Final Report

Yampa-White Basin Roundtable

PROJECTS AND METHODS STUDY

November 2014

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Acronyms

AF	acre-feet
AFY	acre-feet per year
AWC	available water content
BRT	Basin Roundtable
CDSS	Colorado Decision Support Systems
cfs	cubic feet per second
COGCC	Colorado Oil and Gas Conservation Commission
CPW	Colorado Division of Parks and Wildlife
CRWAS	Colorado River Water Availability Study
CRWCD	Colorado River Water Conservation District
CWCB	Colorado Water Conservation Board
CWT	Colorado Water Trust
DWR	Division of Water Resources
ERC	Ecological Resource Consultants, Inc.
ET	evapotranspiration
GCMs	Global Circulation Models
GIS	Geographic Information System
IPPs	identified projects and processes
ISF	instream flow
IWR	Irrigation Water Requirement
M&I	Municipal and Industrial
PBO	Programmatic Biological Opinion
RICD	Recreational In-Channel Diversion
SWSI	Statewide Water Supply Initiative
TNC	The Nature Conservancy
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UYWCD	Upper Yampa Water Conservancy District
WDID	Water District ID
WFET	Watershed Flow Evaluation Tool
WSRA	Water Supply Reserve Account

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Section 1

Introduction

1.1 Introduction and Background

In 2005, House Bill 05-1177, the Colorado Water for the 21st Century Act (Penry, Decker, et al., House Bill 05-1177), was signed into law. Among other provisions, the bill provides for the creation of Basin Roundtables (BRT). Each BRT is charged with formulating a water needs assessment, conducting an analysis of available unappropriated water, and proposing projects or methods for meeting those needs.

In 2010, the Colorado Water Conservation Board (CWCB) completed the second Statewide Water Supply Initiative (SWSI 2010). That study included estimates of water demands in the Yampa and White River Basins through the 2050 planning horizon. While SWSI provided a valuable coarse assessment of water demands for the municipal, industrial, and agricultural sectors, concerns were raised that an in-depth analysis would show that water may not be available on a finer scale in some of the administrative water districts—especially on the tributaries—due to infrastructure restraints, poor water availability in the late irrigation season, and infeasibility to meet shortages with reservoir storage. Evaluations and assessments of potential projects have been performed by various entities to address location specific water supply issues within the Yampa and White Basins; however, the combined improvements have not been evaluated in an integrated manner to see their potential effect on basin needs.

The Statement of Work for the Projects and Methods Study was divided into four tasks:

1. Develop a common understanding of water needs in the Yampa-White Basin.
2. Analyze river operations of the Yampa and White Basins, including alternative model scenarios.
3. Comparison of water right priorities of Statewide SWSI Alternatives to those of the Yampa-White Basin.
4. Draft a report.

1.1.1 Objectives

The sections assembled in this report are intended to provide a complete picture of current and future water related issues in the Yampa and White Basins.

The first Projects and Methods task is to understand the basin under current conditions and subsequently identify existing consumptive and nonconsumptive needs. Information summarized in the Yampa-White's previous Water Supply Reserve Account (WSRA) grant studies (Energy Study, Agricultural Needs Study, and Watershed Flow Evaluation Tool [WFET] Study) and information developed by the CWCB as part of the SWSI 2010 report and Basin Needs Assessments reports were utilized to develop an initial summary of the basin's consumptive and nonconsumptive water needs. Consumptive and nonconsumptive needs and gaps are displayed spatially using Geographic Information System (GIS) software. These objectives are summarized in Section 2 of this report.

The second Projects and Methods task is to further build upon the work completed in the first task and develop models for analyses of potential future scenarios. The modeling will rely on the Consumptive and Nonconsumptive Needs Assessments and input from the Yampa BRT in order to develop operational scenarios to meet consumptive and nonconsumptive needs. The model developed in this task adds elements (Identified Projects and Processes [IPPs] and New Projects) needed for this analysis. These operational scenarios, however, are not finalized as part of this report.

Nonconsumptive needs include recreational boating flows and environmental flows determined by the BRT. Consumptive needs will be incorporated from the following sources—the Agricultural Needs Assessment Study, Energy Development Water Needs Assessment Phase II, and SWSI 2010. Demands will be incorporated into the modeling effort. Both IPPs and additional consumptive and nonconsumptive projects will be considered. Additionally, alternate hydrologies will be evaluated (wet, average, and dry hydrologic conditions). Similar to Task 1, a spatial representation of consumptive and nonconsumptive needs will be developed, which can be used to compare existing conditions within the model.

In order to gain a better understanding of consumptive and nonconsumptive needs in the Yampa and White River Basins, a model of the surface water system was developed that included:

- Future Consumptive Water Demands (low, medium, and high demand levels)
  - Municipal and Industrial (M&I) Demands
  - Agricultural Demands
  - Thermoelectric Power Generation Demands
  - Energy Development Demands
  - Nonconsumptive Needs
- Hydrology Scenarios
- IPPs and New Projects

Each of these elements was compiled to model a large range of potential future scenarios and associated consumptive and nonconsumptive shortages. The objectives of this task are documented in Section 3.

1.1.2 Basin Roundtable Subcommittee

Several of the tasks in this study required input and feedback from the agricultural subcommittee of the Yampa-White-Green BRT and the BRT subcommittee. The BRT subcommittee members include Tom Gray, Jeff Comstock, Mary Brown, Laura Chartrand, Jon Hill, Steve Colby, Chuck Grobe, T. Wright Dickinson, Jacob Bornstein, Geoff Blakeslee, Jeff Deveere, Doug Monger, and Kevin McBride. To date, CDM Smith has met with the BRT subcommittee on multiple occasions to discuss the details regarding model development, demands, IPPs, and modeling results.

Section 2

Develop a Common Understanding of Water Needs in the Yampa and White Basins

2.1 Introduction

This section summarizes the analysis completed to accomplish the objective of Task 1, which is to "Develop a common understanding of the Water Needs in the Yampa and White Basins" as stated in the Statement of Work. The purpose of this task is to develop a common understanding by the Yampa-White BRT and other key public stakeholders of the consumptive and nonconsumptive water needs in the Yampa-White Basin. A spatial representation of its consumptive (M&I and agricultural) and nonconsumptive (environmental and recreational) needs will be used to identify critical areas in the basin study area (shown in **Figure 2-1**) that will need to be considered in any analysis addressing projects and methods to meet the basin's future needs.

2.1.1 Method/Procedure

Information summarized in the Yampa-White Basin's previous WSRA grant studies (Energy Study, Agricultural Needs Study, and WFET Study) and information developed by the CWCB as part of the SWSI 2010 report and Basin Needs Assessments reports were utilized to develop a comprehensive summary of the basin's consumptive and nonconsumptive water needs. The Yampa-White Basin's consumptive and nonconsumptive needs will be summarized. Consumptive and nonconsumptive needs will be displayed spatially using GIS software. Additionally water need "gaps" were displayed spatially. Finally, critical areas in the basin with specific flow needs, such as for endangered species, will be summarized spatially.

2.2 Previous Studies

The introduction section mentions various studies that were previously performed in the Yampa and White River Basins. The Projects and Methods Study included the following information from Yampa-White WSRA grant studies and the SWSI:

- Yampa-White Agricultural Water Needs Assessment Report – examined the water supply issues associated with agricultural water use. Additionally, the effect of return flows, climate change scenarios, and various potential project scenarios were evaluated.
- Colorado River Water Availability Study (CRWAS) – determined how much water may be available to meet Colorado's future water needs under alternate hydrologies.
- Yampa-White Basin Roundtable Watershed Flow Evaluation Tool Study – provided metrics to evaluate environmental and recreational nonconsumptive needs throughout the basins.

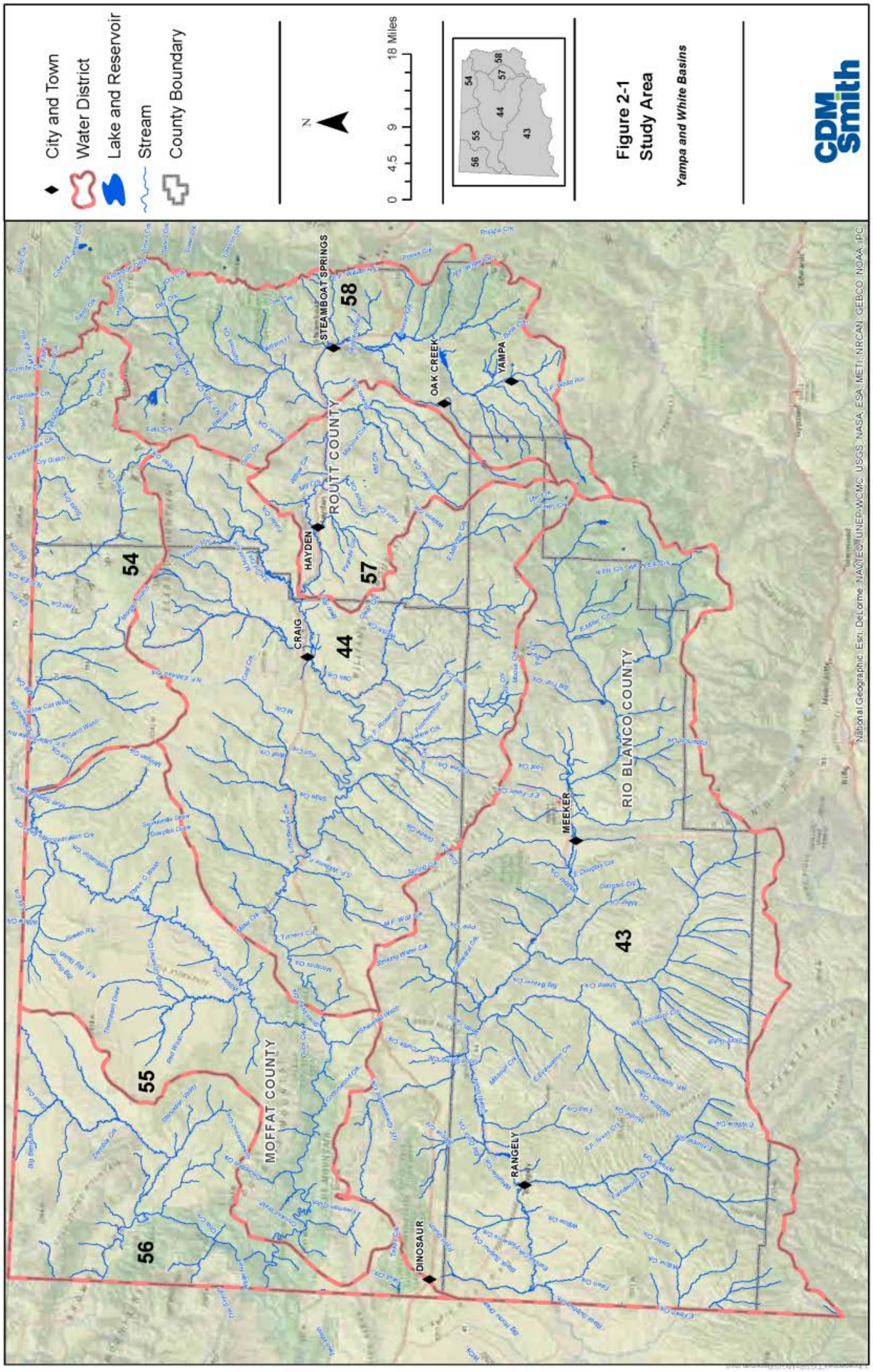

Figure 2-1
Study Area

- Energy Development Water Needs Assessment Phase II – continued with the work performed in Phase I of the study. Low, medium, and high demand projections were calculated for short-term, mid-term, and long-term planning horizons. The Phase II study focuses on the supply availability of oil shale development and three water allocation modeling scenarios were developed to determine feasible supply options.

- SWSI 2010 – examined 2050 demand scenarios on a coarse scale, which provided a basis for more detailed analysis.

Other studies were identified through the course of the project that provided additional information used in this study:

- The Upper Yampa Water Conservancy District Master Plan – evaluated water availability of the upper portion of the Yampa River mainstem and modeled operations of projects to meet future demands.

- Peabody Trout Creek Project Energy Study – Provided project information and operations of the Peabody Trout Creek Reservoir to meet energy development demands.

2.2.1 SWSI 2010 and Basin Needs Assessment

In 2003, the Colorado General Assembly authorized the CWCB to implement the Statewide Water Supply Initiative. SWSI is a comprehensive identification of Colorado's current and future water needs and it examines a variety of approaches Colorado could take to meet those needs. SWSI implemented a collaborative approach to water resource issues by establishing SWSI roundtables. Membership in these roundtables represented a broad range of water user interests. SWSI focused on using a common technical basis for identifying and quantifying water needs and issues (the report can be viewed at the CWCB website). In 2010, the original SWSI was updated to include new data obtained throughout the state as well as develop projections through a future planning horizon of 2050. SWSI 2010, along with the Basin Needs Assessments, were developed as a basis for further studies such as the Projects and Methods Study as well as the Basin Implementation Plans that will be developed through the following year.

2.2.2 Colorado River Water Availability Study (Phase I)

The purpose of the CRWAS is to provide a common platform to determine consumptive and nonconsumptive uses throughout the western slope. StateMod models developed by Colorado Decision Support Systems (CDSS) for the Colorado River mainstem, Gunnison River, Dolores/San Juan/San Miguel Rivers, and the Yampa-White-Green Rivers were used in the development process. Current demands, operations, and historical hydrology, as well as a suite of climate change demands and hydrologies, were used to determine the current and potential future state of water availability along the western slope of Colorado. The CRWAS final report can be viewed in its entirety on the CWCB website.

2.2.3 Yampa-White Agricultural Water Needs Assessment Study

The Yampa-White Agricultural Water Needs Assessment Study was completed in 2011. The study's objectives were to refine and update previous estimates of current agricultural uses and supplies, evaluate future agricultural demands, assess climate change and energy development sector impacts on agricultural water availability, and develop alternatives to satisfy shortages.

2.2.4 Energy Development Water Needs Assessment (Phase II)

The Yampa-White Energy Development Water Needs Assessment was completed at the beginning of 2011. The purpose was to refine the previous (Phase I) future demand estimates through the 2050 planning horizon for the oil shale, natural gas, coal, and uranium energy sectors. Due to the assumption that the majority of energy sector demands would be from oil shale demand, water supplies and gaps for oil shale production were studied in greater depth than the other energy demand sectors.

The final report for the Energy Development Water Needs Assessment (Phase II) can be found on the Colorado River Water Conservation District website.

2.2.5 Yampa-White Watershed Flow Evaluation Tool Study

The purpose of the WFET was to apply the metrics developed during the WFET Pilot Study to identify environmentally or recreationally (collectively called nonconsumptive uses) significant areas to determine the risk levels associated with those areas for those uses and develop a risk level mapping process to locate high risk areas. The associated risks metrics are a metric measuring the impacts of increased water use within the basin on species of fish or vegetation.

The Yampa-White Basin WFET Final Report can be found on The Nature Conservancy (TNC) Conservation Gateway website.

2.3 Consumptive Needs

Water in Colorado is managed to meet the needs of Colorado's citizens' agriculture and environment. Colorado's economy, quality of life, recreational opportunities, and environment are all dependent on water. This requires a balance between consumptive and nonconsumptive needs.

The following sections provide an overview of the consumptive water needs within the Yampa-White-Green River Basins. Consumptive needs are broken out into the following categories—agricultural demands, M&I demands, and thermoelectric power generation demands.

2.3.1 Agricultural Demands

Irrigated acreage in the Yampa-White Basin has varied over the past several decades, fluctuating between 60,000 and 93,000 acres in the Yampa Basin and approximately 26,000 irrigated acres in the White Basin. The primary crop grown in the study area is hay, which has a reputation as being high quality that commands a premium price, according to the Yampa Valley Water Demand Study (BBC Research & Consulting 1998). In addition to hay, there is a small amount of alfalfa grown, and several other crops make up a small percentage (approximately 6 percent) of the total irrigated acreage.

According to the State of Colorado 1993 irrigated acreage datasets[1], there are a total of 124,607 irrigated acres in the study area, of which 26,820 acres are in the White Basin, and 92,787 acres are in the Yampa and Green Basins. The State of Colorado developed a year 2000 irrigated acreage coverage, but CWCB staff has indicated that this coverage is not as reliable as the 1993 coverage and

[1] The 1993 irrigated acreage coverage serves as the basis for the irrigated acreage estimate for the Yampa-White Projects and Methods Study. The State of Colorado developed a year 2000 irrigated acreage coverage, but CWCB staff indicated that this coverage is not as reliable as the 1993 coverage and recommended using only the 1993 acreage (meeting with CWCB staff, May 2009). Additionally, a 2005 irrigated acreage coverage has also been developed by CWCB, however, since the period of record of the study ends in 2005, this coverage has not been included in the CDSS models at the time of this study.

recommended using only the 1993 acreage (per meeting with CWCB staff, May 2009). Average annual agricultural diversions in the study area from 1975 to 2004 are approximately 721,000 acre-feet per year (AFY), with approximately 284,000 AFY in the White Basin and 436,000 AFY in the Yampa Basin according to the Yampa-White-Green Agricultural Water Needs Study (CDM Smith 2010). Groundwater pumping in the basin is minor compared to surface water diversions and is generally not considered for this study or any of the studies mentioned in Section 2.2.

2.3.2 Municipal and Industrial Demands

M&I demands within the Yampa and White Basins are small compared to the basin wide agricultural demands. According to SWSI 2010, current demands, broken down by county, are as shown in **Table 2-1**:

Table 2-1. Existing Municipal and Industrial Demands

County	Water Demand (AFY)
Moffat	3,200
Rio Blanco	2,000
Routt	6,500
Total	11,700

Large Industrial Demands

Large industrial demands are a subset of the M&I demands that usually use a significant amount of water outside of the typical municipal demands. The large industries identified in the Yampa and White Basins were Steamboat Springs snowmaking demands, the Moffat County mining industry demands, and golf courses in Routt County. The total existing demand in the basin by county according to SWSI 2010 is shown in **Table 2-2**.

Table 2-2. Existing Large Industrial Demands

County	Water Demand (AFY)
Moffat	2,600
Rio Blanco	0
Routt	3,800
Total	6,400

2.3.3 Thermoelectric Power Generation Demands

Two thermoelectric power plants exist within the basin—the Craig and Hayden Plants. Power from the Craig Station is part of a system operated by Tri-State that provides electricity to a service area of 200,000 square miles and about 1.5 million customers. The Hayden Plant is located just east of Hayden in Routt County on Highway 40 and is part of the Xcel Energy system. The total existing demand in the basin by county, according to SWSI 2010, is shown in **Table 2-3**.

Table 2-3. Existing Thermoelectric Power Generation Demands

County	Water Demand (AFY)
Moffat	17,500
Rio Blanco	0
Routt	2,700
Total	20,200

2.4 Nonconsumptive Needs

During the last 20 years, Colorado has experienced a high growth rate attracting new residents and businesses. One of the many attractive attributes of Colorado is the recreational opportunities including skiing, golf, hunting, bicycling, camping, hiking, backpacking, reservoir-based recreation, stream and lake fishing, wildlife viewing, rafting and kayaking, boating, and water skiing. Many of these recreational activities are water based (fishing, boating, rafting, kayaking, and water skiing), rely on water to support the activity, or have water as an integral part of the experience. Nonconsumptive needs are established to maintain or improve upon the natural flows supporting these recreational activities that protect environmental or recreational needs.

Nonconsumptive needs, in contrast to consumptive needs, do not remove water from the system. These needs vary from decreed to nondecreed locations and have varying uses from identified fisheries to recreational boating areas.

Two main sources were used in evaluating nonconsumptive needs in the Yampa-White Basin. The CWCB instream flow (ISF) program decreed reaches in which minimum flows necessary to preserve the environment to a reasonable degree have been adjudicated. The second source is the environmental and recreational reaches defined in the Yampa-White Basin Roundtable Watershed Flow Evaluation Tool (CDM Smith 2012), which were re-evaluated in this study.

2.4.1 Environmental Demands

Two types of environmental demands were considered in this study—CWCB ISF reaches and WFET environmental flow metrics. Both environmental nonconsumptive demands are described below.

CWCB ISF Reaches

CWCB ISF reaches are decreed water rights used to protect flow levels in delineated stream reaches throughout the state. The purpose of these ISFs in the Yampa and White Basins is to protect diverse environments including cold water and warm water fisheries, as well as critical habitat for threatened or endangered native fish (CWCB). Since these ISFs have decreed water rights, they may be protected from upstream and intervening junior water users in order to maintain a decreed flow amount. Although there are numerous ISFs, only 30 fall inside the study area of this project, shown in **Table 2-4**. The associated annual average flow amounts are also shown in Table 2-4; however, it should be noted that some of the ISF water rights vary by month. The annual average water right is shown to provide an idea of magnitude of each individual reach. The locations of all modeled ISFs are shown in **Figure 2-2**.

Table 2-4. ISF Reaches in the Projects and Methods Study Area

ISF Reach Name	Annual Average Minimum Flow (cfs)
Bear River (Middle)	7.93
Bear River (Lower)	12.00
Big Creek	15.00
Coal Creek	5.00
Dome Creek	2.00
East Fork Williams Fork	14.19
Elk River (Lower)	65.00
Elk River (Upper)	65.00
Green Creek	5.00
Hunt Creek	5.00
Marvine Creek	40.00

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Table 2-4. ISF Reaches in the Projects and Methods Study Area

ISF Reach Name	Annual Average Minimum Flow (cfs)
Miller Creek	10.00
North Fork Fish Creek	5.00
North Fork White River	70.00
North Fork White River	120.00
Oak Creek	2.00
Phillips Creek	6.00
Service Creek	6.00
Slater Creek	3.00
Soda Creek	5.00
South Fork White River	80.00
South Fork Williams Fork	5.88
Trout Creek (Lower)	5.00
Ute Creek	6.00
White River	200.00
Williams Fork River	20.71
Willow Creek	7.00
Willow Creek	5.00
Willow Spring & Pond	13.00
Yampa River	56.92

Watershed Flow Evaluation Environmental Flow Metrics

Three environmental WFET flow-ecology relationship metrics were evaluated for this study:

- Trout Flow-Ecology Relationship
- Warm Water Fish Flow-Ecology Relationship
- Riparian Vegetation Flow-Ecology Relationship

Trout Flow-Ecology Relationship represents a relationship between current conditions spawning season flows versus naturalized annual flows. Each Trout Flow – Ecology Relationship is assigned a risk level to display the severity of altering flows due to water use impacts. Naturalized flows are defined as streamflows that would have occurred without the impact of human development. They are calculated by adding diversions back into the stream, subtracting reservoir releases and return flows until all human impacts are removed.

Warm Water Fish Flow-Ecology Relationship represents the reduction in potential biomass of warm water fish based on 30-day minimum flows in a stream. Similar to Trout Flow – Ecology Relationship, each Warm Water Fish Flow – Ecology Relationship location is assigned a risk level to display the impact water use has on the stream.

Riparian Vegetation Flow-Ecology Relationship represents the reduction in flood flows (90-day maximum flows during wet years or annual maximum daily flows) between current and naturalized conditions.

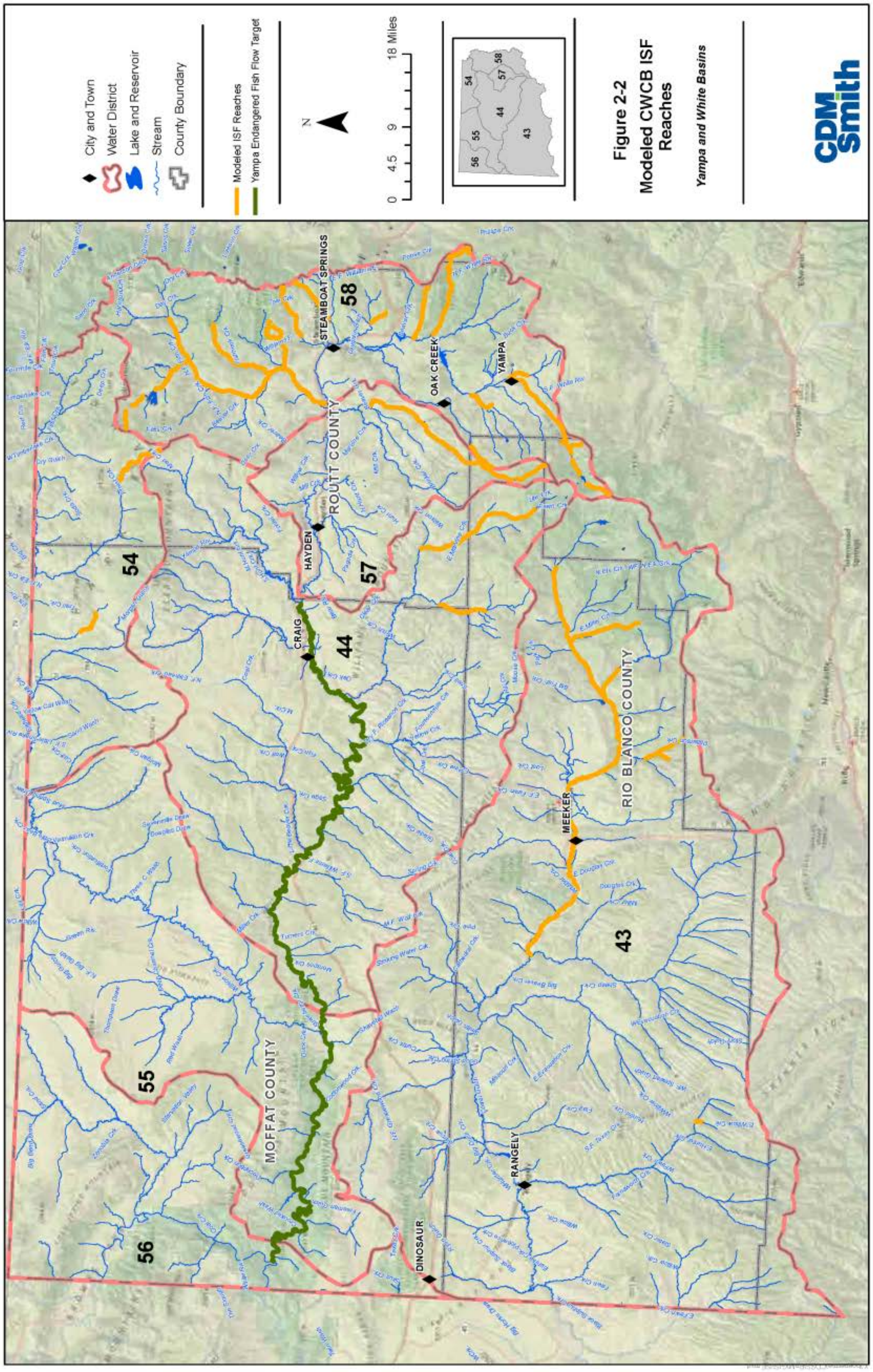
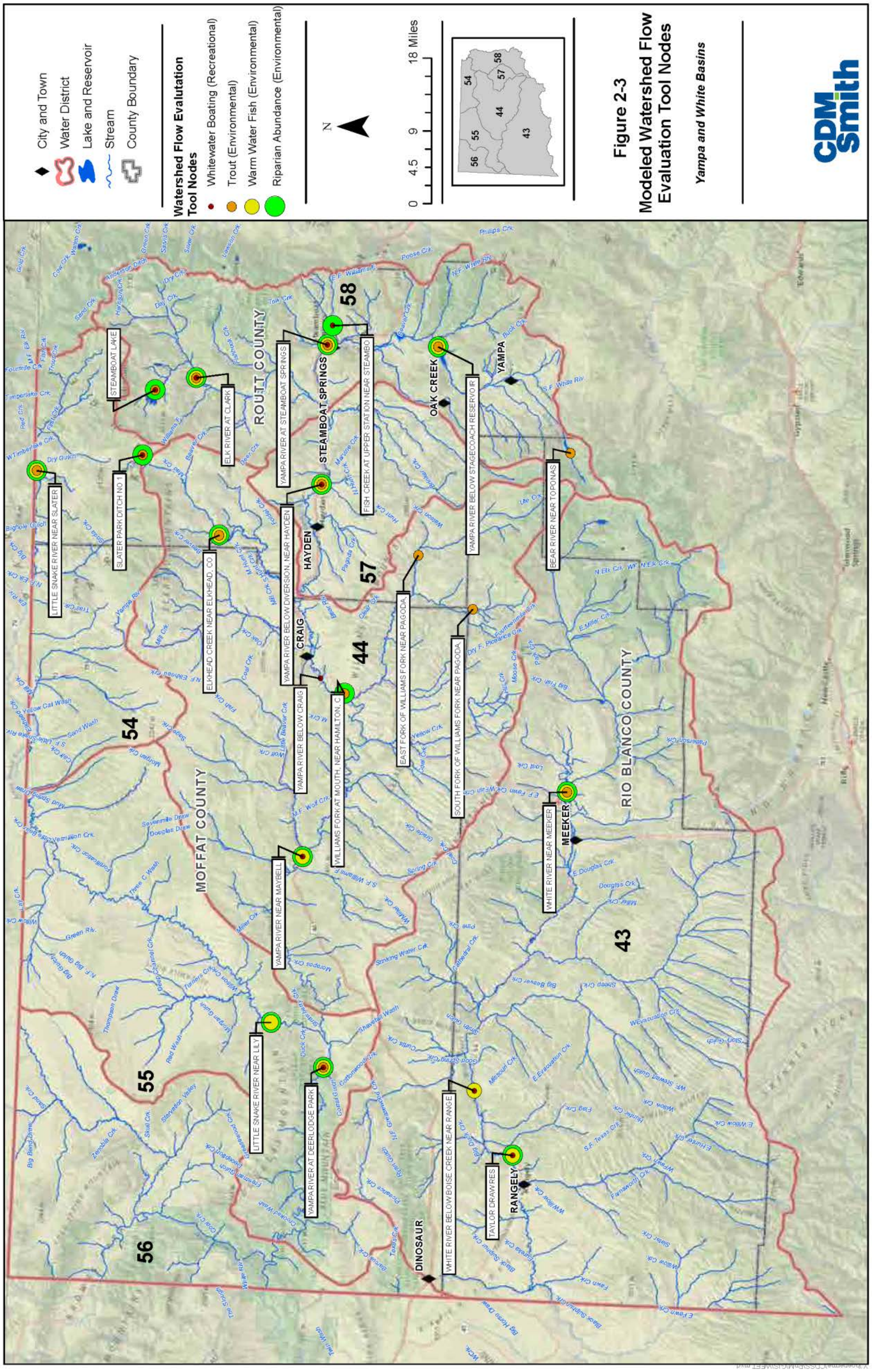


Figure 2-2
Modeled CWCB ISF Reaches
Yampa and White Basins

The WFET metrics were evaluated at a total of 19 locations with environmental nonconsumptive needs based on Table 3-2 of the Yampa-White Basin Watershed Flow Evaluation Tool Final Report. They are as follows:

- Yampa River from entrance of Cross Mountain Canyon (East Cross Mountain) to confluence with Green River
- Yampa River from Pump Station to confluence of Elkhead Creek
- Elk River from headwaters to the County Road 129 Bridge at Clark; including the North, Middle, and South Fork as well as the mainstem of the Elk
- White River from headwaters to Meeker; including the North and South Fork and mainstem of the White
- White River below Kenney Reservoir dam to Utah state line
- White River from Rio Blanco Lake to Kenney Reservoir
- Slater Creek from headwaters to the Beaver Creek confluence
- Elkhead Creek from headwaters to confluence of North Fork of Elkhead Creek
- South Fork of the Little Snake from headwaters to confluence of Johnson Creek
- East Fork of the Williams Fork from headwaters to the confluence of the Forks
- South Fork of the Williams Fork from headwaters to the confluence of the Forks
- Williams Fork from South Fork to confluence of the Yampa River
- Little Snake River from Moffat County Road 10 to confluence of the Yampa River
- Yampa River from Craig (Hwy 394 Bridge) to mouth of Cross Mountain Canyon
- Yampa River from Stagecoach Reservoir "Tailwaters" to northern boundary of Sarvis Creek State Wildlife area
- Fish Creek from Fish Creek Falls to confluence of the Yampa River
- Yampa River from Chuck Lewis Wildlife Area to Pump Station
- Willow Creek below Steamboat Lake to confluence with the Elk
- Bear River from headwaters to U.S. Forest Service (USFS) boundary

Each of these locations is evaluated for one or more of the flow-ecology relationship metrics described above. The location of the nodes and streamflow segments evaluated for environmental purposes in this study are shown in **Figure 2-3**.


City and Town
Water District
Lake and Reservoir
Stream
County Boundary
Watershed Flow Evalutation Tool Nodes
Whitewater Boating (Recreational)
Trout (Environmental)
Warm Water Fish (Environmental)
Riparian Abundance (Environmental)
N
0 4.5 9 18 Miles
Figure 2-3
Modeled Watershed Flow Evaluation Tool Nodes
Yampa and White Basins
MOFFAT COUNTY
ROUTT COUNTY
RIO BLANCO COUNTY
STEAMBOAT SPRINGS
HAYDEN
CRAIG
OAK CREEK
YAMPA
MEEKER
RANGELY
DINOSAUR
LITTLE SNAKE RIVER NEAR SLATER
SLATER PARK DITCH NO 1
STEAMBOAT LAKE
ELK RIVER AT CLARK
ELKHEAD CREEK NEAR ELKHEAD, CO
YAMPA RIVER AT STEAMBOAT SPRINGS
FISH CREEK AT UPPER STATION NEAR STEAMBO
YAMPA RIVER BELOW DIVERSION, NEAR HAYDEN
YAMPA RIVER BELOW CRAIG
WILLIAMS FORK AT MOUTH, NEAR HAMILTON, C
EAST FORK OF WILLIAMS FORK NEAR PAGODA
SOUTH FORK OF WILLIAMS FORK NEAR PAGODA
YAMPA RIVER BELOW STAGECOACH RESERVOIR
BEAR RIVER NEAR TOPONAS
WHITE RIVER NEAR MEEKER
YAMPA RIVER NEAR MAYBELL
LITTLE SNAKE RIVER NEAR LILY
YAMPA RIVER AT DEERLODGE PARK
WHITE RIVER BELOW BOISE CREEK NEAR RANGE
TAYLOR DRAW RES
54
55
56
57
58
44
43

2.4.2 Recreational Demands

The WFET defines locations with recreational boating demands. There are four flow categories defined for each location—low usable flows, optimal usable flows, high usable flows, and unusable flows (which occur outside the usable flows ranges). **Table 2-5** shows the segments studied as a part of the WFET and their usable flow ranges.

Any whitewater boating segments that did not have an indicated measurement gage in either Table 2-5 or within the body of the WFET text were not considered in this study. The location of the nodes and streamflow segments evaluated for recreational boating purposes in this study are shown in Figure 2-3.

Table 2-5. Recreational Whitewater Boating Demand Locations

Segment	Measurement Gage	Minimum (cfs)	Optimal (cfs)	Highest (cfs)
Fish Creek	USGS FISH CR AT UPPER STA NR STEAMBOAT SPRINGS, CO Gage 09238900	400	800-1,000	1,400
Steamboat Town	USGS YAMPA RIVER AT STEAMBOAT SPRINGS, CO Gage 09239500	700	1,500-2,700	5,000+
Elk River Box	USGS ELK RIVER NEAR MILNER, CO Gage 09242500	700	1,000-2,100	5,000+
Elk River - Clark	USGS ELK RIVER NEAR MILNER, CO Gage 09242500	700	1,300-4,000	5,000+
Willow Creek	DWR WILLOW CREEK, BELOW STEAMBOAT LAKE, CO Gage WILBSLCO	300	700-800	1,250
Mad Creek	Visual	400	400-1,000	2,000+
MF Little Snake	Visual	500	800-1,100	2,000+
Slater Creek	Insufficient survey data points to complete usable days analysis	600	1,100-2,100	3,000+
Yampa – Lower Town	USGS YAMPA RIVER ABOVE ELKHEAD CREEK NEAR HAYDEN, CO Gage 09244410	900	1,500	4,000
Little Yampa Canyon	USGS YAMPA RIVER BELOW CRAIG, CO Gage 09247600	1,100	1,700-2,500	10,000+
Cross Mountain Gorge	USGS YAMPA RIVER NEAR MAYBELL, CO Gage 09251000	700	1,500-3,500	5,000
Yampa Canyon	USGS YAMPA RIVER AT DEERLODGE PARK, CO Gage 09260050	1,300	2,700-20,000	20,000+
Gates of Lodore	USGS GREEN RIVER NEAR GREENDALE, UT Gage 09234500	1,100	1,900-15,000	20,000+
SF White River	Insufficient survey data points to complete usable days analysis	700	2,500-3,500	10,000
White River above Kenney Reservoir	Insufficient survey data points to complete usable days analysis	700	1,500-2,500	10,000+
White River Rangely to Bonanza	USGS WHITE RIVER BELOW BOISE CREEK, NEAR RANGELY, CO Gage 09306290	700	1,500-5,000	10,000+

2.5 Water Allocation Modeling Approach

The State of Colorado has developed several CDSS models for some of the major river basins in the state including the White Basin and the Yampa and Green Basins. The CDSS consumptive use model is called StateCU. The consumptive use model was the basis of determining the crop consumptive use for irrigation demands via the modified Blaney-Criddle method. The results from StateCU serve as an input to generate crop irrigation requirements and diversion demands for the StateMod model.

