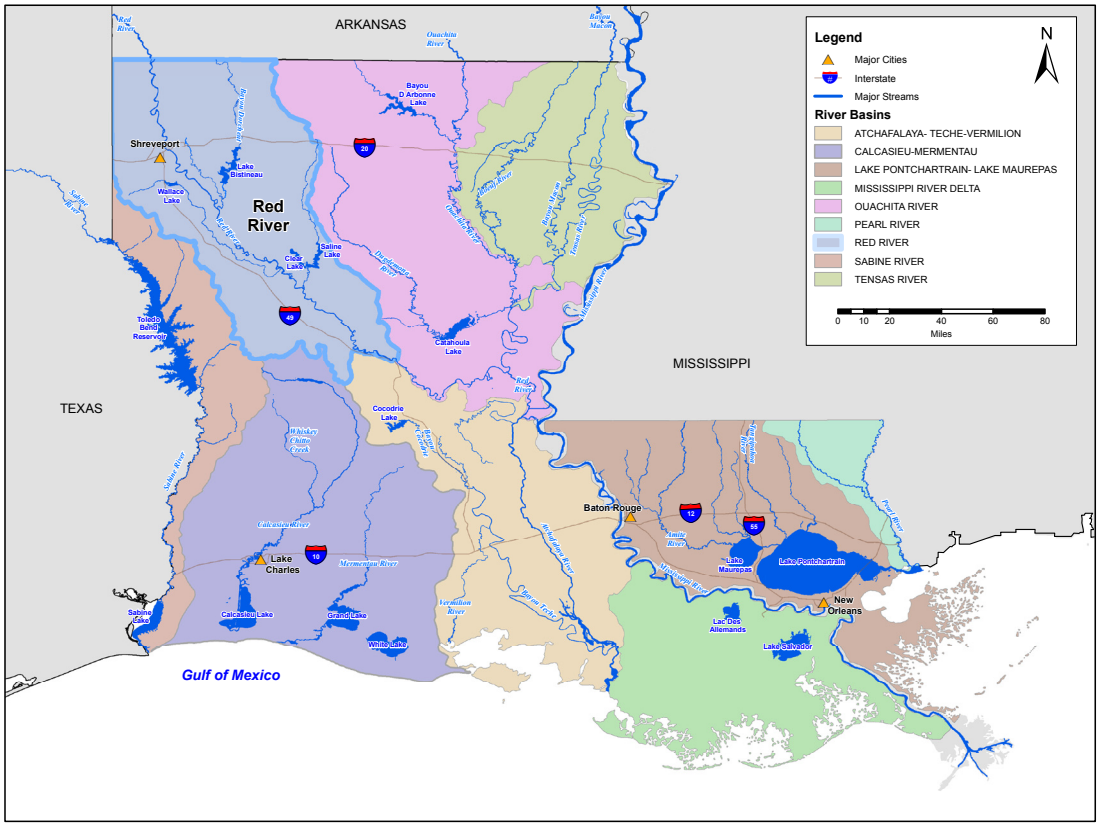
BASIN CHARACTERIZATION REPORT FOR THE RED RIVER BASIN

The Louisiana Department of Transportation and Development (DOTD) is responsible for reviewing and prioritizing proposed reservoir projects for which State of Louisiana (State) funding is being sought, and then recommending projects to the State Legislature. To support reservoir project review, prioritization, and recommendation efforts, DOTD has prepared characterization reports of water resources conditions in each of the nine principal surface water basins in the State. These characterization reports provide an overview of water uses, needs, and concerns, and can be used by applicants for State funding, and by State agencies as they evaluate the applications. The basin characterization reports also contain extensive references that interested parties can use to find more information from Federal, State, and local agencies or other sources. The reports represent a "snapshot" of conditions in early 2009 (or when the references cited in the reports were published).

Based on available data, this basin characterization report provides an overview of the water uses, needs, and key water resources concerns for the Red River Basin (RRB) (**Map 1**). Additional technical information on important issues may be provided in separate technical reports.

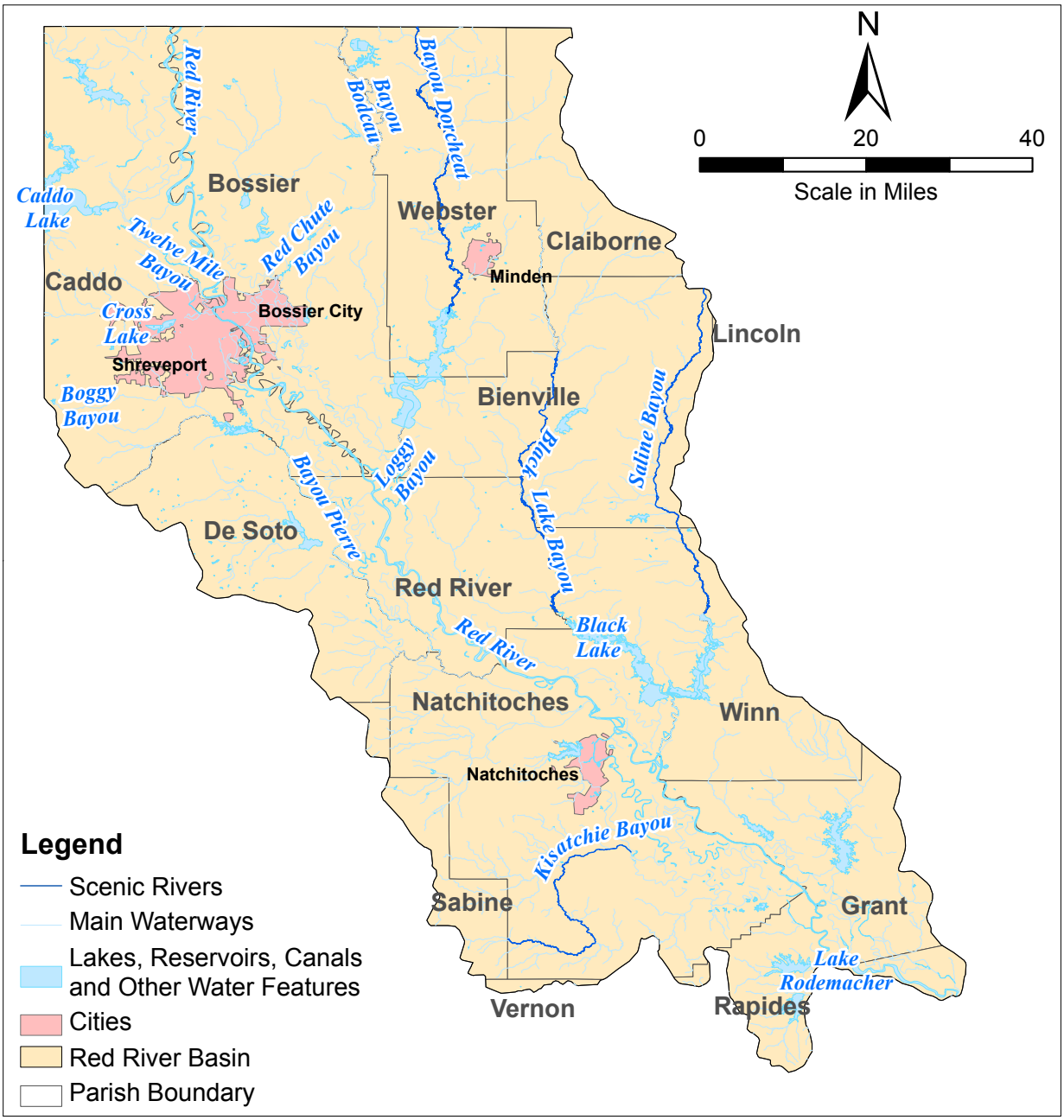
Report Topics **Page**



Map 1. Major Surface Water Basins of Louisiana[1]

BASIN OVERVIEW

The RRB is located in northwestern Louisiana and has an area of 6,358 square miles (see **Map 2**).[2] The RRB is bounded by the Arkansas-Louisiana State line to the north, the Texas-Louisiana State line to the west, the Sabine River, Calcasieu-Mermentau, and Atchafalaya-Teche-Vermilion basins to the south, and the Ouachita River Basin to the east. Main watercourses draining the RRB are the Red River, Loggy Bayou, Saline Bayou, and Bayou Dorcheat.[3]



Map 2. Parishes, Main Waterways, and City Boundaries[4]

Fourteen parishes are either completely or partly encompassed by the RRB. The largest cities and towns in the RRB are Shreveport, Natchitoches, Bossier City, and Minden. Estimated total population in the RRB in 2005 was 503,104. **Table 1** shows the 2005 population distribution in the RRB by parish. **Figure 1** shows historical population in the basin since 1960. From 1960 to 2005, population growth was fairly steady, with an average increase of 18,000 people every 10 years. Continued growth at the historical rate will likely increase demand for high quality potable water sources.

Principal economic activities in the RRB include manufacturing, cotton cultivation, forestry, and timber-related industries.[6] These activities are likely to continue to provide the main economic growth in the future.[7] In addition, there may be opportunity for future expansion of oil and gas extraction in the RRB. Future economic growth, particularly in oil and gas extraction, may substantial increase water supply, treatment and disposal needs.

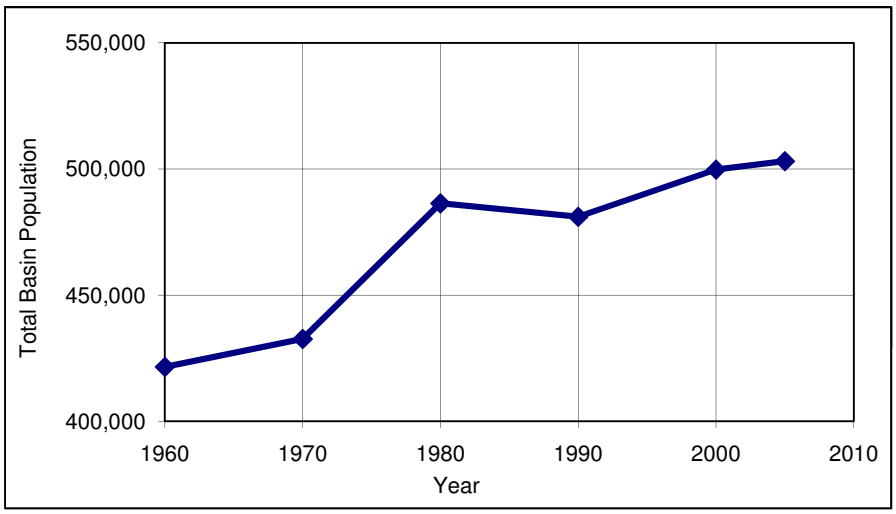


Figure 1. Historical and Projected RRB Population

Table 1. RRB Population by Parish in 2005[5]

Parish	Population
Bienville*	13,596
Bossier	105,341
Caddo*	248,674
Claiborne*	3,864
De Soto*	15,278
Grant*	11,233
Lincoln*	40
Natchitoches	38,775
Rapides*	11,165
Red River	9,217
Sabine*	1,542
Vernon*	56
Webster	40,876
Winn*	3,446
TOTAL	503,104

*Parish is located in more than one basin; population estimate is for the area within the RRB.