StateMod is the water allocation model in CDSS that is used for the primary purpose of modeling water rights and allocating water to those rights. StateMod uses strict prior appropriations (i.e., first in right, first in line) to model diversions. The resulting outputs of the CDSS StateMod models have uses in water planning, and determining impacts of development in the basin. Initially, it is used to generate naturalized streamflows from historical demands. Secondarily, it is used to simulate baseline and future conditions[2]. These simulations serve as the basis for all output results from simulated stream flow to reservoir contents to diversion shortages. This section describes the process used to generate the outputs used for the Projects and Methods Study.

2.5.1 Agricultural Consumptive Use Model (StateCU)

The CDSS StateCU Documentation (CWCB 2008) describes how crop potential evapotranspiration (ET) is developed:

> StateCU allows either the SCS TR-21 modified Blaney-Criddle or the original Blaney-Criddle procedure to estimate monthly ET. The empirical equation relates ET with mean air temperature and mean percentage daytime hours. The SCS TR-21 method was modified from the original Blaney-Criddle method to reasonably estimate monthly or short-period consumptive use. The modifications include the use of (1) climatic coefficients that are directly related to the mean air temperature for each of the consecutive short periods which constitutes the growing season and (2) coefficients which reflect the influence of the crop growth rates on consumptive use rates (SCS TR-21). StateCU generates an estimate of Irrigation Water Requirement (IWR) for the model area. IWR is defined as the portion of potential ET that would come from irrigation water under a full water supply, i.e., the portion of potential ET that is not satisfied by precipitation.

The information generated by the consumptive use model (StateCU) is used to develop the agricultural demands in the surface water allocation model for the Yampa and White Basins.

2.5.2 Water Allocation Modeling (StateMod)

StateMod is the State of Colorado's water allocation model. StateMod has been developed for the Yampa-Green River Basins and the White River Basin with the latest model update, released in late 2009. The purpose of a water allocation model is to allow a user to simulate existing and/or proposed conditions in the basin using historical or a simulated hydrology. The first step is to estimate baseflows, i.e., flows that would be available to the system in the absence of basin operations (e.g., without diversions, storage, imports). Once baseflows are computed, the model must be calibrated in order to adjust simulated streamflows, diversions, and reservoir operations to reproduce—or come close to reproducing—observed data. Once calibrated, a baseline model is developed that simulates current operations using calculated baseflows. This allows the user to analyze system response under variable operations and "what if" scenarios (e.g., how would Elkhead Reservoir perform under 1950's drought conditions?). The baseline model is also used as a point of comparison for other proposed scenarios. Since diversions and modeling are performed on a naturalized flow, historical changes in irrigation practices and reservoir operations are all removed from gaged flow creating a common platform on which to model.

[2] Future conditions are a set of potential scenarios defined in Section 3. These scenarios are represented by a selection of alternate hydrologies, various levels of future demand forecasting, and IPPs.

Baseflows are the primary water inflows to the water allocation model. In the absence of all basin operations, baseflow is often referred to as naturalized or virgin flow, since this is the amount of flow that would be expected in the stream absent any use or alteration by man. Baseflows are calculated at multiple locations by StateMod using historical gaged data, diversions, changes in storage, return flows, evaporation losses, imports, exports, and physical characteristics of ungaged basins such as precipitation and area.

2.5.3 Baseline Scenario

The baseline model represents current basin conditions and operation, including all reservoirs, water rights, imports, diversions, and return flow patterns while using the historical hydrology and climate over the period of record from 1950 through 2005[3]. The baseline model serves as the point of comparison for all proposed scenarios (e.g., supply projects, climate change, new demands, etc.) and will be used to quantify the benefits and impacts of the proposed scenarios relative to current conditions, which is discussed in Section 3.

For irrigation demands, the baseline scenario uses the IWR time series from StateCU model output for agricultural demands, and computes a demand at the headgate by computing average monthly structure efficiencies based on historical use ($IWR/Demand_{historical}$). Baseline demands are calculated as the maximum of either historical diversion (explicit demand) or IWR divided by the average monthly efficiency (implicit[4] demand). This approach allows IWR to drive demands instead of historical diversions, which allows the user to perform scenarios where IWR increases or decreases to meet future needs.

All other uses (municipal, industrial, instream flows) use a 12-month pattern representing current conditions; i.e., demands for the Town of Craig vary between 60 acre-feet (AF) per month in the winter and 350 AF per month in the summer each year, which is based on the average demands in Craig between 1999 and 2004.

The basis of the water allocation modeling for the Yampa-White-Green Projects and Methods Study are the 2009 releases of the Yampa-Green Basin StateMod model and the White Basin StateMod model. Some modifications to these models were performed per various studies (described further in Section 2.5.5) used to improve the accuracy of some elements within the "off the shelf" CDSS 2009 release.

2.5.4 Existing 2009 Release of the Model

The existing model maintained by CDSS has been in development since 1994 through the present. For each iteration, accuracy improves by incorporating new data as it becomes available as well as taking advantage of new code improvements within the StateMod executable. The 2009 release of both the White and Yampa Basins served as the basis of modeling for this study.

Through the various versions of the models, the developers have attempted to capture existing operations as accurately as possible. New information added to each iteration of the model has come

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[3] The 1950-2005 period of record was used for the Baseline model as well as the models used in the Analyze River Operations task in Section 3.

[4] Implicit demands are demands based on IWR, not on historical record. The demands are based on a function of acreage and climate, calculates IWR using the modified Blaney-Criddle equation. Subsequently, IWR is converted into a headgate demand, (which considers system efficiencies).

from studies performed by consultants, such as this study. The following sections describe some methods used that affect Projects and Methods modeling and results.

Aggregate Irrigation Nodes

In the earliest efforts of development, simulated demands only accounted for approximately 75 percent of the actual water use in the basin. In the following steps of development, the remaining 25 percent of demands were collected together to form aggregate irrigation nodes to model the full 100 percent of demand observed in the basin. The methodology used to determine whether a diversion was explicitly modeled or aggregated is based on the total water rights adjudicated for each diversion. If a diversion's water rights total to a decreed rate of 5 cubic feet per second (cfs) or greater (4.8 cfs or greater for the White River Basin), the diversion was explicitly modeled. If the total decreed rate of a diversion was less than 5 cfs (4.8 cfs for the White River Basin), the diversion was geographically grouped with all other similar sized diversions in the same drainage upstream of the nearest baseflow node. The result was a total of 43 aggregate nodes in the Yampa and White Basins.

This methodology of grouping smaller diversions was applied to other water supply structures within these basins including small M&I diversions, stock ponds, and small reservoirs.

Municipal and Industrial Demands

Modeling for M&I demands in StateMod are nuanced. Details and available information for M&I demands vary widely. Major population centers such as Craig are modeled explicitly, while other smaller demands may be aggregated and grouped together for the entire basin. For example, water rights, historical use, and reservoir water are all available for Craig, CO, which are explicitly modeled. However, in some other parts of the model, less is known about the water use and municipal demands are aggregated (similar to the method used for agricultural aggregates). These minor M&I demands are aggregated in CDSS modeling in the Yampa and White Basins are given super-senior water rights (administration = 1.00000) and are 100 percent consumptive.

Thermoelectric Power Generation Demands

Thermoelectric Power Generation water demands are modeled explicitly, as they represent large water demands. The two thermoelectric diversions in the basin are the Hayden Station and Craig Station. To maintain a constant power supply service—due to having water rights that are junior to some of the agricultural diversions—diversions are augmented with water from Steamboat Lake (Hayden Station), Stagecoach Reservoir, and Elkhead Reservoir (Craig Station). Since there are no returns back to the stream, both power plants are modeled as being fully consumptive.

2.5.5 Previous Study Modifications

Colorado River Water Availability Study

The CRWAS Study was a study funded by the CWCB and led by AECOM to assess the impacts of increasing consumptive and nonconsumptive demands statewide, especially due to the increased concerns of greater climate variability and the droughts associated with this variability. StateMod modeling was used as a basis to determine hydrologic impacts under existing and future conditions. The 2009 release of the CDSS StateMod model was used as a basis for the CRWAS modeling efforts. To maintain a consistent modeling platform that takes all previous known models improvements into consideration, a few modifications were made to the Projects and Methods model based on the CRWAS model.

In the CRWAS existing conditions model, the changes largely revolved around updating water rights and reservoir accounts.

- An additional account for conservation was added to Elkhead Reservoir.
- The High Savery Reservoir and Fish Creek Reservoir area-capacity curves were updated.
- Any updates from HydroBase were added into the model, i.e., diversion capacities, corrections to water rights, etc.
- Releases from Elkhead Reservoir to the Endangered Species Fish Target Flows reach were altered. The Endangered Species Fish Target node was changed into a nonconsumptive diversion (100 percent of the diversion is returned immediately). This method ensured that Elkhead Reservoir releases operate correctly.
- Reservoir rights were altered to more closely reflect which accounts they should fill.

The additional conservation pool for Elkhead Reservoir, the revised area-capacity curves for High Savery and Fish Creek Reservoirs, reservoir fill rights, and the updated HydroBase data were all included in the Projects and Methods model. The operations used in the CRWAS for Elkhead Reservoir releases to the Endangered Species Fish Target Flows were not included since the BRT subcommittee suggested that the WFET releases from Elkhead Reservoir better represent current operations.

Yampa-White Agricultural Needs Study

The Yampa-White Agricultural Needs Study included a significant number of changes to the model including:

- Disaggregating aggregate diversion structures into two structures. These disaggregated structures represent diversions that are on the modeled stream ("A" aggregates) and diversions that are on tributaries to the modeled stream ("B" aggregates). Since "B" aggregates do not exist on the modeled stream, their supplies also differ from that of the modeled stream. Instead, they were given streamflows equal to their historical diversions (the greatest known amount they diverted under historical conditions, and therefore, flows at the "B" aggregate structures were historically at least this high). This methodology models the aggregated diversions with a higher level of accuracy.
- Due to the high frequency of low efficiency diversions in some locations, minimum efficiencies were limited to 30 percent. This effectively brackets demands so that the model does not calculate unreasonably high or low demands. This decision was made to determine if shortages were caused by low system efficiencies or water availability.
- Due to the uneven terrain of the Yampa Basin, it was assumed that the CDSS standard 60 percent maximum flood irrigation efficiency may be an overestimation of what is possible in the Yampa Basin. A 50 percent maximum flood irrigation efficiency was determined by assuming that flood irrigation was 10 percent less efficient from the terrain relative to other basins for which CDSS models have been created.

More information on each of these bullets can be found in Technical Memorandum 1 for the Yampa-White Agricultural Water Needs Study. All three bullets were used from the Agricultural Water Needs Study were included in the Projects and Methods model.

Yampa-White Watershed Flow Evaluation Tool

The Yampa-White WFET (CDM Smith 2012) was incorporated into the Projects and Methods modeling to assess nonconsumptive needs in the basin.

The methodology introduced in the CRWAS study for operational releases from Elkhead Reservoir to the Endangered Species Fish Flow target was not used. The WFET methodology releases stored water from Elkhead in line with suggestions from the Programmatic Biological Opinion (PBO) (U.S. Fish and Wildlife Service [USFWS] 2005). In previous models (CRWAS and the CDSS 2009 release of the StateMod models), releases from Elkhead were made available for diversion immediately downstream of the Yampa River stream gage at Maybell. The modeling method used in the WFET, instead, protects Elkhead Releases from Maybell to the Little Snake River, which acts as a critical flow point in the model.

After discussions with the BRT subcommittee and the Division Engineer, it was decided to implement the WFET methodology for modeling Elkhead releases due to the fact it better represents how the releases are operated.

Yampa-White-Green Basin Roundtable Subcommittee Discussion

For Task 1 of the Projects and Methods Study (Developing a Common Understanding of Water Needs in the Basin), the main concerns revolved around discrepancies in the model from actual operations and how they may cause the model to misrepresent shortages and available water. Specifically concerns were raised regarding operations in Elkhead Reservoir, Steamboat Lake, and Stagecoach Reservoir. In later meetings, further concerns regarding water availability on Fortification Creek surfaced. The following discussion provides a brief summary of the concerns that arose for the operations of these three reservoirs and the path used to proceed forward.

Steamboat Lake

Steamboat Lake is a jointly owned reservoir with storage accounts for Xcel Energy and Colorado Division of Parks and Wildlife (CPW). Steamboat Lake is used largely for recreational purposes; however, due to the original funding by the Salt River Generating Co. and Colorado-Ute Electric Association (predecessors to Xcel Energy), a perpetual 5,000 AF is stored in Steamboat Lake to firm the supply for the Hayden Station Power Plant. CDM Smith had conversations with Bahman Hatami from CPW and Amy Willhite from Xcel Energy.

Per a phone conversation on May 10, 2013, Mr. Hatami's comments regarding Steamboat Lake were that storage is used explicitly for recreational purposes until Labor Day. After Labor Day, the most junior water right for 3,155 AF of storage is used to meet ISF water rights for portion of the Elk River ISF downstream of Steamboat Lake and Willow Creek. The remaining 23,209 AF of water is retained in the lake year-round for recreational purposes or releases to the Hayden Station.

Per a phone conversation on May 8, 2013, Ms. Willhite's comments confirmed that Xcel Energy owns 5,000 AF of storage in Steamboat Lake and also confirmed that Hayden Power Plant uses between 5,000 AFY and 5,500 AFY of water on average, and releases from Steamboat Lake have only ever been made once (in 2002) to meet demands. She had no other comments regarding required modifications.

Stagecoach Reservoir

Stagecoach Reservoir stores water for multiple benefits operated by the Upper Yampa Water Conservancy District (UYWCD). Supplementing M&I demands and leasing to ISF locations are among

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the uses in Stagecoach. Kevin McBride of the UYWCD voiced concerns that the 2009 release of the Yampa StateMod model was not accurately representing current operations of Stagecoach Reservoir and that the operations in the 2009 release of the model were outdated. The UYWCD and AMEC were concurrently working on a model for the UYWCD Master Plan. In the UYWCD study, some changes were made to the 2009 release of the CDSS model for Stagecoach Reservoir. The modifications AMEC made to the model were:

- Changing Stagecoach Reservoir storage accounts to the following:
  - Tri-State – 7,000 AF
  - Municipal Storage – 2,000 AF
  - Emergency Remainder – 15,000 AF
  - Preferred Remainder – 3,275 AF
  - Augmentation Pool – 2,000 AF
  - Yamcolo Exchange Pool – 4,000 AF
  - Raise – 3,185 AF
- Releases to generate hydropower have been turned off. Mr. McBride suggested that Stagecoach Reservoir's operational flexibility should be modeled without releases to Stagecoach Hydropower. Making hydropower releases could understate un-contracted water needs within the basin. Evaluating operations of storage at Stagecoach to meet additional uses than those currently modeled the large municipal and power plant uses, will need to be completed after a shortages in the basin are evaluated.
- Five wells identified in the Steamboat Water Supply Plan (Stantec 2008) were added as diversion structures.
- Releases are made from Stagecoach Reservoir to the wells.
- Releases from Stagecoach Reservoir are made to the Colorado Water Trust (CWT) lease to meet to the Upper Yampa River ISF.
- Releases from Stagecoach Reservoir for a minimum 20 cfs flow criteria between August and November can be made from the remainder pool.
- Although not related to Stagecoach Reservoir, the Stantec model also identified an 8 cfs conditional water right on the Elk River belonging to Steamboat Springs that the UYWCD also included in their study.

The enhancements developed by the UYWCD and AMEC were incorporated into the Projects and Methods modeling. The well "diversions" from the Steamboat Water Supply Plan included by AMEC were included as well as all of the modifications to the modeling representation, except for the releases made for the CWT lease for minimum flow requirements and the 8 cfs Steamboat Springs Supply. The CWT minimum flow requirements were not included in the baseline scenario of the Projects and Methods Study because they are part of a temporary lease or are currently a conditional water right; only permanent agreements are included in the Projects and Methods models. The 8 cfs Steamboat Springs Supply was not included as it is not part of the existing infrastructure in the basin and it represents an IPP that will be discussed further in Section 3.

Elkhead Reservoir

Elkhead Reservoir makes releases to the Craig Station Power Plant, the City of Craig, and the Endangered Species Fish Flow Target at Maybell. Don Meyer from the Colorado River Water Conservation District (CRWCD) was contacted on May 7, 2013, to confirm operations of Elkhead Reservoir were accurately represented. Mr. Meyer said that releases to the Craig Station Power Plant were infrequent and small. He also suggested that the actual releases to the Endangered Species Fish Flows have not been finalized yet and that the flow targets defined in the WFET and used in the Projects and Methods model sounded reasonable.

To summarize the WFET methodology used in the Project and Methods model, Elkhead releases are made to meet a target based on flows at the Yampa River at Maybell gage up to 50 cfs. Releases are made from only the CWCB 5,000 AF of storage, as the additional storage that CWCB may lease from the CRWCD is not permanent and therefore not included in the baseline run. The releases from Elkhead Reservoir are protected from any diversions along the reach down to the confluence with the Little Snake River, which was determined to be the critical point in the model during the WFET study. To further clarify this, only the releases from Elkhead Reservoir are protected over the length of this reach, diversions located within the Endangered Species Fish Flow Reach may still divert native water.

Tri-State Thermoelectric Energy

Per a phone call on May 8, 2013, CDM Smith spoke with George Fosha who acted as a representative for Tri-State and the Craig Power Plant. Mr. Fosha had few suggestions regarding current operations of the Craig Power Plant. Mr. Fosha's main comment was that their storage is used differently than the way the model represents it. Mr. Fosha said that there are three units in Craig Station for which the demand is split evenly across all three units. The Craig Power Plant owns storage in both Stagecoach Reservoir (7,000 AF) and Elkhead Reservoir (8,400 AF). Demands from units 1 and 2 (two-thirds of the total demand) are supplemented by storage in Elkhead Reservoir and demands from unit 3 (one-third of the total demand) are supplemented by Stagecoach Reservoir.

This modeling had not been performed in any previous studies. A limitation of the model is that releases will be made entirely from whichever reservoir has a senior operating rule. If two reservoirs share the same operation seniority, the model will make releases from whichever reservoir appears first in that file. To overcome that limitation, the Craig Power Plant demands were broken down into two separate nodes; one representing units 1 and 2 and the other node representing unit 3. Demands were divided evenly amongst the three units; therefore, the first node accounts for two-thirds of the original demand and the second node accounts for one-third of the original demand. Elkhead Reservoir makes releases to the first node (with two-thirds of demand), while Stagecoach makes releases to the second node (with one-third of demand).

Fortification Creek

During the September 18, 2013 BRT subcommittee meeting, Tom Gray raised some concerns regarding the representation of preliminary shortages shown on Fortification Creek. Although the majority of the diversions in the Fortification Creek drainage show shortages, Wisconsin Ditch, which is the largest, most senior diversion in the drainage, does not. After reviewing the preliminary modeling output from the subcommittee meeting, Wisconsin Ditch shows few shortages for the following reasons:

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- The simulated diversions for Wisconsin Ditch show that water is available to divert throughout the season in a majority of years. This conflicts with personal observations from Mr. Gray that water is only available in the late irrigation season during the wettest irrigation seasons.
- The simulated water available from soil moisture may be overestimated in this area. Anecdotal evidence from Mr. Gray suggests that within 2 weeks of his last diversion, his crops start showing stress, whereas the model simulates that crop IWR is fully met almost every year by diversions and soil moisture.
- Due to the uneven terrain observed in the Fortification Creek Basin, it is not likely that irrigation efficiencies are as high as in the rest of the basin.

For this reason, some modifications were made to diversions in the Fortification Creek drainage. The 2009 release of the CDSS Yampa StateMod model applied an available water content (AWC) factor of 15 to 18 percent to the structures on Fortification Creek. Soil moisture is calculated for each diversion as a function of AWC, root depth, and irrigated acreage. AWC was reduced by 75 percent (down to 4.5 percent) to simulate the reduced soil moisture observed in the field. This AWC was determined by a sensitivity analysis at Wisconsin Ditch to show that approximately one-half of a month of crop consumptive use needs could be met with the AWC equal to 4.5 percent. This modeling change more accurately represents the soil moisture conditions that Mr. Gray observes.

The 2009 release of the CDSS Yampa StateMod model applied a maximum flood efficiency of 54 percent (60 percent flood irrigation efficiency and 90 percent system efficiency), which had been reduced system wide to 50 percent per the modifications described from the Agricultural Water Needs Assessment. A further reduction in flood irrigation efficiencies was applied to diversions in the Fortification Creek drainage; all structures were given a 40 percent maximum efficiency (calculated as 45 percent flood irrigation efficiency and 90 percent system efficiency).

In addition to these modeling modifications, through subsequent conversations with Mr. Gray, it was determined that both the 1993 acreage (542 acres) and the 2000 acreage (462 acres) used in the model underestimates actual acreage that Mr. Gray irrigates. Mr. Gray was able to provide documentation for a 1988 SCS study for a syphon project for Wisconsin Ditch that estimated the irrigated acreage to be 1,040 acres. This was used in the model instead.

Following this discovery, the BRT subcommittee recommended a verification of irrigated areas for a select number of ditches. They identified two structures on the Little Snake River, one on the Williams Fork, one on the Elk River, and one on Hunt Creek in the upper Yampa River Basin and requested that the Water Commissioners contact the owners to see if they disagreed with the 1993 irrigated acres used in the model. The Water Commissioners found that the owners did not disagree with the 1993 irrigated acres used in the model.

Additional Modeling

Two additional modeling steps were required during the baseline development in preparation of the future scenarios modeling. These modifications revolved around the additions of Peabody-Trout Creek Reservoir and the Morrison Creek Project, which will be described in further detail in Section 3.

A separate study performed by URS and Ecological Resource Consultants, Inc. (ERC) to evaluate the proposed Peabody-Trout Creek Reservoir revealed that the Trout Creek baseflow node was overestimating observed flows at the headwaters. The Area-Precipitation factors were reduced in the Projects and Methods model in line with the URC/ERC study.

In addition to the modifications shown in the Stagecoach Reservoir section above, AMEC and CDM Smith worked together to add an additional baseflow node on Morrison Creek to allow for modeling the Morrison Creek Project during the future scenarios modeling.

The addition/modification of these baseflow nodes required CDM Smith to re-run the "baseflows" module in StateMod to generate a new naturalized flow file. To maintain a mass balance in StateMod, any difference simulated between any two baseflow nodes is considered a gain (if positive) or a loss (if negative) and originate from unmeasured tributaries or groundwater inflow or outflow. All gains or losses are realized in their entirety at the downstream baseflow node. Altering the baseflow nodes for Trout Creek and Morrison Creek simply reduce any gains observed on the reach to which they are confluent and instead explicitly models them[5].

2.5.6 Output Tool

An output tool was generated in order to provide a method to visualize user defined data without significant understanding of how StateMod works. The output tool is made up of a series of tabs that allow the user to select a modeled location and look at each data type for each model scenario. The data types extracted from the model and imported into the tool are:

- Flows
- Diversions
- CU Shortages
- Reservoir End-of-Month Contents
- Instream Flow Reach Shortages
- Nonconsumptive Metrics for all WFET nodes

The output tool allows the user to visualize each dataset in both a time series format as well as a monthly average format. A "slider" bar allows the user to select subsets of the period of record, and checkboxes allow the user to hide model scenario datasets, so comparisons between model scenarios are clearer.

This model output tool was developed modularly; this allows the user to compare results of the baseline to other modeling scenarios (further explained in Section 3). Any additional models developed as a part of the additional funding may also be added to the existing tool and visualized along with the model scenarios developed in the Projects and Methods Study.

A copy of the tool is included with this report as an electronic appendix (Appendix A).

[5] Instead of realizing the gains along the reaches containing Trout Creek and Morrison Creek entirely at the downstream baseflow node, flows from Trout Creek or Morrison Creek are explicitly accounted for at Trout Creek and Morrison Creek.

2.6 Consumptive and Nonconsumptive Gaps

In the Yampa-White Agricultural Needs Study, agricultural diversions were categorized by annual average demand and average annual percent of CU that is short ($\frac{CU\ Short}{CU}\ x\ 100\%$). Where the method used in the Agricultural Needs Study focused on agriculturally short ditches, the Projects and Methods scope is significantly larger and includes agricultural, M&I, and thermoelectric demands. The method used in the Agricultural Needs Study is still very effective in showing the locality of any type of shortage, consumptive or nonconsumptive. The consumptive and nonconsumptive shortages for these three demands are described in the following sections.

Figures 2-4 through 2-10 show each modeled diversion as well as the nonconsumptive demand locations.

2.6.1 Agricultural Gaps

There are two types of shortages calculated in StateMod, total (or diversion) shortages and CU shortages. Both offer advantages in portraying where the most severe and most frequent shortages occur. Diversion shortages are the difference between the diversion demand and the amount of water physically and legally available in the stream. For agricultural demands, CU shortage is the difference between IWR and the amount of water actually diverted and multiplied by the diversion's maximum application efficiency.

For the purpose of both the Agricultural Needs Study and the Projects and Methods Study, CU shortage was used in both cases. Using CU shortage avoids reporting shortages if crop consumptive needs are met, not if maximum allowable legal diversions are not met. That is, CU shortages represent the difference between the amount of water required to meet the crop irrigation requirement and the amount of water delivered to the crops.

As shown in Figures 2-4 through 2-10, the greatest shortages occur on upper tributaries, such as Piceance Creek, Morapos Creek, Fortification Creek, and the "B" aggregates. **Table 2-6** shows the shortages for all agricultural diversions in the study area. The modeled structure name, water district ID (WDID[6]), average annual diversion amount, and average percentage of IWR not met are included in Table 2-6. These shortages should be evaluated, along with others, with respect to basin needs in order to evaluate IPP's, new projects, reservoir operations and administrative options.

[6] WDID is the primary structure identifier used in CDSS modeling. The first 2 digits of the WDID represent the water district in which the structure resides. For explicitly modeled structures, the last four digits represent the structure number; e.g., Beckman Ditch is structure 537 and it resides in water district 43; therefore, the WDID is 430537.

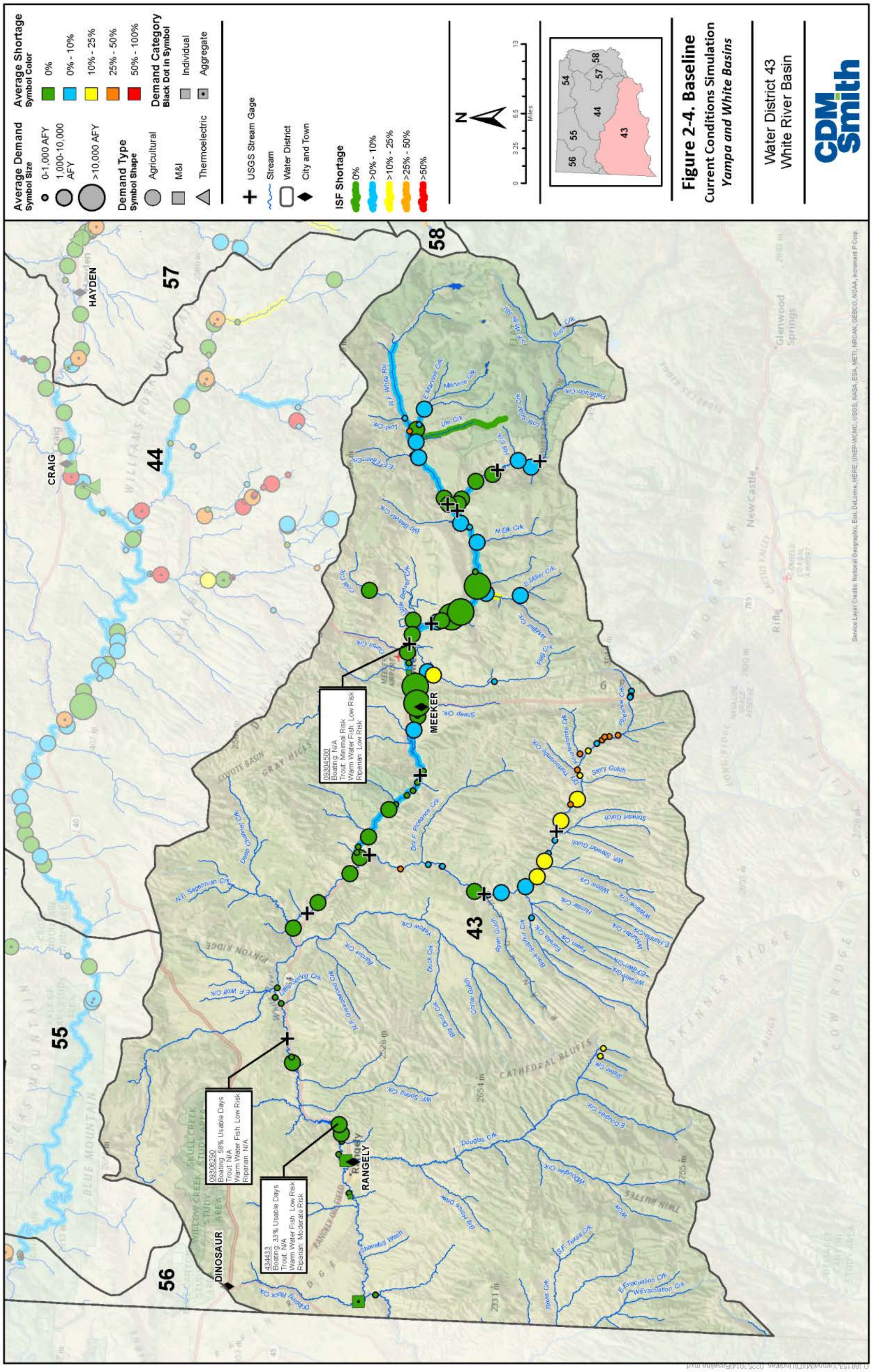
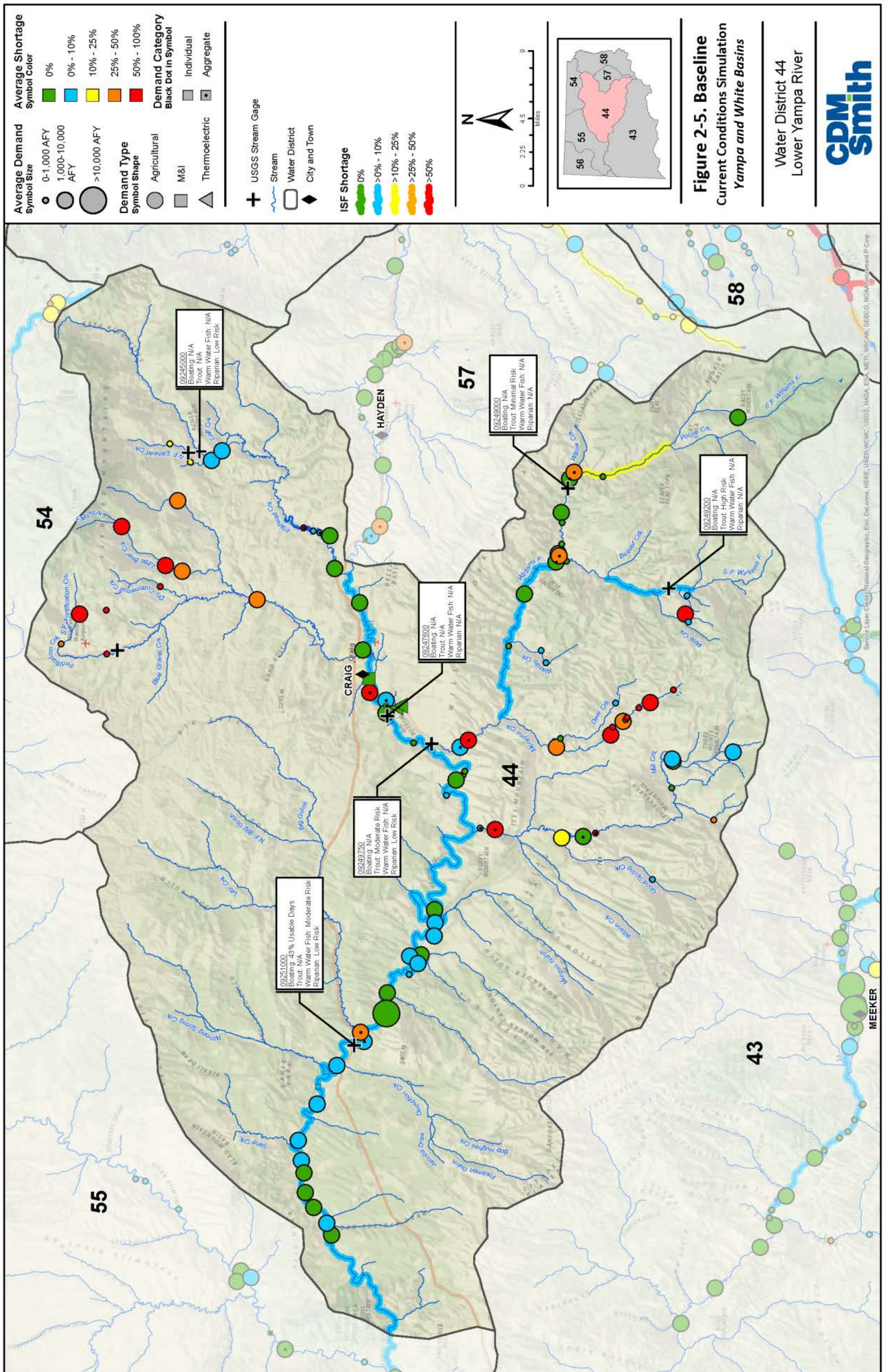


Figure 2-4. Baseline
Current Conditions Simulation
Yampa and White Basins


Average Demand
Symbol Size
0-1,000 AFY
1,000-10,000 AFY
>10,000 AFY
Demand Type
Symbol Shape
Agricultural
M&I
Thermoelectric
Average Shortage
Symbol Color
0%
0% - 10%
10% - 25%
25% - 50%
50% - 100%
Demand Category
Black Dot in Symbol
Individual
Aggregate
USGS Stream Gage
Stream
Water District
City and Town
ISF Shortage
0%
>0% - 10%
>10% - 25%
>25% - 50%
>50%
Miles
Figure 2-5. Baseline
Current Conditions Simulation
Yampa and White Basins
Water District 44
Lower Yampa River
CRAIG
HAYDEN
MEEKER
54
55
56
57
58
43
44
09245000
Boating: N/A
Trout: N/A
Warm Water Fish: N/A
Riparian: Low Risk
09249000
Boating: N/A
Trout: Minimal Risk
Warm Water Fish: N/A
Riparian: N/A
09247600
Boating: N/A
Trout: N/A
Warm Water Fish: N/A
Riparian: N/A
09249200
Boating: N/A
Trout: High Risk
Warm Water Fish: N/A
Riparian: N/A
09249750
Boating: N/A
Trout: Moderate Risk
Warm Water Fish: N/A
Riparian: Low Risk
09251000
Boating: 43% Usable Days
Trout: N/A
Warm Water Fish: Moderate Risk
Riparian: Low Risk

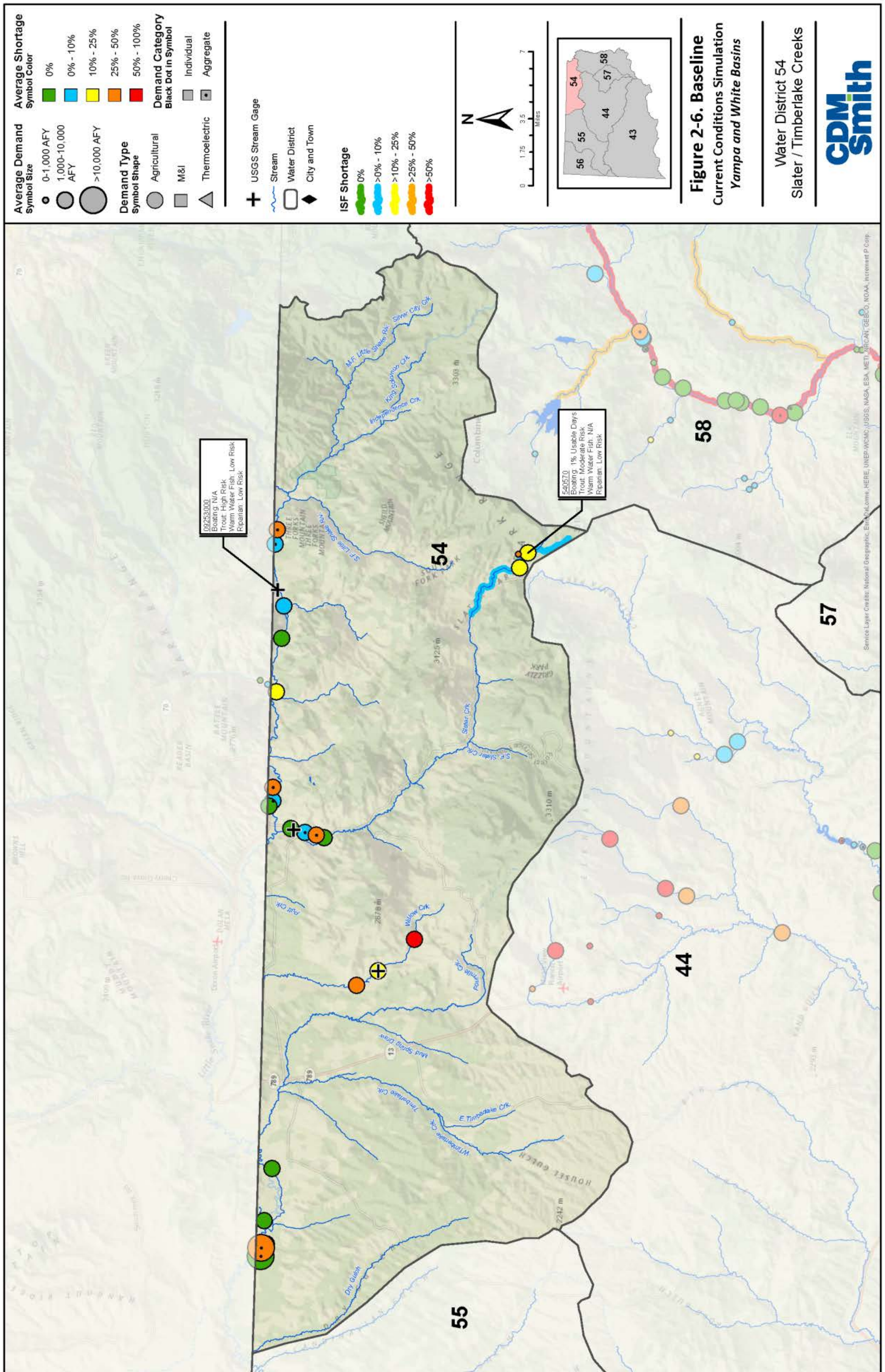


Figure 2-6. Baseline
Current Conditions Simulation
Yampa and White Basins
Water District 54
Slater / Timberlake Creeks

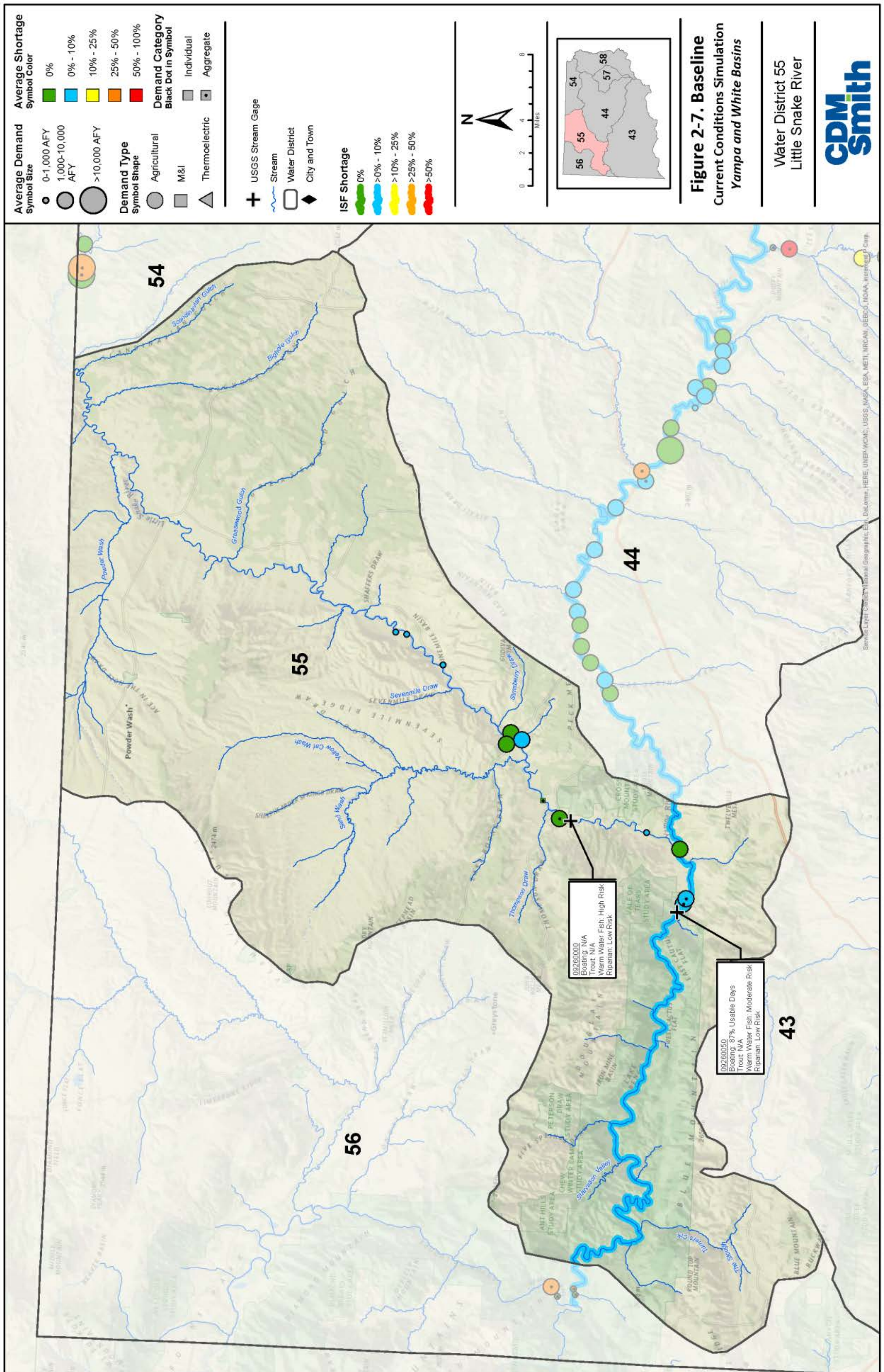


Figure 2-7. Baseline
Current Conditions Simulation
Yampa and White Basins

Water District 55
Little Snake River

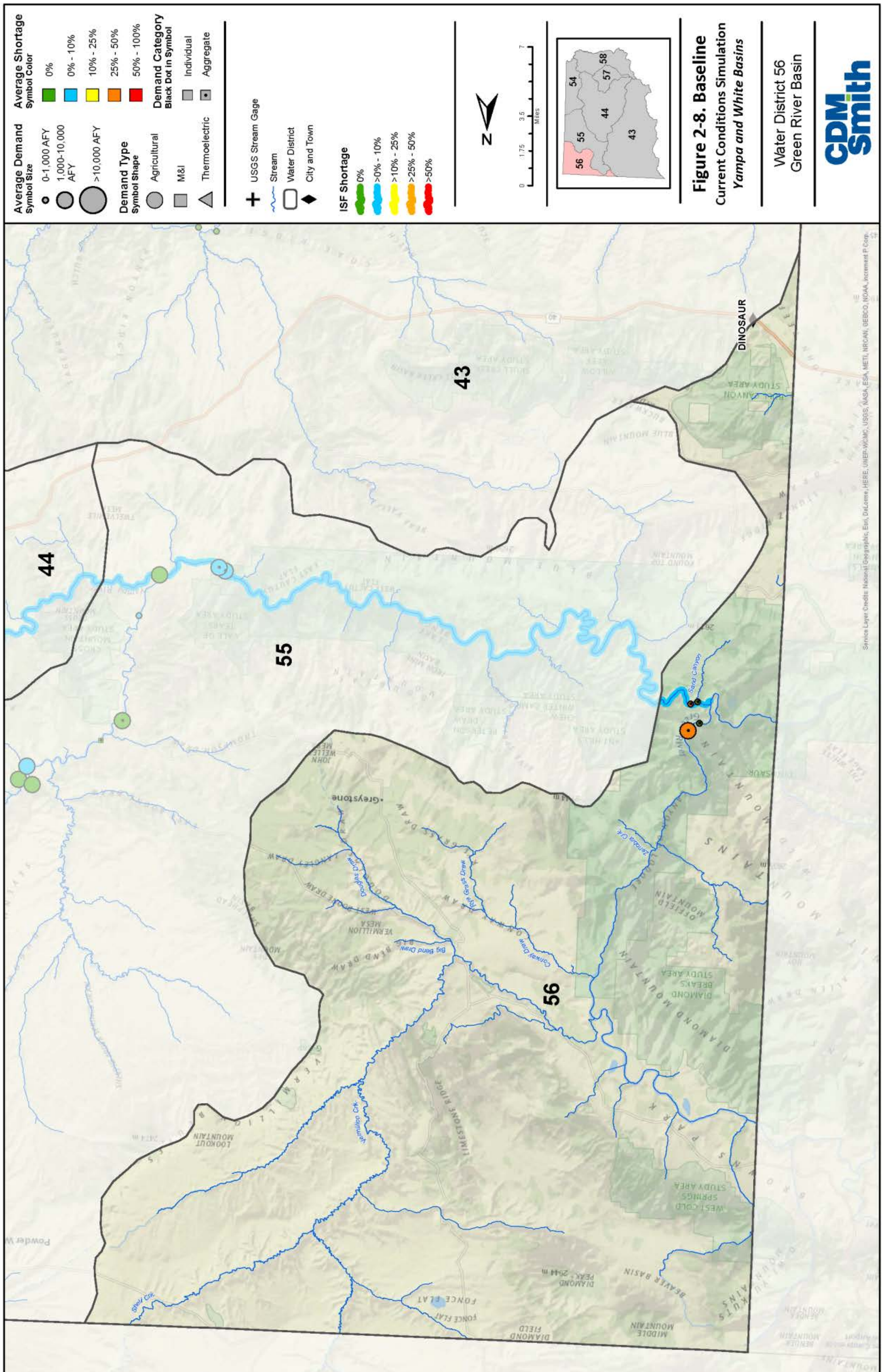
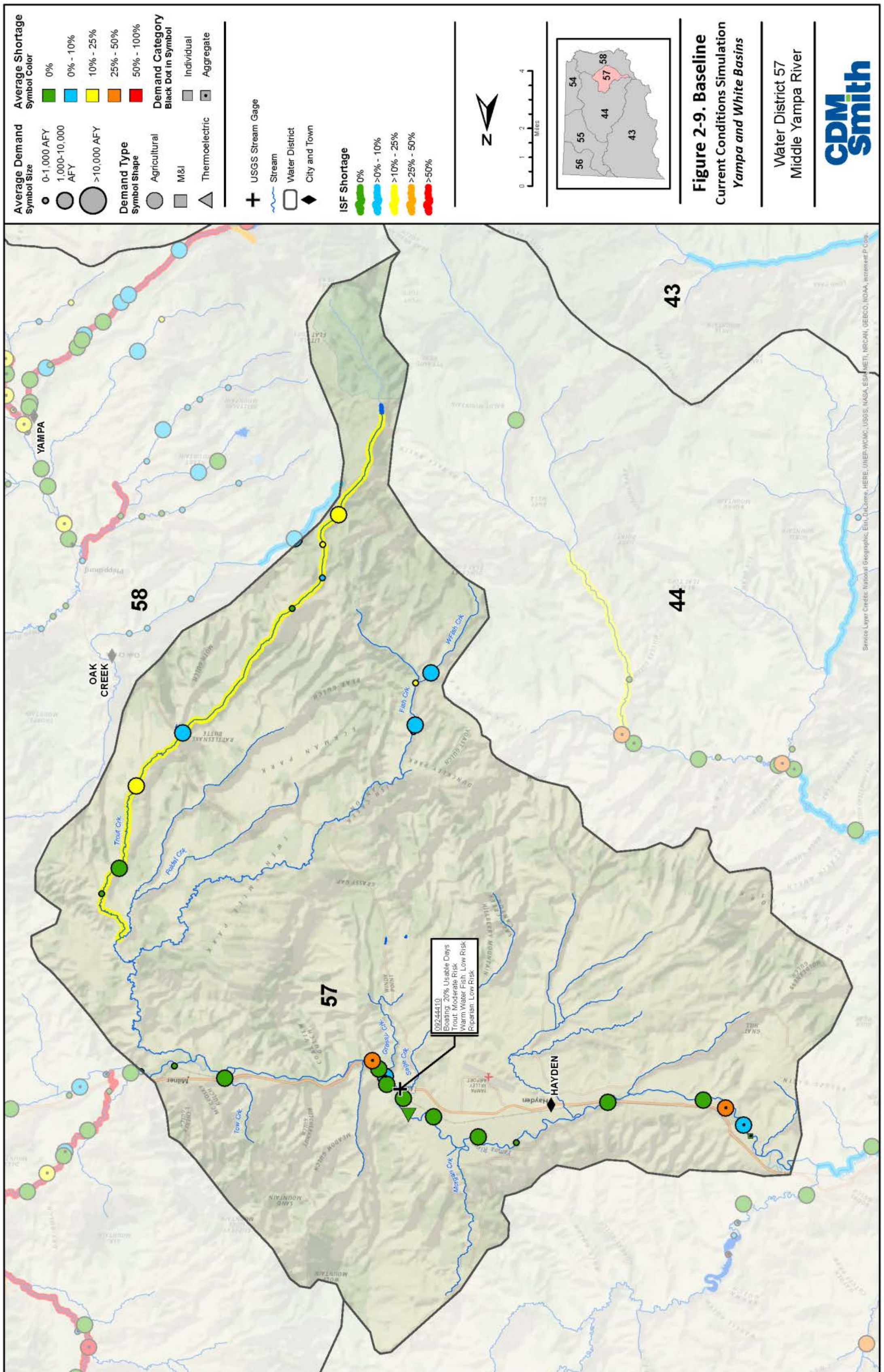


Figure 2-8. Baseline
Current Conditions Simulation
Yampa and White Basins


Average Demand
Symbol Size
0-1,000 AFY
1,000-10,000 AFY
>10,000 AFY
Demand Type
Symbol Shape
Agricultural
M&I
Thermoelectric
Average Shortage
Symbol Color
0%
0% - 10%
10% - 25%
25% - 50%
50% - 100%
Demand Category
Black Dot in Symbol
Individual
Aggregate
USGS Stream Gage
Stream
Water District
City and Town
ISF Shortage
0%
>0% - 10%
>10% - 25%
>25% - 50%
>50%
N
Miles
Figure 2-9. Baseline
Current Conditions Simulation
Yampa and White Basins
Water District 57
Middle Yampa River
CDM Smith
YAMPA
OAK CREEK
HAYDEN
57
58
43
44
09244410
Boating: 20% Usable Days
Trout: Moderate Risk
Warm Water Fish: Low Risk
Riparian: Low Risk

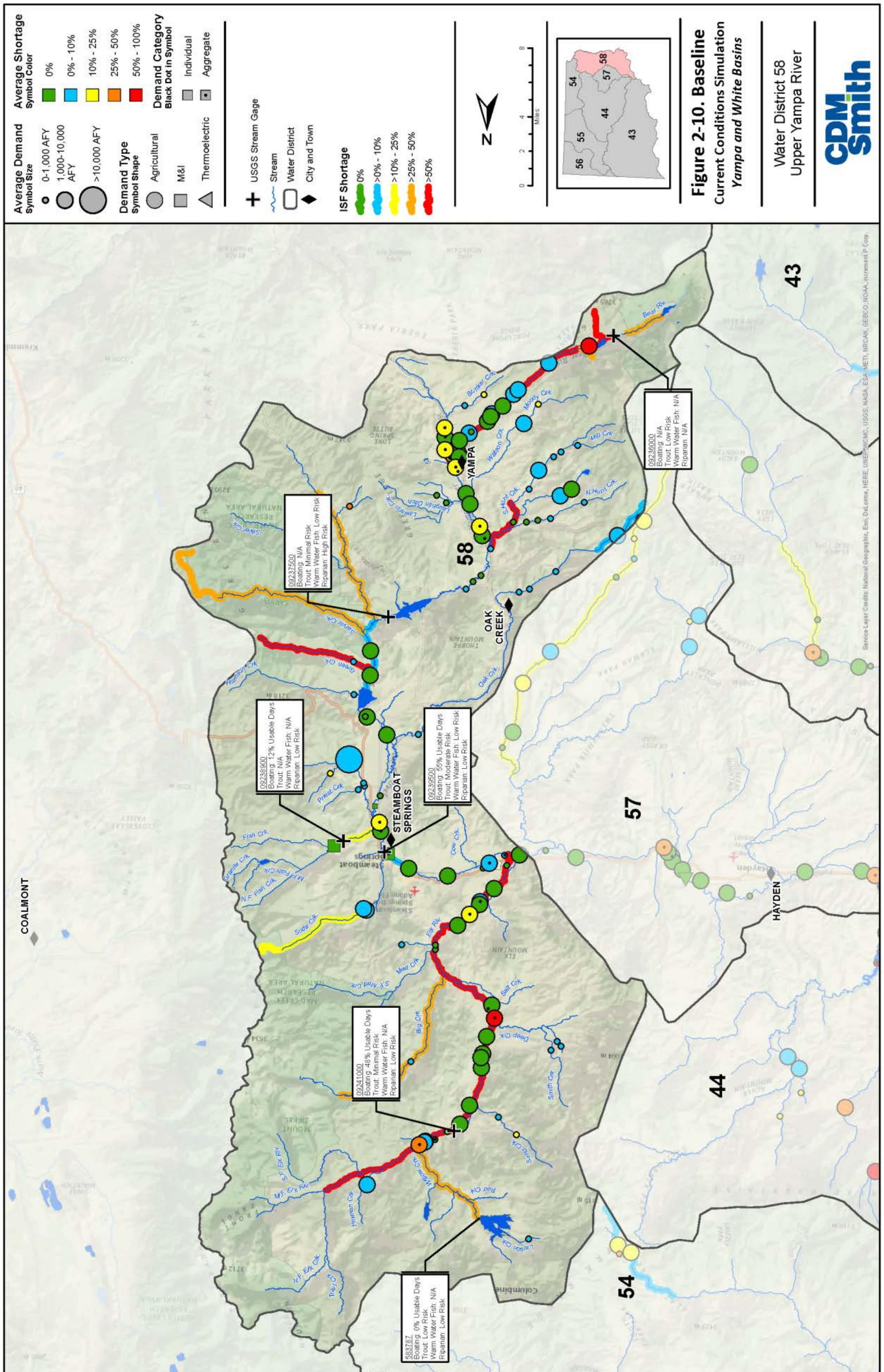


Figure 2-10. Baseline
Current Conditions Simulation
Yampa and White Basins

CDM Smith

Table 2-6. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
NORT_ADW WhiteNorthF	43_ADW001A	1,560	0.0%
NORT_ADW WhiteNorthFB	43_ADW001B	5,040	0.0%
SOUT_ADW WhiteSouthF	43_ADW002A	360	0.0%
SOUT_ADW WhiteSouthFB	43_ADW002B	2,020	0.0%
WHIT_ADW WhiteAbCole	43_ADW003A	1,040	0.0%
WHIT_ADW WhiteAbColeB	43_ADW003B	3,340	0.0%
WHITE RIVER NEAR MEEKERB	43_ADW004B	3,110	0.0%
WHIT_ADW WhiteNBLMee	43_ADW005A	80	0.0%
WHIT_ADW WhiteNBLMeeB	43_ADW005B	750	0.0%
WHIT_ADW WhiteAbPice	43_ADW006A	320	0.0%
WHIT_ADW WhiteAbPiceB	43_ADW006B	480	0.0%
PICE_ADW Upper	43_ADW007A	2,900	22.3%
PICE_ADW UpperB	43_ADW007B	930	0.0%
PICE_ADW PicCrBlRioB	43_ADW008A	780	18.7%
PICE_ADW PicCrBlRioBB	43_ADW008B	300	41.4%
PICE_ADW PicCrAbHunt	43_ADW009A	760	54.3%
PICE_ADW PicCrAbHuntB	43_ADW009B	3,260	1.4%
PICE_ADW PicCrBlRyan	43_ADW010B	5,300	4.3%
PICE_ADW Piceance@Wh	43_ADW011A	850	7.8%
PICE_ADW Piceance@WhB	43_ADW011B	1,540	4.4%
WHIT_ADW WhiteBlBois	43_ADW012A	2,230	0.0%
WHIT_ADW WhiteBlBoisB	43_ADW012B	4,350	0.0%
WHIT_ADW WhiteBlDoug	43_ADW013A	2,310	0.0%
WHIT_ADW WhiteBlDougB	43_ADW013B	2,450	0.0%
WHIT_ADW WhiteNrStat	43_ADW014A	2,700	0.0%
EVAC_ADW Evac Creek	43_ADW015A	1,990	4.6%
EVAC_ADW Evac CreekB	43_ADW015B	140	8.8%
WHIT_ADW WhiteSBLMee	43_ADW016A	120	39.4%
WHIT_ADW WhiteSBLMeeB	43_ADW016B	870	0.0%
WHIT_AMW AggMuni&Ind	43_AMW001	1,100	0.0%
B A & B DITCH NO 1	430511	1,940	0.4%
B M & H DITCH 1	430513	1,250	2.8%
BARBOUR NORTH SIDE D	430526	1,270	0.0%
BECKMAN DITCH	430537	2,220	1.0%
BIG BEAVER DITCH	430539	1,120	3.8%
BLACK EAGLE D NO 1	430543	320	3.7%
BLACK EAGLE D NO 2	430544	310	5.3%
BLAIR DITCH	430546	1,440	0.0%
CALHOUN DITCH	430563	320	0.0%
CALIFORNIA CO WATER	430564	510	0.0%
CALVAT DITCH	430570	860	0.0%
CHARLIE SMITH DITCH	430572	1,680	0.0%
CHASE & COLTHARP D	430573	700	0.0%
CLOHERTY DITCH	430575	1,060	0.0%
COAL CREEK FEEDER DI	430577	520	0.0%
COAL CREEK MESA DITC	430578	4,650	0.0%
DORRELL DITCH 2	430605	400	0.0%
DREIFUSS DITCH	430607	1,710	0.0%
DREYFUSS DITCH	430608	1,450	5.4%
ELK CREEK DITCH	430623	1,310	2.7%
EMILY DITCH	430625	930	2.5%
FORNEY CORCORAN DITC	430640	1,130	0.0%
G V DITCH	430652	1,290	4.7%

Table 2-6. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
GEORGE S WITTER DITC	430653	1,590	0.0%
GREENSTREET DITCH EX	430665	770	0.4%
HANRAHAN DITCH NO 1	430678	100	35.2%
HAY BRETHERTON DITCH	430681	4,290	0.0%
HAY DITCH 2	430684	660	0.0%
HEFLEY PUMP PLANT NO	430687	1,110	0.0%
HEFLEY PUMP PLANT NO	430688	1,070	0.0%
HERWICK DITCH 1	430693	310	43.2%
HIGHLAND DITCH	430694	32,140	0.0%
HILL CREEK NO 3 DITC	430695	750	4.7%
HILL CREEK NO 2 DITC	430696	1,830	0.9%
HOME DITCH	430701	690	1.6%
IMES & REYNOLDS DITC	430710	2,460	0.0%
INDEPENDENT DITCH	430711	730	0.0%
IVO E SHULTS D & PUM	430714	320	0.0%
JAMES HAYES DITCH	430718	1,150	0.2%
JANES DITCH	430719	50	37.1%
LAKE CREEK POOL DITC	430753	330	22.5%
LARSON DITCH	430754	710	4.2%
LAWRENCE DITCH NO 1	430758	610	0.0%
LITTLE DITCH	430769	2,020	0.0%
LOWLAND DITCH	430777	2,520	7.0%
M H M GERMAN CONS D	430782	1,300	2.8%
MARCOTT DITCH	430788	4,240	0.0%
MARTIN DITCH	430789	1,300	0.0%
MARVINE DITCH 1	430790	1,280	0.0%
MARVINE NO 3 DITCH	430791	600	1.0%
MEEKER DITCH	430808	4,310	0.0%
MEEKER POWER DITCH	430809	210	0.0%
MELVIN DITCH	430813	650	1.4%
METZ & REIGAN DITCH	430815	930	0.1%
METZ DITCH	430816	880	6.3%
MIKKELSON DITCH	430818	90	42.8%
MILLER CREEK DITCH	430819	25,630	0.0%
MINER MARTIN DITCH	430823	680	0.0%
MOONEY DITCH	430828	1,360	0.0%
MORGAN DITCH 2	430831	230	25.8%
MORGAN DITCH 1	430832	390	0.1%
NEW ARCHER WARNER DI	430841	980	0.0%
NIBLOCK DITCH	430842	13,560	0.0%
OAK RIDGE PARK DITCH	430848	21,140	0.0%
OLD AGENCY DITCH	430849	7,780	0.0%
OLDLAND DITCH 1	430850	1,220	11.0%
OLDLAND DITCH 2	430851	770	46.2%
PATTISON DITCH NO 1	430862	800	0.0%
PEASE DITCH	430867	4,230	0.0%
PEDRICK DITCH	430868	3,110	0.0%
PICEANCE CREEK DITCH	430873	950	4.1%
POTHOLE DITCH	430881	1,370	6.0%
POWELL PARK DITCH	430883	14,200	0.0%
RANGELY WATER PLANT	430889	1,710	0.0%
REDDIN DITCH	430895	100	39.2%
ROBERT MCKEE DITCH	430903	1,440	11.7%

Table 2-6. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
RYAN DITCH	430908	530	0.2%
RYE GRASS DITCH	430909	1,210	20.7%
SAYER DITCH	430919	310	7.1%
SCHUTTE DITCH	430923	710	15.9%
SHERIDAN & MORTON D	430926	890	0.0%
SIMPSON DITCH	430928	770	0.1%
SIZEMORE DITCH 1	430929	480	43.8%
SKELTON DITCH	430931	1,110	0.0%
SOLDIER CREEK DITCH	430934	570	18.8%
SOUTH SIDE HIGHLINE	430935	6,280	0.0%
SPROD DITCH 1	430944	1,000	11.9%
SQUARE S CONS D SYS	430948	2,280	0.0%
STADTMAN DITCH	430949	970	0.0%
STOREY DITCH 1	430954	590	0.0%
SWEEDE DITCH	430961	2,860	0.0%
THOMAS DITCH	430965	510	0.0%
THOMAS DITCH 2	430966	470	0.0%
UPPER DITCH	430975	170	20.6%
UTE CREEK DITCH	430980	2,160	0.1%
WHITE RIVER MESA DIT	431010	930	27.6%
BELOT MOFFAT DITCH	431027	1,510	11.8%
GORDON DITCH	431031	190	40.0%
LAWRENCE DITCH	431033	670	0.0%
MCDOWELL NO. 1 DITCH	431034	500	0.0%
JACOBS PUMP & PL	431108	510	0.0%
COX PUMP NO 1	431272	1,230	0.0%
REIGAN PUMP NO 1	431273	710	0.0%
GOFF DITCH	431494	670	0.0%
KENNEY PUMP NO 1	432099	820	0.0%
44_ADY012_ElkheadCre	44_ADY012A	740	5.9%
44_ADY012_ElkheadCreB	44_ADY012B	930	59.0%
44_ADY013_YampaRbelC	44_ADY013A	2,710	2.3%
44_ADY013_YampaRbelCB	44_ADY013B	2,150	53.7%
44_ADY014_EFkWilliam	44_ADY014A	2,060	0.0%
44_ADY014_EFkWilliamB	44_ADY014B	4,290	40.3%
44_ADY015_SFkWilliam	44_ADY015A	2,760	0.0%
44_ADY015_SFkWilliamB	44_ADY015B	1,680	31.5%
44_ADY016_WilliamsFo	44_ADY016A	3,850	1.5%
44_ADY016_WilliamsFoB	44_ADY016B	2,220	55.0%
44_ADY017_MilkCrabvG	44_ADY017A	790	14.7%
44_ADY017_MilkCrabvGB	44_ADY017B	490	72.9%
44_ADY018_MilkCreek	44_ADY018A	560	6.0%
44_ADY018_MilkCreekB	44_ADY018B	2,150	49.6%
44_ADY019_YampaRnrMa	44_ADY019A	1,330	0.5%
44_ADY019_YampaRnrMaB	44_ADY019B	2,300	34.4%
44_ADY025_YampaR@Dee	44_ADY025A	3,130	0.3%
44_ADY025_YampaR@DeeB	44_ADY025B	1,190	3.9%
WILSON DITCH	440509	1,470	0.0%
WISCONSIN DITCH	440511	4,780	26.4%
WOOLEY & JOHNSON D	440514	710	0.4%
YAMPA VAL STOCK BR C	440517	2,460	0.0%
YELLOW JACKET DITCH	440518	710	31.0%
A Q DITCH 1	440524	280	4.0%

Table 2-6. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
AIR LINE IRR D	440527	840	0.0%
ANDERSON DITCH	440533	330	20.0%
BAILEY DITCH	440541	1,000	0.0%
CARD DITCH	440570	1,400	0.0%
CARRIGAN-AVERILL D	440572	400	55.5%
CATARACT DITCH	440573	3,860	68.3%
CRAIG WATER SUPPLY P	440581	2,200	0.0%
CROSS MTN PUMP - GRO	440583	3,110	0.0%
CROSS MTN PUMP NO 1	440584	2,900	0.0%
CRYSTAL CK DITCH	440585	420	0.4%
D D & E DITCH	440586	3,510	0.0%
D D FERGUSON D NO 2	440587	2,680	4.7%
DEEP CUT IRR D	440589	5,940	0.0%
DEER CK & MORAPOS D	440590	1,730	25.8%
DENNISON & MARTIN D	440593	1,090	49.8%
DUNSTON DITCH	440601	740	0.0%
EGRY MESA DITCH	440607	2,950	0.0%
ELK TRAIL DITCH	440611	1,200	54.4%
ELKHORN IRR DITCH	440612	1,570	55.9%
ELLGEN DITCH	440613	710	0.6%
ELLIS & KITCHENS D	440614	290	11.8%
GIBBONS WILSON JORDA	440628	720	50.1%
GRIESER DITCH	440635	580	0.0%
HADDEN BASE DITCH	440638	1,050	68.4%
HARPER DITCH 1	440644	900	0.9%
HARPER DITCH 2	440645	270	5.0%
HAUGHEY IRR DITCH	440647	1,570	50.2%
HIGHLINE MESA BAKER	440650	340	52.6%
HIGHLAND DITCH	440651	3,260	27.1%
HIGHLAND AKA HIGHLIN	440652	1,220	0.0%
J A MARTIN DITCH	440660	740	0.0%
J P MORIN DITCH	440661	760	0.0%
JUNIPER MTN TUNNEL	440675	5,440	0.0%
K DIAMOND DITCH	440677	2,000	0.0%
LAMB IRR DITCH	440681	570	39.5%
LILY PARK D PUMP STA	440687	2,700	0.0%
LITTLE BEAR DITCH	440688	2,270	32.2%
M DITCH	440691	1,210	0.0%
MARTIN CK DITCH	440692	2,760	5.2%
MAYBELL CANAL	440694	13,150	0.1%
MAYBELL MILL PIPELINE	440695	350	0.7%
MCDONALD DITCH	440698	720	58.0%
MCKINLAY DITCH NO 1	440699	1,560	0.0%
MCKINLAY DITCH NO 2	440700	2,480	4.9%
MCINTYRE DITCH	440702	1,990	0.6%
MILK CK DITCH	440706	1,930	18.4%
MOCK DITCH	440711	1,020	0.1%
MULLEN DITCH	440716	620	0.1%
NICHOLS DITCH NO 1	440723	1,040	0.1%
NORVELL DITCH	440724	2,300	0.0%
PATRICK SWEENEY D	440729	1,890	0.6%
PECK IRRIG D	440731	1,350	0.0%
PINE CK DITCH	440735	880	5.1%

Table 2-6. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
RATCLIFF DITCH	440740	610	0.0%
ROBY D AKA ROBY D NO	440747	970	70.2%
ROBY DITCH NO 2	440748	690	59.6%
ROUND BOTTOM D NO 1	440749	290	0.0%
ROUND BOTTOM D NO 2	440750	360	0.0%
ROUND BOTTOM DITCH	440751	1,020	0.0%
SMITH DITCH	440763	1,770	0.0%
STARR IRRIG DITCH	440770	280	0.1%
SUNBEAM DITCH	440778	1,420	0.1%
TIPTON IRR DITCH	440785	1,840	46.7%
TISDEL D NO 2	440786	1,800	0.0%
UTLEY DITCH	440790	940	0.0%
CROSS MTN PUMP - GUE	440801	1,140	0.0%
ELLGEN NO 2 DITCH	440806	410	0.8%
HART DITCH	440812	590	73.4%
HIGHLINE DITCH	440814	800	0.0%
LOWRY SEELEY PUMP	440820	1,450	0.6%
MACK DITCH	440821	520	0.4%
OLD SWEENEY DITCH	440830	1,530	0.8%
HENRY SWEENEY DITCH	440863	1,690	0.6%
DRY COTTONWOOD DITCH	440998	650	53.9%
54_ADY020_LSnakeRnrS	54_ADY020A	1,980	0.2%
54_ADY020_LSnakeRnrSB	54_ADY020B	4,990	35.9%
54_ADY021_LSnakeRabv	54_ADY021A	4,180	0.2%
54_ADY021_LSnakeRabvB	54_ADY021B	1,800	33.6%
54_ADY022_SlaterCreek	54_ADY022A	1,350	2.7%
54_ADY022_SlaterCreekB	54_ADY022B	5,590	25.9%
54_ADY023_LSnakeabvD	54_ADY023A	17,140	0.0%
54_ADY023_LSnakeabvDB	54_ADY023B	12,990	30.0%
BEELER DITCH	540507	1,400	0.0%
HEELEY DITCH	540531	4,500	0.0%
HOME SUPPLY DITCH	540532	1,370	0.0%
LUCHINGER DITCH	540543	1,130	15.5%
MORGAN & BEELER DITCH	540548	1,940	0.0%
MORGAN SLATER DITCH	540549	1,080	0.0%
PERKINS FOX DITCH	540554	2,190	52.1%
PERKINS IRR DITCH	540555	2,670	25.5%
SALISBURY DITCH	540564	610	0.0%
SLATER FORK DITCH	540568	1,670	0.0%
SLATER PARK DITCH NO 1	540570	1,880	20.0%
SLATER PARK DITCH NO 2	540571	530	22.2%
TROWEL DITCH	540583	4,940	0.0%
WILLOW CK DITCH	540591	3,610	16.0%
WILSON DITCH	540592	550	0.2%
WOODBURY DITCH	540594	1,800	0.0%
55_ADY024_LSnakeRnrL	55_ADY024A	4,570	0.0%
55_ASY003_LSnakeRnrLB	55_ADY024B	410	100.0%
55_ADY026_YampaR@Gre	55_ADY026A	320	0.0%
55_ADY026_YampaR@GreB	55_ADY026B	440	33.8%
ESCALANTA PUMP 2	550504	1,020	0.0%
MAJORS PUMP NO 2	550506	2,380	0.0%
NINE MILE IRR DITCH	550507	970	6.0%
NINE MILE IRR PL	550508	770	8.7%