RRB = Red River Basin

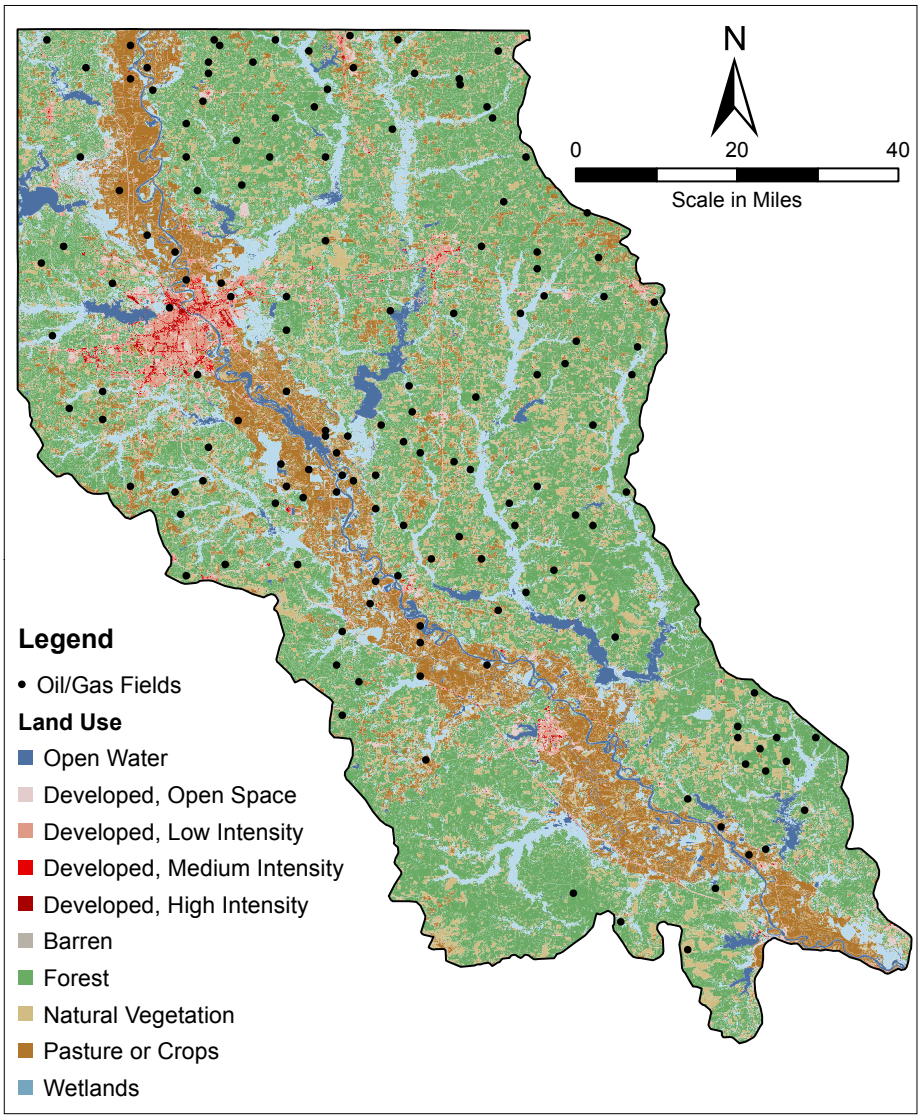
LAND USE AND LEGAL ENTITIES

Map 3 shows 2003 land uses in the basin. Principal land uses include forest, which dominates the upland areas, and agriculture, which dominates the Red River valley. Agricultural areas may have demand for irrigation water. The Shreveport area has been substantially urbanized, particularly by low- and medium-density residential development. One military base, Barksdale Air Force Base, is located in the RRB east of Bossier City. Two active lignite surface mines in the RRB, in De Soto and Red River parishes, produce coal for power generation.[8] Mining can affect both surface water and groundwater resources. Economic modeling for the 1992 to 2020 period indicates that forested land uses may decrease slightly along the Red River in the RRB, and that negligible change in urban land uses is expected.[9]

The RRB contains land considered Prime Farmland by the Federal Natural Resources Conservation Service (NRCS), primarily along the main stem Red River.[11] The NRCS must be contacted regarding the proposed irreversible conversion of any Prime Farmland for reservoir construction and water storage.

Many oil and gas fields have been drilled throughout the basin, as shown in **Map 3**. Oil and gas drilling can require large amounts of water for extraction, which then needs to be disposed, either to surface or groundwater. Existing oil and gas infrastructure and mineral rights holdings may present potential impediments to development of surface water resources.

Table 2 lists legal entities in the RRB that may affect or be affected by water resource development.



Map 3. RRB Land Uses in 2003[10]

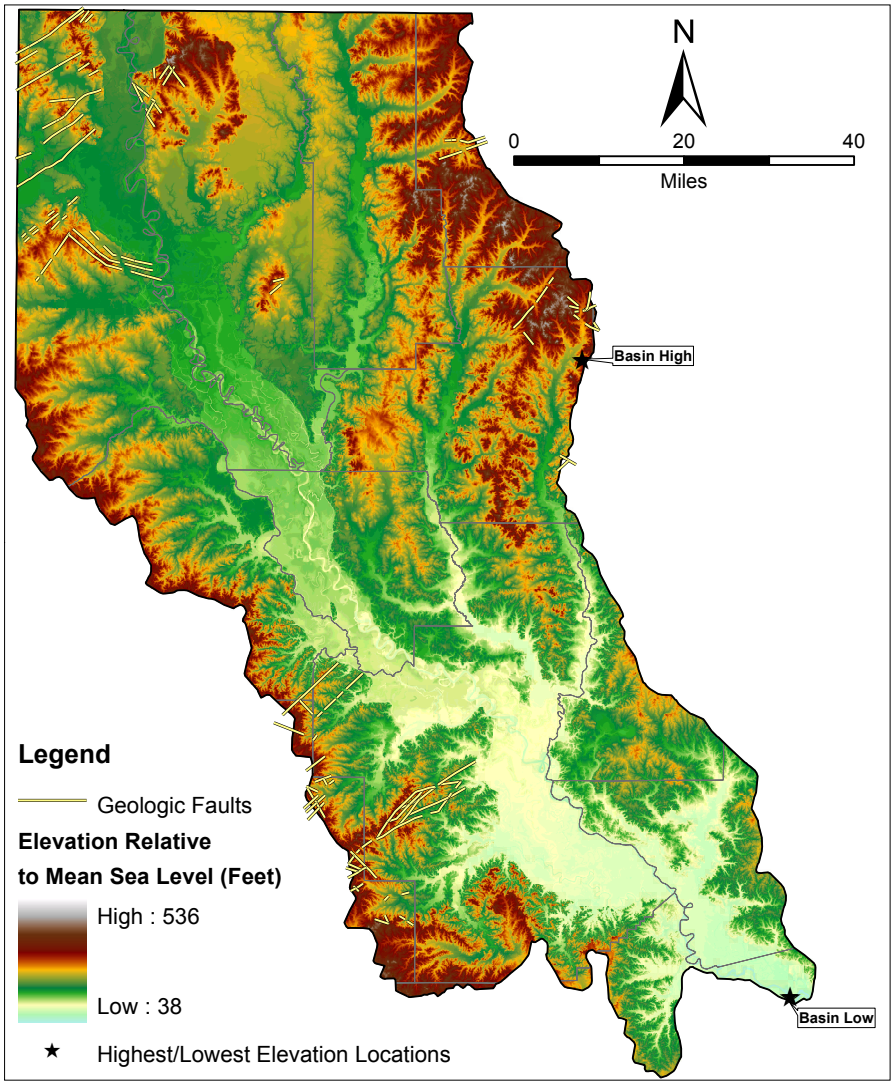
Table 2. RRB Water Resources Legal Entities

Legal Entity	Responsibilities
The Coordinating and Development Corporation	Planning and development in the Arkansas-Louisiana-Texas Region
Kisatchie-Delta Regional Planning and Development District	Planning and development in central Louisiana
Red River Waterway District	Maintaining a navigable waterway in the Red River
The Sparta Ground Water Conservation District	Studying ways to put Sparta water to the highest beneficial use in terms of public welfare

RRB = Red River Basin

PHYSIOGRAPHIC AND CLIMATIC INFORMATION

Map 4 shows general basin topography. The RRB is dominated by the undulating, pine- and hardwood-forested hills of the Pine Hills physiographic division. These uplands are dissected by the Red River valley, which opens into a broad, flat plain in the southeastern basin and is part of the Alluvial Plains physiographic region. The lowest elevation in the RRB is 38 feet above mean sea level, located on the Red River plain at the southeastern basin boundary. The highest point, 536 feet above mean sea level, is located in Bienville Parish on the northeastern basin boundary. Geologic faults are located along the western and northeastern margins of the RRB.



Map 4. RRB Topography[12]

Upland areas are dominated by loamy, clayey soils formed on shaley marine bedrock; alluvial plains are characterized by loamy and clayey low terraces and flood plains.[13]

Average annual rainfall throughout the RRB varies geographically from 30 to 65 inches per year, increasing from north to south.[14] **Figure 2** shows historical annual precipitation at Shreveport, which varies between about 30 and 85 inches per year, with a historical average of about 48 inches per year. Although rainfall and the resulting runoff is plentiful in the ORB, the historical record shows that extended dry periods can occur, such as in the 1960s. Extended dry periods can increase water demand, particularly for irrigation, and stress surface and groundwater supplies. Average annual temperature in the RRB generally increases from north to south from 63 to 86 degrees Fahrenheit (°F).[14] Average high temperature at Shreveport in the warmest month, July, is 93°F; average low temperature in the coldest month, January, is 36°F.[15]

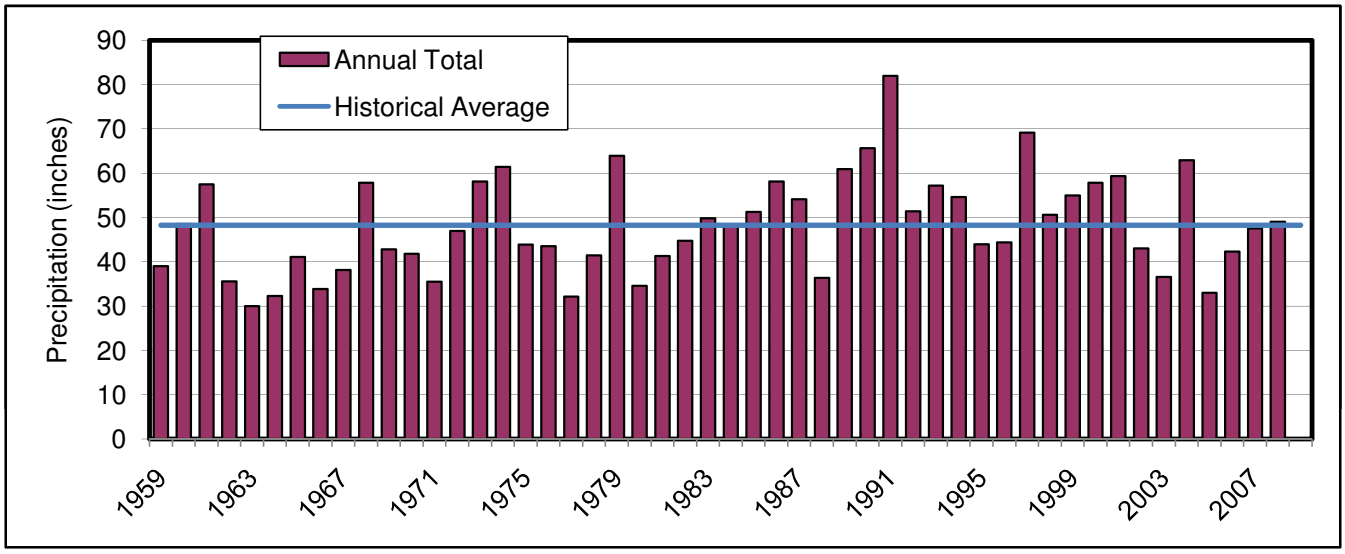


Figure 2. Historical Annual Precipitation at Shreveport[14]

WATER USE

Water use in the RRB is summarized in **Table 3** by sector, water type, parish, and surface water body. **Table 3** is based on water withdrawal data, which may be greater than total water consumptive use. For example, the power generation sector withdraws water for both steam generation and cooling, uses which do not entirely consume the withdrawn water and allow a large percentage of the water to be returned to a waterway. In 2005, total water use in the basin was about 560 million gallons per day (mgd). RRB water demands were met mainly by surface water in combination with a small amount of groundwater. In 2005, the largest surface water use, over 417 mgd, was for power generation, mainly by CLECO Power at the Rodemacher Power Station located on Lake Rodemacher. Of this quantity, 48 mgd was withdrawn from Cross Lake, in Caddo Parish, for power generation.

In 2005, public supply was the largest groundwater user (greater than 15 mgd), followed closely by industry (greater than 14 mgd). Because groundwater use is not reported by surface water basin, individual parish groundwater use was estimated by multiplying total parish groundwater use by the percentage of total parish population within the RRB (**Table 3**); actual groundwater use by parish may differ from this estimation. In 2005, the largest amount of groundwater was used in Bienville Parish, where about 12 mgd were extracted for paper products manufacturing. Webster and Caddo parishes used the second and third largest volumes of groundwater in 2005, respectively. In Webster Parish, two municipal water suppliers reported water use exceeding 1 mgd of groundwater: the Minden water system at 2.1 mgd and the Springhill water system at 1.8 mgd.

Figure 3 shows trends in surface water and groundwater use in the RRB at 5-year intervals from 1990. Between 1990 and 2005, power generation withdrew the largest amount of water each year, ranging from 400 mgd to 600 mgd of surface water. Use of both surface and groundwater for public water supply increased from 1990 to 2005, from 50 mgd to 66 mgd and from 15 to about 18 mgd, respectively. Industrial groundwater use fluctuated from 1990 to 2005, while industrial surface water use increased steadily.

Table 3. RRB Water Use in 2005[16]

Sector	Surface Water (mgd)	Groundwater (mgd)
Aquaculture	3.6	3.2
General irrigation	3.5	4.3
Industry	14.2	14.3
Livestock	0.4	0.7
Power generation	416.6	0.0
Public supply	65.9	15.5
Rice irrigation	5.0	1.0
Rural domestic	0.0	4.9
TOTAL	509	44

Surface Water Body	Use (mgd)
Bayou Pierre	3.2
Black Lake	1.2
Caddo Lake	2.2
Cross Lake	47.9
Lake Rodemacher	402.4
Little River	2.8
Other (not listed)	20.0
Red River	23.6
Sibley Lake	5.2
TOTAL	508.5

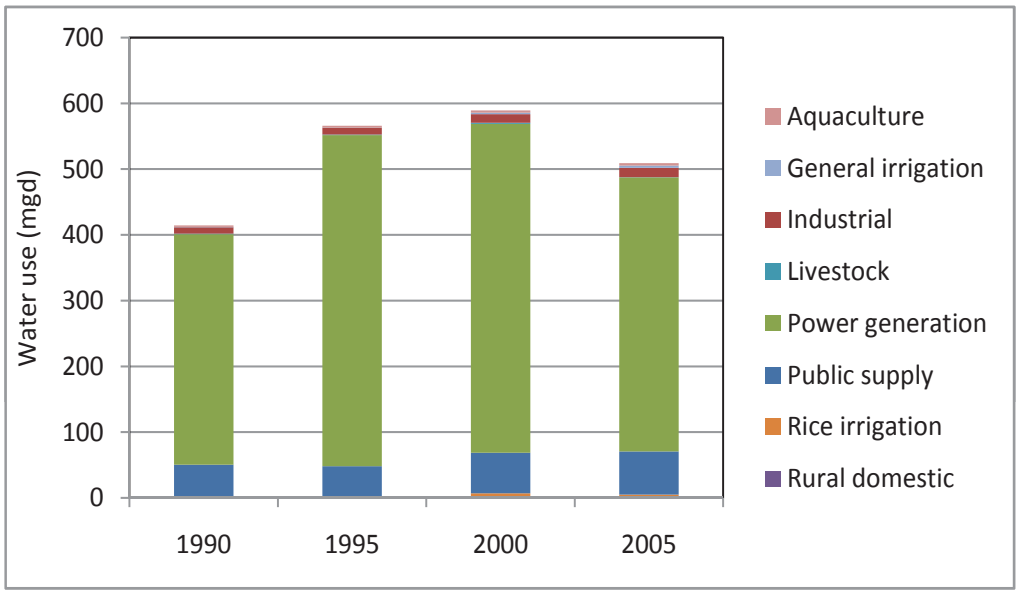
Sector	Surface Water (mgd)	Groundwater* (mgd)
Bienville	0.1	11.9
Bossier	11.7	4.1
Caddo	65.5	7.7
Claiborne	0.0	0.6
De Soto	0.2	2.1
Grant	0.0	1.1
Natchitoches	29.2	4.6
Rapides	402.4	0.0
Red River	0.3	1.7
Sabine	0.0	0.1
Webster	0.2	9.3
Winn	0.0	0.8
TOTAL	509.6	44.0

*Groundwater use estimated for parishes with at least five percent of their population within the RRB.

mgd=million gallons per day

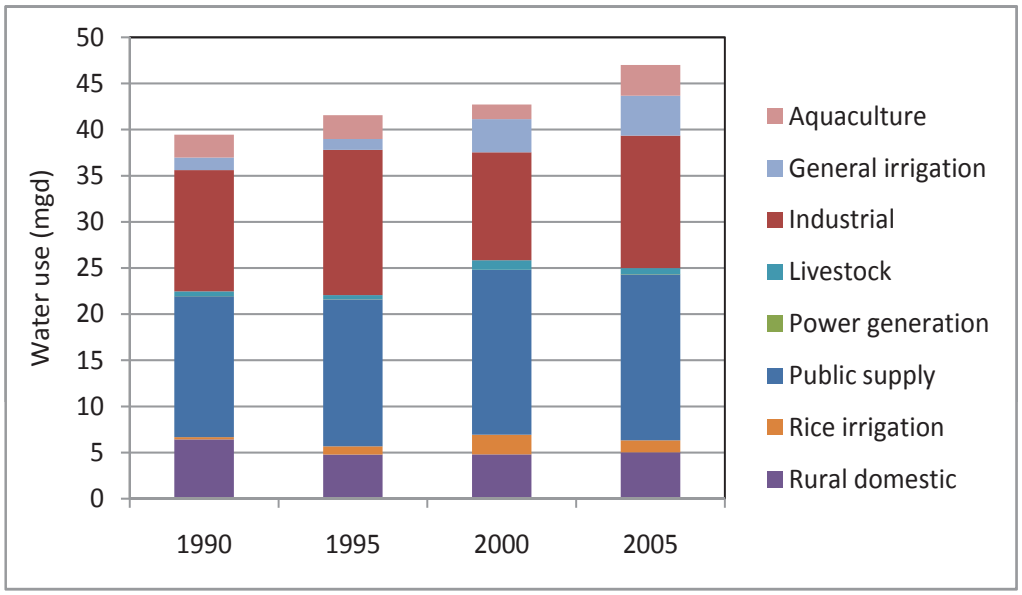
RRB=Red River Basin

Recent Historical Surface Water Use



mgd=million gallons per day

Recent Historical Groundwater Use



mgd=million gallons per day

Figure 3. Trends in Water Use in RRB by Sector[17]

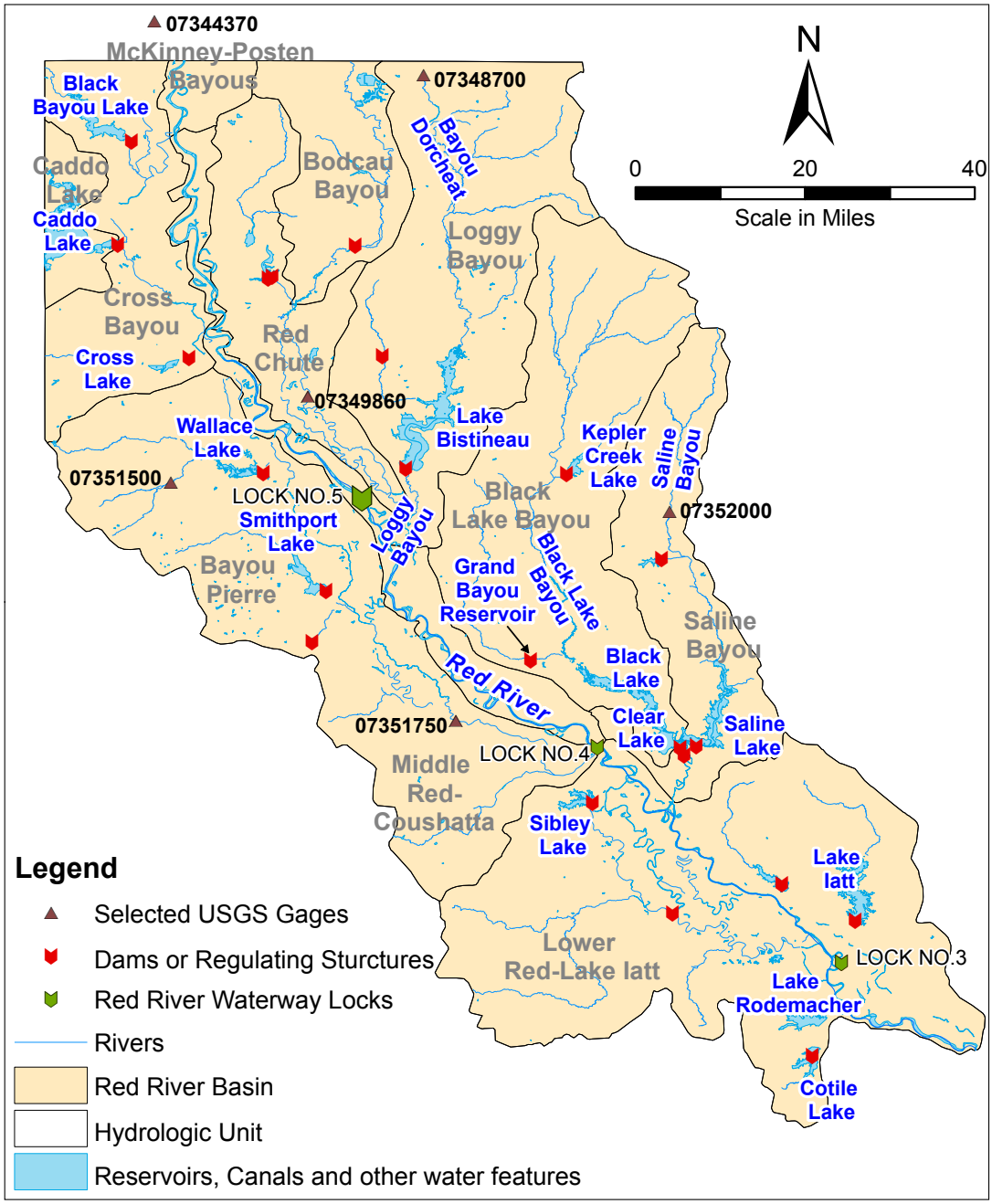
Per capita water use in 2005 (based on reported rural domestic and public supply uses by parish and population) for RRB parishes varied from 102 gallons per capita (person) per day (gpcd) in Red River Parish to 213 gpcd in Rapides Parish.[17] It is not clear why there is such a wide range in per capita water use. Water conservation has been encouraged in northern Louisiana, particularly through the "Reduce the Use" campaign led by the Louisiana State University AgCenter. At the same time, oil and gas development is increasing in northern Louisiana. Oil and gas extraction wells may require large amounts of water for hydraulic fracturing, and may also produce large amounts of wastewater. Both population growth and expansion of oil and gas production may increase water demand in the RRB in the future.