Table 2-6. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
VISINTAINER DITCH	550513	750	3.5%
RINKER PUMP DITCH	550519	800	5.1%
LEFEVRE NO 1 PUMP	550537	1,690	4.6%
56_027_GreenRiver	56_ADY027A	510	0.0%
56_027_GreenRiverB	56_ADY027B	9,150	25.3%
57_ADY009_TroutCreek	57_ADY009A	3,720	0.9%
57_ADY009_TroutCreekB	57_ADY009B	1,220	36.8%
57_ADY010_YampaRnrHa	57_ADY010A	300	5.7%
57_ADY010_YampaRnrHaB	57_ADY010B	1,890	6.3%
57_ADY011_YampaRabvE	57_ADY011A	1,410	3.7%
57_ADY011_YampaRabvEB	57_ADY011B	1,410	40.0%
BROCK DITCH	570508	2,860	0.0%
CARY DITCH CO DITCH	570510	3,670	0.0%
COLO UTILITIES D & PL	570512	4,890	0.0%
DAVID M CHAPMAN DITC	570517	820	5.5%
DENNIS & BLEWITT D	570519	1,080	0.0%
EAST SIDE DITCH	570524	670	12.2%
EAST SIDE DITCH 2	570525	950	19.5%
ERWIN IRRIGATING DIT	570535	590	0.0%
GIBRALTAR DITCH	570539	7,120	0.0%
HIGHLAND DITCH	570544	1,770	0.6%
HOMESTEAD DITCH	570545	1,450	10.1%
LAST CHANCE DITCH	570555	1,280	12.0%
MALE MOORE CO DITCH	570561	480	12.0%
MARSHALL ROBERTS DIT	570563	3,800	0.0%
ORNO DITCH	570576	870	0.0%
R E CLARK DITCH	570579	980	0.0%
SADDLE MOUNTAIN DITC	570584	780	0.3%
SHELTON DITCH	570592	7,670	0.0%
TROUT CREEK DITCH 3	570608	1,900	0.0%
TROUT CREEK DITCH 2	570609	580	0.0%
WALKER IRRIG DITCH	570611	6,470	0.0%
WILLIAMS IRRIG DITCH	570622	2,460	0.0%
WILLIAMS PARK DITCH	570623	1,280	4.2%
KOLL DITCH	570635	1,560	3.1%
58_ADY001_UpperBearR	58_ADY001A	1,810	0.0%
58_ADY001_UpperBearRB	58_ADY001B	2,430	13.5%
58_ADY002_ChemneyCre	58_ADY002A	790	15.9%
58_ADY002_ChemneyCreB	58_ADY002B	3,170	11.4%
58_ADY003_BearRabvHu	58_ADY003A	460	0.0%
58_ADY003_BearRabvHuB	58_ADY003B	5,380	21.1%
58_ADY004_BearRabvSt	58_ADY004A	690	19.2%
58_ADY004_BearRabvStB	58_ADY004B	3,430	20.0%
58_ADY005_YampaRabvS	58_ADY005A	1,150	0.0%
58_ADY005_YampaRabvSB	58_ADY005B	6,710	20.5%
58_ADY006_ElkRivernr	58_ADY006A	230	0.0%
58_ADY006_ElkRivernrB	58_ADY006B	1,910	38.8%
58_ADY007_MiddleElkR	58_ADY007A	720	0.6%
58_ADY007_MiddleElkRB	58_ADY007B	3,390	66.5%
58_ADY008_LowerElkRi	58_ADY008A	2,900	0.2%
58_ADY008_LowerElkRiB	58_ADY008B	4,680	16.3%
ACTON DITCH	580500	1,930	0.9%
ALLEN BASIN SUPPLY DITCH	580506	190	0.0%

Table 2-6. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
ALPHA DITCH	580508	1,540	1.5%
BAXTER DITCH	580530	3,550	0.0%
BEAVER CREEK DITCH	580532	780	33.4%
BIG MESA DITCH	580539	5,110	1.9%
BIRD DITCH	580541	2,180	0.0%
BRINKER CREEK DITCH	580556	660	2.2%
BROOKS DITCH	580559	930	0.0%
BRUMBACK DITCH	580561	550	0.0%
BUCKINGHAM MANDALL DITCH	580564	3,500	1.0%
BURNETT DITCH	580568	2,100	0.0%
BURNT MESA DITCH	580569	750	3.4%
C R BROWN MOFFAT COAL DITCH	580574	570	0.4%
CAMPBELL DITCH	580577	1,730	0.0%
CHARLES & A LEIGHTON	580582	510	3.6%
CHARLES H KEMMER D	580583	380	0.0%
CLARK & BURKE DITCH	580588	960	0.0%
COLEMAN DITCH	580590	690	0.0%
COLLINS DITCH	580591	1,060	0.1%
CULLEN DITCH 2	580599	780	0.0%
DAY DITCH	580604	820	3.7%
DEVER DITCH	580612	850	0.0%
DUQUETTE DITCH	580618	1,840	0.0%
EGERIA DITCH	580622	2,150	0.0%
EKHART DITCH	580623	1,530	0.0%
ELK VALLEY DITCH CO.	580626	3,760	0.0%
ENTERPRISE DITCH	580627	3,150	7.4%
EXCELSIOR DITCH	580628	800	3.8%
FELIX BORGHI DITCH	580633	1,040	0.0%
FERGUSON DITCH	580634	1,370	0.2%
FIRST CHANCE DITCH	580640	740	0.1%
FISH CR MUN WATER INTAK	580642	2,910	0.0%
FIX DITCH	580643	2,270	0.0%
FRANZ DITCH	580649	3,270	0.0%
GRAHAM & BENNETT D	580662	2,650	0.0%
GREER DITCH	580663	890	10.7%
GUIDO DITCH	580665	450	2.6%
HERNAGE & KOLBE DITCH	580684	1,100	0.4%
HIGH MESA IRR D	580685	700	0.7%
HIGHLINE BEAVER DITCH	580687	930	15.3%
HOOVER JACQUES DITCH	580694	2,740	0.1%
HOT SPGS CR HIGHLINE	580695	800	0.3%
KELLER DITCH	580714	3,370	0.0%
KINNEY DITCH	580717	1,290	0.5%
L L WILSON D	580721	520	0.0%
LAFON DITCH	580722	680	0.0%
LARSON DITCH	580728	1,070	0.0%
LATERAL A DITCH	580730	1,250	0.6%
LAUGHLIN DITCH	580731	470	0.5%
LINDSEY DITCH	580738	2,390	3.5%
LOWER PLEASANT VALLEY	580749	1,070	0.0%
LYON DITCH 2	580756	660	1.1%
MANDALL DITCH	580763	5,270	0.0%
MAYFLOWER DITCH	580767	590	1.0%

Table 2-6. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
MILL DITCH 1	580777	650	0.0%
MOODY DITCH	580782	630	15.2%
MORIN DITCH	580783	3,240	0.0%
NICKELL DITCH	580798	1,450	0.0%
NORTH HUNT CREEK DITCH	580801	670	0.0%
OAK CREEK DITCH	580805	890	0.1%
OAK DALE DITCH	580807	820	3.6%
OAKTON DITCH	580808	1,460	0.0%
OLD CABIN DITCH	580809	560	0.0%
OLIGARCHY DITCH	580811	570	0.0%
PALISADE DITCH	580813	650	0.0%
PENNSYLVANIA DITCH	580821	1,620	0.0%
PONY CREEK D	580826	600	20.3%
PRIEST DITCH	580830	370	0.4%
SAGE HEN DITCH	580844	540	0.0%
SAND CREEK DITCH	580847	700	0.1%
SIMON DITCH	580863	2,650	0.0%
SNOW BANK DITCH	580866	920	0.1%
SODA CREEK DITCH	580868	2,410	1.1%
SOUTH SIDE DITCH	580872	780	0.0%
STAFFORD DITCH	580879	2,670	0.0%
SUNNYSIDE DITCH 1	580895	1,280	0.9%
SUTTLE DITCH	580897	4,680	0.0%
TRULL MORIN DITCH	580908	850	0.0%
UNION DITCH	580914	1,360	41.7%
UPPER ELK RIVER D CO	580915	1,300	0.0%
UPPER PLEASANT VALLEY	580916	1,630	0.0%
VAIL SAVAGE DITCH	580917	770	0.0%
WALTON CREEK DITCH	580920	10,240	0.4%
WEISKOPF DITCH	580922	750	0.0%
WELCH & MONSON DITCH	580924	480	0.0%
WHEELER BROS DITCH	580928	680	0.0%
WHIPPLE DITCH	580933	1,090	0.0%
WINDSOR DITCH	580939	430	0.3%
WOODCHUCK D SODA CK	580943	1,630	6.5%
WOOLERY DITCH	580944	3,870	0.0%
WOOLEY DITCH	580945	1,600	0.0%
GABIOUD DITCH	580980	670	6.6%
LEE IRRIGATION D	581021	950	0.0%
NORTH SIDE DITCH	581035	580	0.4%
ROSSI HIGHLINE DITCH	581074	620	6.4%
MILL CREEK DITCH	581085	690	0.1%
DOME CR DITCH	584630	330	18.4%

2.6.2 Municipal and Industrial Gaps

Similar to agricultural use gaps, M&I gaps are calculated using consumptive use shortages[7]. M&I demands make up a small minority of the total demands in the basin with a total average demand of 11,570 AFY.

Table 2-7. M&I Demand Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
Existing M&I	43_AMW001	1,100	0.0%
Rangely Water	430889	1,710	0.0%
Meeker Wells	436045	360	0.0%
Existing M&I	44_AMY001	740	0.0%
Craig Water Supply Plant	440581	2,200	0.0%
Maybell Mill Pipeline	440695	350	0.7%
Existing M&I	55_AMY003	10	0.0%
Existing M&I	57_AMY001	480	0.0%
Existing M&I	58_AMY001	1,340	0.0%
Fish Creek Municipal Intake	580642	2,910	0.0%
Meeker Demand	950810	370	0.0%

Due to the reasons discussed in Section 2.5.4—augmentation, senior water rights, and small demands, M&I gaps are small or zero. In the case of the Maybell Mill Pipeline, the 0.7 percent represents demands not being met in August 2002 by 80 AF during the drought of record.

2.6.3 Thermoelectric Power Generation Water Gaps

Thermoelectric power generation water gaps are also calculated using consumptive use shortages[8]. **Table 2-8** shows that demands are supplied during each month of the simulation.

Table 2-8. Thermoelectric Power Generation Water Demand Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short
COLO UTILITIES D & PL (Hayden Station)	570512	4,890	0.0%
CRAIG STATION D & PL (Units 1&2)	440522	8,040	0.0%
Tri-State (Unit 3)	440522b	4,020	0.0%

Although demands are not always met through direct diversions, supplies are firmed at each individual diversion by Steamboat Lake, Stagecoach Reservoir, and Elkhead Reservoir. In the baseline scenario, demands can be met by direct diversions in all but the driest years.

[7] It should be noted that since consumption is always proportional to demands for M&I diversions in StateMod, the resulting percentage short is the same for both; i.e., if 50 percent of the total diversion demand is not met, 50 percent of the consumptive use needs will also not be met.

[8] Thermoelectric Power Generation water demands are 100 percent consumptive, thus a consumptive use shortage is the same as the total diversion shortage.

2.6.4 Environmental Gaps

Two types of environmental gaps were evaluated—decreed ISF gaps and Fishery and Riparian Flow-Ecology Relationship Risks. Since ISFs have a decreed water right, they play a role in determining how the river operates and may potentially call diversions out if in priority. Shortages for ISF are calculated internally in the model while Fisheries and Riparian Flow-Ecology Relationship Risks are not decreed and do not play a part in the administration of river operations.

2.6.4.1 Instream Flow Gaps

ISF flows are calculated within the model and use the following process to determine if gaps exist or not:

- Flows are calculated at the upstream and downstream terminus of the ISF as well as at each intervening structure between the two ends.
- If the ISF is in priority, it calls any junior diversion upstream of the lower terminus and the model recalculates flows.
- If the ISF is short, but has storage in the reservoir, releases are made; i.e., Steamboat Lake makes late season releases to Elk River and Willow Creek.
- The difference between the decreed ISF water right and the lowest flow within the reach is what the model reports as a shortage. StateMod internally calculates ISF flows and shortages at each diversion within the reach and uses those flows at each location to administer water right calls. Conversely, water commissioners typically will only administer ISFs at DWR/USGS gages.

Some concern was brought up with regards to reporting shortages for ISF reaches. According to Jeff Baessler at CWCB (personal communication, 02/06/2013), any and all available means are used to estimate flows along reaches included, but not limited to, U.S. Geological Survey (USGS) and Colorado Division of Water Resources (DWR) gages, the CWCB automated alert system for monitoring low flows, field spot measurements, and public word of mouth (i.e., concerned citizens). Typically, the only method that division engineers accept for administering ISF water rights is USGS/DWR gages. Consequently, the model may estimate ISF shortages using a more conservative method than what can actually be administered.

Modeled ISF shortages show the difference between the target and the minimum flow along that reach. **Table 2-9** shows the average annual flow target and how much of that average annual target flow is met at a minimum along the reach (i.e., the Average Annual Target Flow minus the ISF shortage). Additional details on the simulated flows are available via the Yampa-White model output tool.

Table 2-9. ISF Target Flow Shortages

Diversion Name	WDID	Average Annual Minimum Flow (cfs)	Simulated Average Minimum Flow Along Reach (cfs)
Bear River (Middle)	582404	7.9	4.1
Bear River (Lower)	582202	12.0	5.8
Big Creek	582206	15.0	10.7
Coal Creek	582214	5.0	3.4
Dome Creek	582216	2.0	0.3
East Fork Williams Fork	441452	14.2	12.2
Elk River (Lower)	581355	65.0	26.9
Elk River (Upper)	582219	65.0	27.3
Green Creek	582245	5.0	2.1
Hunt Creek	582519	5.0	2.4
Marvine Creek	432334	40.0	39.1
Miller Creek	432337	10.0	8.4
North Fork Fish Creek	582287	5.0	4.3
North Fork White River	432339	70.0	69.7
North Fork White River	432338	120.0	117.6
Oak Creek	582290	2.0	1.9
Phillips Creek	582409	6.0	2.4
Service Creek	582306	6.0	3.9
Slater Creek	542076	3.0	2.9
Soda Creek	582311	5.0	4.1
South Fork White River	432344	80.0	74.8
South Fork Williams Fork	441456	5.9	5.4
Trout Creek (Lower)	571009	5.0	3.8
Ute Creek	432372	6.0	6.0
White River	431845	200.0	192.8
Williams Fork River	441448	20.7	20.3
Willow Creek	582332	7.0	4.0
Willow Creek	581461	5.0	3.0
Willow Spring & Pond	582162	13.0	6.7
Yampa River	582164	56.9	52.5

Yampa River Endangered Species Fish Flow Target

Although the Yampa River Endangered Species Fish Flow Target acts similar to an ISF, there are a few differences.

- The flow targets are not decreed and therefore cannot protect any native flows in the stream
- The releases from Elkhead Reservoir are, however, protected from any—including the most senior—diversions

Releases are made from Elkhead Reservoir at a rate of up to 50 cfs until the permanent 5,000 AF of CWCB storage is depleted. Although only the releases are protected, shortages are calculated using the same method as other ISFs. **Table 2-10** shows the monthly targets from the Yampa PBO and the average of the minimum flow target that was met along the reach.

Table 2-10. Yampa River Endangered Species Fish Flow Shortages

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Flow Target (cfs)	120	169	169	169	167	0	0	0	0	138	120	120
Average Minimum Simulated Flows Along the Reach (cfs)*	117	168	153	164	158	0	0	0	0	120	57	88

* Includes releases from Elkhead Reservoir as well as Native Flows

The 5,000 AF CWCB account in Elkhead Reservoir tends to fill from March through June (when there is no flow target) and begins releasing in July. During dry years, the account may empty as early as August if 50 cfs is released at a constant rate. On the other hand, in wetter years, the account may not fall below 2,000 AF of storage.

Target flow shortages may be caused by two less obvious conditions than releasing the 5,000 AF of storage from Elkhead Reservoir:

- Releases from Elkhead Reservoir are limited to 50 cfs. Shortages to the Yampa River Endangered Species Fish Flow reach occur if the native flows cannot make up the difference.
- If the flow target is met at Maybell without releases from Elkhead Reservoir, the model will not release water to the Endangered Species Fish Flow reach, even if a diversion made downstream of Maybell causes the flow somewhere within the reach to fall below the target. This is due to the way the operations of Elkhead Reservoir are written in the Yampa PBO. Releases are based upon the flow targets being met at the Yampa River gage at Maybell, CO.

2.6.4.2 Fisheries and Riparian Flow-Ecology Relationship Risks

Fisheries and riparian flow-ecology relationships are metrics defined in the Yampa-White WFET study. A set of equations that relate naturalized condition flows to current conditions flows were defined for Trout, Warm Water Fish, and Riparian Habitats.

The environmental fish flow-ecology locations and metrics (trout flow-ecology and warm water fish flow-ecology) were used in the Yampa Projects and Methods Study as nondecreed, nonconsumptive environmental demands. Further information can be found in the Yampa-White Basin Roundtable Watershed Flow Evaluation Tool Study Report (CDM Smith 2012).

Trout Flow-Ecology Relationship

The Trout Flow-Ecology Relationship is a relation between late season (autumn) flows and naturalized flows. The relationship estimates the ability for a stream to support trout based on the following equation:

$$Trout\ Flow - Ecology\ Relationship = \frac{\frac{\text{Mean August } Q_{\text{Existing}} + Mean\ September\ Q_{Existing}}{2}}{Mean\ Annual\ Q_{natural}}$$

The lower the percentage of average August and September flows, the higher the risk of a particular location.

Warm Water Fish Flow-Ecology Relationship

The flow-ecology metric for native bluehead sucker and flannelmouth sucker fish is represented by the following equation:

$$\%\, maximum\ native\ sucker\ potential\ biomass = 0.1025 \times 30 - day \min flow^{0.3021}$$

The risk associated with Warm Water Fish Flow-Ecology metric is calculated as a relative percent change from natural conditions to existing conditions and is represented via the following equation:

$$Warm\ Water\ Fish\ Flow - Ecology\ Relationship = \frac{\%\, maximimum\ potential\ biomass_{Natural} - \%\, maximimum\ potential\ biomass_{Existing}}{\%\, maximimum\ potential\ biomass_{Natural}}$$

This equation represents the relative reduction in maximum native sucker potential biomass due to the impacts of development. The greater the relative reduction in maximum native sucker potential biomass, the higher the risk.

Riparian Flow-Ecology Relationship

The WFET pilot study for the Roaring Fork Watershed developed a quantitative relationship between flow alteration and riparian vegetation. The WFET refined the original approach to include two conditions.

- Quantitative flow-ecology relationships were developed for the two riparian types—cottonwoods on low- and moderate-gradient, meandering (open or unconfined) rivers, or cottonwoods in moderate-gradient rivers of confined valleys and high-gradient rivers in unconfined valleys.

In the WFET, for cottonwood in unconfined geomorphic settings, the attribute was applied for CDSS node locations with a geomorphic setting of moderate-energy unconfined, low-energy floodplain, and glacial trough. In addition, the metric was not applied in locations above 8,700 feet in elevation. Two quantitative flow-ecology relationships exist for cottonwood in unconfined settings—one for adult cottonwood abundance and the other for cottonwood recruitment. The hydrologic metric for adult cottonwood abundance is the change in average 90-day maximum flow in wet years only between current and natural scenarios. "Wet years" are those in the top 30th percentile for mean annual flow in the natural flow time series. Cottonwood abundance is calculated as:

$$\%\, abundance = 1.038x\ \%flow\ alteration + 1.005$$

For cottonwood abundance, a higher percentage correlates to a higher risk.

For cottonwood in confined settings, the method develop in the WFET pilot study was retained but applied only in moderate-energy confined geomorphic settings and at elevations less than 8,700 feet. The flow-ecology metric was calculated using the following equation:

$$\%\, departure\ from\ reference\ condition = \frac{Annual\ Peak\ Daily\ Flow_{current} - Annual\ Peak\ Daily\ Flow_{natural}}{Annual\ Peak\ Daily\ Flow_{natural}}$$

For cottonwood in confined settings, a higher percentage departure from reference conditions correlates to a higher risk.

Originally daily flows are required to calculate cottonwood abundance in confined settings. The current release of the Yampa and White StateMod models, 2009 release, simulates river operations on a monthly timestep. Since annual peak daily flows could not be calculated, the metric for calculating cottonwood abundance in confined settings was not possible. As a proxy, cottonwood abundance for unconfined settings was calculated for all locations evaluated for Riparian Vegetation Flow-Ecology Relationships by the Yampa-White WFET Study.

Risk levels are defined as shown in **Table 2-11**.

Table 2-11. Risk Levels of Nonconsumptive Flow Metrics

Risk Classes	Low Risk	Minimal Risk	Moderate Risk	High Risk	Very High Risk
Trout Flow - Ecology Relationship	>55%	25% - 55%	15% - 25%	10% - 15%	<10%
Warm Water Fish Flow - Ecology Relationship	<10%		10% - 25%	25% - 50%	50% - 100%
Cottonwood Abundance	0% - 15%		15% - 30%	30% - 50%	50% - 100%

The nonconsumptive flow metric results for the baseline scenario were evaluated at the locations listed in Section 2.4.1. **Table 2-12** shows the risk levels for each flow-ecology relationship location.

Table 2-12. Baseline Nonconsumptive Flow Metric Results

Reach Name	Evaluation Node	Trout Flow-Ecology Relationship	Warm Water Fish Flow-Ecology Relationship	Cottonwood Abundance
Yampa River from entrance of Cross Mountain Canyon East Cross Mountain to confluence with Green River	09260050	n/a	Moderate Risk	Low Risk
Yampa River from Pump Station to confluence of Elkhead Creek	09244410	Moderate Risk	Low Risk	Low Risk
Elk River from headwaters to the County Road 129 bridge at Clark including the North Middle and South Fork as well as the mainstem of the Elk	09241000	Minimal Risk	n/a	Low Risk
White River from headwaters to Meeker including the North and South Fork and mainstem of the White	09304500	Minimal Risk	Low Risk	Low Risk
White River below Kenney Reservoir dam to Utah State line	434433	n/a	Low Risk	Moderate Risk
White River from Rio Blanco Lake Dam to Kenney Reservoir	09306290	n/a	Low Risk	n/a
Slater Creek from headwaters to the Beaver Creek confluence	540570	Moderate Risk		Low Risk
South Fork of the Little Snake from headwaters to confluence of Johnson Creek	09253000	High Risk	Low Risk	Low Risk
East Fork of the Williams Fork from headwaters to the confluence of the Forks	09249000	Minimal Risk	n/a	n/a
South Fork of the Williams Fork from headwaters to the confluence of the Forks	09249200	High Risk	n/a	n/a

Table 2-12. Baseline Nonconsumptive Flow Metric Results

Reach Name	Evaluation Node	Trout Flow-Ecology Relationship	Warm Water Fish Flow-Ecology Relationship	Cottonwood Abundance
Williams Fork from South Fork to the confluence of the Yampa River	09249750	Moderate Risk	n/a	Low Risk
Little Snake River from Moffat County Road 10 to confluence of the Yampa River	09260000	n/a	High Risk	Low Risk
Yampa River from Craig Hwy 394 Bridge to mouth of Cross Mountain Canyon	09251000	n/a	Moderate Risk	Low Risk
Yampa River from Stagecoach Reservoir Tailwaters to northern boundary of Sarvis Creek State Wildlife area	09237500	Minimal Risk	Low Risk	High Risk
Fish Creek from Fish Creek Falls to confluence of the Yampa River	09238900	n/a	n/a	Low Risk
Yampa River from Chuck Lewis Wildlife Area to Pump Station	09239500	Moderate Risk	Low Risk	Low Risk
Willow Creek below Steamboat Lake to confluence with the Elk	583787	Low Risk	n/a	Low Risk
Bear River from headwaters to USFS boundary	09236000	Low Risk	n/a	n/a

2.6.5 Recreational Gaps

Recreational gaps revolved around the set of boating locations listed in Section 2.4.2. Gaps are defined as the number of months below the defined minimum usable flow or above the defined highest usable flow. The WFET defined the gage that the useable flow metric was based on as well as the usable flow ranges, which are shown in **Table 2-13**.

Table 2-13. WFET Whitewater Boating Flows

Segment	Measurement Gage	Minimum (cfs)	Optimal (cfs)	Highest (cfs)	Season
Fish Creek	09238900	400	800-1,000	1,400	April through July
Steamboat Town	09239500	700	1,500-2,700	5,000+	April through July
Elk River Box	09242500[1]	700	1,000-2,100	5,000+	April through July
Elk River - Clark	09241000	700	1,300-4,000	5,000+	April through July
Willow Creek	583787	300	700-800	1,250	April through July
Mad Creek	Visual	400	400-1,000	2,000+	April through July
MF Little Snake	Visual	500	800-1,100	2,000+	April through July
Slater Creek	540570[2]	600	1,100-2,100	3,000+	April through July
Yampa - Lower Town	09244410	900	1,500-1,500	4,000	April through July
Little Yampa Canyon	09247600	1,100	1,700-2,500	10,000+	April through July
Cross Mountain Gorge	09251000	700	1,500-3,500	5,000	April through July
Yampa Canyon	09260050	1,300	2,700-20,000	20,000+	April through July
Gates of Lodore	09234500[3]	1,100	1,900-15,000	20,000+	April through July
SF White River	No Defined Gage[4]	700	2,500-3,500	10,000	April through July
White River below Kenney Reservoir	434433	700	1,500-2,500	10,000+	March through October
White River Rangely to Bonanza	09306290	700	1,500-5,000	10,000+	April through July

[1] Gage not in the StateMod Model
[2] Not evaluated in the WFET, due to insufficient data
[3] Gage not in the StateMod Model
[4] No defined location in the WFET study to evaluate whitewater boating flows

Table 2-14 shows the percentage of months with usable flows. It should be noted that the frequency of high flow and low flow days are averaged in the Projects and Methods Study since modeling was evaluated on a monthly time step, reducing variability in the results.

Table 2-14. Baseline Recreational Whitewater Boating Non-Consumptive Results

Segment	Measurement Gage	Minimum Flow Months	Optimal Flow Months	Highest Flow Months
Yampa River from entrance of Cross Mountain Canyon (East Cross Mountain) to confluence with Green River	09260050	24%	63%	0%
Yampa River from Pump Station to confluence of Elkhead Creek	09244410	20%	0%	0%
Elk River from headwaters to the County Road 129 bridge at Clark; including the North, Middle and South Fork as well as the mainstem of the Elk	09241000	25%	22%	0%
White River below Kenney Reservoir dam to Utah State line	434433	19%	12%	4%
White River from Rio Blanco Lake to Kenney Reservoir	09306290	30%	31%	0%
Slater Creek from headwaters to the Beaver Creek confluence	540570	1%	0%	0%
Yampa River from Craig (Hwy 394 Bridge) to mouth of Cross Mountain Canyon	09251000	13%	30%	0%
Fish Creek from Fish Creek Falls to confluence of the Yampa River	09238900	13%	0%	0%
Yampa River from Chuck Lewis Wildlife Area to Pump Station	09239500	26%	24%	4%
Willow Creek below Steamboat Lake to confluence with the Elk	583787	0%	0%	0%
Little Yampa Canyon	09247600	16%	13%	53%

Steamboat Recreational In-Channel Diversion

The Steamboat Recreational In-Channel Diversion (RICD) is a location in addition to the WFET defined locations. Additionally, the RICD has a decreed flow rate, although it is a junior priority. Due to the RICD's water right, it acts similarly to an ISF. According to Erin Light (Personal Communication, 05/30/2013) the decreed flows for the Steamboat RICD are:

- 400 cfs from April 15 to April 30
- 650 cfs from May 1 to May 15
- 1,000 cfs from May 16 to May 31
- 1,400 cfs from June 1 to June 15
- 650 cfs from June 16 to June 30
- 250 cfs from July 1 to July 15
- 100 cfs from July 16 to July 31
- 95 cfs from August 1 to August 15

Since StateMod operates on a monthly time step, the flows were converted to monthly average decreed flows.

- 200 cfs for April
- 825 cfs for May
- 1025 cfs for June
- 175 cfs for July
- 47.5 cfs for August

Due to the low physical availability of water, junior RICD water right status, and the relatively high flow decree, RICD target flows are most often short during June and July during dry years. Due to the monthly time step and averaging method used, shortages may be larger or small depending on the timing and magnitude of flow.

2.7 Baseline Model Gap Summary

Several locations shown on Figures 2-4 through 2-10 were identified as having consumptive or nonconsumptive gaps.

2.7.1 Baseline Consumptive Gaps

- Piceance Creek (Figure 2-4 – Water District 43) – Piceance Creek was previously identified in the Agricultural Water Needs Study as the highest shortage drainage in the White Basin. The Piceance Creek drainage is central to the oil shale energy sector development in the Energy Development Water Needs Assessment

- Fortification Creek (Figure 2-5 – Water District 44) – Fortification Creek was identified in the Yampa-White Agricultural Water Needs Study as having one of the largest gaps between water supplies and IWR. Fortification Creek is the one of the chief drainages examined in the Yampa River Basin Small Reservoir Study (Phase 2) (Montgomery Watson 2000).

- Morapos Creek (Figure 2-5 – Water District 44) - Morapos Creek was identified in the Yampa-White Agricultural Water Needs Study as having one of the largest gaps between water supplies and IWR. Morapos Creek is also examined in the Yampa River Basin Small Reservoir Study (Phase 2).

- Agricultural Diversions on Upper Tributaries (Figures 2-4 through 2-20) – Due to the low irrigation efficiencies and small drainage area of the basins in the upper tributaries of the basin, water supplies are not reliable as irrigation sources. "B" aggregates and some diversions at higher elevations often times cannot meet their IWR later in the irrigation year due to poor water supply availability.

2.7.2 Baseline Nonconsumptive Gaps

- Trout Creek ISF (Figure 2-9 – Water District 57) – Flows in Trout Creek cannot, on average, meet the ISF minimum flow between July and October.

- Elk River ISF, Willow Creek ISF (Figure 2-10 – Water District 58) – Although releases are made to Elk River and Willow Creek by Steamboat Lake, the amount of storage available for releases to the ISFs is too small to meet the entire ISF gap.

- Water District 58 Upper Tributaries (Figure 2-10 – Water District 58) – Many of the upper tributaries protected by ISF rights are often not met runoff with high peak flows in the spring and low or zero flows in the late summer through winter.

- High Risk WFET Trout Flow-Ecology Relationship nodes (Figure 2-4 through 2-10) – Trout Flow-Ecology Relationships are susceptible to late summer/early fall flows varying from naturalized average annual flows. The most vulnerable reaches tend to be on streams with low flows in the upper tributaries. It is characteristic for upper tributary flows in the Yampa to be low or zero for this part of the year, which oftentimes will make these upper tributary streams "high risk" even if there is no development on it.

- High Risk WFET Warm Water Fish Flow-Ecology Relationship nodes (Figure 2-4 through 2-10) – Warm Water Fish Flow-Ecology Relationship risks are associated with increased development in the stream. Water District 58 is further up in the basin, thus having fewer cumulative impacts to streamflows, which generally yields a lower risk flow-ecology relationships. The Little Snake River from Moffat County Road 10 to the Confluence of the Yampa River (USGS 09260000) shows a high risk due to the impacts of diversions relative to the natural flows.

Section 3

Analyze River Operations for the Yampa and White Basins

3.1 Introduction

This section summarizes the analysis completed to accomplish the objective of Task 2, which is to "Analyze River Operations for the Yampa and White Basins" as stated in the Statement of Work. The purpose of this section is to further build upon the work completed in Section 2 and develop models to analyze potential future scenarios. The modeling will rely on the Consumptive and Nonconsumptive Needs Assessments and input from the Yampa BRT to develop operational scenarios to meet consumptive and nonconsumptive needs.

Nonconsumptive needs include recreational boating flows and environmental flows determined by the BRT. Consumptive needs will be incorporated from the following sources—the Agricultural Water Needs Assessment Study, Yampa-White Energy Water Needs Assessment, and SWSI 2010. Demands will be incorporated into the modeling effort at the county level. Both IPPs and additional consumptive and nonconsumptive projects will be considered. Additionally, alternate hydrologies will be evaluated (wet, average, and dry hydrologic conditions). Similar to Task 1, a spatial representation of consumptive and nonconsumptive needs will be developed, which can be used to compare to existing conditions within the model.

In order to gain a better understanding of consumptive and nonconsumptive needs in the Yampa and White River Basins a model of the surface water system was developed, which included:

- Future Consumptive Water Demands (low, medium, and high demand levels)
  - M&I Demands
  - Agricultural Demands
  - Thermoelectric Power Generation Demands
  - Energy Development Demands
- Nonconsumptive Needs
- Hydrology Scenarios
- IPPs

Each of these elements was compiled to model a large range of potential future scenarios and provide an estimate of future associated consumptive and nonconsumptive shortages.

3.2 Future Water Demands

Future water demands were developed through the 2050 planning horizon in SWSI 2010. The low, medium, and high demand projections were developed using a "driver multiplied by rate of use" approach. The various drivers ranged from population to economic drivers such as job growth. Demand projections were generated for each of the use sectors for each county. SWSI 2010 demand projections were performed on a county basis and were not associated with explicit locations. To develop demands for the model, a disaggregation method was developed to apply county level demands to specific locations within the model. This disaggregation method is described in the following sections.

3.2.1 Consumptive Demands

SWSI 2010 identifies future demands for the 2035 and 2050 planning horizons for six demand sectors:

- M&I Demands
- Agricultural Demands
- Large Industrial
- Snowmaking
- Thermoelectric Power Generation
- Energy Development

The various demand sectors were divided into a low, medium, and high projection for 2050. Each projection corresponds to a low, medium, and high demand for each demand sector described below.

3.2.1.1 M&I Demands

The SWSI M&I demand forecast is aimed at capturing the water needs of an increasing population. M&I demands are the water uses typical of municipal systems including residential, commercial, light industrial, nonagricultural related irrigation, nonrevenue water, and firefighting. The county level demand forecast for 2050 demands and passive conservation w ere used as demand estimates for the Projects and Methods Study. Passive conservation is water demand reductions that chiefly relate to the water demand reductions associated with the impacts of state and federal policy measures and do not include the active conservation measures and programs sponsored by water providers. They are shown **Table 3-1**.

Table 3-1. Future M&I Demand Forecast

	Current Water Demands (AFY)	Water Demands with Passive Conservation (AFY)		
County	2008	2050 Low	2050 Medium	2050 High
Rio Blanco	2,000	4,900	9,600	17,000
Moffat	3,200	5,300	5,700	6,400
Routt	6,500	13,000	14,000	16,000
Total	11,700	23,200	29,300	39,400

Since one of the major drivers for additional water use is population growth, which is expected to at least double—if not triple in the high growth scenario, the associated water demands with passive conservation may grow at a similar magnitude.

These county demands needed to be broken down into discreet locations, so some assumptions were needed to add these demands into the model. The primary assumption used to add M&I demands into the model was applying a scaling factor to existing M&I demands within the model based on the expected growth in SWSI. For example, if there are two M&I nodes in the county within the model and their consumptive uses are 100 AFY for node 1 and 900 AFY for node 2. If future demands for the county were 2,000 AFY, the forecasted demand for node 1 would be 10 percent of 2,000 AFY (200 AFY) and the forecasted demand for node 2 would be 90 percent of 2,000 AFY (1,800 AFY).

Moffat County demands were split between two aggregate municipal diversions and the City of Craig. Rio Blanco County demands were split between one aggregate municipal diversion, the City of Rangely, and the City of Meeker. Routt County demands were split between an aggregate node above Craig and another aggregate at Steamboat Springs. Aggregate municipal diversions do not represent any explicit population center and instead represents demand from the remainder of the population not in the population centers. This methodology is similar to the aggregated irrigation diversions described in Section 2.5.4.

A Mt. Werner Water and Sanitation District diversion also exists within the model on Fish Creek; however, due to uncertainties with infrastructure, future demands in Routt County were instead applied to the Water District 58 aggregate municipal diversion near Steamboat Springs.

3.2.1.2 Agricultural Demands

SWSI 2010 describes future scenarios where the most current irrigated acreage was used as a baseline and 2050 acreages were based on the following factors affecting agricultural demands:

- Urbanization of existing irrigated areas
- Agricultural to municipal water transfers
- Water management decisions
- Demographic factors
- Biofuels production
- Climate change
- Farm programs
- Subdivision of agricultural lands and lifestyle farms
- Yield and productivity
- Open space and conservation easements
- Economics of agriculture

SWSI was able to quantify the first three factors (urbanization of existing irrigated areas , agricultural to municipal water transfers, and water management decisions) based on future growth estimates, and interviews with water management agencies across the state. The other factors were qualitatively discussed in SWSI but were not considered in the Projects and Methods modeling.

Table 3-2 shows the statewide estimates of losses of agriculturally irrigated lands to various other uses. This table is taken from Table 3-10 of the Yampa-White Basin Agricultural Needs Assessment.