SURFACE WATER

Primary surface water features in the RRB include streams, rivers, and bayous, such as the Red River, Loggy Bayou, Saline Bayou, and Bayou Dorcheat, and several lakes and reservoirs (**Map 5**). **Map 5** also shows the 11 subwatersheds, or hydrologic units, delineated by the U. S. Geological Survey (USGS), and stream gages referenced in this report.

The Red River is more than 1,200 miles long, and is a major tributary to the Mississippi River. Flows in the Red River are affected by upstream dams in Texas, Oklahoma, and Arkansas.[3]

Extensive surface and groundwater data for Louisiana, including gaged streamflows and lake levels, are available through the USGS National Water Information System (NWIS) Web site.[19] Some gages in the RRB only measure stage, with undefined stage-discharge relationships. Streamflow statistics for selected RRB gages with long-term streamflow records are summarized in **Table 4**.



Map 5. Surface Water Features[18]

Table 4. Historical Streamflow Statistics for Selected Gages[19]

Stream Gage Informaiton			Period of Record Streamflow Statistics (cfs)				Percent of Streamflows Exceed (cfs)		
				Instantaneous					
Location (USGS Gage)	Drainage Area (mi^2)	Period of Record	Annual Average	Max. Peak (date)	Low Flow (date)	7Q10[20]	10	50	90
Red River at Spring Bank, AR (07344370) [about 5 miles upstream of State line]	NA	1995 - present	19,070	140,000 3/14/01	1,070 10/11/06	1,250[a]	49,400	9,010	2,760
Cypress Bayou near Keithville, LA (07351500)	66	1938 - present	82.9	27,200 1/29/99	0 Several	0	115	4.8	0
Bayou Dorcheat near Springhill, LA (07348700)	605	1957 - present	606	36,700 4/6/97	0 Several	0.6	1,660	121	2.5
Red Chute Bayou at Sligo, LA (07349860)	980	1960 - present	978	6,800 4/14/91	NA	4.4	2,620	450	19
Saline Bayou near Lucky, LA (07352000)	154	1940 - present	177	13,500 1/1/45	4.4 9/10/98	4.4	441	60	11
Bayou Pierre near Lake End, LA (07351750)	860	1980 – present	1,022	13,700 2/2/99	6.5[b] 12/6/06	21	NA	NA	NA

[a] Annual seven-day minimum
[b] Minimum daily (not instantaneous)
7Q10=7-day low flow with 10-year recurrence
Avg.=average
cfs=cubic foot per second
LA=Louisiana
Max.=maximum
mi^2=square mile

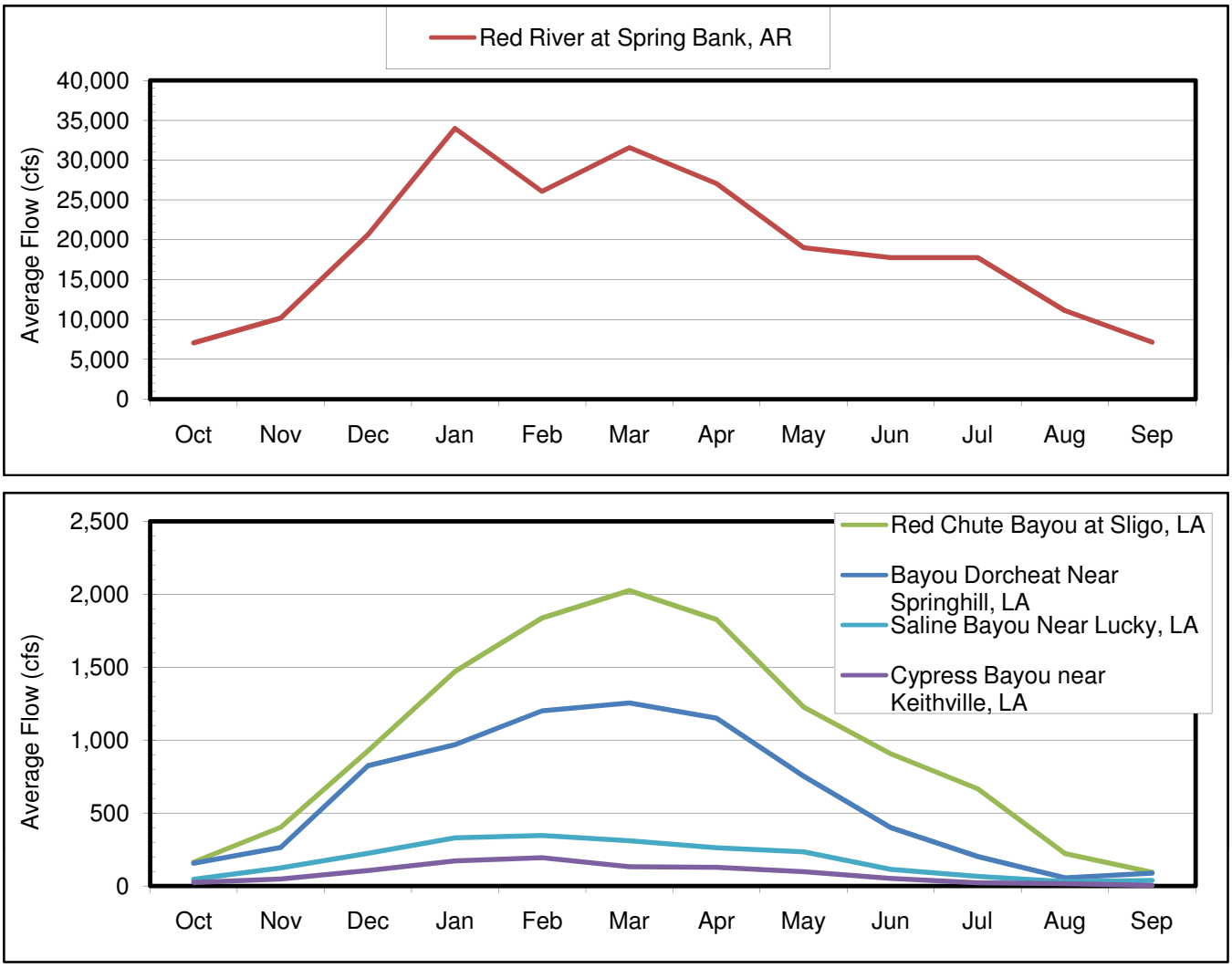
Statistics summarized in **Table 4** can be useful for various purposes. The 7-day low flow with a recurrence interval of 10 years (7Q10) is the statistic used to calculate available dilution in surface water discharge permits. Water bodies with low 7Q10 flows, less than a few cfs, typically have extended periods of low flows. For example, Cypress Bayou and Bayou Dorcheat have very low 7Q10 flows, and likely could not provide reliable water supplies without construction of storage reservoirs. Peak flows, including maximum instantaneous discharge, and streamflow exceeded by only 10 percent of flows, are useful for characterizing flooding and high-flow conditions on a stream.

Figure 4 shows historical monthly average flows for selected gages with available data in the RRB. Flow at these gages follows a seasonal pattern: highest flows occur in winter and spring, and minimal runoff occurs in late summer and early fall. With this seasonal pattern, reservoir storage is needed to make water available for year-round uses, such as municipal and industrial supplies.

The RRB contains 335 miles of streams designated under Louisiana's Natural and Scenic River System (shown in **Map 2**) under the Louisiana Natural and Scenic River Act. These waterways are protected by a permit process and certain restrictions, including prohibitions against channelization, impoundment construction, and channel realignment.[22]

Published characteristics of major lakes and reservoirs in the RRB are summarized in **Table 5**. Dependable yields listed for these water bodies is generally the maximum annual water supply available from the water body, with the understanding that lower yields will occur with a given frequency, such as every 20 years.[23]

Cross Lake, which was constructed on the west side of Shreveport to serve as municipal water supply for the city, is the subject of an ongoing U.S. Army Corps of Engineers (USACE) feasibility study. As part of this study, alternatives for increasing the water supply for Shreveport, as well as other water resources improvements, are being evaluated.[25]



cfs=cubic feet per second

Figure 4. Historical Monthly Average Streamflow for Selected Gages[21]

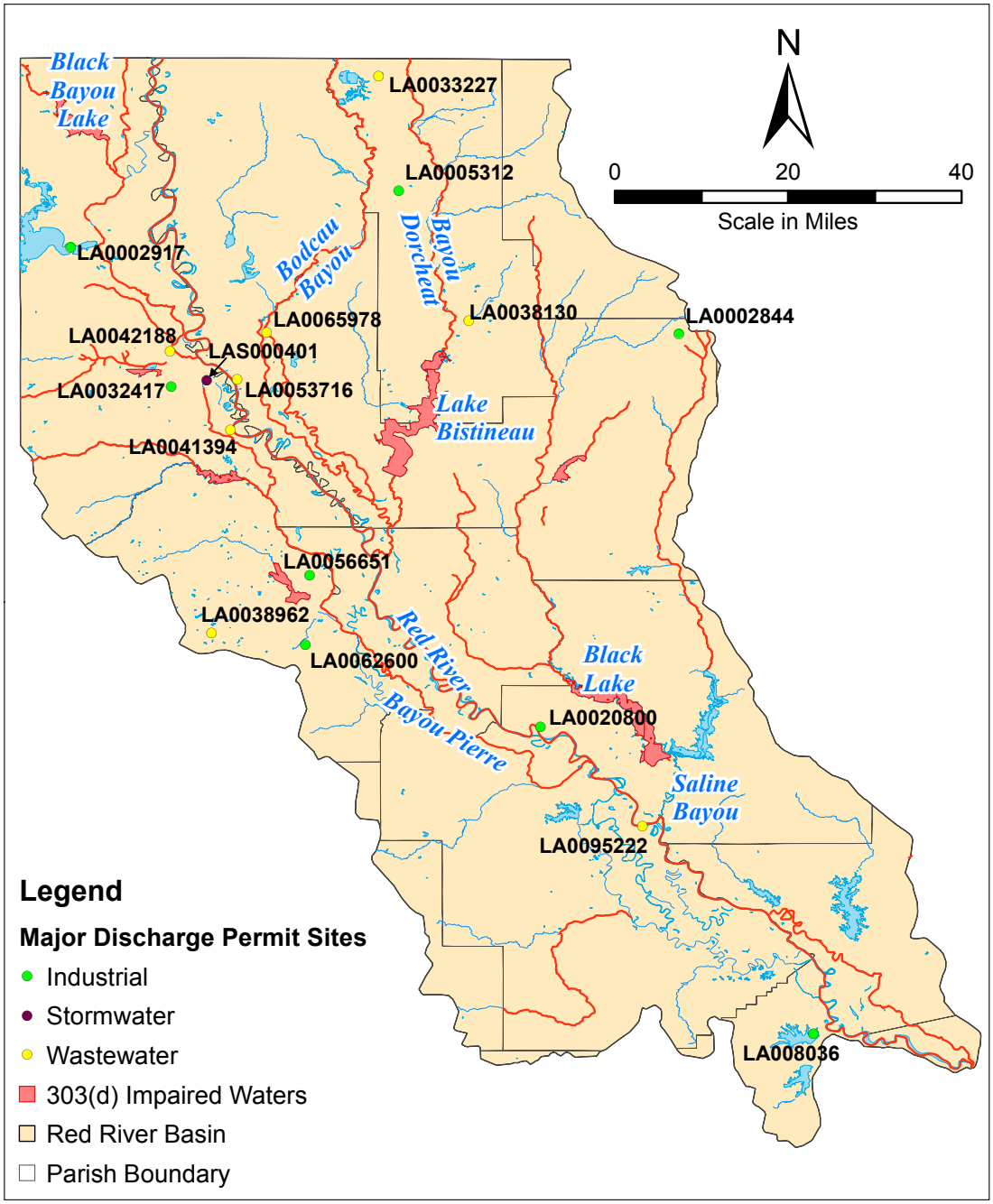
Table 5. Characteristics of Major Lakes and Reservoirs in the RRB[24]

Name	Surface Area (acres)	Volume (acre-feet)	Dependable Yield (mgd)
Bayou Bodcau Reservoir*	44,950	357,300	NA
Black Bayou Lake	3,690	17,750	20
Black Lake	12,190	109,000	70
Caddo Lake**	32,640	188,000	NA
Cotile Reservoir	1,850	25,000	111
Cross Lake	8,840	77,600	21
Grand Bayou Reservoir	2,700	27,000	NA
Keppler Creek Lake	1,925	16,800	NA
Iatt Lake	7100	31,000	NA
Lake Bisteneau	17,220	120,000	5
Saline Lake	8,960	61,000	50
Sibley Lake	2,176	19,500	8
Smithport Lake	2,950	11,500	14
Wallace Lake	9,300	7,800	5

*A flood control reservoir with no maintained pool
**Located in Texas and Louisiana
RRB = Red River Basin
mgd=million gallons per day
NA=not available

Surface Water Quality

The 303(d) list (named after Section 303(d) of the Federal Clean Water Act) included in Louisiana's Integrated Water Quality Report provides an overview of surface water locations where water quality standards are not met.[26] In these cases, designated uses of the waters, such as fish and wildlife propagation, recreation, or drinking water supply may be impaired. Stream and lake sub-segments on the 2006 303(d) list for the RRB are shown in **Map 6**. **Table 6** summarizes the number of stream and lake sub-segments in the RRB that are on the 2006 303(d) list and identifies impaired uses and parameters causing impairments. Several major surface waters in the RRB are included on the 303(d) list. Additional information on all dischargers in Louisiana can be obtained from LDEQ through their public records request process.[27] Design of new reservoirs either impounding impaired waters or discharging to impaired waters would need to consider these water quality challenges and any ongoing or planned water quality improvement projects.



Map 6. RRB Impaired Waters from 303(d) List and Major Permitted Discharge Sites[28]

Fish and wildlife propagation is the most frequently affected use in the RRB, with 106 affected sub-segments. Fish and wildlife propagation is impaired by low dissolved oxygen, mercury, elevated nutrients, and several other parameters.

Nearly all large lakes and reservoirs in the RRB are impaired for mercury in fish tissue, leading to consumption advisories. The Louisiana Department of Environmental Quality (LDEQ) has been investigating the mercury problem throughout the State since fish tissue data for the Ouachita River first resulted in a fish consumption advisory in 1992.[29]

Low dissolved oxygen, affecting fish and wildlife production, is a common impairment in the RRB. Dissolved oxygen impairments and low pH are generally attributed to natural causes within the basin. Runoff and return flows from agricultural areas are common suspected causes of impairment in the RRB for parameters including sediments and turbidity. In two sub-segments, chloride impairment is due to petroleum production. Fecal coliform impairments are attributed to several causes including managed pasture grazing, wildlife other than waterfowl, and inadequate sewage treatment. There has been some concern about water quality impacts from lignite mining in De Soto and Red River parishes.[30] Mining can affect both groundwater and surface water resources, although mine operators must meet the requirements of their permits and must conduct mine reclamation activities following mining operations.

A 2002 report for the Louisiana Ground Water Management Commission noted that Red River water quality "may not be desirable for certain water uses".[2] The 2006 303(d) list shows that the Red River within the RRB is impaired for both color and sulfate, and does not support drinking water supply and fish and wildlife propagation uses.[26]

Specific conductance, the ability of water to conduct electrical current, is an indicator of the total dissolved solids (TDS) concentration in water. Historical specific conductance data suggest that the Red River has exceeded the secondary drinking water standard for TDS concentration in the past, particularly in the northern RRB near Shreveport.[31] TDS concentration affects many water uses, including agriculture and power generation cooling water, and should be considered in the planning of any water resources project. TDS concentrations historically observed at other locations throughout the RRB were generally below the secondary water quality standard.[31]

Table 6. Summary of Surface Water Quality Impairments in the RRB[26]

Impaired Use	Sub-segments
Fish and wildlife propagation	106
Primary contact recreation	8
Drinking water supply	7

DWS=drinking water supply
FWP=fish and wildlife propagation
PCR=primary contact recreation (swimming)
RRB =Red River Basin

Parameter Causing Impairment (affected use)	Sub-segments
Dissolved Oxygen (FWP)	34
Mercury (FWP)	20
Nutrients (FWP)	15
Dissolved Solids (FWP)	11
Fecal Coliform (PCR)	8
Color (FWP and DWS)	6
Non-native Aquatic Plants (FWP)	6
Low pH (FWP)	6
Sulfate (FWP)	5
Turbidity (FWP)	3
Chloride (FWP)	2
Sediments (FWP)	2
Polychlorinated Biphenyls (FWP)	1
Suspended Solids (FWP)	1

Permitted Surface Water Discharges

LDEQ issues permits for discharges of municipal and industrial wastewater. Permitted discharges classified as "major" by the U.S. Environmental Protection Agency (USEPA) (generally those with flow greater than 1 mgd) are shown in **Map 6**. Major municipal wastewater discharges are summarized in **Table 7** and major industrial permitted discharges in **Table 8**. The Shreveport Lucas Wastewater Treatment Plant is the largest municipal discharge at 24 mgd, followed by Bossier City at 8 mgd. Industrial dischargers include power facilities, industrial chemical facilities, and paper mills, the largest being International Paper, with a permitted flow of over 21 mgd. The city of Shreveport also has a stormwater discharge permit, which is classified as a major discharge. Discharge permit conditions are based on receiving-water low-flow quantity and quality. Future water development projects that change low-flow quantity or quality at discharge locations could affect the ability of permit holders to comply with permit conditions.

Table 7. Major Municipal Wastewater Discharge Permits in the RRB[32]

Discharger	Permit Number	Permitted Discharge (mgd)	Receiving Water	Parish
Bossier City	LA0053716	8.0	Red River	Bossier
Bossier City Northeast	LA0065978	6.0	Red River	Bossier
Mansfield, City of	LA0038962	1.0	Bayou Nabonchasse	De Soto
Minden, City of	LA0038130	2.4	Bayou Dorcheat	Webster
Natchitoches, City of	LA0095222	4.9	Red River	Natchitoches
Shreveport, City of (Lucas)	LA0041394	24.0	Red River	Caddo
Shreveport, City of (North Highland)	LA0042188	3.5	Red River	Caddo
Springhill, City of	LA0033227	1.5	Crooked Creek-Bayou Dorcheat	Webster

Information presented in this table is directly from USEPA (2009a). For detailed explanation, this reference should be consulted.
mgd=million gallons per day
RRB = Red River Basin

Table 8. Major Industrial Discharge Permits in the RRB[32]

Discharger	Type	Permit Number	Permitted Discharge (mgd)	Receiving Water	Parish
Calumet Lubricants and Waxes LLC (Shreveport)	Petroleum Refining	LA0032417	4.2	Brush Bayou	Caddo
Calumet Lubricants (Cotton Valley)	Petroleum Refining	LA0005312	6.1	French Creek	Webster
Cleco Dolet Hills Power Station	Electric Services	LA0062600	12.3	Red River/ Mundy Creek	De Soto
Cleco Rodemacher Power Station	Electric Services	LA0008036	3.12	Rodemacher Lake-Bayou Jean de Jean	Rapides
Raeford Farms of Louisiana	Poultry Slaughtering / Processing	LA0002844	0.97	Saline Bayou	Bienville
International Paper	Pulp Mills	LA0056651	21.5	Red River	De Soto
Southwestern Electric Power Co - Lieberman Power Plant	Electric Services	LA0002917	4.2	Caddo Lake	Caddo
Willamette Industries Incorporated	Paperboard Mills	LA0020800	8.0	Red River	Natchitoches

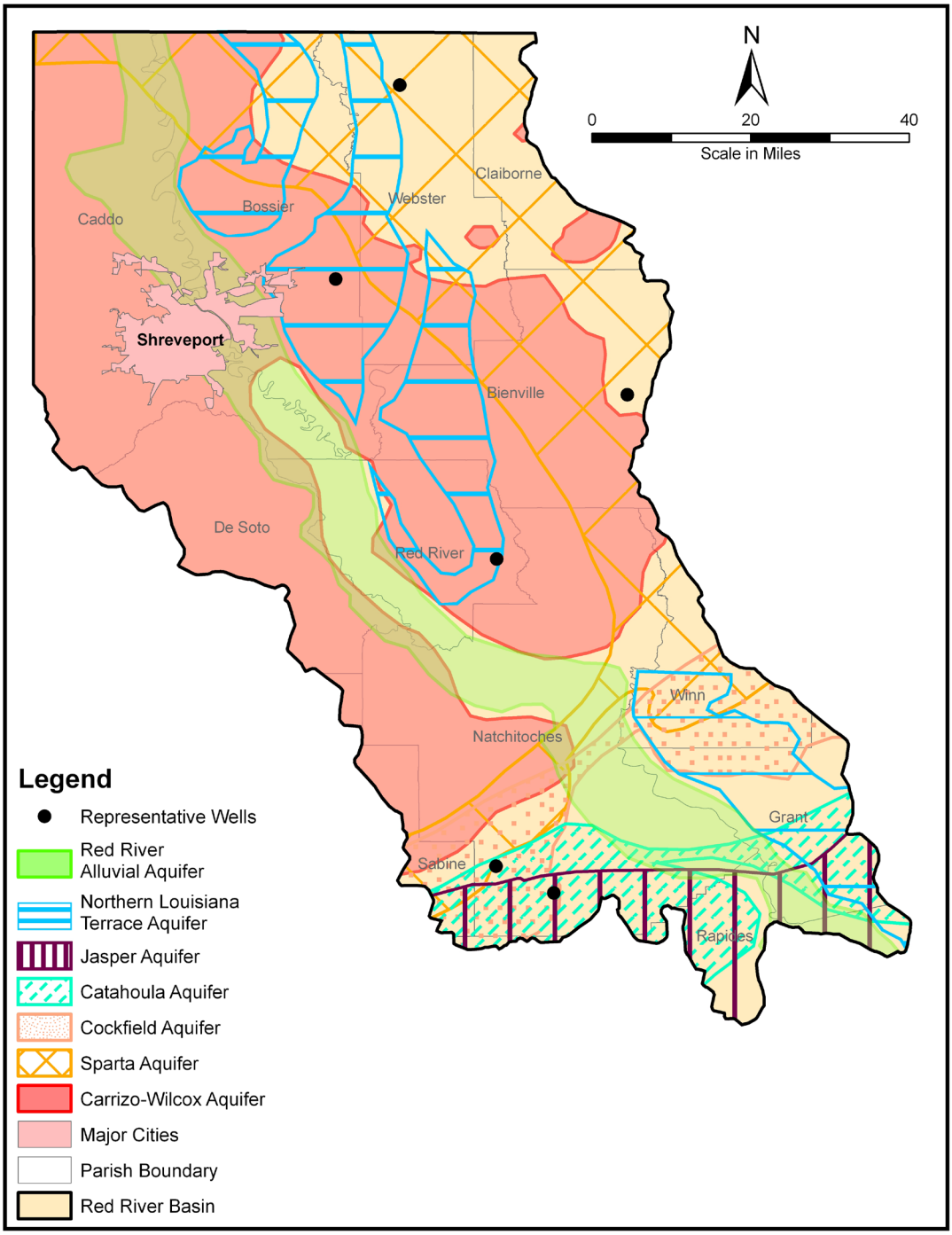
Information presented in this table is directly from USEPA (2009a). For detailed explanation, this reference should be consulted.
mgd=million gallons per day
RRB = Red River Basin
LLC = Limited Liability Company