Table 3-2. Current and Future Estimated Acreage

Basin	Current Irrigated Acres	Decrease in Irrigated Acres Due to Urbanization		Decreases in Irrigated Acres Due to Other Reasons	Decreases in Irrigated Acres from Agricultural to Municipal Transfers	Decreases in Irrigated Acres from Transfers to Address M&I Gap		Estimated 2050 Irrigated	
		Low	High			Low	High	Low	High
Arkansas	428,000	2,000	3,000	—	7,000	26,000	63,000	355,000	393,000
Colorado	268,000	40,000	58,000	—	200	11,000	19,000	190,800	216,800
Gunnison	272,000	20,000	26,000	—	—	1,000	2,000	244,000	251,000
North Platte	117,000	—	—	—	—	—	—	117,000	117,000
Republican	550,000	300	600	109,000	—	—	—	440,400	440,700
Rio Grande	622,000	800	1,000	80,000	—	2,000	3,000	538,000	539,200
South Platte	831,000	47,000	58,000	14,000	19,000	100,000	176,000	564,000	651,000
Southwest	259,000	4,000	6,000	—	—	3,000	7,000	246,000	252,000
Yampa-White	**119,000**	**1,000**	**2,000**	**—**	**—**	**3,000**	**64,000**	**53,000**	**115,000**
Statewide Total	**3,466,000**	**115,100**	**154,600**	**203,000**	**26,200**	**146,000**	**334,000**	**2,748,200**	**2,975,700**

As shown in Table 3-2, less than 2 percent of irrigated lands are expected to decrease due to urbanization. A much wider variability of expected decreases in irrigated acres from transfers to address M&I gaps is observed. The other basins are shown as a matter of comparison to show the ranges of reductions of irrigated acreage projected throughout the state.

Due to the uncertainty of both the corresponding magnitude and location of reduced irrigated acreage paired with the possible negligible decreases in the low reduction scenarios, reductions of irrigated acreage were ignored for the Projects and Methods Study.

For future demands, SWSI identified[9] 14,805 acres of potentially irrigable acreage along the oxbows of the Yampa River. Various levels of future development of these irrigable acres were evaluated to create a low, medium, and high demand scenario.

- Low demands correspond to 7,402 acres developed, which requires a diversion (at the headgate) of 32,500 AFY on average annually.
- Medium demands correspond to 11,104 acres developed, which requires a diversion (at the headgate) of 48,800 AFY on average annually.
- High demands correspond to 14,805 acres developed, which requires a diversion (at the headgate) of 65,055 AFY on average annually.

The exact location of headgates and diversions for the oxbows is unknown and therefore the oxbows was treated as an aggregate agricultural diversion and all demands are placed on the downstream terminus of the reach and the diversion is given a junior water right (2013 appropriation date) (which would not affect any existing user within the basin).

One concern about the oxbows development is the impacts on the Endangered Species Flow targets downstream of Maybell and how the two would interact. Since there is no decreed water right for the Endangered Species Flow targets, native water is not protected, only water released from Elkhead Reservoir is protected from diversions by the Division Engineer.

3.2.1.3 Thermoelectric Power Generation Demand

Thermoelectric demands are intrinsically tied to population growth and subsequently will trend similarly. If economic and population drivers increase M&I demands to the high projection, the same economic drivers tend to increase thermoelectric demands as well, i.e., job growth and population. SWSI identified county level forecast projections for 2050 thermoelectric power generation demands (low, medium, and high). **Table 3-3** shows the varying demands associated with each forecast level.

Table 3-3. Future Thermoelectric Power Generation Demand Forecast

County	Current Water Demands (AFY)	Water Demands with Passive Conservation (AFY)		
	2008	2050 Low	2050 Medium	2050 High
Rio Blanco	0	0	0	0
Moffat	17,500	24,700	26,200	26,900
Routt	2,700	12,000	14,300	17,100
Total	20,200	36,700	40,500	44,000

[9] As part of the Agricultural Needs Assessment.

In conversations with both Amy Willhite from Xcel Energy (via phone call on 5/8/2013) and George Fosha, acting representative for Tri-State Generation and Transmission Association Inc. (via phone call on 5/8/2013), both energy companies are either working on or have their own water demand estimates for future use. Xcel Energy intends to perform a study for future estimates of water demands; however, the planning horizon would not likely reach out to 2050. It was also noted that the study would not be available in time to incorporate into the Projects and Methods Study. Mr. Fosha suggested that Tri-State had already performed a study on a future demand forecast; however, this study was not made available to CDM Smith. As a result the SWSI 2010 demands for thermoelectric power generation were used as the most accurate estimates for future demand scenarios.

Since only one power plant exists in each county for Routt and Moffat counties, all demand for Moffat County was applied to the Craig Station power plant and all demand in Routt County was applied to the Hayden Station power plant. This assumes that future power generation demands will be met from existing facilities and that no new locations/diversions will be required elsewhere in the basin.

3.2.1.4 Energy Development Demand

SWSI 2010 reports significant growth in the energy development sector between coal, oil shale, natural gas, and uranium mining[10]. The water needs demand forecasting was developed in three separate parts:

- **Direct Water Demands** – include the water required for the construction, operation, production, and reclamation needed to support the energy extractions and development processes.
- **Indirect Water Demands** – water demands that result from the increase in the region's population due to the energy development and production.
- **Thermoelectric Power Generation Demands** – energy development direct water demands are tied closely to increases in thermoelectric power generation demands, i.e., increased mining typically requires an increase in electrical needs and subsequently an increase in thermoelectric power generation water demands.

Indirect water demands were already considered as an economic driver for the M&I sector demand forecast. Thermoelectric power generation demands driven by both increases in population as well as increases in direct needs for the energy development sectors were also considered in the SWSI thermoelectric power generation demand forecast.

For the remaining direct demands, a matrix was developed as part of the Energy Development Water Needs Assessment that defined the level of demands for three different planning horizons (near-term, mid-term, and long-term) for three different production scenarios (low, medium, and high). Since the Projects and Methods Study focuses on the 2050 planning horizon, only the long-term planning horizon—which corresponds to development from 2036 to 2050—was used. **Table 3-4** shows the low, medium, and high production scenarios for the long-term planning horizon for each energy sector.

[10] SWSI references the water demand forecasts developed as part of the Energy Development Water Needs Assessment.

Table 3-4. Future Energy Sector Development Demand Forecast

Energy Sector	Production Levels (AFY)		
	2050 Low	2050 Medium	2050 High
Natural Gas	15,635	21,085	23,010
Coal	3,070	3,900	8,590
Uranium	0	0	130
Oil Shale (Direct Demands Only)	-16,000	54,000	110,000
Total	2,705	78,985	141,730

The ability to identify locations to apply each demand was met with varying success.

Natural Gas

Demands for natural gas production are on the majority from the hydraulic fracturing process (fracking), which only occurs at the onset of the natural gas well installation. For this reason, permanent water rights—such as agricultural diversion water rights—are not necessary for natural gas production. According to the Colorado Oil and Gas Conservation Commission (COGCC) Oil and Gas Water Sources Fact Sheet (Colorado Oil and Gas Conservation Commission, et al. 2012), natural gas typically procures their water from the following sources:

- Water transported from outside the state – An Operator may transport water from outside of the state. As long as the transport and the use of the water carry no legal obligation to Colorado, this is an allowable source of water from a water rights perspective.
- Irrigation water leased or purchased from a landowner – A landowner may have rights to surface water, delivered by a ditch or canal, which is used to irrigate land. An Operator may choose to enter into an agreement with the owner of the water rights to purchase or lease a portion of that water. While this is allowable, however, in nearly every case the use of an irrigation water right is likely limited to irrigation use only and cannot be used for Well Construction. To allow its use for Well Construction, the owner of the water right and the Operator may apply to change the water right through a formal process such as a water court approved change in use or a temporary plan approved by the State Engineer.
- Treated water or raw water leased or purchased from a municipal water provider – An Operator may choose to enter into an agreement with a municipal water provider to purchase or lease water from the water provider's system. Municipalities and other water providers may have a surplus of water in their system before it is treated (raw water) or after treatment that can be used for Well Construction. Such an arrangement would be allowed only if the Operator's use is compliant with the municipal water provider's water rights.
- Water treated at a wastewater treatment plant leased or purchased from a municipal water provider – An Operator may choose to enter into an agreement with a water provider to purchase or lease water that has been used for municipal purposes, and then treated as waste water. Municipalities and other water providers discharge their treated waste water into the streams where it becomes part of the public resource, ready to be appropriated once again in the priority system. But for many municipalities a portion of the water that is discharged has the character of being "reusable." As a result, it is possible that after having been discharged to the stream, it could be diverted by the Operator to be used for Well Construction. Such an arrangement could only be exercised with the approval of the DWR's Division Engineer and

would be allowed only if the water provider's water rights include industrial use outside its boundaries.

- New diversion of surface water flowing in streams and rivers – In most parts of the state, the surface streams are "over appropriated"; that is, the flows do not reliably occur in such a magnitude that all of the vested water rights on those streams can be satisfied. Therefore, the only time that an Operator will be able to divert water directly from the river is during periods of higher flow and lesser demand. Those periods do occur but not necessarily reliably or predictably.

- Groundwater diverted from wells completed in tributary formations outside Designated Groundwater Basins ("Designated Basins") – An Operator may choose to enter into an agreement with the owner of a well outside of the Designated Basins to divert the well's water for Well Construction, or to divert additional water for Well Construction. However, most existing wells will be located in parts of the state where the surface streams are over appropriated. In those locations, because of the wells' relatively junior water rights, the well is actually a diversion structure only and not a source of appropriated water. Instead, all water withdrawn by the well must be withdrawn according to a plan that acknowledges the impact of the well's pumping on the over-appropriated stream and an accompanying plan for replacing that water to the stream to correct for the depletive impact. Therefore, the complexity of using the well to divert groundwater for Well Construction will be primarily a result of the need to develop a plan for replacing depletions to the stream system.

- Groundwater diverted from wells completed or to be completed in nontributary aquifers – An Operator may choose to enter into an agreement with a landowner to divert nontributary groundwater from the aquifer underlying the landowner's land. There may be some deep aquifers in the study area that may be classified as nontributary by the DWR. The DWR would have to issue a nontributary water well permit for industrial use. In most cases there are no restrictions on the types of use allowed for nontributary groundwater if it is not already subject to a decree or a well permit. There are, however, limits to the amount of water that may be withdrawn in a given period of time. Specifically, the amount of water that may be withdrawn from a parcel of land on which a well permit is under consideration is the amount of groundwater calculated to be contained in the aquifer underlying that land; and no more than one percent of the amount calculated may be withdrawn annually (many will recognize this limitation as the basis for the term "100-year aquifer life"). This withdrawal limitation would be applied to any well permit that allows the use of Well Construction and it is the exact same limitation that would be applied to wells that would withdraw the water for domestic, commercial, agricultural, or other uses.

- Produced Water – An Operator may choose to use water produced in conjunction with oil or gas production at an existing oil or gas well. The water that is produced from an oil or gas well falls under the administrative purview of the State Engineer's Office and as a result is either nontributary, in which case it is administered independent of the prior appropriation system; or is tributary, in which case the depletions from its withdrawal must be fully augmented if the depletions occur in an over-appropriated basin. The result in either case is that the produced water is available for consumption for other purposes, including Well Construction. The water must not be encumbered by other needs and a proper water well permit must be obtained by the Operator before the water can be used for Well Construction. The exception to this permitting requirement is the allowance in Section 37-90-137(7), C.R.S., whereby produced water from a nontributary formation using a noncoal-bed methane operation may be applied to uses associated with Well Construction without a well permit.

- Reused or Recycled Well Construction Water – For all of the different sources listed above that are used for Well Construction, the water right in question must contain provisions that allow the water to be fully consumed. Under that scenario, water that is used for Well Construction of one well may be recovered and reused in the construction of subsequent oil or gas wells.

None of the above sources of water would affect existing or future diversions (with conditional water rights); thus, natural gas water related demands were not included in the model.

Coal

From personal communication with a representative at Xcel Energy, coal mining demands are difficult to estimate, due to being economically driven (Willhite 2013). Although demands through 2050 were estimated as part of the Energy Development Water Needs Assessment, the locations for those demands were vague. Deserado, Colowyo, Trapper, and Foidel Creek Mines all exist within the study area. However, water demands associated with coal mining may occur entirely at one location, divided evenly amongst all mining locations, or at an entirely new location.

As a part of the study on Peabody-Trout Creek, a project with associated demands was identified by URS, which gives an explicit location for additional water use. A constant demand of 500 AF per month on Trout Creek was placed just upstream of the confluence with the Yampa River. No conditional water rights were defined for this 6,000 AFY demand, and the entire demand is met from stored water from the Peabody-Trout Creek Project. Since this was the best available information regarding a coal demand location, this was used in lieu of the Energy Development Water Needs Assessment demands.

Uranium

Due to the small demands from future uranium mining, and uncertain location, uranium energy sector water demands were not considered for the Yampa Projects and Methods Study.

Oil Shale

Oil shale was the focus of Phase II of the Energy Development Water Needs Assessment. The primary target for oil shale production is the Piceance Creek Basin in the White River Basin. For existing conditions, flows on Piceance Creek from July through February are between 20 and 30 cfs on average. Oil shale production demands for the high demand scenario are a constant demand of approximately 150 cfs. Since the native water demands could not reliably support oil shale production demands, as part of the Energy Development Water Needs Assessment modeling, the demands were not diverted from Piceance Creek. Instead, water from multiple sources including storage would be required to reliably meet the high demand scenario of 110,000 AFY. The system of storage and undecreed water right diversions used in the Projects and Method study is explained further in the IPPs section for the White River Basin.

3.2.2 Nonconsumptive Needs

No new future nonconsumptive needs are defined as part of the Projects and Methods Study. The two nonconsumptive needs defined in Section 2 for existing conditions were carried forward and evaluated for each of the modeling scenarios. CWCB ISF flows maintain both their decreed water right seniority as well as flow rates. Locations identified in the Yampa-White WFET Study were simply evaluated for impacts from the various conditions determined as part of the scenario development.

3.3 Hydrology Scenarios

Various alternate hydrology scenarios were made available from other studies from the basin. The primary two that would provide a direct input for the StateMod modeling were climate change hydrologies from the CRWAS and "paleo-record flows," which were used in the UYWCD planning model.

Paleo-Record Flows

Paleo-record flows use an extended period of record to generate baseflow streamflow data. Extended datasets are created by calculating a correlation between historical streamflow records and tree growth (via tree ring thickness),which is used to extrapolate the period of record back historically to synthesize a much longer period of record—back through 762 AD. The longer period of record allows the model to run through any paleo-observed conditions, i.e., wetter periods, longer and/or more severe drought conditions.

During the modeling phase of the Projects and Methods Study, historical paleo-record flows were only available for the Yampa River Basin. Using paleo-record flows for the Yampa would mean that there would not be a consistent methodology between the Yampa and White River Basins, and therefore the pale-record method was not used.

CRWAS Climate Change Hydrology Flows

As part of the CRWAS, 10 Global Circulation Models (GCMs) were selected to determine potential future conditions within its study area. These climate change models were selected to provide a collection of conditions that range from cool and wet to hot and dry. Each of the GCMs represent a point along the two-axis spectrum—1. Cool to hot and 2. Wet to dry.

Ten climate scenarios were selected in CRWAS – Five based on the 2040 planning horizon and five based on the 2070 planning horizon. The projections represent future emission[11] scenarios (low, medium, and high) and temperature and precipitation estimates. The output from selected GCMs were regionally downscaled and used to develop the alternate hydrologies. Characteristics of the GCMs are summarized in **Table 3-5** from information included in Chapter 2 of the CRWAS report.

[11] Emission scenarios relate to the amount of greenhouse gasses released into the atmosphere.

Table 3-5. GCM Characteristics

Designation	Qualitative Scenario	Characteristic Temperature	Characteristic Precipitation	Flow Change (%)	Emission Scenario	GCM
2040 Selected Projections						
2040-A	Hot and Dry	90th Percentile	10th Percentile	-21%	A2	miroc-3.2.medres-Run 1
2040-B	Warm and Dry	30th Percentile	30th Percentile	-10%	A2	mri_cgcm-2.3.2a-Run 1
2040-C	Hot and Wet	70th Percentile	70th Percentile	-7%	A1B	ncar_ccsm-3-Run 2
2040-D	Median	50th Percentile	50th Percentile	4%	B1	cccma_cgcm-3.1-Run 2
2040-E	Warm and Wet	10th Percentile	90th Percentile	16%	A2	ncar_pcm-1-Run 3
2070 Selected Projections						
2070-F	Hot and Dry	90th Percentile	10th Percentile	-24%	A2	ncar_ccsm-3-Run 4
2070-G	Warm and Dry	30th Percentile	30th Percentile	-13%	A1B	mpi_echam-5-Run 3
2070-H	Hot and Wet	70th Percentile	70th Percentile	-8%	A2	mpi_echam-5-Run 1
2070-I	Median	50th Percentile	50th Percentile	1%	A2	ncar_pcm-1-Run 3
2070-J	Warm and Wet	10th Percentile	90th Percentile	13%	A2	cccma_cgcm-3.1-Run 2

The task presented in the Projects and Methods Study was simpler as the purpose of selecting climate change scenarios was not with the intent to select full climate change scenarios, only the hydrologies related to those climate change scenarios. Thus, the purpose of this selection was not to determine how climate change scenarios would affect the basin—as was performed in the CRWAS—but instead to provide a suite of alternate hydrologies that may occur.

The baseflow files used for each of the 10 climate change hydrologies were requested from Leonard Rice Engineers, and the baseflow files for 7 of them were obtained (2040_C, 2040_D, and 2070_G were not received). The 56-year time series of annual streamflows for one representative stream gage in the White River Basin and one stream gage in the Yampa River Basin were analyzed based on a drought run analysis. The representative stream gages include the following:

- Yampa River at Maybell (USGS ID 09304500)
- White River at Meeker (USGS ID 09251000)

The drought runs were summarized based on the length of the run, the cumulative drought volume of the run (deviation from the mean), and the intensity of the run (average annual drought volume).

The results of the drought analysis are summarized in **Tables 3-6 and 3-7**. A primary objective of the alternate hydrology analysis is to use an input baseflow time series that represents hydrologies both wetter and drier than historical conditions.

Table 3-6. Drought Run Analysis for WHITE RIVER AT MEEKER, CO (USGS 09251000)

Scenario	Mean (ac-ft/yr)	% of Historical Mean	Histogram - Variation from Mean (years)						Drought Run Analysis		
			< 50%	50% - 75%	75% - 100%	100% - 125%	125% - 150%	< 150%	Maximum (years)	Number of 3-, 4-, 5-, 6-, 7-year runs	> 2 yr. intensity (KAF/yr, avg.)
Historical	496,475	100%	0	11	19	17	8	1	5	2, 1, 2, 0, 0	88, 84, 96, 0, 0
2040_A	375,143	76%	3	10	19	10	8	6	7	2, 0, 0, 0, 2	77, 0, 0, 0, 81
2040_B	446,411	90%	2	9	20	13	10	2	7	2, 1, 0, 1, 1	85, 62, 0, 94, 75
2040_E	364,831	73%	8	11	12	11	5	9	7	2, 0, 1, 0, 1	113, 0, 83, 0, 93
2070_F	446,411	90%	2	9	20	13	10	2	7	2, 1, 0, 1, 1	85, 62, 0, 94, 75
2070_H	461,822	93%	6	8	15	13	9	5	5	2, 1, 1, 0, 0	109, 90, 121, 0, 0
2070_I	485,675	98%	2	10	20	10	12	2	7	1, 3, 0, 0, 1	84, 85, 0, 0, 89
2070_J	627,639	126%	4	10	14	12	13	3	5	2, 1, 1, 0, 0	141, 157, 158, 0, 0

Table 3-7. Drought Run Analysis for YAMPA RIVER AT MAYBELL, CO (USGS 09304500)

Scenario	Mean (ac-ft/yr)	% of Historical Mean	Histogram - Variation From Mean (years)						Drought Run Analysis		
			< 50%	50% - 75%	75% - 100%	100% - 125%	125% - 150%	< 150%	Maximum (years)	Number of 3-, 4-, 5-, 6-, 7-year runs	> 2 yr. intensity (KAF/yr, avg.)
Historical	1,241,476	100%	2	12	16	12	11	3	6	1, 1, 1, 1, 0	295, 313, 335, 322
2040_A	1,112,626	90%	5	8	17	12	11	3	7	2, 0, 0, 1, 1	269, 0, 0, 297, 233
2040_B	1,258,146	101%	3	12	14	13	11	3	6	2, 0, 0, 2, 0	351, 0, 0, 316, 0
2040_E	1,123,943	91%	6	10	13	12	9	6	7	2, 0, 0, 1, 1	307, 0, 0, 316, 283
2070_F	1,258,146	101%	3	12	14	13	11	3	6	2, 0, 0, 2, 0	351, 0, 0, 316, 0
2070_H	1,306,492	105%	5	10	15	13	6	7	7	2, 0, 0, 1, 1	339, 0, 0, 378, 308
2070_I	1,431,717	115%	3	12	15	11	13	2	6	2, 0, 0, 2, 0	372, 0, 0, 372, 0
2070_J	1,946,477	157%	3	11	16	14	7	5	7	2, 0, 0, 1, 1	511, 0, 0, 531, 437

Multiple selections could be made as the wettest and driest hydrologies to be used in the Projects and Methods Study:

- Most frequent drought conditions
- Most severe drought conditions
- Single greatest duration of drought conditions
- Percentage of historical mean
- Variance from mean flows

Any of these parameters could arguably be used to determine the wettest and driest hydrologies; however, since this selection simply is intended to provide alternate hydrologies, the analysis was taken to mean which hydrology had the greatest total volume of water (wet hydrology), which hydrology had the smallest total volume of water (dry hydrology), and which hydrology had a volume of water most similar to historical conditions (average hydrology).

The hydrologies selected for each of these conditions are as follows:

- Yampa River Basin
  - Wet hydrology – 2070_J
  - Average hydrology – 2070_I
  - Dry hydrology – 2040_A

- White River Basin
  - Wet hydrology – 2070_J
  - Average hydrology – 2070_F
  - Dry hydrology – 2040_A

Figures 3-1 and 3-2 show the naturalized average monthly flows simulated at Yampa River at Maybell (USGS ID 09304500) and White River at Meeker (USGS ID 09251000), respectively.

It must be specified that these hydrologies are independent from the historical conditions. For example, even though the 2070_J hydrology was selected as the wet condition, it does not categorically mean that for any given month flows would be greater (or less) than historical flows for that month. This fact may cause concern due to retiming of flows seen in most scenarios. This retiming of flows generally manifests as having peak flows earlier in the year and low late season flows. Even in some wet hydrologic conditions, late season flows may be less than historical conditions (see June and July flows for both wet hydrologies in Figures 3-1 and 3-2). This is caused by warmer temperatures in all climate change scenarios, which leads to snow melting earlier in the year, regardless of the increase or decrease in characteristic precipitation.

Intuitively, this contradicts what most readers may think, which would be that historical hydrologies are scaled up or down to generate wet or dry conditions. However, these hydrologies were meant to provide alternatives to the historical hydrology, not provide a scaled re-sequencing of the historical hydrology.

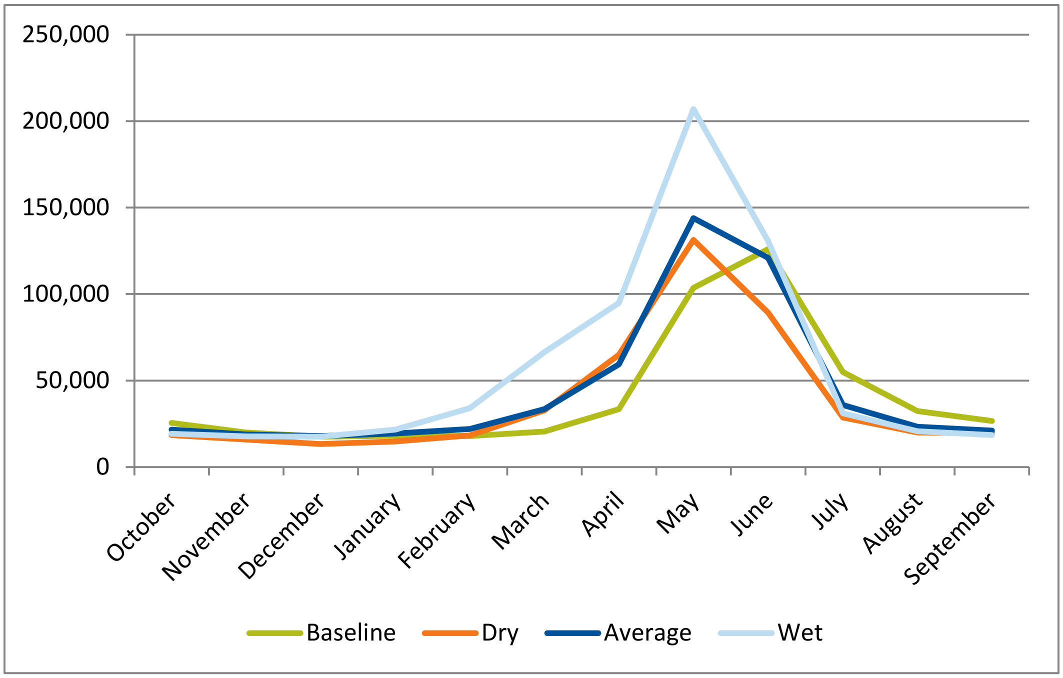


Figure 3-1. Comparison of Hydrology Scenarios at Yampa River Gage at Maybell (USGS 09304500)

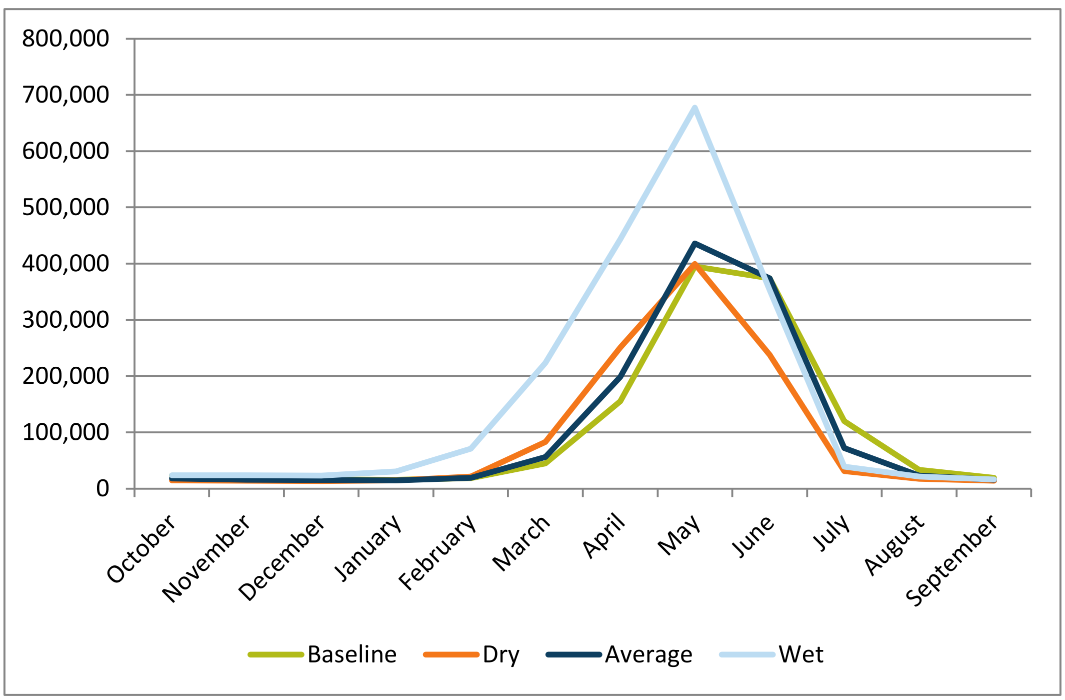


Figure 3-2. Comparison of Hydrology Scenarios at White River Gage at Meeker (USGS 09251000)

3.4 Water Allocation Modeling Approach

Water allocation modeling in the second task of the Projects and Methods Study serves a similar purpose as the water allocation modeling in the first task. The baseline model was used as the basis for all modeling performed for the second task; therefore, modeling modifications described in Section 2 also apply to this section. Similar to the Baseline model, the model uses a 56-year hydrologic period of record.

Per Section 3.2.1.2, agricultural demands for all existing agriculture remain the same, i.e., it was assumed that no reductions in irrigated acreage will take place, the baseline StateCU model described in Section 2.5.1 continues to apply to all future models. Additional modeling was almost[12] exclusively in StateMod.

The baseline StateMod model used to generate the results in Section 2 was further developed to create future model scenarios. The term "Model Scenario" is used to describe a unique combination of one demand scenario, one hydrology scenario, and one or more IPPs. The following sections will describe how each of those model scenario elements (demands, hydrologies, and IPPs) was developed.

3.4.1 Demand Scenarios

Demand scenarios were split up into three levels—low, medium, and high. Using the demands defined in Section 3.2, three separate demand inputs were developed.

- Low, medium, and high M&I demands were split up by county into each county's respective existing M&I demand nodes.
- Reductions in agricultural demands due to urbanization, agricultural to municipal transfers, or any of the other reasons described in Section 3.2.1.2were not considered. The only demand that the low, medium, and high demand scenarios affect are the demands for the 14,805 potentially irrigable acres found along the Yampa River oxbows. The low demand scenario represents development of 50 percent of the acreage, the medium scenario represents development of 75 percent of the acreage, and the high scenario represents development of 100 percent of the acreage.
- Thermoelectric power generation demands were split up by county into each county's respective existing thermoelectric power generation facilities using a similar methodology to the M&I demands.
- Energy development demands were split into sectors and located using various sources of information (COGCC, Energy Development Water Needs Assessment, Peabody-Trout Creek Project).
    - Natural gas demands may grow significantly through the 2050 planning horizon; however, since demands will not be met through direct diversion water rights, natural gas demands were not modeled[13].

---

[12] Consumptive use demands for the oxbows development demands did require further StateCU modeling. However, this was the only calculations performed outside of StateMod.

[13] Per the Natural Gas description in Section 3.2.1.4, although demands are not explicitly modeled in StateMod, other sources of supply that do not effect groundwater may still be used to supply Natural Gas Demands.

- Coal mining development was not associated with any specific mines in the basin; however, as part of the Peabody-Trout Creek Project, a location was identified that accounted for 6,000 AFY of demand. Since this was the best available information on the location of coal mining development, the location of these demands on Trout Creek as well as the magnitude was used in lieu of the Energy Development Water Needs Assessment coal sector demand forecast.

- Uranium production is expected to be small comparatively to the other sectors, even at the high production level. Additionally, a location/source of supply for the demands is uncertain; therefore, uranium production demands were not modeled.

- Oil shale demands were modeled using the same methodology found in the Energy Development Water Needs Assessment model. The actual diversion point of the system is located downstream of Lake Avery; however, the actual point of use would be in the Piceance Creek Basin. Low, medium, and high demand levels for oil shale development were determined by the long-term (2036 to 2050) low, medium, and high production forecasts.

3.4.2 Hydrology Scenarios

Hydrology scenarios defined in Section 3.3 used a similar selection process as the demand scenarios. Inputs were generated for dry, average, and wet hydrologies. The wet hydrology represents a scenario where more water exists in the future than historically. The dry hydrology represents a scenario where less water exists in the future than historically. The average hydrology represents a scenario with average annual flows most similar to historical flows. With each of these hydrologies, respective drought characteristics may occur, i.e., frequency of droughts, duration of droughts, intensity of droughts, variations in flows, etc.

3.4.3 Identified Projects and Processes

IPPs are projects at varying degrees of feasibility identified in one or more of the previous studies performed in the Yampa and White Basins as well as some projects defined by the BRT subcommittee as a part of this study. Each IPP must contain the following elements in order to be modeled:

- Project Proponent – Acted as a source of information, i.e., reports, project stakeholder, etc.
- Location
- Physical Characteristics
- Operations
- Water Rights – Either conditional water rights, or an undecreed water right, is assumed as a proxy

The following sections describe each of the IPPs modeled in the Projects and Methods model, along with the data associated with each of them.

3.4.3.1 Reservoirs (Yampa)

Little Bear I Reservoir

Little Bear I Reservoir was originally identified as part of the Yampa River Basin Small Reservoir Study – Phase 2 (Montgomery Watson 2000). It was one of three reservoirs carried forward from the Phase 2 study as a need was determined and upon a field visit, no fatal flaws were found. A location, capacity, and yield were determined as part of the study. Little Bear I Reservoir had the following characteristics:

- Location – Fortification Creek Basin
- Capacity – 800 AF
- Storage Right
  - No conditional storage rights, junior storage right assumed
- Operations
  - Releases are made to three aggregate diversions (WDID 440511, 440612, and 440688), which were identified as the three diversions to which Little Bear I Reservoir could release water as described in the Agricultural Water Needs Study.

South Fork II Reservoir

South Fork II Reservoir was originally identified as part of the Yampa River Basin Small Reservoir Study – Phase 2. It was one of three reservoirs carried forward from the Phase 2 study as a need was determined and upon a field visit, no fatal flaws were found. A location, capacity, and yield were determined as part of the study. South Fork II Reservoir had the following characteristics:

- Location – Fortification Creek Basin
- Capacity – 1,700 AF
- Storage Right
  - No conditional storage rights, junior storage right assumed
- Operations
  - Releases are made to seven aggregate diversions (WDID 440511, 440612, 440647, 440650, 440681, 440688 and 440998), which were identified as the seven diversions to which South Fork II Reservoir could release water as described in the Agricultural Water Needs Study.

Monument Butte Reservoir

Monument Butte Reservoir was originally identified as part of the Yampa River Basin Small Reservoir Study – Phase 2 (Montgomery Watson 2000). It was one of three reservoirs carried forward from the Phase 2 study as a need was determined and upon a field visit, no fatal flaws were found. A location, capacity, and yield were determined as part of the study. Monument Butte Reservoir had the following characteristics:

- Location – Morapos Creek Basin
- Capacity – 4,390 AF
- Storage Right
  - No conditional storage rights, junior storage right assumed
- Operations
  - Releases are made to four aggregate diversions (WDID 440590, 440651, 440814, and aggregate diversion 44_ADY016A), which were identified as the diversions to which Monument Butte Reservoir could release water to as described in the Agricultural Water Needs Study.

Rampart Reservoir

Rampart Reservoir was originally identified as part of the Yampa River Basin Small Reservoir Study – Phase 2. Based upon preliminary field reconnaissance and subsequent screening, Rampart Reservoir was not recommended for further analysis due to being a historical area[14], sediment load, extent of dam, need to relocate Highway 13, and location on federal land (Bureau of Land Management). During the October 3, 2013 subcommittee meeting, Tom Gray suggested that due diligence was recently performed on a conditional storage right for Rampart Reservoir and that it should be considered as an IPP. In the Yampa River Basin Small Reservoir Study, a location, capacity, and yield were determined. Rampart Reservoir had the following characteristics:

- Location – Lower Fortification Creek upstream of Wisconsin Ditch
- Capacity – 12,133 AF
- Storage Right
  - A first fill water right with administration number 41126.00000 and conditional storage of 12,133 AF
  - A second fill water right with administration number 47905.00000 and conditional storage of 11,692 AF
- Operations
  - Since Rampart Reservoir is only located upstream of two potentially short water diversions (the oxbows aggregate diversion and WDID 440511), releases are made to the oxbows aggregate diversion and WDID 440511
  - The second set of operations for Rampart Reservoir is to exchange water upstream to South Fork II and Little Bear I
  - The last set of operations for Rampart Reservoir is to exchange water upstream to each individual diversion on Fortification Creek

Peabody-Trout Creek Reservoir

Peabody-Trout Creek Reservoir was identified as part of a supply project to meet energy development demands for the Peabody energy development demands described in Section 3.2.1.4. Modeling for the Peabody-Trout Creek Reservoir supply project was performed by ERC. A model was received from ERC and details of the modeling were clarified through personal communications (Thompson 2013). The following characteristics for Peabody-Trout Creek Reservoir were identified:

- Location – Trout Creek upstream of the confluence with the Yampa River
- Capacity – 11,720 AF
- Storage Right
  - A first fill water right with administration number 43575.00000 and conditional storage of 15,000 AF

---

[14] Fortification Rocks are a historic landmark and were used as fortresses by Native Americans.