GROUNDWATER

The State has registered about 3,200 groundwater wells in the RRB, mainly in the following major aquifers that underlie parts of the RRB:19

- Red River Alluvial Aquifer
- Northern Louisiana Terrace Aquifer
- Jasper Aquifer
- Catahoula Aquifer
- Cockfield Aquifer
- Sparta Aquifer
- Carrizo-Wilcox Aquifer

Major aquifers in the RRB are shown in Map 7 and their characteristics are summarized in Table 9. Aquifer areas overlap because the aquifers occur at different depths. Although the Catahoula Aquifer extends into the RRB, it is not heavily used in the basin. Figure 5 shows water levels in the most heavily used aquifers in the RRB.



Map 7. Spatial Extents of Major RRB Aquifers[33]

Table 9. Overview of RRB Major Aquifer Characteristics[2]

Aquifer	Range of Thickness of Freshwater Interval (feet)	Typical Well Yields (gpm)	Hydraulic Conductivity (feet/day)	Specific Capacity (gal/min/ft of drawdown)	Depth to Groundwater in 2005 (feet)
Red River Alluvial	50 - 200	500 – 2,800	10 - 530	5 - 90	0 - 16
Northern Louisiana Terrace	25 – 240	100 – 1,700	150 – 270	1 – 50	10 - 30
Jasper	50 – 2400	40 – 800 3,000 (large capacity)	20 – 260	2 – 30	30 - 80
Catahoula	50 – 450	50 – 400	20 – 260	2 – 30	120 - 145
Cockfield	50 – 600	50 – 500 700 (large capacity)	25 – 100	1.5 – 7.5	6 - 10
Sparta	50 – 700	100 – 1,800	25 – 100	1.5 – 7.5	7 - 50
Carrizo-Wilcox	50 – 850	30 – 150 400 (large capacity)	2 – 40	0.5 – 4	13 - 105

gpm=gallons per minute
gal/min/ft=gallons per minute per foot of drawdown
RRB=Red River Basin

The Sparta Aquifer, one of the major aquifers underlying the basin, is found in the north and northeastern RRB, with a narrow tongue underlying Natchitoches Parish in the south-central RRB. The Sparta Aquifer has been pumped extensively across the basin for municipal, industrial, and domestic purposes.[30] Long-term pumping of large amounts of groundwater can reduce the volume of groundwater in aquifer storage and cause localized areas of significant drop in groundwater levels, resulting in decreased well yields. Eventually, this can lead to subsidence, the irreversible loss of aquifer storage capacity. Since the mid-1990s, declining water levels in the Sparta Aquifer in southern Arkansas and northern Louisiana have been problematic, leading to declaration by the Louisiana Department of Natural Resources Commissioner of Conservation (Commissioner) of three Areas of Groundwater Concern in the Sparta Aquifer in the Ouachita River Basin, east of the RRB.[34] A joint study between the USGS and the Sparta Groundwater Conservation District was conducted to monitor water levels and water quality as well as to develop a groundwater model. Groundwater use has been reduced and groundwater levels, particularly in the Arkansas portion of the Sparta Aquifer, have increased in recent years.[35] Historical data from well Bi-261, completed in the Sparta Aquifer in Bienville Parish, suggest that groundwater levels have remained stable over the past 30 years in the north-central RRB. Historical data from well Wb-399, completed in the Sparta Aquifer in Webster Parish, show a slight decline in groundwater levels in the northeastern basin from 2004 to present. Additional USGS data from 1996 and 2005 indicate that groundwater levels in the Sparta Aquifer decreased by 2 to 8 feet in some parts of the RRB between 1996 and 2005.[36]

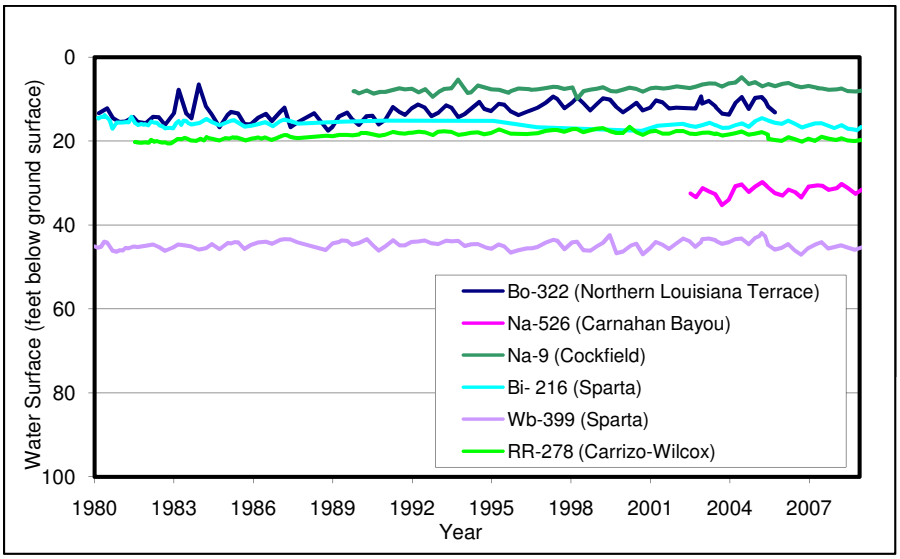


Figure 5. Historical Trends in RRB Groundwater Levels in Representative Wells[19]

Historical data from well Bo-322, completed in the Northern Louisiana Terrace Aquifer in Bossier Parish, indicates that groundwater levels rose slightly between 1995 and 2004. Similar historical trends have been observed in wells completed in this aquifer in adjacent basins. Groundwater levels in

surficial aquifers, such as the Northern Louisiana Terrace Aquifer, generally reflect seasonal fluctuations as well as long-term trends in precipitation.

In the RRB, the Jasper Aquifer comprises the Carnahan Bayou and Williamson Creek aquifers. Historical data from well Na-526, completed in the Carnahan Bayou aquifer, indicate that groundwater levels have remained stable in this aquifer for the past 6 years. Although earlier historical data is not available for the Carnahan Bayou Aquifer in the RRB, historical data from wells completed in this aquifer in neighboring basins show that, despite groundwater level decline of about 5 feet per year from 1980 to 1995, groundwater levels have been stable since 1995. Similar trends have been observed in the Williamson Creek Aquifer.[37]

The Cockfield Aquifer, underlying the northeastern RRB, is a source of small municipal and domestic water supplies.[30] In the area between the Red and Ouachita rivers, the Cockfield Aquifer is recharged by rainfall. Downgradient of the recharge area, the Cockfield aquifer discharges into numerous streams. The Cockfield aquifer is unique because fresh water is present at a greater depth in the aquifer in the RRB than in any other aquifer in western Louisiana. In Natchitoches and northwestern Vernon parishes, fresh water is produced to a depth of almost 2,000 feet.[38] Historical data from well N-9, completed in the Cockfield Aquifer in Natchitoches Parish, suggests that groundwater levels have remained stable since 1989.

The Carrizo-Wilcox Aquifer underlies nearly all of the RRB and is a major groundwater source in the basin. Water from this aquifer is used for many purposes, including municipal and domestic supplies and small industry. However, well yields are generally too low for industrial needs requiring large amounts of water.[30] Groundwater withdrawals from the Carrizo-Wilcox Aquifer increased from 13.3 mgd in 1990 to 17.6 mgd in 2005, although historical data from well RR-278, completed in the Carrizo-Wilcox Aquifer in Red River Parish, show stable groundwater levels since the early 1980s.[39] However, the Carrizo-Wilcox Aquifer is the sole groundwater source for some communities in DeSoto and Caddo parishes, making them vulnerable to local groundwater level declines.

The Red River Alluvial Aquifer is subject to limited use within the RRB, primarily for irrigation and aquaculture.[16] The Red River Alluvial Aquifer is hydraulically connected to the Red River and its major streams, and is recharged by overbank stream flooding, direct infiltration of rainfall, and lateral and upward movement of water from adjacent and underlying aquifers. Water levels fluctuate seasonally in response to precipitation and river stage.[40] Because of rapid recharge from overlying surface water, this aquifer shows stable long-term groundwater levels.

Groundwater Quality

Groundwater quality issues identified in the 2005 and 2006 LDEQ Baseline Monitoring Program reports are summarized in **Table 10**.[41] Groundwater quality is sufficient for most purposes in the RRB. Water in none of the wells measured in the major RRB aquifers exceeded Federal primary drinking water standards, although some wells exceeded secondary standards for pH, TDS, color, chloride, and iron. Lead was detected at concentrations below the Federal primary drinking water standard in water in one Red River Alluvial Aquifer well.

Table 10. Secondary Drinking Water Standards Exceedences in Major RRB Aquifers

Aquifer	pH	TDS	Color	Chloride	Iron
Red River Alluvial		■	■	■	■
Northern Louisiana Terrace	■	■		■	■
Jasper: Williamson Creek Carnahan Bayou	 ■	 ■	 ■ ■		■
Catahoula					■
Cockfield	■	■	■		■
Sparta	■	■	■	■	■
Carrizo-Wilcox		■	■		■

■ – One or more wells exceeded the secondary standard
TDS=total dissolved solids
RRB = Red River Basin

FLOODING

Flooding within the RRB is caused by overbank flooding due to intense rainfall events as well as backwater effects along the Red River. Six of the parishes located in the RRB (Bienville, Bossier, Caddo, Grant, Natchitoches, and Webster) have become participants in the National Flood Insurance Program (NFIP) offered through the Federal Emergency Management Agency (FEMA). As part of the NFIP, FEMA prepares Flood Insurance Studies (FIS) and Flood Insurance Rate Maps (FIRM) for rivers and bayous prone to damaging floods in a parish; member communities regulate development in floodplains. These studies and maps document flooding problems within parishes and delineate 100-year flood zones along major waterways. Some 100-year flood zones are currently available as digital geographic information system layers; detailed maps and reports can be obtained from FEMA.[42]

Limited flood control improvements made in the RRB during the 1800's under small appropriations did not resolve flooding problems in the basin. More recently, an integrated approach to flood control has been adopted, with the concept of applying comprehensive basin planning and development to the entire river valley.[3] Examples of completed flood control projects in the RRB include:

- Red River Valley Comprehensive Planning – Several dams constructed in upstream states as well as levees on the west bank of the Red River for nearly its entire length in the RRB and for segments on the east bank.
- Bayou Nicholas and Coushatta – a ring levee for the protection of Coushatta.
- Black Bayou – Pine Island Area – This project consists of about 7 miles of levees along the right bank of Black Bayou and a drainage structure for discharge of interior runoff.

USACE is currently conducting a flood risk management study for Bossier Parish. This study will evaluate the area near and downstream of Bayou Bodcau Dam, which was constructed for flood control purposes. The project may result in the addition of gates to the reservoir outlet to reduce flood risk in the area below the dam.[25]

USGS estimated flood flow magnitudes for different return periods at streamflow gages throughout the State. Gages within the RRB where significant historical data has been collected are listed in **Table 11** along with their estimated peak discharges for various recurrence intervals. The USGS analysis is only valid for rural, unaltered waterways. Also included in **Table 11** are peak discharges for major waterways as reported in FISs.

Table 11. Estimated Peak Flow Discharges of RRB Streams[43]

Source	Location		Flood Magnitude (cfs)			
	Gage Number	Name	2-year	10-year	100-year	500-year
USGS	07348700	Bayou Dorcheat near Springhill, LA	6,960	19,900	44,100	65,900
	07352000	Saline Bayou near Lucky, LA	2,790	8,870	21,800	33,800
	07351500	Cypress Bayou near Keithville, LA	4,790	11,500	22,500	31,900
	07349500	Bodcau Bayou near Sarepta, LA	4,470	10,600	20,200	27,700
FIS	Saline Bayou at mouth		NA	5,300	8,500	10,900
	Mill Creek at mouth		NA	5,100	8,300	10,650
	Flat River at confluence of Cutoff Bayou		NA	13,264	20,418	22,932
	Red Chute Bayou at State Highway 527		NA	13,264	20,257	22,707
	Red River at Highway 79/80		NA	125,000	205,000	227,000
	Cross Lake at spillway		NA	18,987	34,670	42,387
	Cross Bayou at mouth		NA	26,600	47,100	71,000
	Bayou Kisatchie at confluence with Old River		NA	15,880	38,856	63,052
	Bayou Dupont at confluence with Little River		NA	15,570	24,280	30,770

cfs=cubic feet per second
FIS=Flood Insurance Studies
LA=Louisiana
USGS=U.S. Geological Survey
RRB = Red River Basin

ENVIRONMENTAL AND CULTURAL ISSUES

Environmental and cultural resources are important elements of the quality of life in Louisiana, and can affect siting and operation of water resource facilities, as regulated by State and Federal permitting requirements.

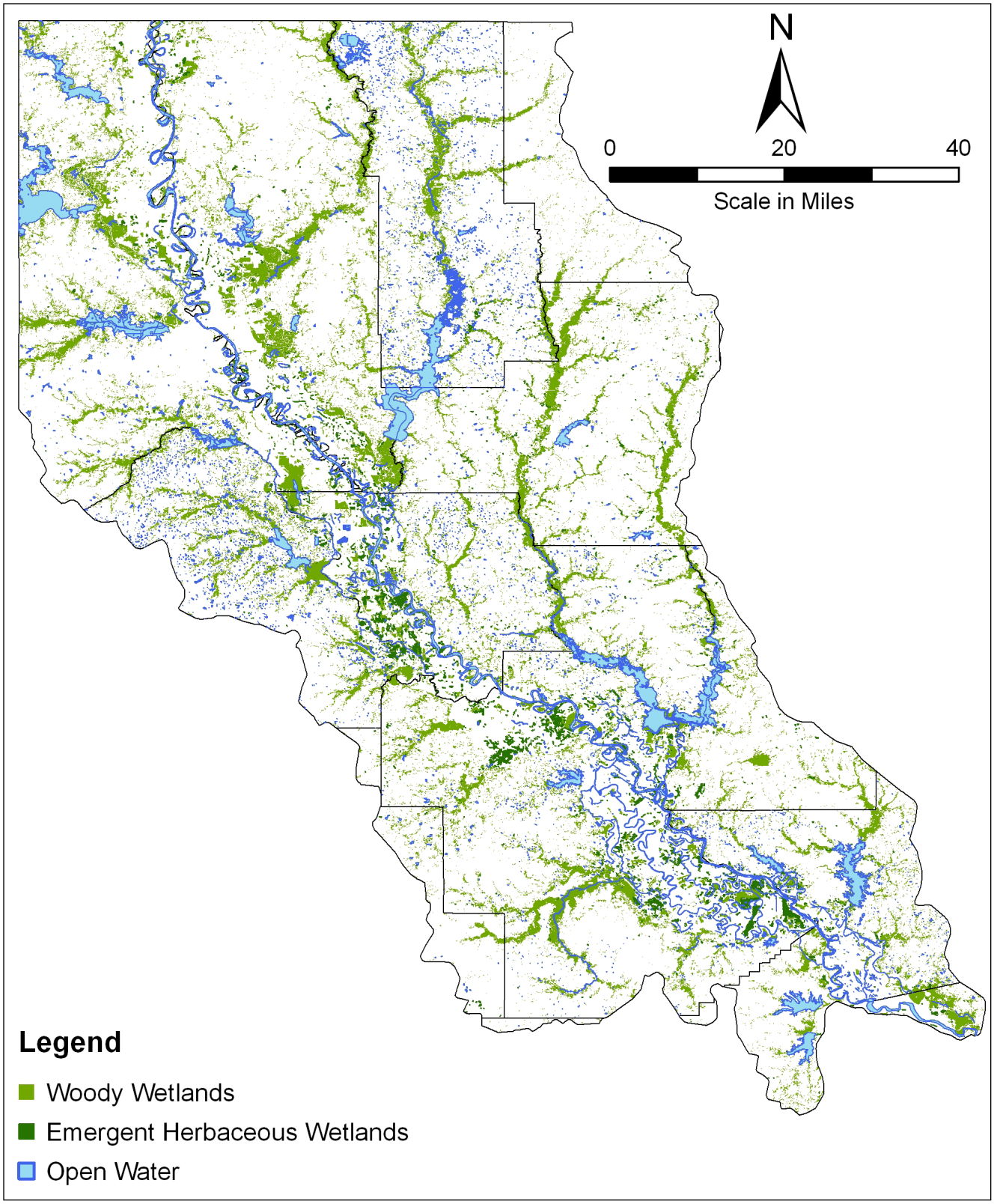
Habitat and Wildlife

The RRB includes parts of the South Central Plains ecoregion, as designated by USEPA.[44] An ecoregion contains a range of habitats, some of which are associated with species of conservation concern. The Louisiana Comprehensive Wildlife Conservation Strategy (Wildlife Action Plan) prioritizes particular terrestrial habitat types within each ecoregion for conservation.[22]

Terrestrial species Federally listed threatened or endangered that may reside in the RRB are the Louisiana black bear, Louisiana pine snake, red-cockaded woodpecker, interior least tern, and earth fruit.[45]

Aquatic habitats in the RRB support about 99 species of freshwater fishes, 36 species of mussels, and 18 species of crawfish.[21] State species of concern include four crustacean, nine freshwater fish, two mussel, and two reptile species. The State regulates aquatic habitat through surface water quality standards in water bodies designated for fish and wildlife propagation.[46] The Wildlife Action Plan does not prioritize aquatic habitats for conservation. The U.S. Fish and Wildlife Service (USFWS) has identified several subwatersheds in the RRB with surface waters important for conservation of the pallid sturgeon and the Louisiana pearlshell mussel, which are species Federally listed as threatened or endangered.[47]

Wetlands are an important environmental resource throughout the United States, particularly in Louisiana. Alteration of these areas often requires a Federal Section 404 permit through USACE. **Map 8** shows areas of wetlands in the RRB. About 12 percent of RRB surface area, or 773 square miles, is woody wetlands (i.e., areas where forest or shrubland vegetation accounts for a large portion of the cover, and the soil is periodically saturated or inundated). Less than 1 percent is emergent herbaceous wetlands (i.e., areas where perennial herbaceous vegetation accounts for most of the cover, and the soil is periodically saturated or inundated).[48]

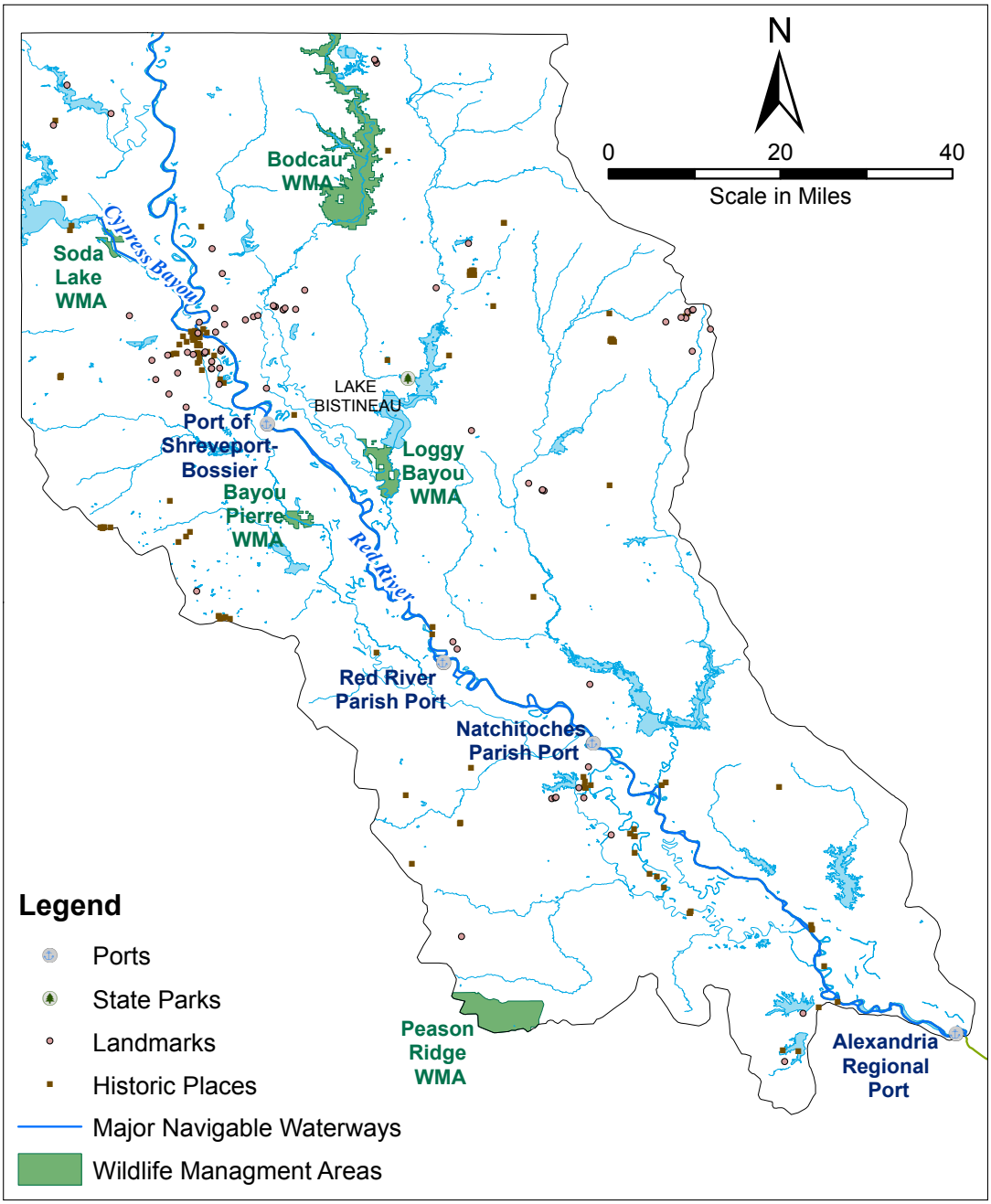


Map 8. Wetlands in the RRB[32]

Cultural Resources

Information on cultural issues and resources is provided by parish-level organizations. Prehistoric (before European colonization) and historical sites are registered with the Louisiana Department of Culture, Recreation, and Tourism (LCRT) and the National Register of Historic Places (NRHP). Featured historic sites in the basin include churches, courthouses, post offices, and schools. Two historic districts and 134 historic points exist in the RRB, as shown in **Map 9**. Two archaeological sites in the RRB, in Bienville and Natchitoches Parishes, are listed on the NRHP.[49] Locations of known cultural resources that could affect reservoir siting or operations are available from the NRHP. Additional information is available from the LCRT, Office of Cultural Development, Division of Historic Preservation.