- Operations
  - The sole purpose of the Peabody-Trout Creek Reservoir is to meet the 6,000 AFY energy development demands (which do not have a direct diversion water right) that are also part of the Peabody-Trout Creek Project

Milk Creek Reservoir

Details for Milk Creek Reservoir were discussed through personal communications with Tri-State Generation & Transmission Association (Chartrand 2013). Milk Creek Reservoir is part of a potential industrial supply project to meet future energy development demands. Although Milk Creek Reservoir currently has storage rights for industrial beneficial uses only, the BRT subcommittee requested that Milk Creek Reservoir be modeled for both industrial uses and agricultural uses.

- Location – Milk Creek Reservoir upstream of the confluence with the Yampa River
- Capacity – 70,000 AF
- Storage Right
  - An existing conditional water right with a 1976 date of decree of 70,000 AF; however, this is only for industrial beneficial uses. Since the BRT subcommittee wanted to examine Milk Creek Reservoir for agricultural use, it was agreed with Tri-State that the reservoir would be half used for industrial uses and half used for agricultural uses. For the Projects and Methods Study, this conditional right maintained its 1976 water right date, but the storage was reduced to 35,000 AF.
  - The remaining 35,000 AF of storage is filled using an undecreed water right for agricultural uses.
- Operations
  - Similar to Rampart Reservoir, Milk Creek Reservoir cannot release to any water short diversions on upper Milk Creek; however, releases are made to the Yampa River oxbows diversion.
  - Milk Creek Reservoir also exchanges to all diversions upstream on Milk Creek if exchange capacity exists on the creek.
  - Since no demands were associated with the industrial portion of Milk Creek Reservoir, no operations were defined for the industrial storage account
- Additional Source – Yampa River - Milk Creek Pipeline
  - The Yampa River - Milk Creek Pipeline is also part of the Milk Creek Project. The Yampa River - Milk Creek Pipeline is used to fill Milk Creek Reservoir using water from the Yampa River.
  - The following characteristics were determined from case number 08CW86: the pipeline has a 400 cfs conditional water right (administration number = 45923.00000). However, this water right is for industrial beneficial uses only (similar to the storage right for Milk Creek Reservoir). The pipeline water right was also split in half to fill both storage accounts (industrial and agricultural). The industrial half retained its water right seniority, but the

rate was reduced to 200 cfs. The agricultural portion uses an undecreed water right also with a 200 cfs rate.

Morrison Creek Reservoir

Details for Morrison Creek Reservoir were discussed through personal communications with UYWCD through their modeling team from AMEC (Musleh 2013). The modeling approach used to include Morrison Creek Reservoir into the Projects and Methods model was directly derived from the modeling used in the UYWCD model sent via email (dated 7/26/2013). Morrison Creek Reservoir is part of a potential supply project to meet future supplies in a similar manner to Stagecoach Reservoir.

- Location – Morrison Creek
- Capacity – 4,965 AF
- Storage Right
  - There are two storage rights for Morrison Creek Reservoir, a first fill and a second fill. The first fill right has a 4,965 AF conditional water right (administration number = 41272.39991) and the second fill has a 5,655 AF conditional water right (administration number = 57676.00000).
- Operations – in order of seniority
  - Releases to augment Stagecoach reservoir supplies
  - Releases to Craig
  - Releases to Walker Irrigation Ditch
  - Releases to Mount Werner Water
  - Releases are made to Steamboat Wells A, G, and H from the "First Fill" pool
  - A bypass to the Willow Spring & Pond ISF
- Additional Source – Morrison Creek Pipeline
  - A 50 cfs conditional water right (administration number = 52959.00000) above Morrison Creek Reservoir was studied by the UYWCD. The modeling received from AMEC that was used in this study did not have any operations assigned and did not transfer water within the model.

3.4.3.2 New Diversions (Yampa)

Steamboat Supply

The Steamboat Supply pipeline was originally identified in the Steamboat Supply Master Plan (Stantec 2008) through a conditional water right that Steamboat Springs owns on the Elk River. The Steamboat Supply was reevaluated in the UYWCD Supply Plan model, for which the methodology was carried into the Projects and Methods Study. The Steamboat Supply has the following characteristics:

- Demands for the Steamboat Supply were defined in the report using a repeating monthly time series shown in **Table 3-8**.

Table 3-8. Steamboat Supply Demands

Month	Demand (AF)
October	217
November	197
December	229
January	263
February	228
March	264
April	184
May	257
June	328
July	492
August	431
September	365
July	492
August	431
September	365

These demands are not augmented and are met with a junior water right (appropriation date = 12/14/1999) with an 8 cfs conditional rate.

The methodology for modeling the Steamboat Supply was developed using the UYWCD Water Plan methodology. Demands developed for the Steamboat Supply were separate and in addition to the M&I demands described in Section 3.2.1.1.

3.4.3.3 Reservoirs (White River Basin)

Lake Avery Enlargement

The Lake Avery Enlargement was identified in the Energy Development Water Needs Assessment as part of the oil shale production supply system. The Lake Avery Enlargement is the secondary source of supply used in the oil shale production supply system (after direct diversions from the White River). The Lake Avery Enlargement has the following characteristics:

- Location – Expansion to Big Beaver Reservoir (Avery Lake)
- Capacity – 48,274 AF + 7,658 AF (original capacity of Big Beaver Reservoir)
- Storage Right
  - The purpose of the Scenario 2 and 3 models of the Energy Development Water Needs Assessment was to reliably meet oil shale production demands with rights junior to all other diversions in the basin. That methodology was also used in the Projects and Methods Study. Therefore it is modeled with an undecreed water right.
  - The Lake Avery Enlargement is filled both by a pipeline diverting water from the White River upstream of Big Beaver Creek and a direct storage right on Big Beaver Creek.
- Operations
  - The only operation for the Lake Avery Enlargement is making direct releases to meet oil shale production demands.

Wolf Creek Reservoir

Wolf Creek Reservoir was identified in the Energy Development Water Needs Assessment as part of the oil shale production supply system. The Energy Development Water Needs Assessment recognized that under current conditions, oil shale production demands can be met using the other elements in the oil shale production supply system (Lake Avery Enlargement, Diversion from White River to fill Lake Avery, Direct Diversion from the White River (above Piceance Creek) to meet Oil Shale Demands). However, Wolf Creek Reservoir was used as an IPP in the model to demands under some of the Modeling Scenarios with drier hydrologies. Wolf Creek has the following characteristics:

- Location – On the White River downstream of the confluence with Piceance Creek
- Capacity – 162,400 AF
- Storage Right
  - The purpose of the Scenario 2 and 3 models of the Energy Development Water Needs Assessment was to reliably meet oil shale production demands with rights junior to all other diversions in the basin. That methodology was also used in the Projects and Methods Study; therefore, it is modeled with a 2013 water right.
  - The only water right Wolf Creek Reservoir uses to store water is an undecreed water right on the White River
- Operations
  - Water from Wolf Creek Reservoir is transported upstream via carrier to directly meet oil shale production demands.

3.4.3.4 New Diversions (White)

Oil Shale Production Pipelines/Diversions

The model used for Scenario 3 of the Energy Development Water Needs Assessment is a conceptual supply system rather than an actual system with physical components. Therefore, the actual physical infrastructure required to implement this supply system may differ from the model. In the modeling there are three pipeline/diversion elements that carry water to meet demands. The following describes each element and how it conceptually works:

- White River direct diversion to meet oil shale production demands on Piceance Creek – This diversion is the first source of supply used to meet the oil shale production demands. It is located on the White River just upstream of the confluence with Piceance Creek. It has a 165.05 cfs water right (120,000 AFY) that is augmented by the Avery Lake Enlargement as well as Wolf Creek Reservoir.
- White River pipeline used to fill the Lake Avery Enlargement – A pipeline located on the White River upstream of Big Beaver Creek is used to fill the Lake Avery Enlargement. Although both Scenarios 2 and 3 of the Energy Development Water Needs Assessment use this pipeline, Scenario 2 uses a very large pipeline (1,677 cfs) to fill the Lake Avery Enlargement, while Scenario 3 uses a smaller pipeline (100 cfs). In either case it was shown that all oil shale production demands under the high production level could be met without augmentation from Wolf Creek Reservoir. The model received from AMEC for this study was the Scenario 3 model

with a 100 cfs pipeline filling the Lake Avery Enlargement, which was used for the Projects and Methods modeling.

- As part of the Wolf Creek Reservoir operations from Scenario 2, oil shale production demands were augmented by water delivered via a carrier from Wolf Creek Reservoir. Although this operating rule was not activated in Scenario 2 of the Energy Development Water Needs Assessment, the operating rule was carried forward into the Projects and Methods model.

3.4.3.5 Other IPPs

The IPP that does not explicitly fit into this section as a reservoir or a new pipeline/diversion was identified as part of the Agricultural Water Needs Study (CDM Smith 2010), is modifying all "B" aggregates to use sprinklers instead of flood irrigation, thereby increasing their maximum efficiencies. Under water long conditions where each aggregate diverts in excess of their IWR water needs, this makes no difference in any of the results. However, under water short conditions, or near water short conditions, this allows "B" aggregates to meet a greater percentage of their IWR.

3.4.4 Scenario Development

In order to better understand current and future water resources development in the Yampa and White River Basins, several scenarios were defined to determine the impacts of future demands, varying hydrology, and benefits of proposed IPPs. Modeling scenarios are made up of a combination of the following elements as shown in **Figure 3-3**.

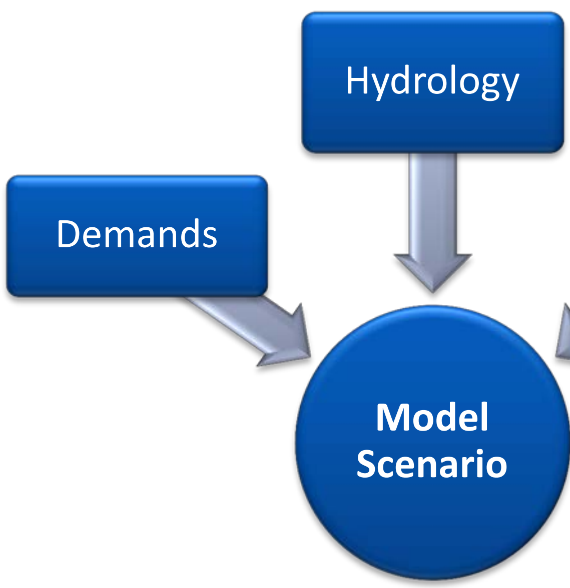


Figure 3-3. Scenario Elements

As shown in Figure 3-3, model scenarios were developed by combining a demand scenario, a hydrology scenario, and a combination of IPPs. As part of the BRT meetings, a total of six model scenarios were to be recommended to evaluate a range of potential future scenarios. Each of these scenarios was developed from the Baseline models, which were used as a basis of comparison. The Baseline "model scenario" was made up of existing demands, historical hydrology, and no IPPs. The BRT subcommittee determined the model scenarios by selecting from the following:

- For demands, one of the four demand scenarios could be chosen: (Historical, Low, Medium, and High)
- For hydrologies, one of the four hydrology scenarios could be chosen: (Historical, Dry, Average, and Wet)
- For the IPPs, one, all, or a subset of all of the IPPs defined in Section 3.4.3 may be turned on or off

Two meetings were held with the BRT subcommittee to identify the selected scenarios to be performed as a part of this study. The scenarios incorporate variations in demands, hydrology, and inclusion of IPPs. The list of final scenarios developed for the Projects and Methods Study are shown in **Table 3-9**.

Table 3-9. Model Scenario Components

Model Scenario	Demand Scenario	Hydrology Scenario	IPPs
Scenario 1[1]	High	Dry	All IPPs Selected
Scenario 2[1]	Medium	Dry	All IPPs Selected
Scenario 3[1]	Medium	Average	All IPPs Selected
Scenario 4[2]	Existing	Dry	No IPPs Selected
Scenario 5[2]	Existing	Wet	All IPPs Selected
Scenario 6[2]	High	Dry	No IPPs Selected

[1] Scenarios were selected during the July 17, 2013 BR technical subcommittee meeting
[2] Scenarios were selected after the results from the first three model scenarios were shown during the October 3, 2013 BRT subcommittee meeting

3.5 Modeling Results

Water supply gaps were reevaluated in the same method described in Section 2. Agricultural, M&I, and Thermoelectric shortages are determined on the basis of the percentage of consumptive use demand that is not met. Nonconsumptive use gaps are defined based on which type of nonconsumptive use it is. CWCB ISF gaps are defined as the difference between the decreed flow rates and the minimum flow simulated along the reach. Environmental WFET flows continue to use the flow metrics defined in Section 2.6.4.2. Recreation WFET flow metrics also use the same method described in Section 2.6.5.

3.5.1 Scenario 1

Scenario 1 represents the case to evaluate how IPPs perform under the highest demand, driest hydrology model scenario. As such, basin wide existing agricultural shortages increase except where water is augmented by an IPP. Some additional agricultural shortages also appear within the basin. This increase in agricultural shortages primarily comes as a result of the dry alternate hydrology.

Generally, agricultural demands have more senior water rights than M&I and thermoelectric demands; therefore, the demand level projections have a negligible effect on agricultural shortages[15]

The results of model Scenario 1 are shown graphically in **Figures 3-4 through 3-10.**

[15] This can be seen in Table 3-9 in Section 3.5.7 by comparing Scenario 1 and Scenario 2 results.

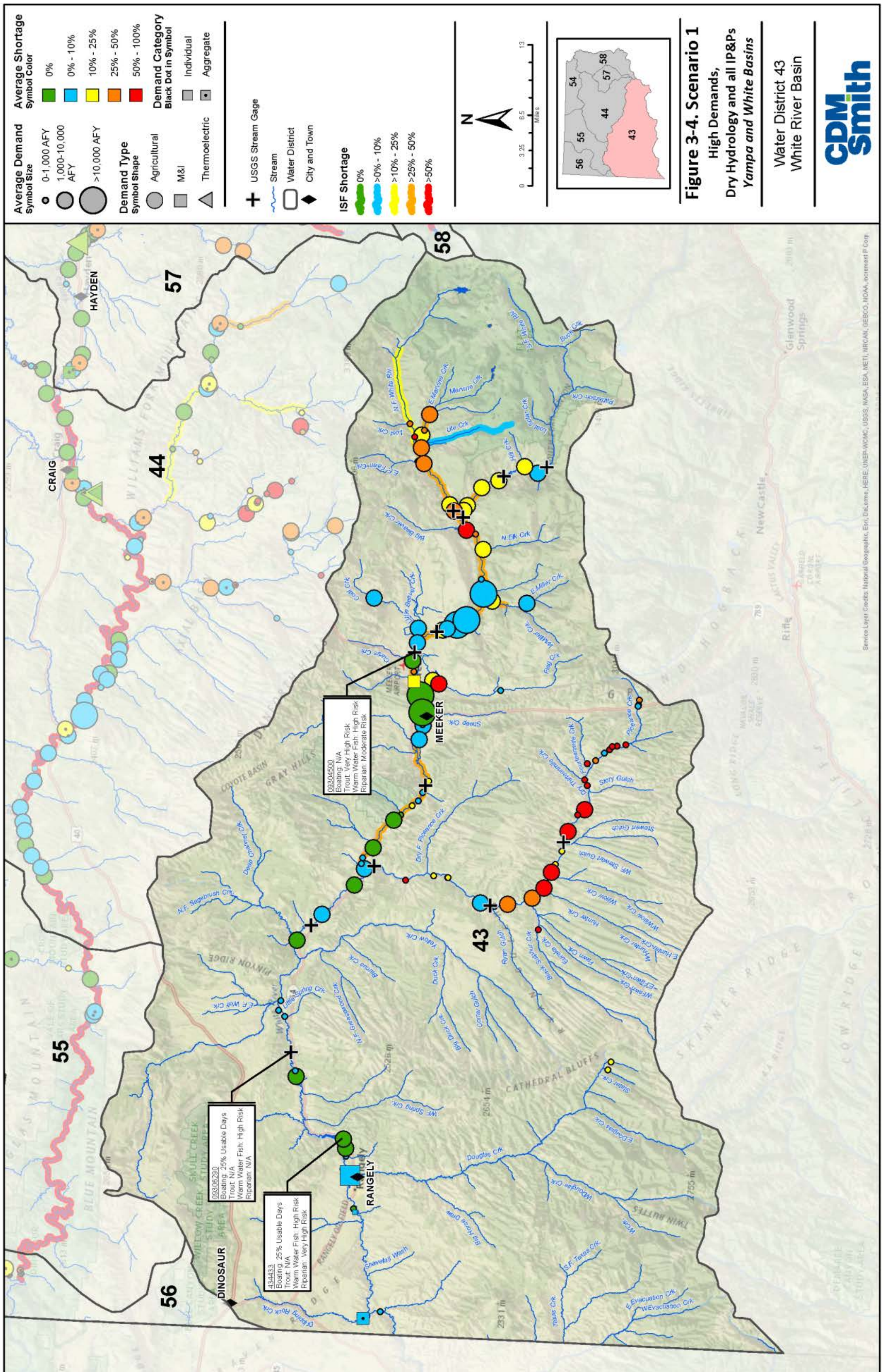


Figure 3-4. Scenario 1
High Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins

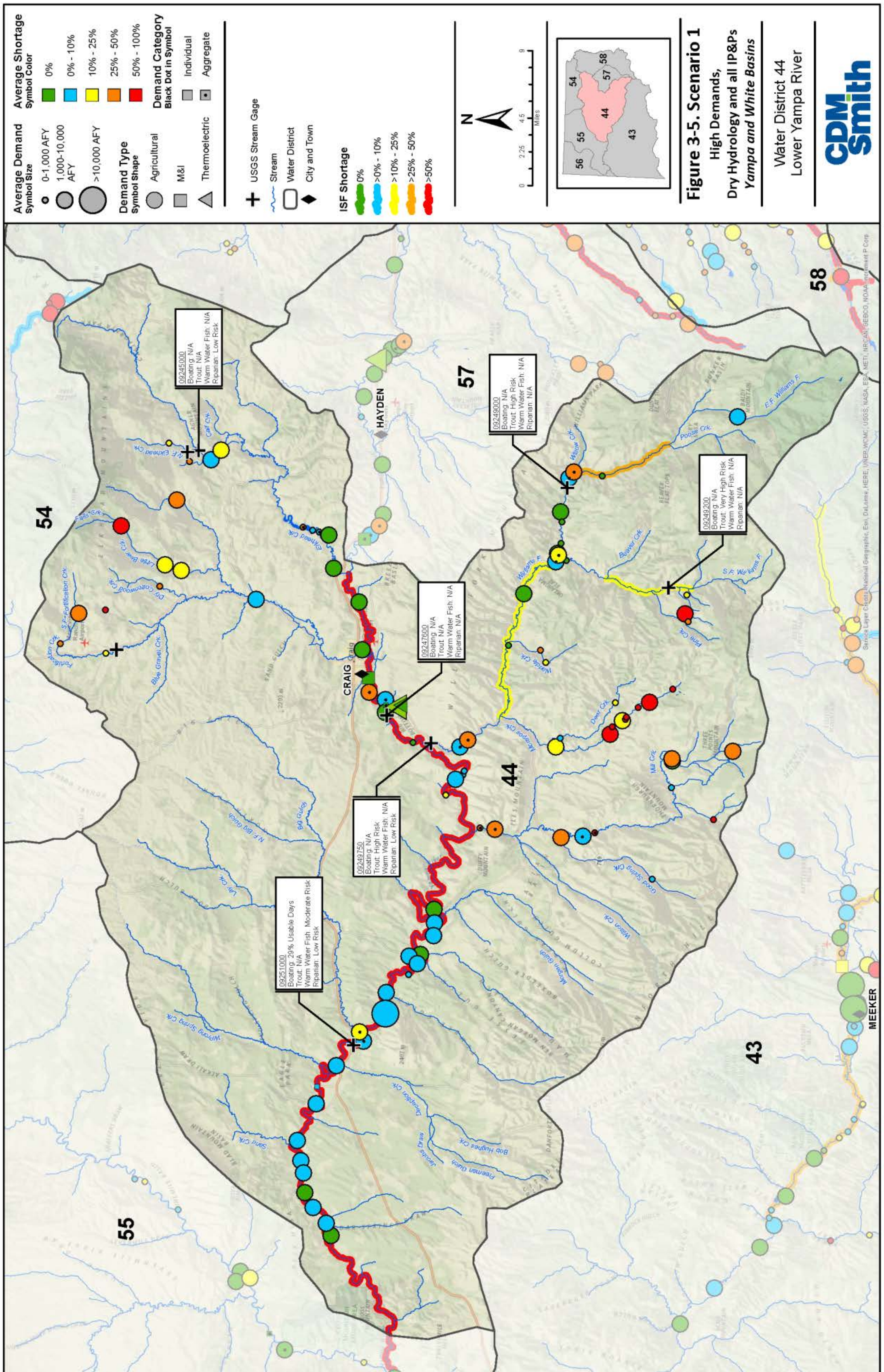
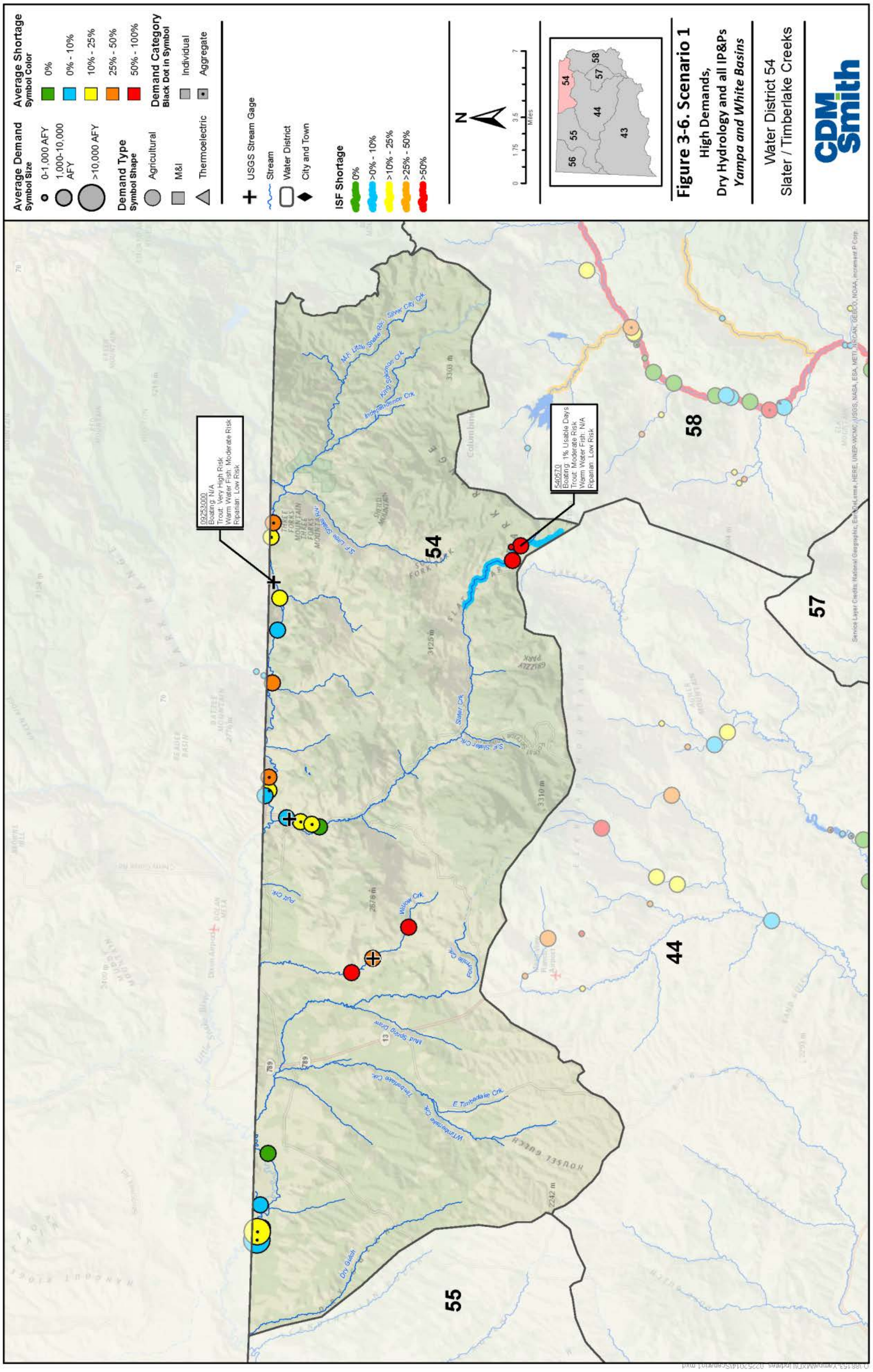


Figure 3-5. Scenario 1
High Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins

Water District 44
Lower Yampa River


Average Demand
Symbol Size
0-1,000 AFY
1,000-10,000 AFY
>10,000 AFY
Demand Type
Symbol Shape
Agricultural
M&I
Thermoelectric
Average Shortage
Symbol Color
0%
0% - 10%
10% - 25%
25% - 50%
50% - 100%
Demand Category
Black Dot in Symbol
Individual
Aggregate
USGS Stream Gage
Stream
Water District
City and Town
ISF Shortage
0%
>0% - 10%
>10% - 25%
>25% - 50%
>50%
Miles
Figure 3-6. Scenario 1
High Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins
Water District 54
Slater / Timberlake Creeks
09253000
Boating: N/A
Trout: Very High Risk
Warm Water Fish: Moderate Risk
Riparian: Low Risk
54
55
58
57
44

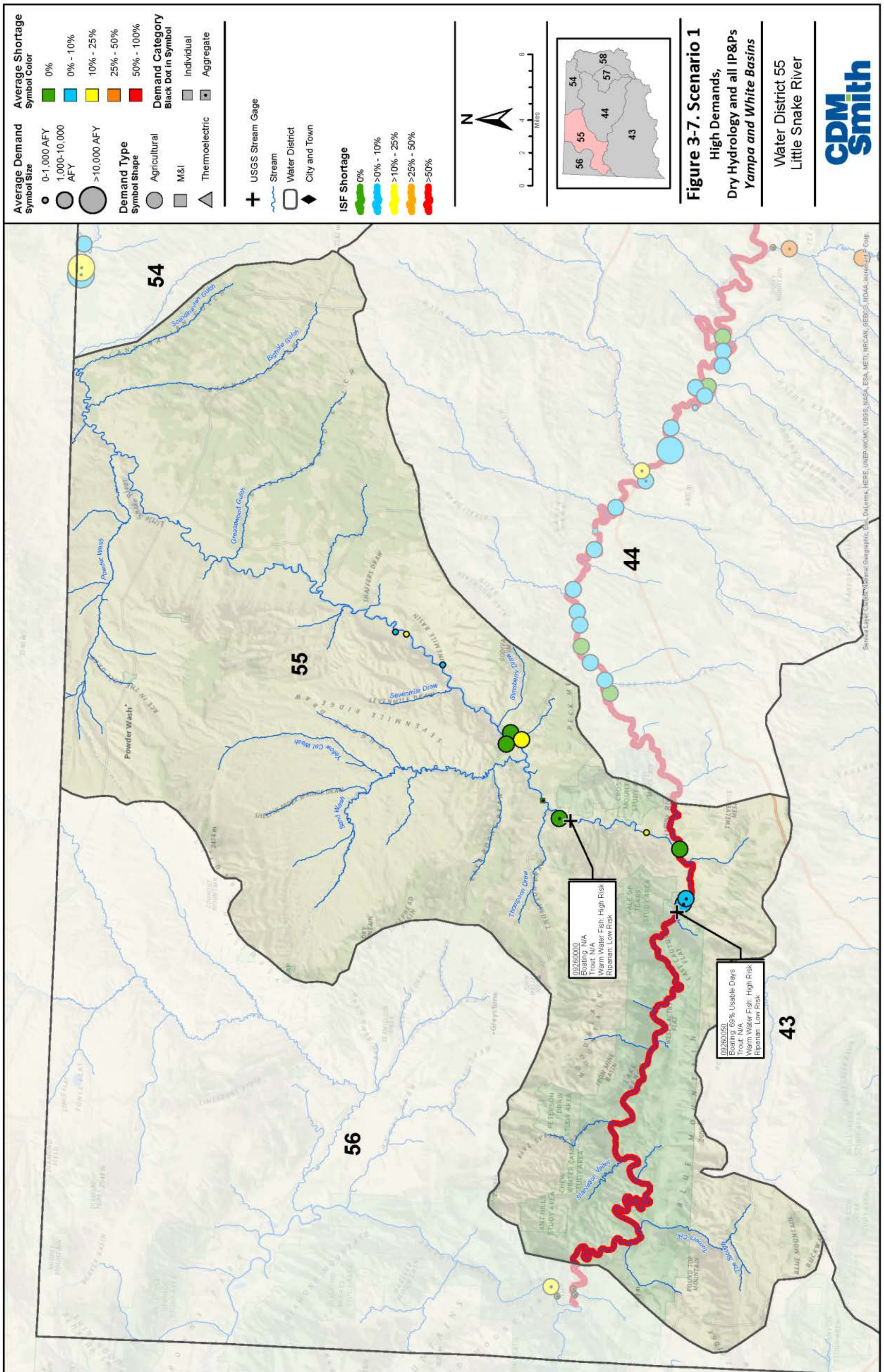


Figure 3-7. Scenario 1
High Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins

Water District 55
Little Snake River

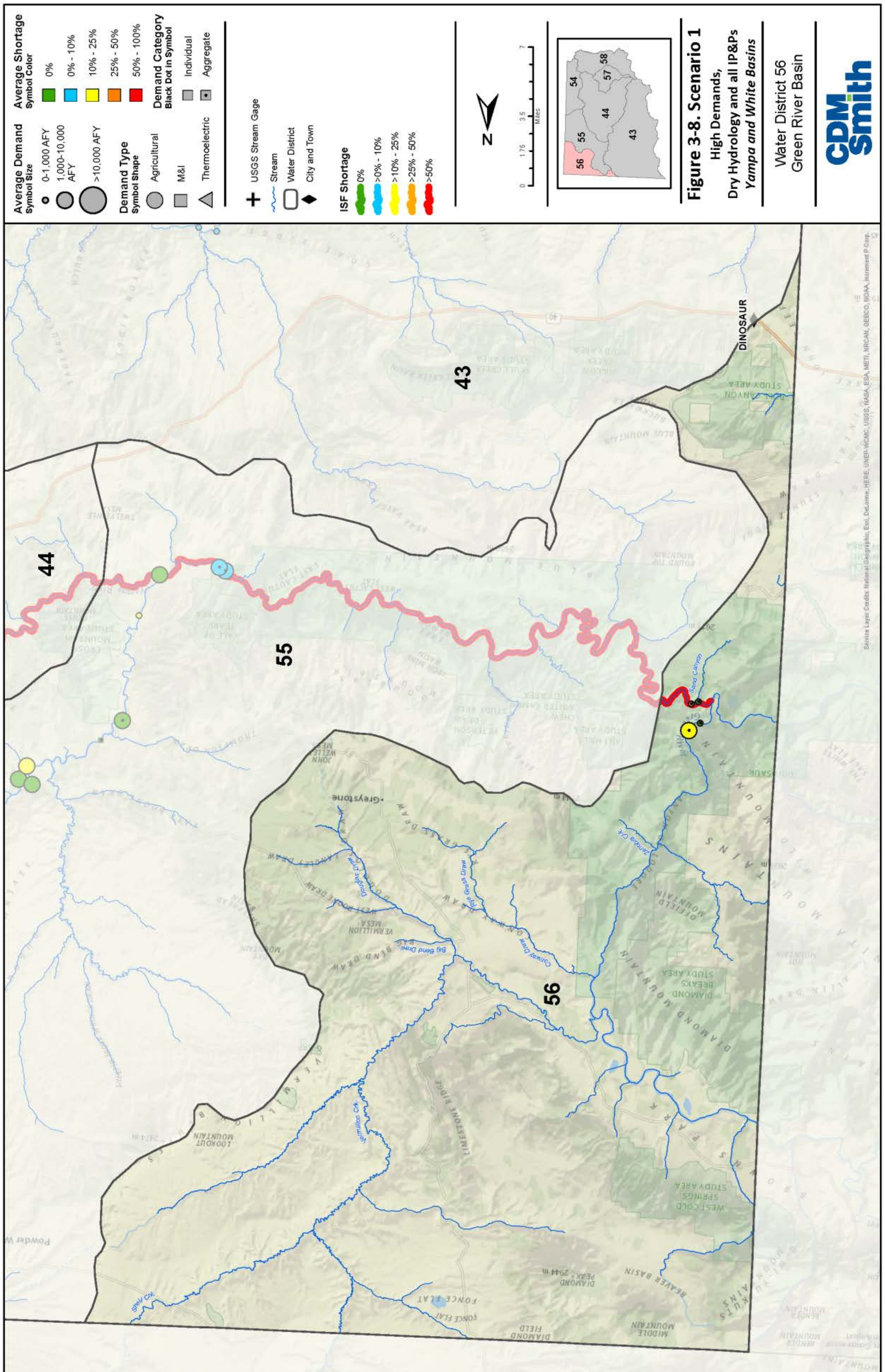


Figure 3-8. Scenario 1
High Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins

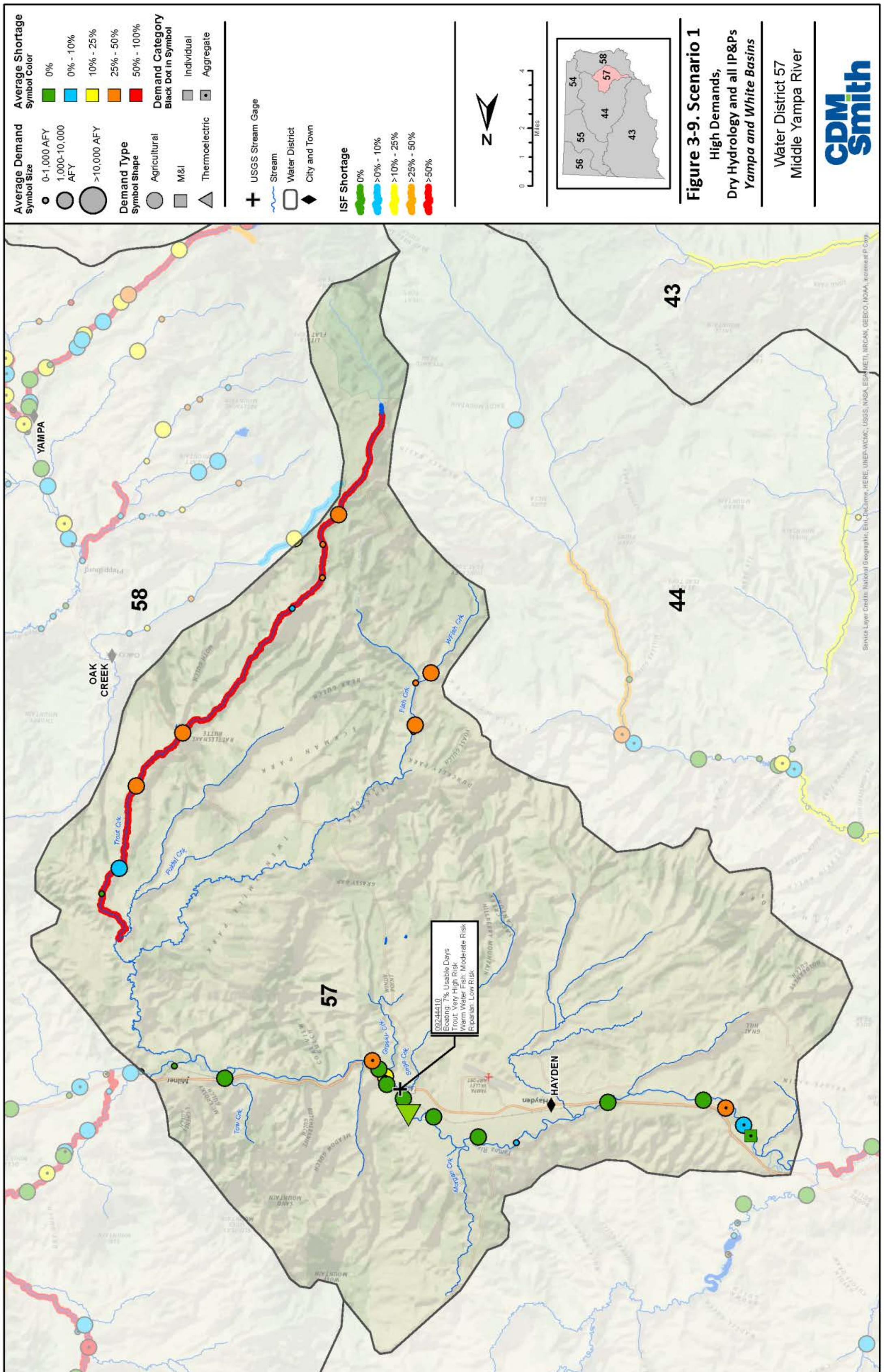


Figure 3-9. Scenario 1
High Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins

Water District 57
Middle Yampa River

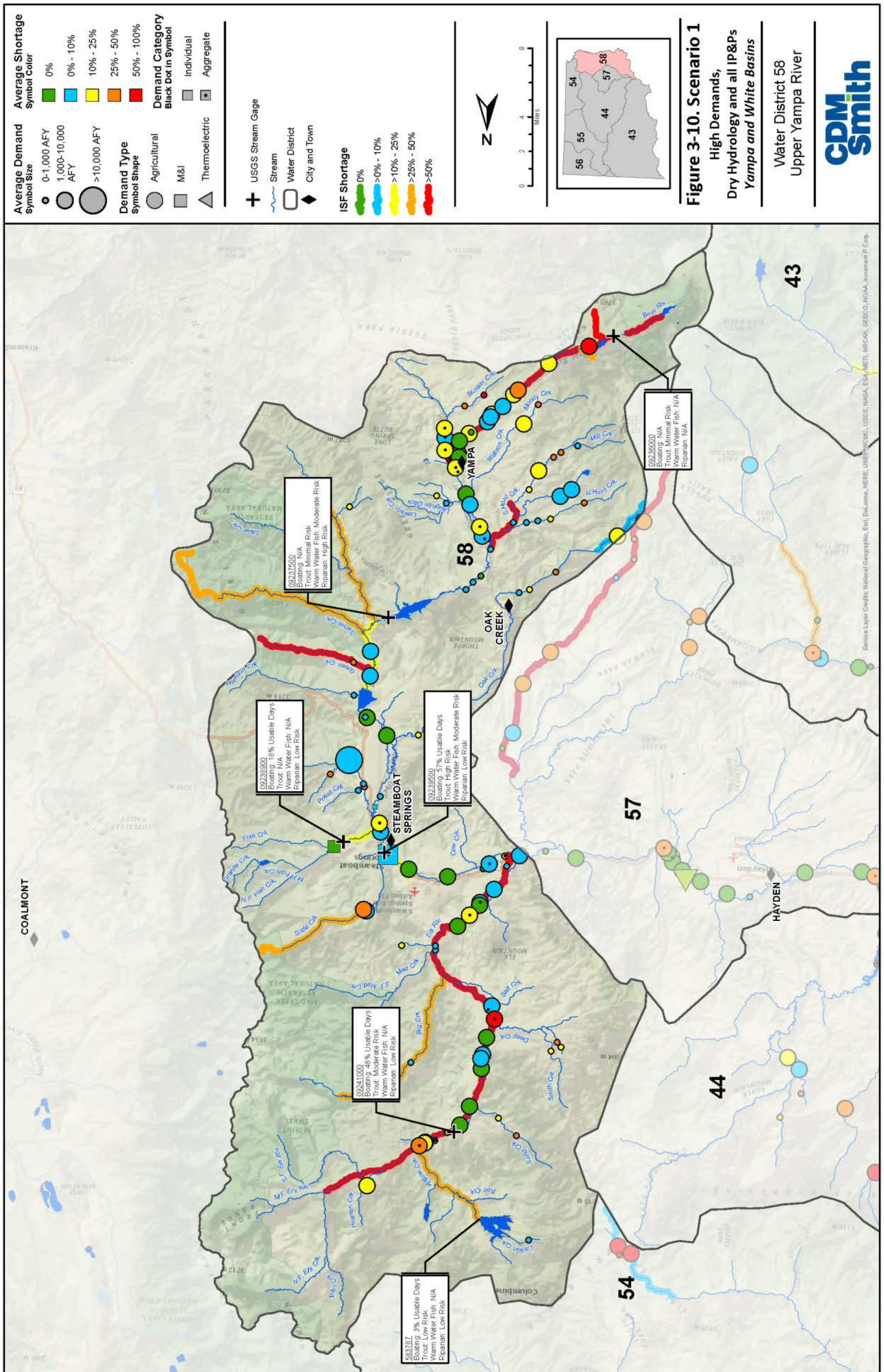
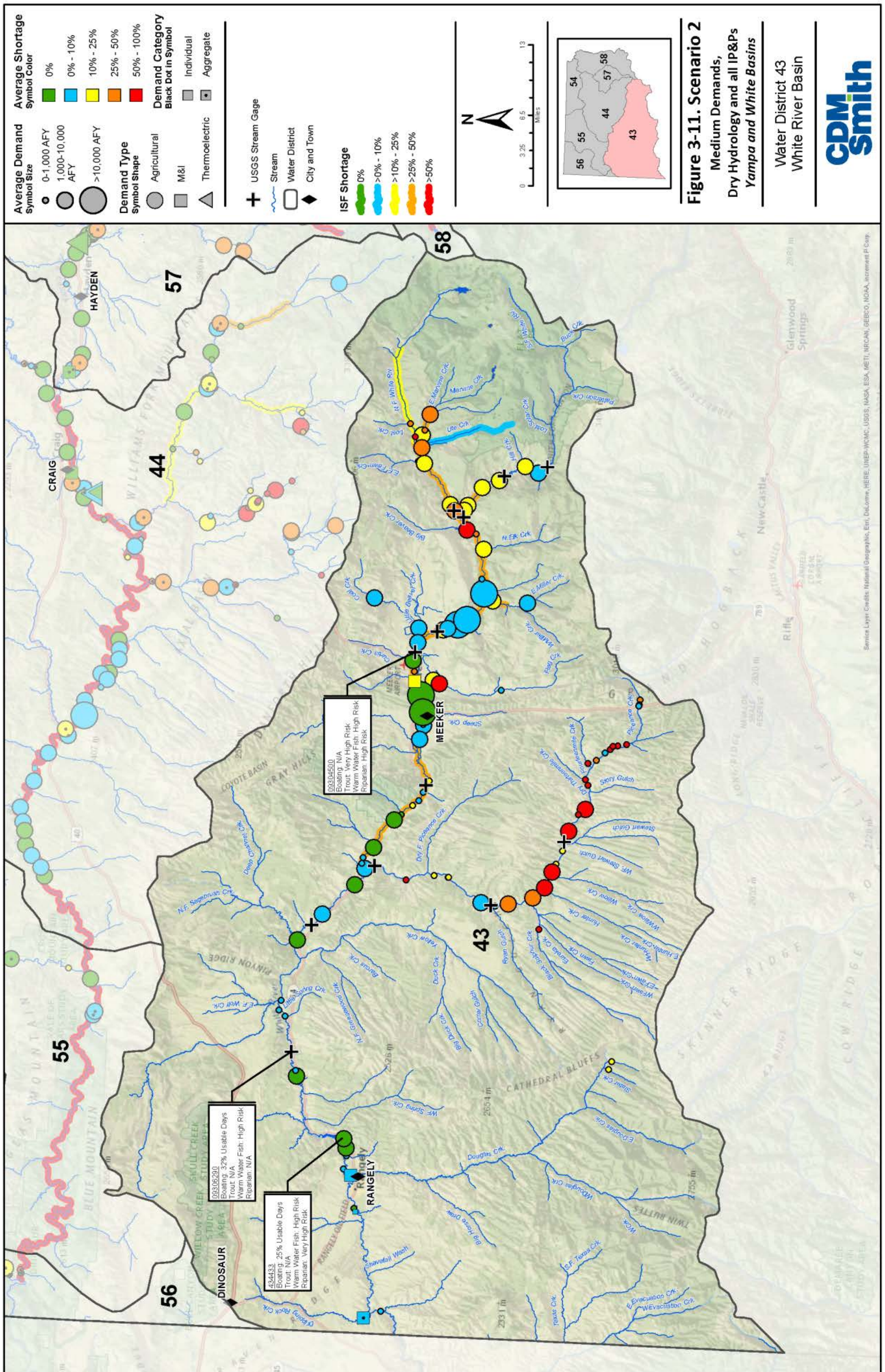


Figure 3-10. Scenario 1
High Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins

3.5.2 Scenario 2

Model Scenario 2 was selected to create a less severe version of model Scenario 1. The only difference between model Scenarios 1 and 2 is that model Scenario 2 uses the medium level demand projection instead of the high level demand projection. The difference between Scenarios 1 and 2 highlights the impacts of medium versus high demand projections.

Similar to Scenario 1, generally, agricultural demands have more senior water rights than M&I and thermoelectric demands; therefore, the demand level projections have a negligible effect on agricultural shortages. The results of model Scenario 2 are shown graphically in **Figures 3-11 through 3-17**.


Average Demand
Symbol Size
0-1,000 AFY
1,000-10,000 AFY
>10,000 AFY
Demand Type
Symbol Shape
Agricultural
M&I
Thermoelectric
Average Shortage
Symbol Color
0%
0% - 10%
10% - 25%
25% - 50%
50% - 100%
Demand Category
Black Dot in Symbol
Individual
Aggregate
USGS Stream Gage
Stream
Water District
City and Town
ISF Shortage
0%
>0% - 10%
>10% - 25%
>25% - 50%
>50%
Miles
Figure 3-11. Scenario 2
Medium Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins
Water District 43
White River Basin
CDM Smith
CRAIG
HAYDEN
MEEKER
RANGELY
DINOSAUR
43
44
55
56
57
58
09306500
Boating: N/A
Trout: Very High Risk
Warm Water Fish: High Risk
Riparian: High Risk
09306290
Boating: 32% Usable Days
Trout: N/A
Warm Water Fish: High Risk
Riparian: N/A
434433
Boating: 25% Usable Days
Trout: N/A
Warm Water Fish: High Risk
Riparian: Very High Risk

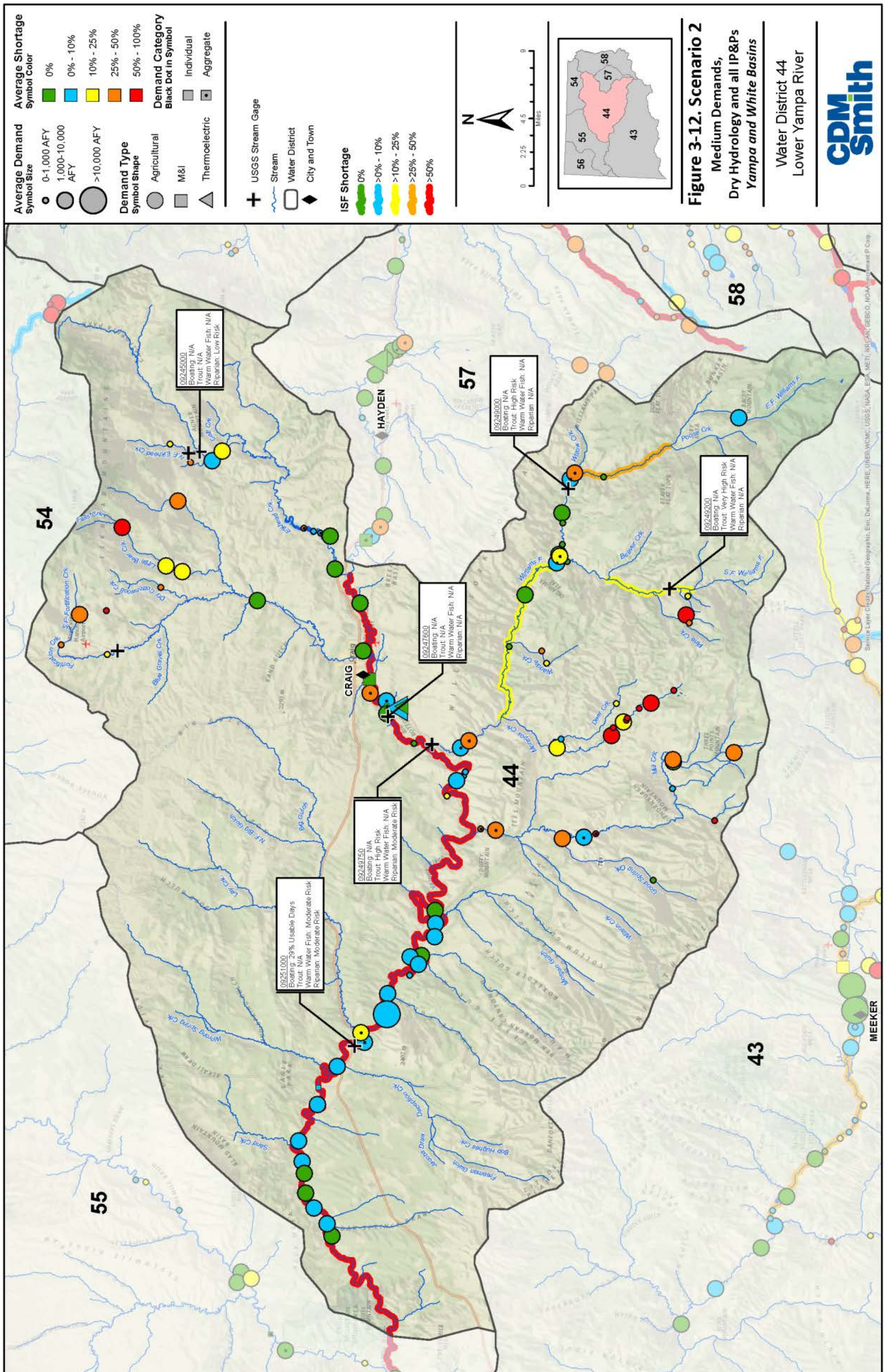


Figure 3-12. Scenario 2
Medium Demands, Dry Hydrology and all IP&Ps
Yampa and White Basins

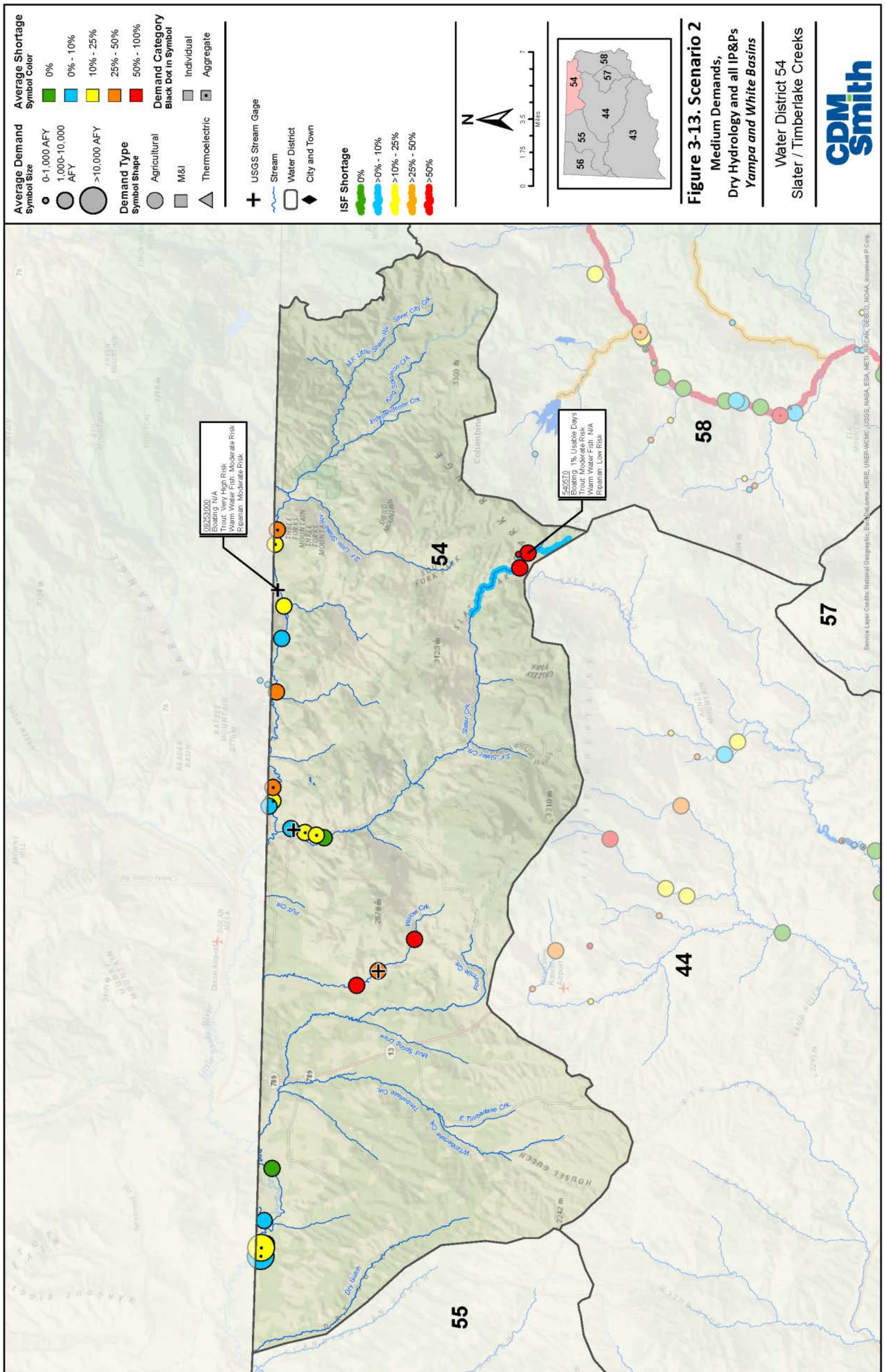


Figure 3-13. Scenario 2
Medium Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins

Water District 54
Slater / Timberlake Creeks

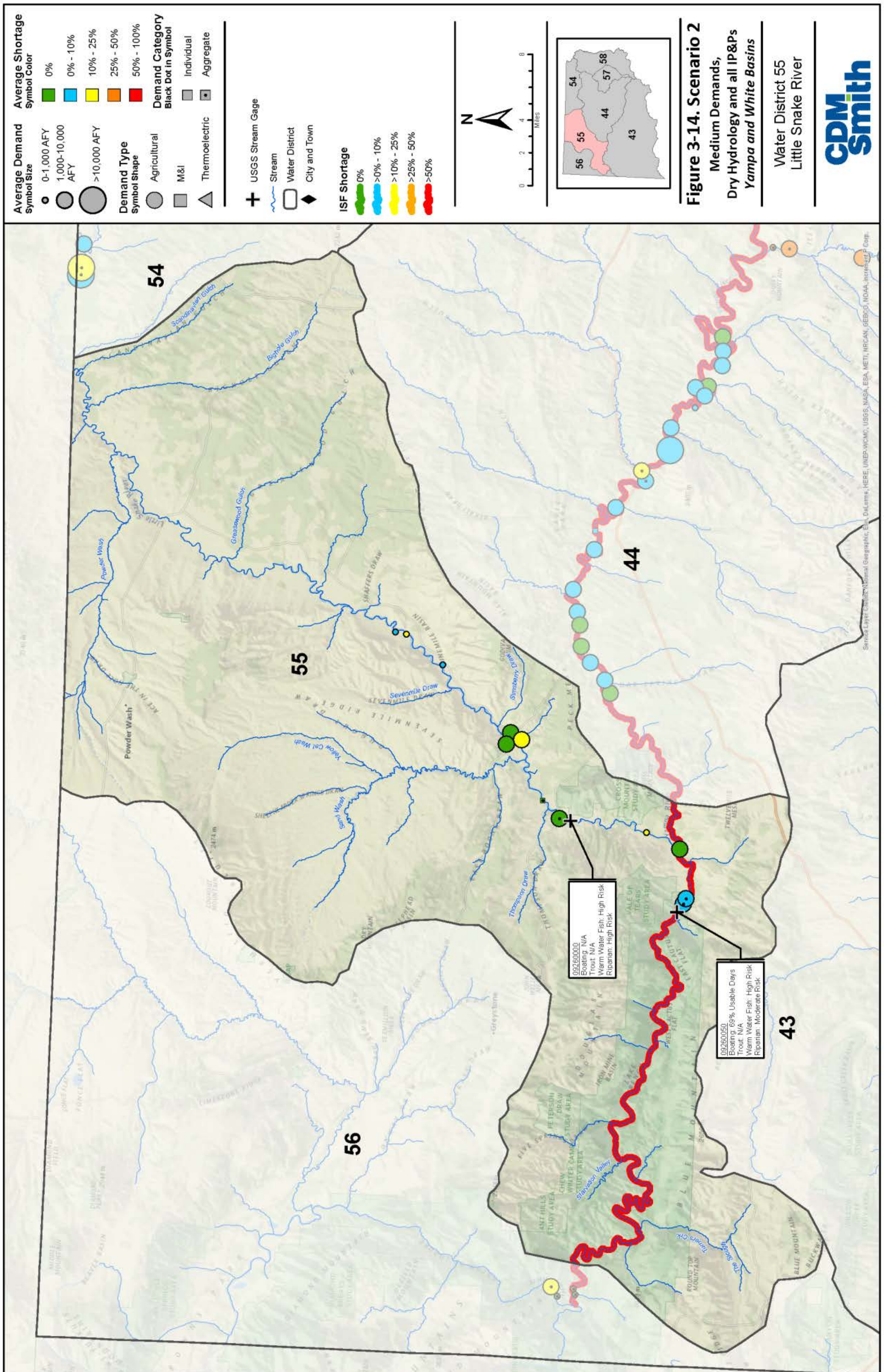


Figure 3-14. Scenario 2
Medium Demands, Dry Hydrology and all IP&Ps
Yampa and White Basins

CDM Smith

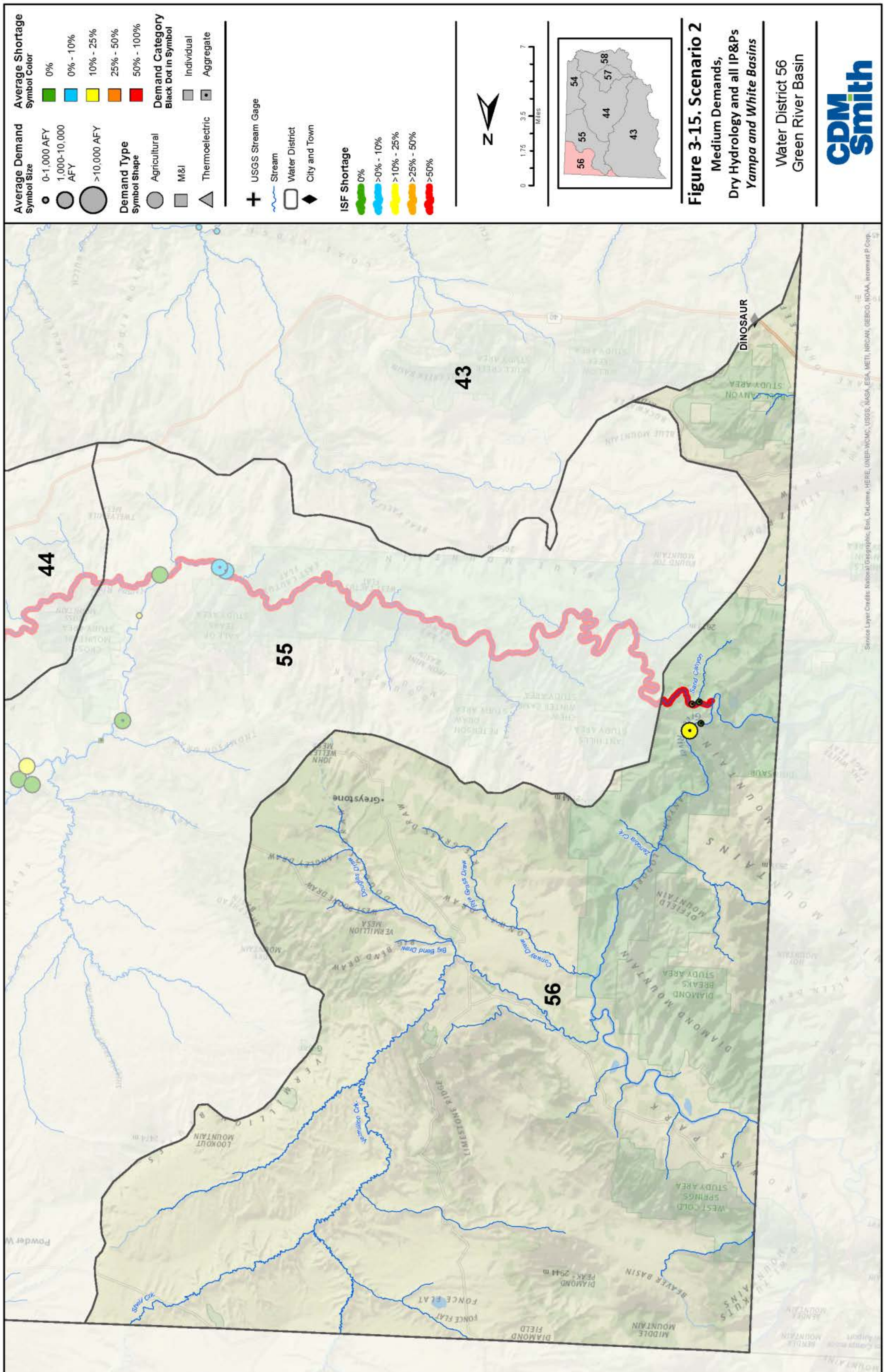


Figure 3-15. Scenario 2
Medium Demands, Dry Hydrology and all IP&Ps
Yampa and White Basins

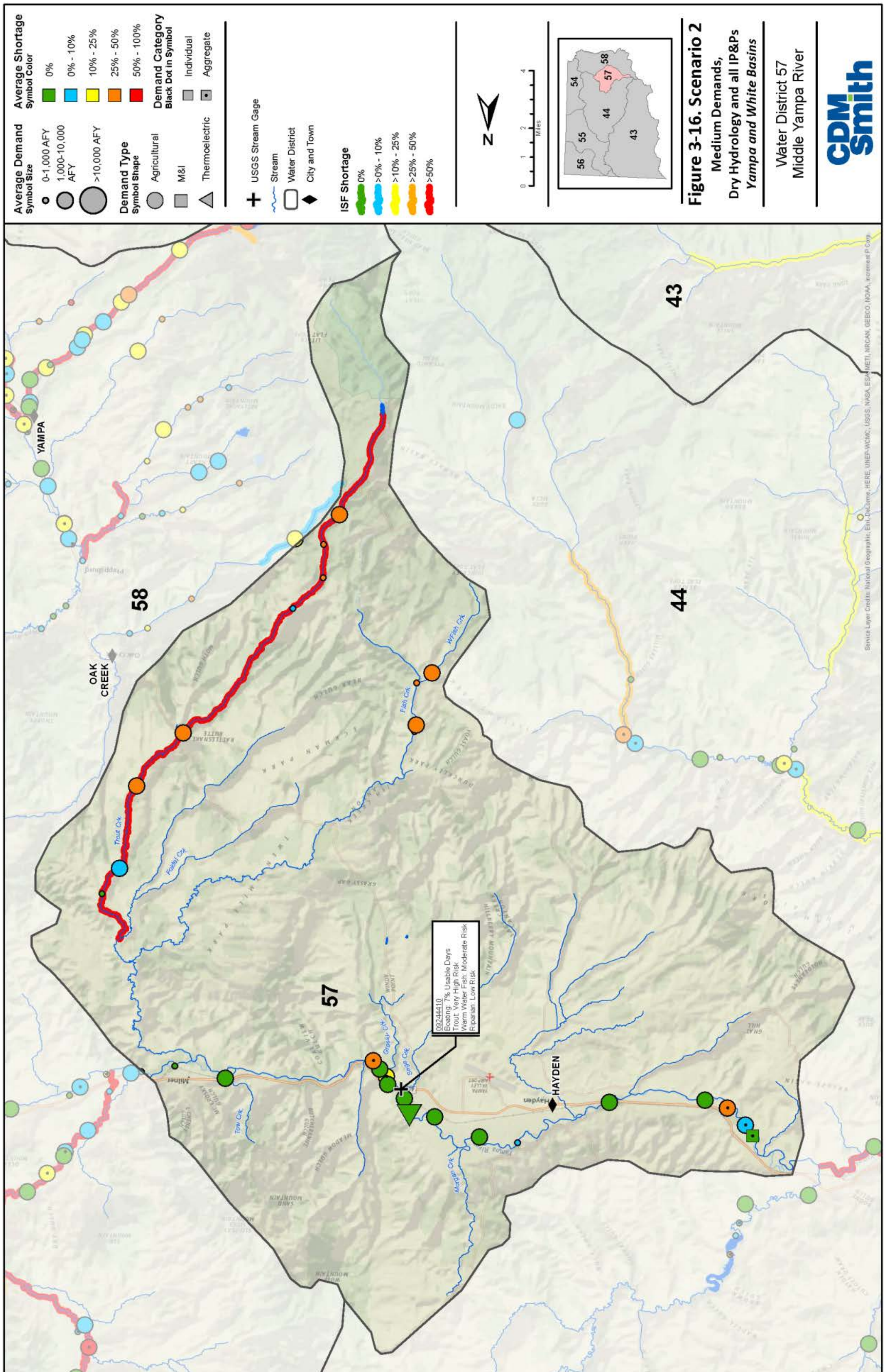


Figure 3-16. Scenario 2
Medium Demands, Dry Hydrology and all IP&Ps
Yampa and White Basins
Water District 57
Middle Yampa River

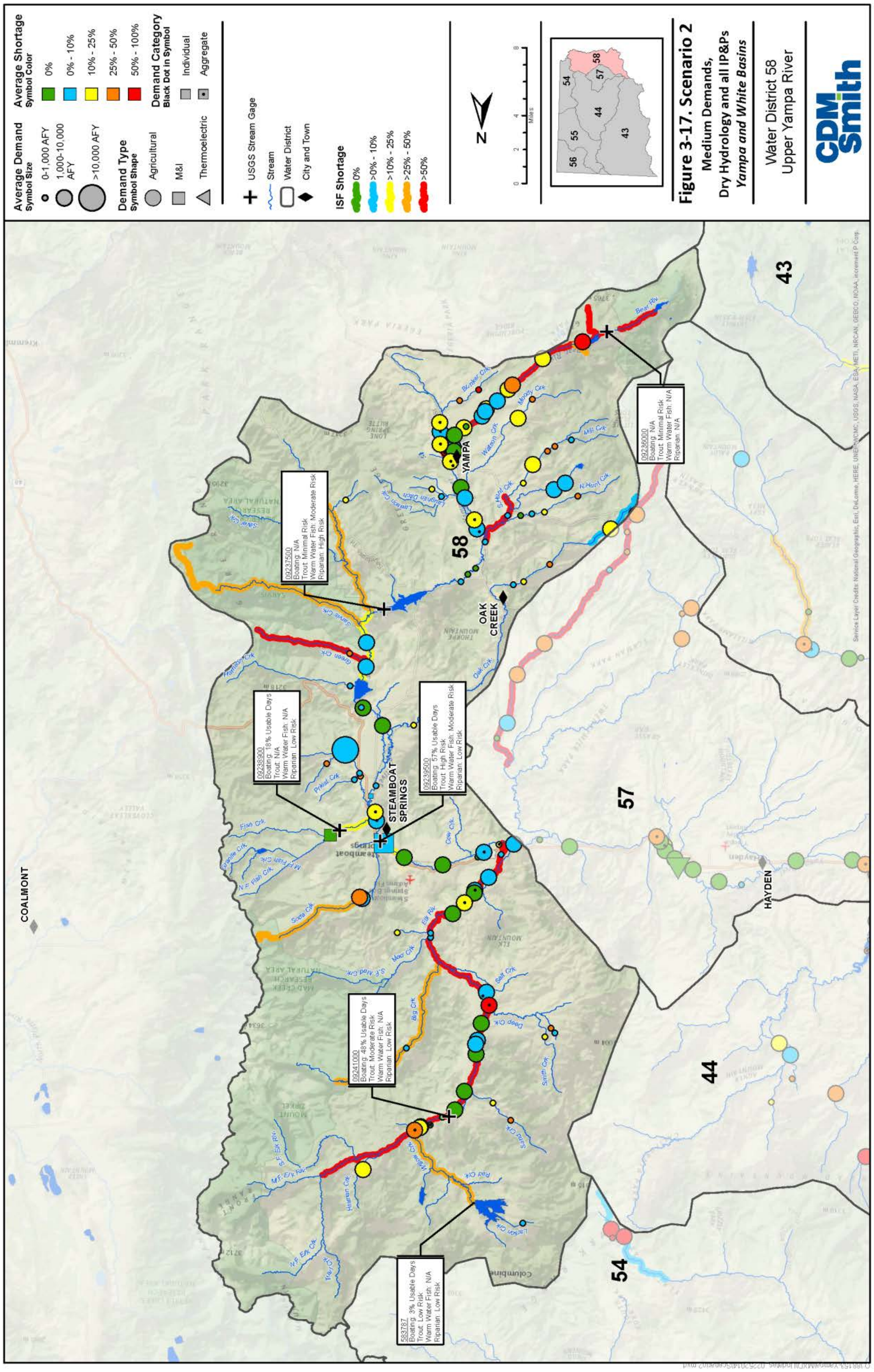


Figure 3-17. Scenario 2
Medium Demands,
Dry Hydrology and all IP&Ps
Yampa and White Basins

3.5.3 Scenario 3

Model Scenario 3 was selected to create a version of model Scenario 2 that was less severe. The difference between model Scenarios 2 and 3 are that model Scenario 3 uses the average hydrology projection instead of the dry level demand projection. The difference between Scenarios 2 and 3 highlights the impacts of average and dry hydrologies.