Potentially affected Native American tribes must be notified of any proposed reservoir plans. There are no Federally recognized Native American tribes in the RRB. State-recognized tribes include the Caddo Adai Tribe, the Choctaw Apache Tribe of Ebarb, the Four Winds Tribe, and the Clifton Choctaw Tribe.[50]



Map 9. Cultural and Recreational Resources and Navigable Waterways in the RRB[30]

RECREATION, NAVIGATION, AND HYDROPOWER

Water resource development projects, particularly surface water reservoirs, can provide opportunities for creating and maintaining regional recreation resources. The RRB is used extensively for water-oriented recreation; hunting, fishing, boating, and swimming are popular activities in the area.[30] Five Wildlife Management Areas in the RRB serve as hunting and camping grounds for the general public. Specific recreational resources of regional value are shown in **Map 9**.

Navigable waterways are important to the State and regional economy, and would have to be maintained by any future water development projects. Two recognized navigable waterways, Cypress Bayou and the Red River, are located within the RRB (**Map 9**). Navigable water depths and waterway lengths are listed in **Table 12**. Commerce has not been reported on Cypress Bayou since 1979; however, the waterway offers facilities for camping, boating, fishing, hunting, and other recreational activites. Visitors to the bayou number 500,000 to 1,000,000 annually.[3]

Navigation improvements along the Red River in Louisiana have been ongoing since the early 1800s. The Red River Waterway Project, completed in 1994, enables year-round navigation on the Red River from the Mississippi River to Shreveport. This project straightened the river, stabilized its banks, and added a series of five lock and dam complexes to prevent flooding. Three of the locks are located in the RRB (**Map 5**) and two are located downstream in the Ouachita River Basin. The navigable depth of the Red River from the Mississippi River to Shreveport is now 9 feet.[25] The Red River upstream of Shreveport is not suitable for commercial navigation. Sharp curves, channel migration, and sand bars make navigation with towboats and barges difficult. The Army Corps is currently studying the feasibility of making channel improvements to allow commercial navigation into Arkansas.[25]

Recreational visitors to the Red River Waterway Project approach 2 million annually. Types of recreational facilities provided include day-use areas with playing fields and picnic facilities, boat ramps, bank fishing areas, nature trails, comfort stations, parking areas, amphitheaters, and recreational vehicle camp sites.

Four ports are located within the RRB: Port of Shreveport-Bossier, Red River Parish Port, Natchitoches Parish Port, and Alexandria Regional Port. The Port of Shreveport-Bossier is located at the most upstream navigable point on the Red River Waterway in northwest Louisiana, about four miles south of the city of Shreveport. Average annual tonnage and primary cargoes for each port can be obtained from the Ports Association of Louisiana.[52]

No hydropower projects exist in the RRB. The U.S. Department of Energy has identified many potential sites for hydropower projects, ranging in capacity from microhydropower projects (less than 100 kilowatts) to small hydropower projects (between 1 and 30 megawatts).[53] Proposed reservoir projects should evaluate the potential for hydroelectric energy generation.

Table 12. Summary of Navigable Waterways in the RRB

River	Outflow	Navigable Depth (feet)[51]	Navigable Length (miles)
Cypress Bayou	Red River	6	30
Red River Below Shreveport	Old River/Atchafalaya River	9	225

RRB = Red River Basin

INTERBASIN AND INTERSTATE ISSUES

Both surface water and groundwater resources in the RRB are shared with neighboring states, and as such, interstate issues must be considered during development of these shared water resources.

The Red River Compact (Compact) is an interstate agreement entered into by the states of Louisiana, Oklahoma, Texas, and Arkansas with the consent of the U.S. Congress that provides for distribution of the waters of the Red River Basin.[54] The principal purposes of the Compact are the following:

- To promote interstate comity and remove causes of controversy between each affected states by governing the use, control, and distribution of the interstate waters of the Red River and its tributaries.
- To provide an equitable apportionment among the signatory states of the water of the Red River and its tributaries.
- To promote an active program for the control and alleviation of natural deterioration and pollution of the waters of the Red River Basin and to provide for enforcement of the laws related thereto.
- To provide the means for an active program for the conservation of water, protection of lives and property from floods, improvement of water quality, development of navigation, and regulation of flows in the Red River Basin.
- To provide a basis for state or joint state planning and action by ascertaining and identifying each state's share in the interstate waters of the Red River Basin and the apportionment thereof.

A major municipal groundwater source in the RRB, the Carrizo-Wilcox Aquifer, extends across State lines into both Arkansas and Texas. In addition to Louisiana and Arkansas users, sixty Texas counties rely on the Carrizo-Wilcox Aquifer, primarily for irrigation and municipal water supply. From 1990 to 2000, water levels in the Carrizo-Wilcox Aquifer in Texas declined 2.9 feet.[55] Although groundwater levels in the RRB in Louisiana have remained stable (**Figure 5**), continued groundwater use in all three states could expand the area of groundwater drawdown. Furthermore, water quality of the Carrizo-Wilcox Aquifer is more degraded in Texas than in Louisiana. Although water quality in the aquifer in Louisiana has not exceeded Federal primary drinking water standards, water in wells in the Carrizo-Wilcox Aquifer in Texas have exceeded state maximum contaminant levels for fluoride, nitrate, and lead.[56] Although water quality issues in Texas do not appear to currently adversely affect the aquifer underlying Louisiana, continued groundwater pumping could facilitate migration of contaminants between states.

SUMMARY OF MAJOR WATER RESOURCES NEEDS

To identify and prioritize statewide water resources issues, a needs assessment of each of the nine major surface water basins within Louisiana was performed. Because the needs assessment provides the foundation for developing reservoir priority evaluation criteria, it focuses on needs that can be addressed by surface water reservoirs. At the same time, the integrated nature of water resources management requires evaluating issues that could not necessarily be solved by, but could be affected by, a reservoir.

Based on the existing compiled information, eight categories of State water resources needs that could be addressed or affected by construction of surface water reservoirs were identified and evaluated. Evaluation criteria were developed for each category to allow interbasin comparison of the needs. To maintain objectivity in the evaluation process, evaluation criteria were developed based on factors that could be evaluated as quantitatively as possible across all basins. High, medium, and low levels of current need were defined based on differences in these factors between basins. Future needs in each basin were assessed by determining whether each current need is increasing, constant, or decreasing. Evaluation criteria are described in detail in the main body of the Statewide Perspective on Water Management Report, to which this basin characterization is an appendix.

Assessed needs in the RRB are summarized below. Details of the assessed needs for all nine major Louisiana surface water basins, as well as a comparison of statewide needs by

issue, are presented in the Statewide Perspective on Water Management Report.

Assessed needs in the RRB are shown in **Table 13**, and are discussed below in general order of need, from high-level needs (colored red in **Table 13**) to low-level needs (colored green in **Table 13**). No low-level needs were identified in the RRB.

Surface water supply was evaluated as the only high-level need in the basin. The RRB is highly dependent on surface water, using 509 mgd. At the same time, most surface water supply exhibits high seasonal variability. Late summer flows of major gaged water bodies are only 5 to 22 percent of the average annual flow, making development of significant amounts of surface water for dependable year-round use challenging without storage. If population continues to grow in the RRB, demand for surface water will likely increase.

Surface water quality was ranked as a medium-level need that is expected to increase in importance in the future. Some reaches of surface water are designated as having impaired water quality in the RRB. Common constituents causing impairments are dissolved oxygen, mercury, and nutrients. Although most of these impairments are related to aquatic habitat, seven impairments for color affect usability for drinking water purposes. Surface water quality is expected to deteriorate with increasing development and population growth.

Groundwater supply was ranked as a medium-level need, with increasing importance in the future. The current trend of increasing withdrawals from the Carrizo-Wilcox Aquifer in Louisiana, combined with a trend of decreasing ground water levels in this aquifer in Texas, could compromise future use of this aquifer to supply demands in the Shreveport-Bossier area and surrounding communities. Minor decreasing water levels in the Sparta and Williamson aquifers in the RRB could be a precursor of future more serious sustainability concerns. Furthermore, the possibility of expanded oil and gas production could further stress regional groundwater resources.

Flood control was ranked as a medium-level need with increasing importance in the future. Some areas of potential flooding that could affect highly developed areas are present in the RRB, particularly in the Red River valley. Comprehensive flood control projects have been conducted for much of the main stem Red River, but flood control and floodplain management measures may still be needed to protect existing land uses and minimize future flood damages.

Environmental protection and enhancement was also ranked as a medium-level need with increasing importance in the future. Several environmental issues threaten protection of existing water resources and/or constrain future development of additional water supplies, including wetland and naturally vegetated areas that cover over 75 percent of the basin, and two aquatic threatened and endangered species.

Recreation was evaluated as a medium-level need. Seven major water bodies including the Red River, three wildlife refuges, and one state park with direct water access provide good recreational opportunities, although the relatively high population of the RRB places significant demands on the existing resources.

Navigation was ranked as a medium-level need with increasing importance in the future. Over 250 miles of navigable waterways and four major ports in the RRB, including Shreveport-Bossier City, currently accommodate more than 1.1 million tons of cargo per year. Cargo throughput has been increasing since the 1995 opening of the J. Bennett Johnston Waterway, and it is expected to increase to 16 million tons by 2046.

Table 13. Assessed Water Resources Needs in the RRB

Category	Current	Future
Surface Water Supply	high	↑
Surface Water Quality	medium	↑
Groundwater Supply	medium	↑
Groundwater Quality	medium	↑
Flood Control	medium	–
Environmental Protection and Enhancement	medium	↑
Recreation	medium	–
Navigation	medium	↑

RRB = Red River Basin
Red = high-level need; Yellow=medium-level need; Green=low-level need
↑ = increasing importance
– = same importance
↓ = decreasing importance

ABBREVIATIONS

°F	degrees Fahrenheit
7Q10	7-day low flow with a recurrence interval of 10 years
cfs	cubic feet per second
Commissioner	Louisiana Department of Natural Resources Commissioner of Conservation
Compact	Red River Compact
DOTD	Louisiana Department of Transportation and Development
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
gpcd	gallons per capita per day
LCRT	Louisiana Department of Culture, Recreation, and Tourism
LDEQ	Louisiana Department of Environmental Quality
mgd	million gallons per day
NFIP	National Flood Insurance Program
NRCS	Federal Natural Resources Convention Service
NRHP	National Register of Historic Places
NWIS	National Water Information System
RRB	Red River Basin
State	State of Louisiana
TDS	total dissolved solids
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
Wildlife Action Plan	Louisiana Comprehensive Wildlife Conservation Strategy

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