In contrast to the negligible effect the different demand projection has on agricultural shortages, the impact that the dry versus average hydrology has on agricultural shortages is significantly more. The results of model Scenario 3 are shown graphically in **Figures 3-18 through 3-24.**

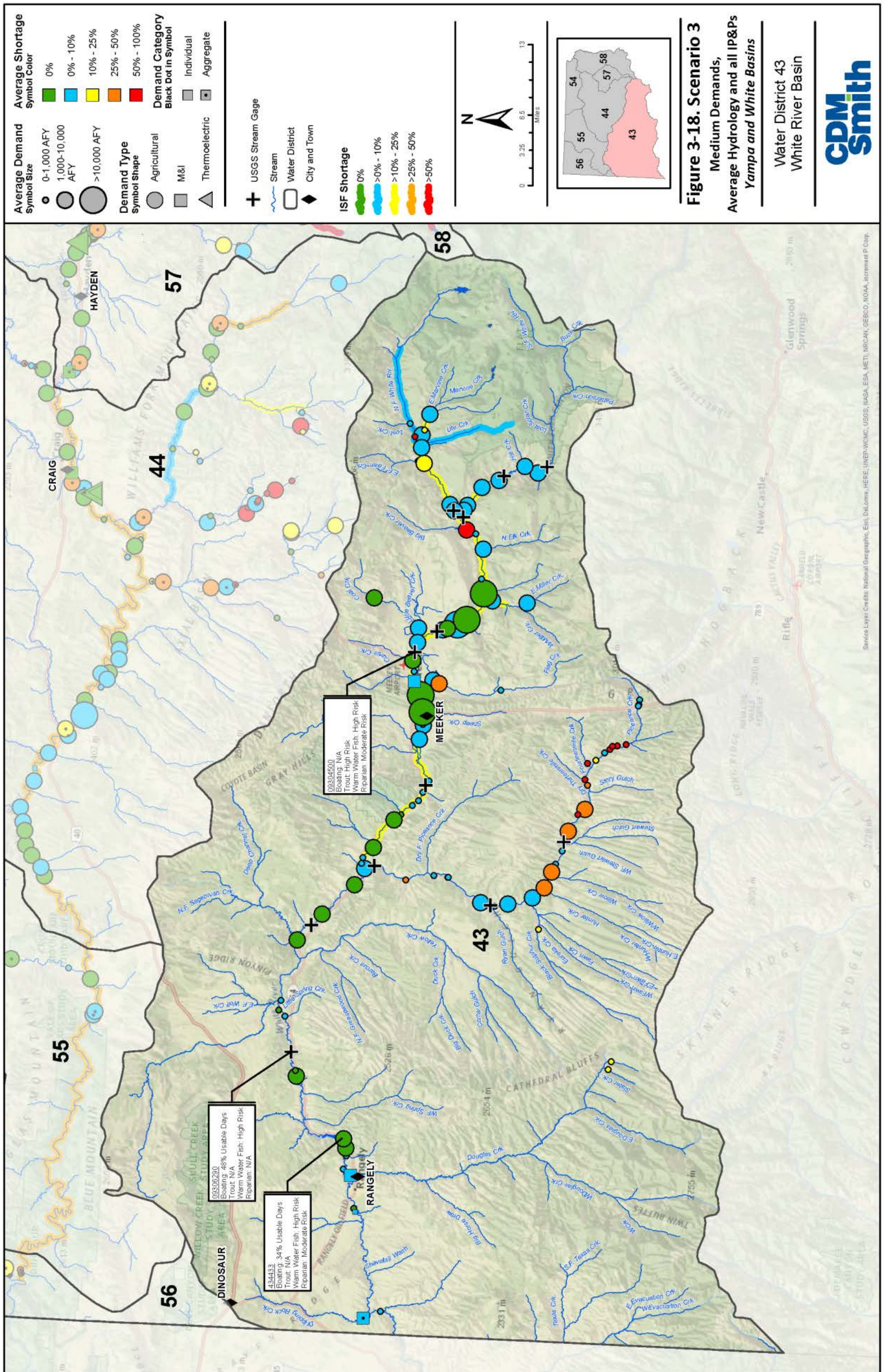
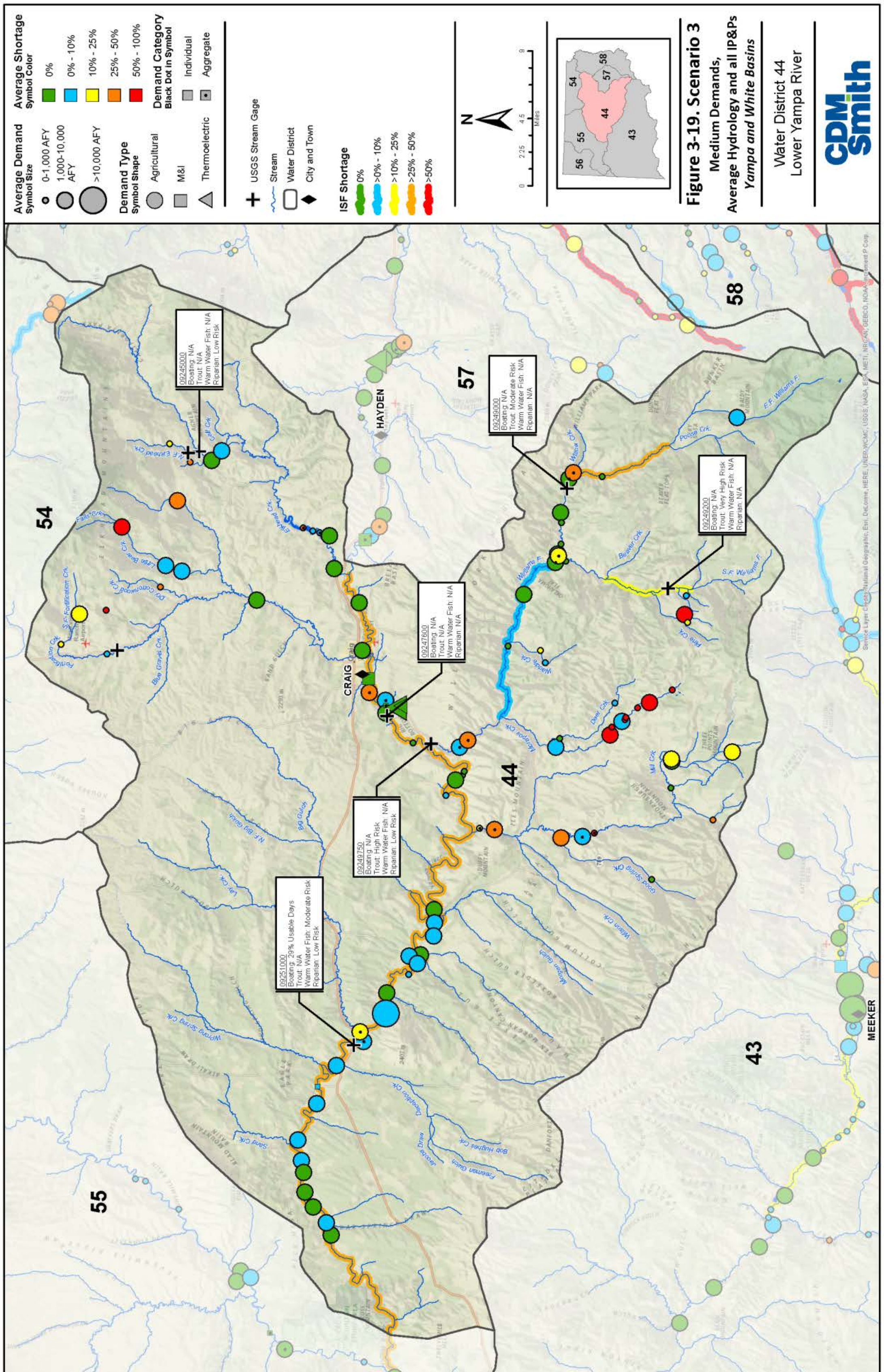


Figure 3-18. Scenario 3
Medium Demands,
Average Hydrology and all IP&Ps
Yampa and White Basins


Average Demand
Symbol Size
0-1,000 AFY
1,000-10,000 AFY
>10,000 AFY
Demand Type
Symbol Shape
Agricultural
M&I
Thermoelectric
Average Shortage
Symbol Color
0%
0% - 10%
10% - 25%
25% - 50%
50% - 100%
Demand Category
Black Dot in Symbol
Individual
Aggregate
USGS Stream Gage
Stream
Water District
City and Town
ISF Shortage
0%
>0% - 10%
>10% - 25%
>25% - 50%
>50%
N
0 2.25 4.5 9
Miles
Figure 3-19. Scenario 3
Medium Demands,
Average Hydrology and all IP&Ps
Yampa and White Basins
Water District 44
Lower Yampa River
CDM Smith
54
55
57
58
44
43
CRAIG
HAYDEN
MEEKER
09245000
Boating: N/A
Trout: N/A
Warm Water Fish: N/A
Riparian: Low Risk
09247600
Boating: N/A
Trout: N/A
Warm Water Fish: N/A
Riparian: N/A
09249000
Boating: N/A
Trout: Moderate Risk
Warm Water Fish: N/A
Riparian: N/A
09249200
Boating: N/A
Trout: Very High Risk
Warm Water Fish: N/A
Riparian: N/A
09249750
Boating: N/A
Trout: High Risk
Warm Water Fish: N/A
Riparian: Low Risk
09251000
Boating: 29% Usable Days
Trout: N/A
Warm Water Fish: Moderate Risk
Riparian: Low Risk

CDM Smith

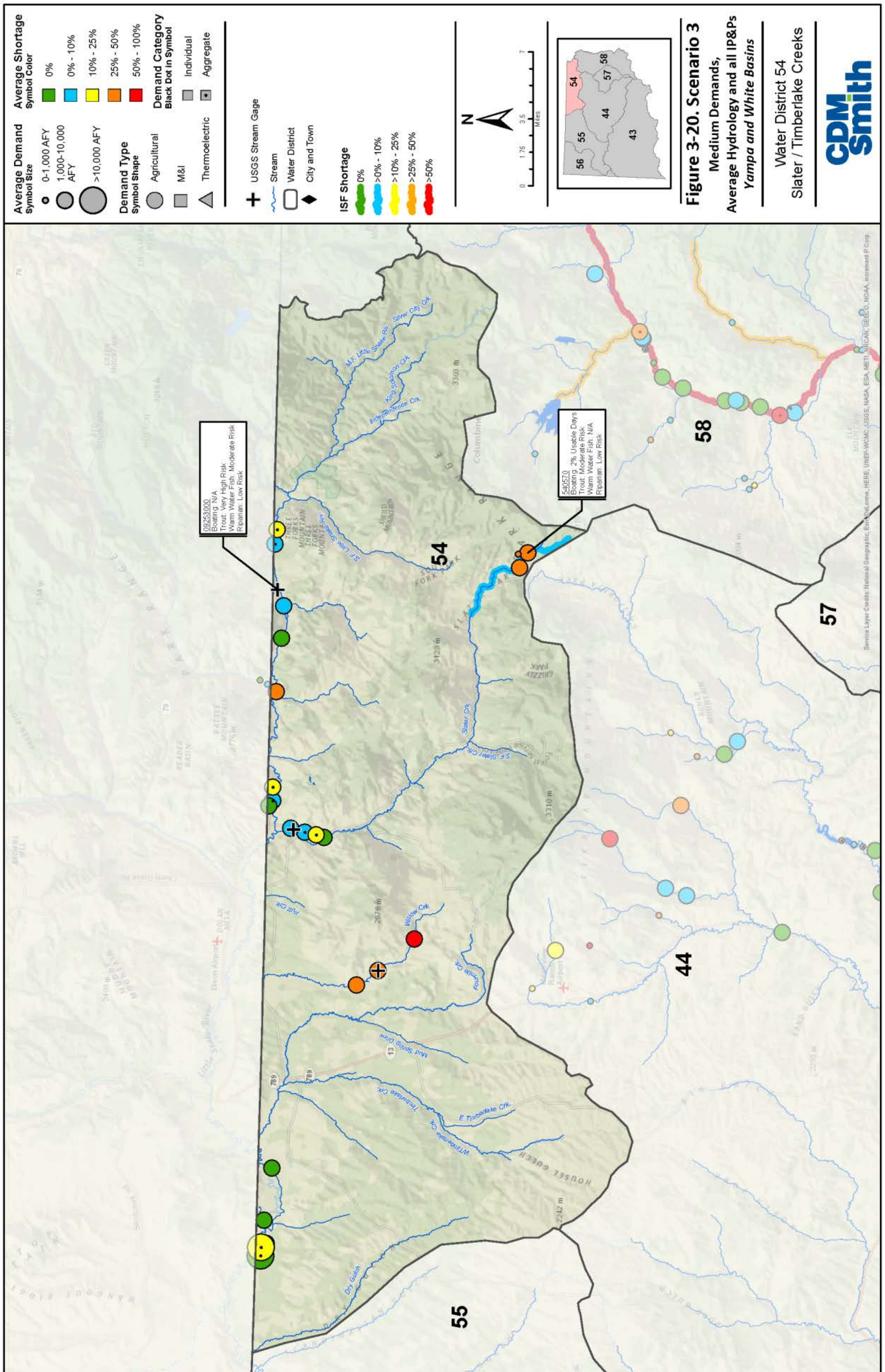
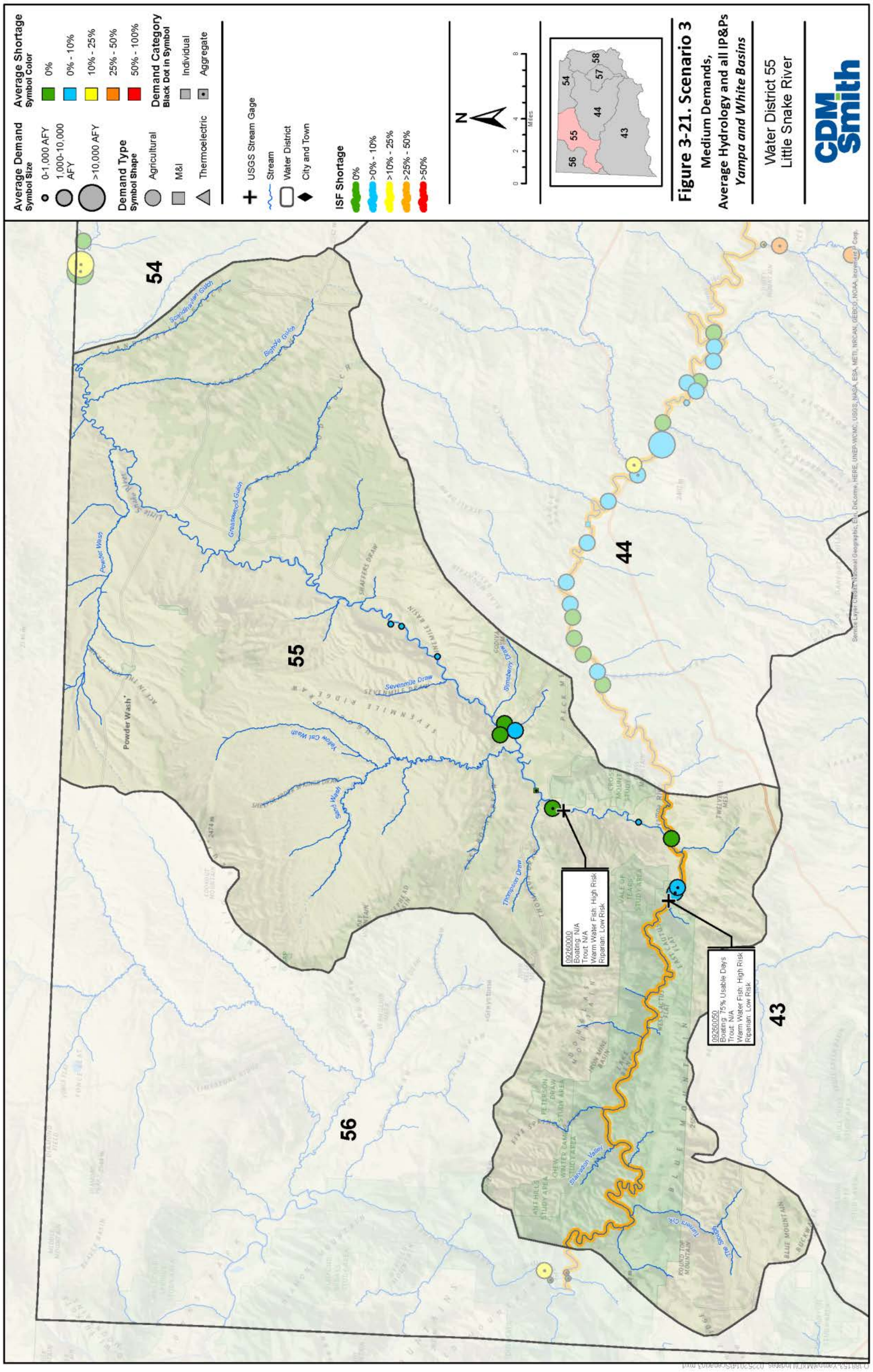


Figure 3-20. Scenario 3
Medium Demands,
Average Hydrology and all IP&Ps
Yampa and White Basins

Water District 54
Slater / Timberlake Creeks


Average Demand
Symbol Size
0-1,000 AFY
1,000-10,000 AFY
>10,000 AFY
Demand Type
Symbol Shape
Agricultural
M&I
Thermoelectric
Average Shortage
Symbol Color
0%
0% - 10%
10% - 25%
25% - 50%
50% - 100%
Demand Category
Black Dot in Symbol
Individual
Aggregate
USGS Stream Gage
Stream
Water District
City and Town
ISF Shortage
0%
>0% - 10%
>10% - 25%
>25% - 50%
>50%
N
Miles
Figure 3-21. Scenario 3
Medium Demands,
Average Hydrology and all IP&Ps
Yampa and White Basins
Water District 55
Little Snake River
CDM Smith
54
55
44
43
56
09260000
Boating: N/A
Trout: N/A
Warm Water Fish: High Risk
Riparian: Low Risk
09260050
Boating: 75% Usable Days
Trout: N/A
Warm Water Fish: High Risk
Riparian: Low Risk

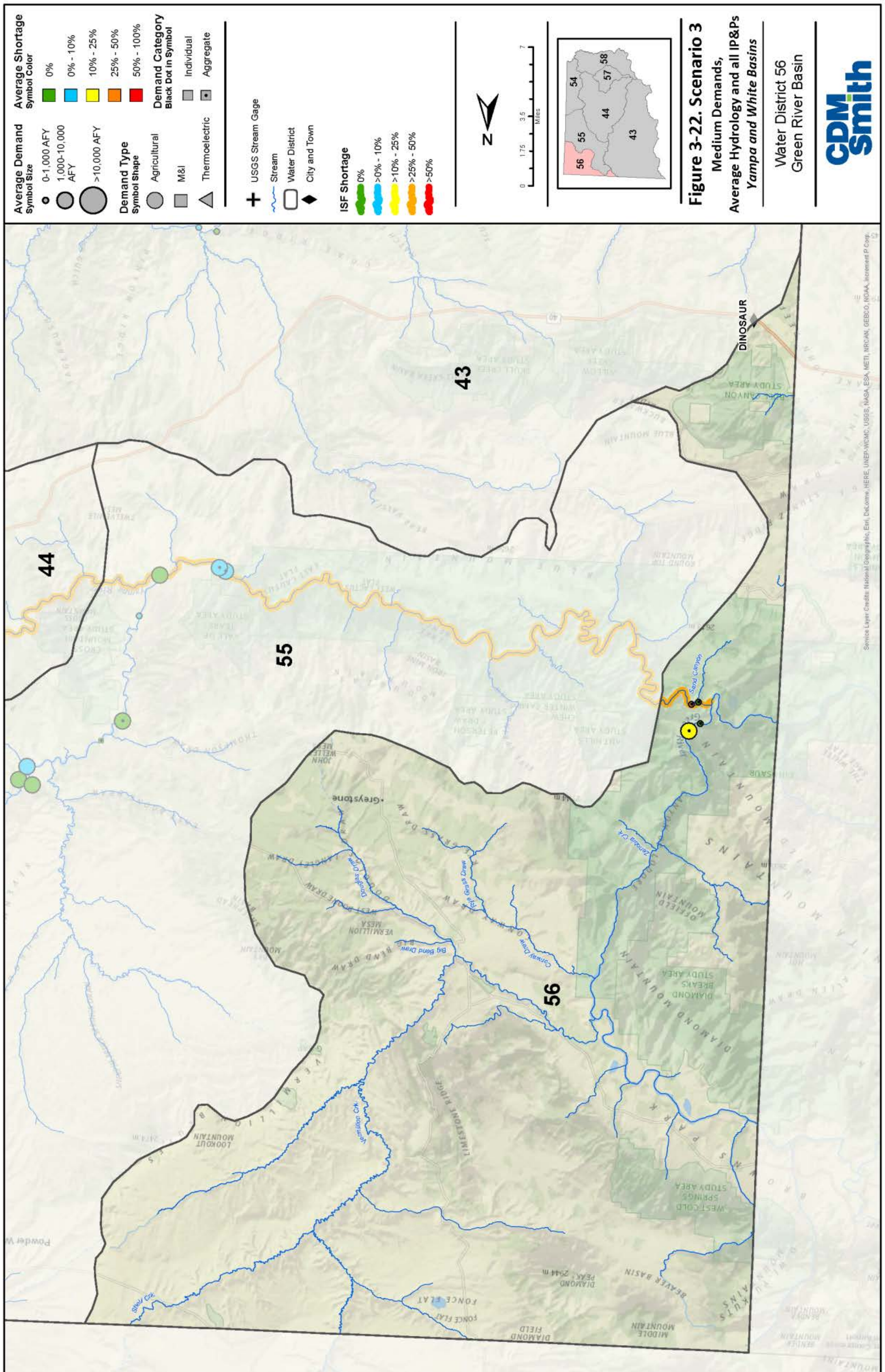


Figure 3-22. Scenario 3
Medium Demands,
Average Hydrology and all IP&Ps
Yampa and White Basins

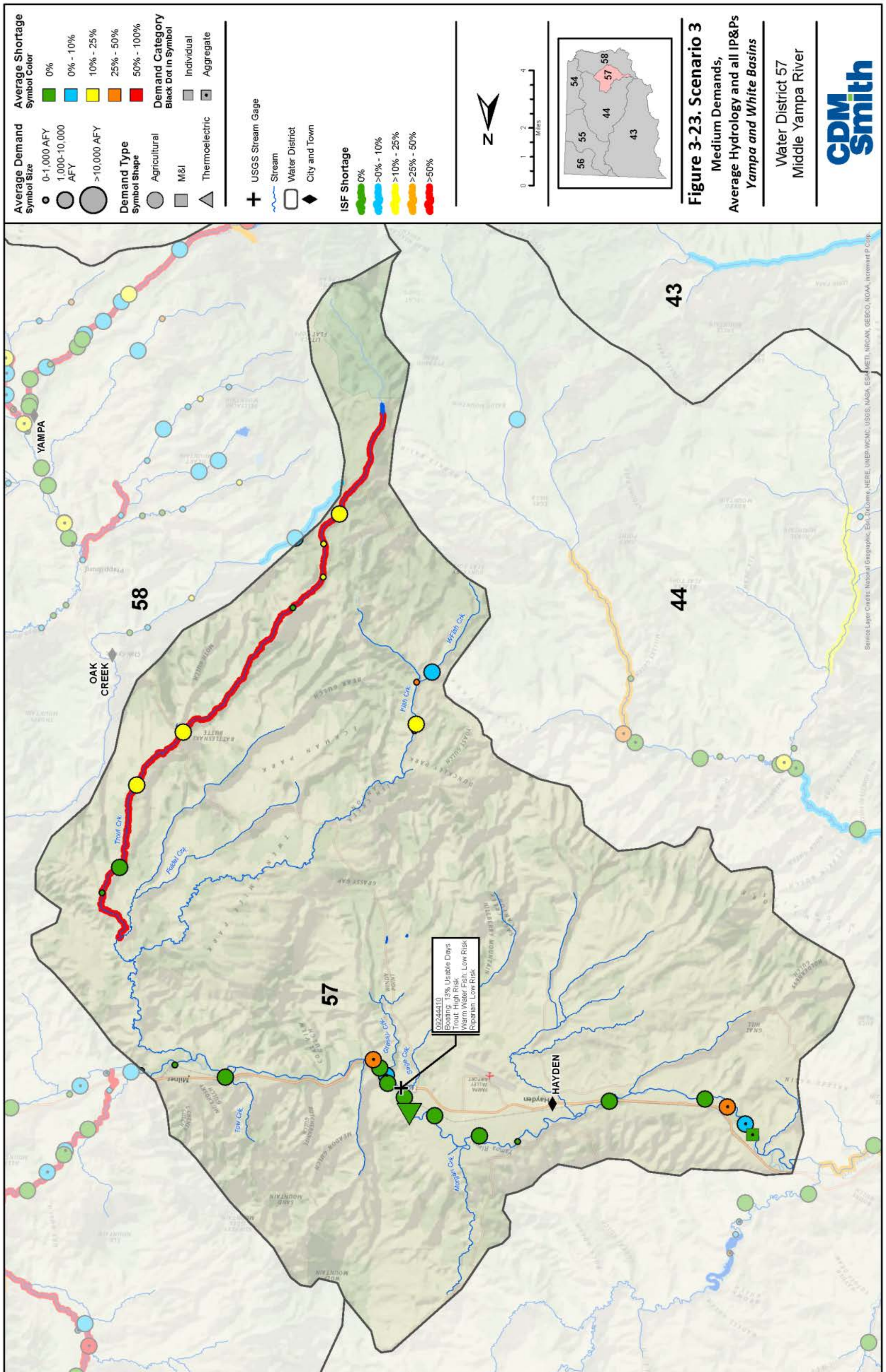


Figure 3-23. Scenario 3
Medium Demands,
Average Hydrology and all IP&Ps
Yampa and White Basins

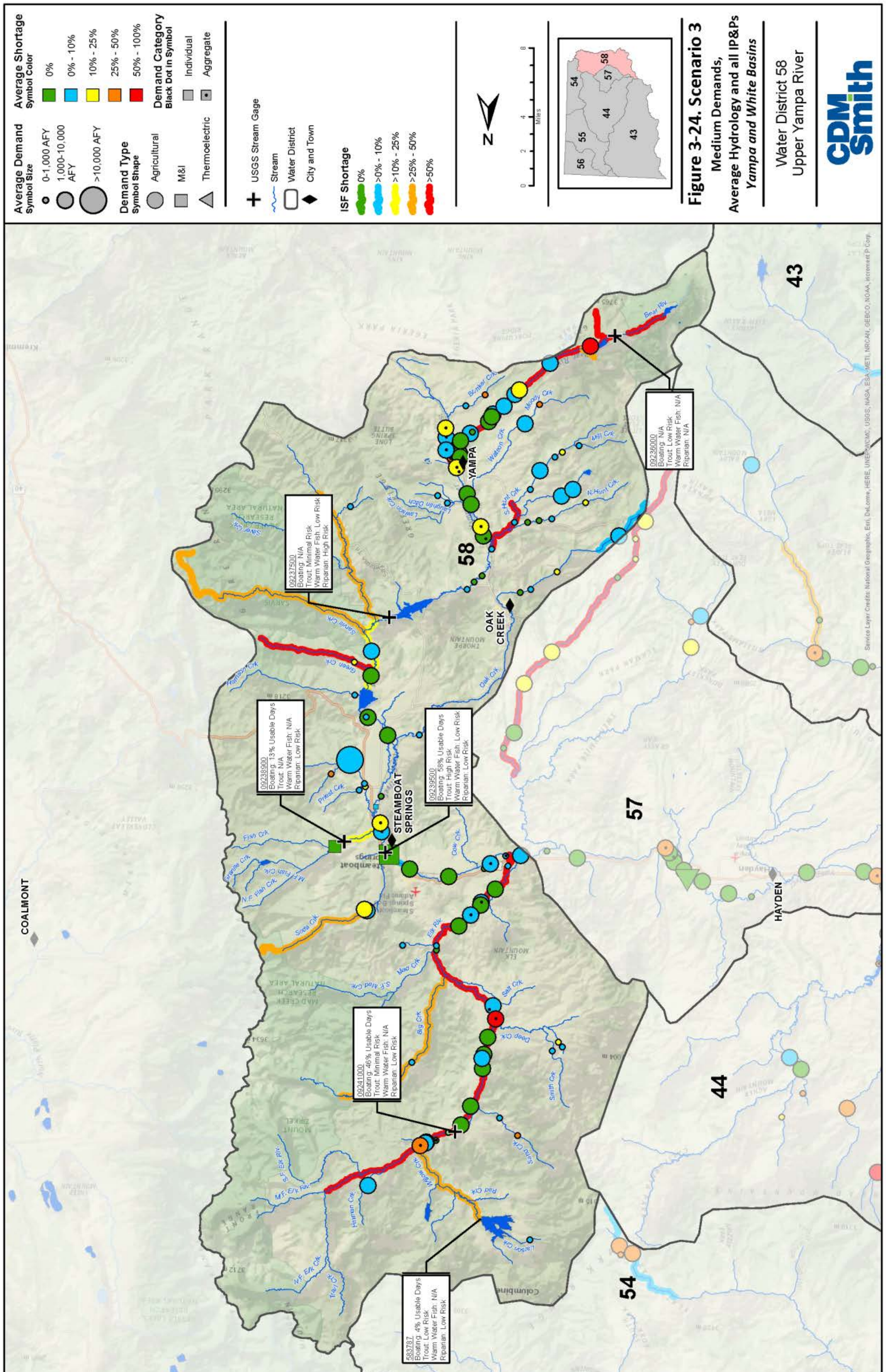


Figure 3-24. Scenario 3
Medium Demands, Average Hydrology and all IP&Ps
Yampa and White Basins
Water District 58
Upper Yampa River

3.5.4 Scenario 4

Scenario 4 was the first of the three scenarios evaluated after the results from Scenarios 1 through 3 were reviewed by the BRT subcommittee. Scenarios 1 through 3 did not provide a direct comparison to the baseline model since more than one model scenario component changed. The main purpose of model Scenario 4 was to provide a basis for comparing the impacts of a dry hydrology on otherwise baseline conditions.

Due to the significant impacts caused by the dry hydrology without the implementation of any IPPs, shortages for all demand sectors are shown to increase. The results of model Scenario 4 are shown graphically in **Figures 3-25 through 3-31.**

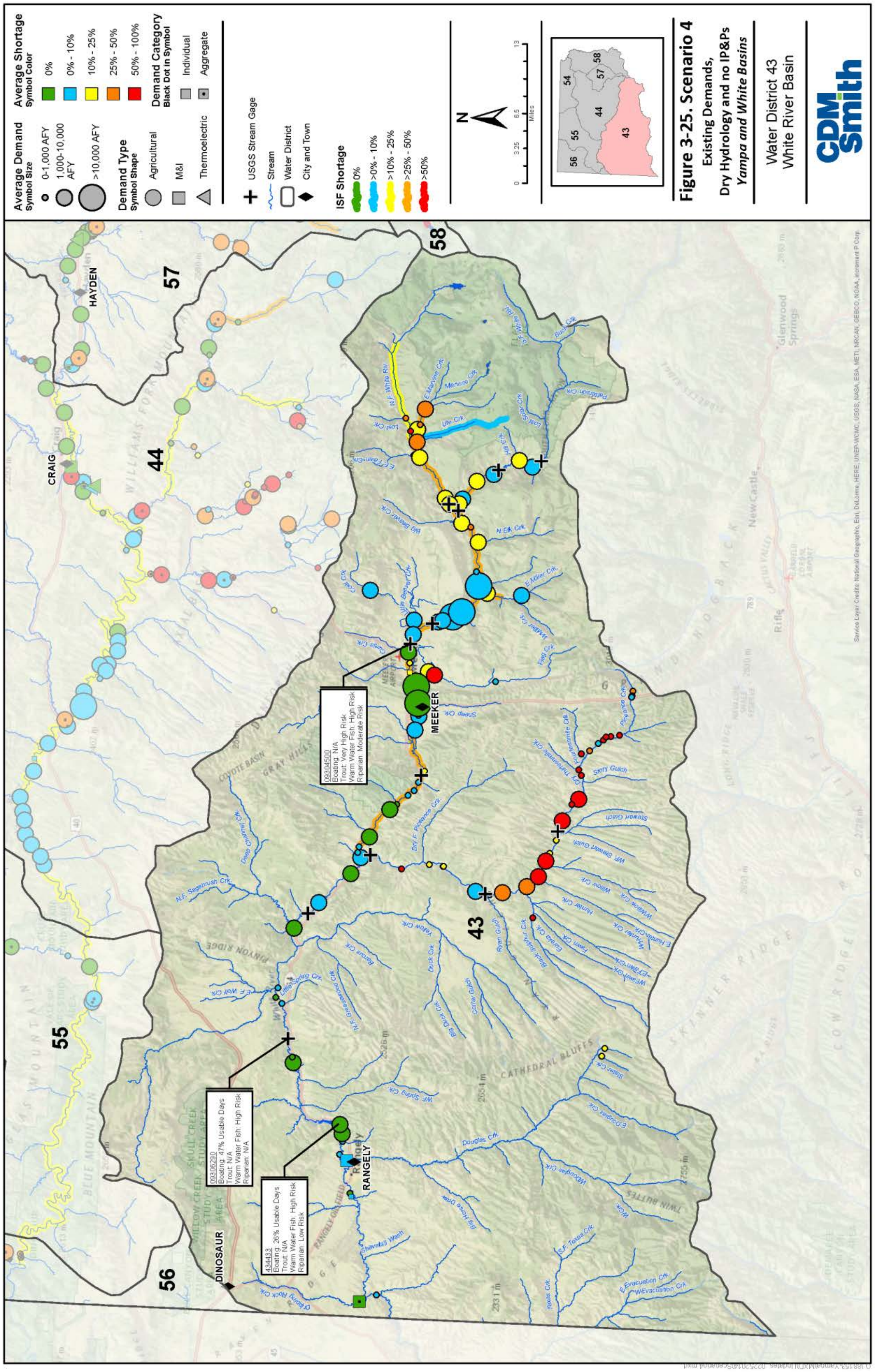
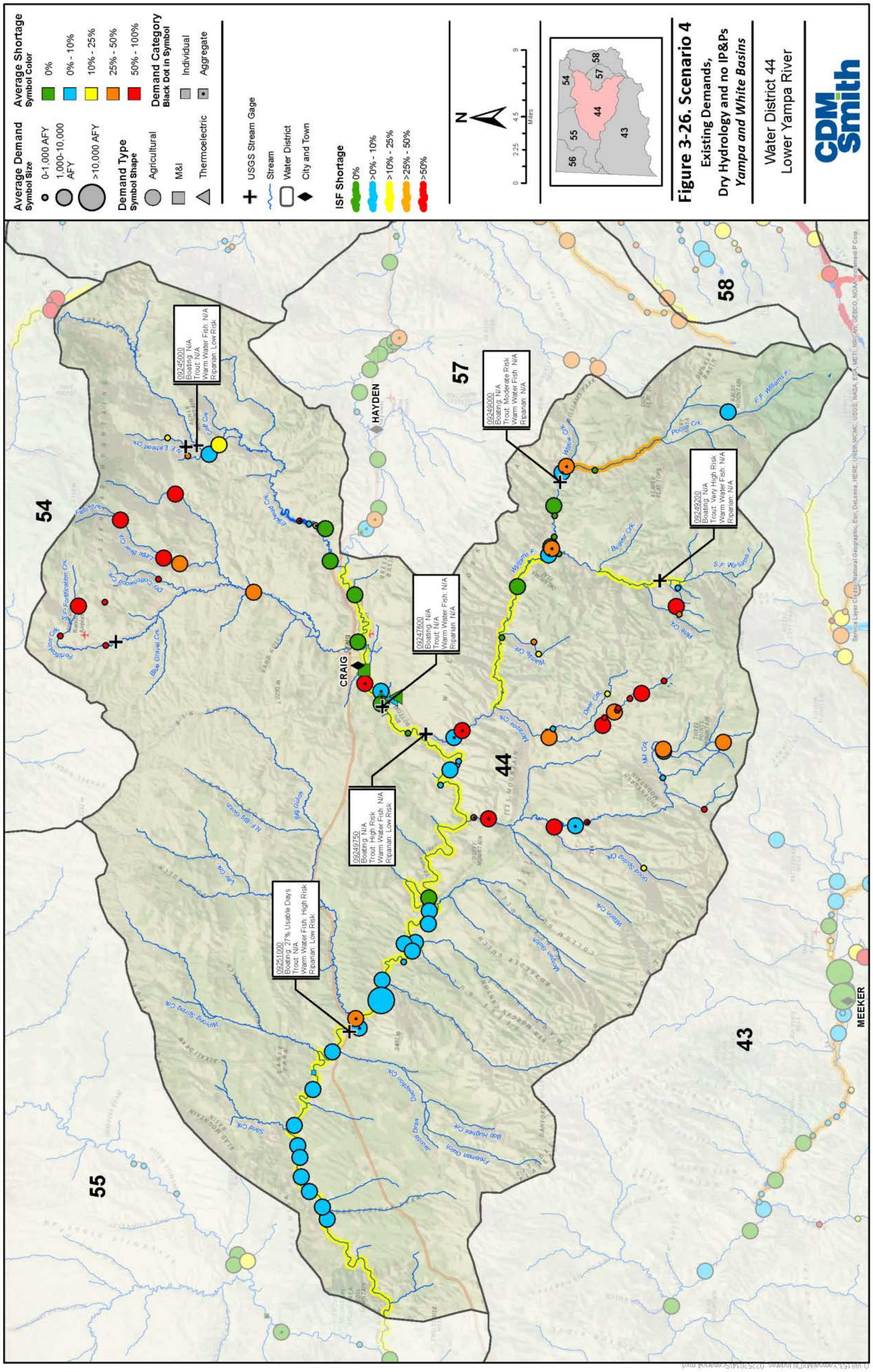


Figure 3-25. Scenario 4
Existing Demands, Dry Hydrology and no IP&Ps
Yampa and White Basins


Average Demand
Symbol Size
0-1,000 AFY
1,000-10,000 AFY
>10,000 AFY
Demand Type
Symbol Shape
Agricultural
M&I
Thermoelectric
Average Shortage
Symbol Color
0%
0% - 10%
10% - 25%
25% - 50%
50% - 100%
Demand Category
Black Dot in Symbol
Individual
Aggregate
USGS Stream Gage
Stream
Water District
City and Town
ISF Shortage
0%
>0% - 10%
>10% - 25%
>25% - 50%
>50%
N
Miles
Figure 3-26. Scenario 4
Existing Demands,
Dry Hydrology and no IP&Ps
Yampa and White Basins
Water District 44
Lower Yampa River
CDM Smith
54
55
57
58
44
43
CRAIG
HAYDEN
MEEKER
09245000
Boating: N/A
Trout: N/A
Warm Water Fish: N/A
Riparian: Low Risk
09249000
Boating: N/A
Trout: Moderate Risk
Warm Water Fish: N/A
Riparian: N/A
09247600
Boating: N/A
Trout: N/A
Warm Water Fish: N/A
Riparian: N/A
09249200
Boating: N/A
Trout: Very High Risk
Warm Water Fish: N/A
Riparian: N/A
09249750
Boating: N/A
Trout: High Risk
Warm Water Fish: N/A
Riparian: Low Risk
09251000
Boating: 27% Usable Days
Trout: N/A
Warm Water Fish: High Risk
Riparian: Low Risk

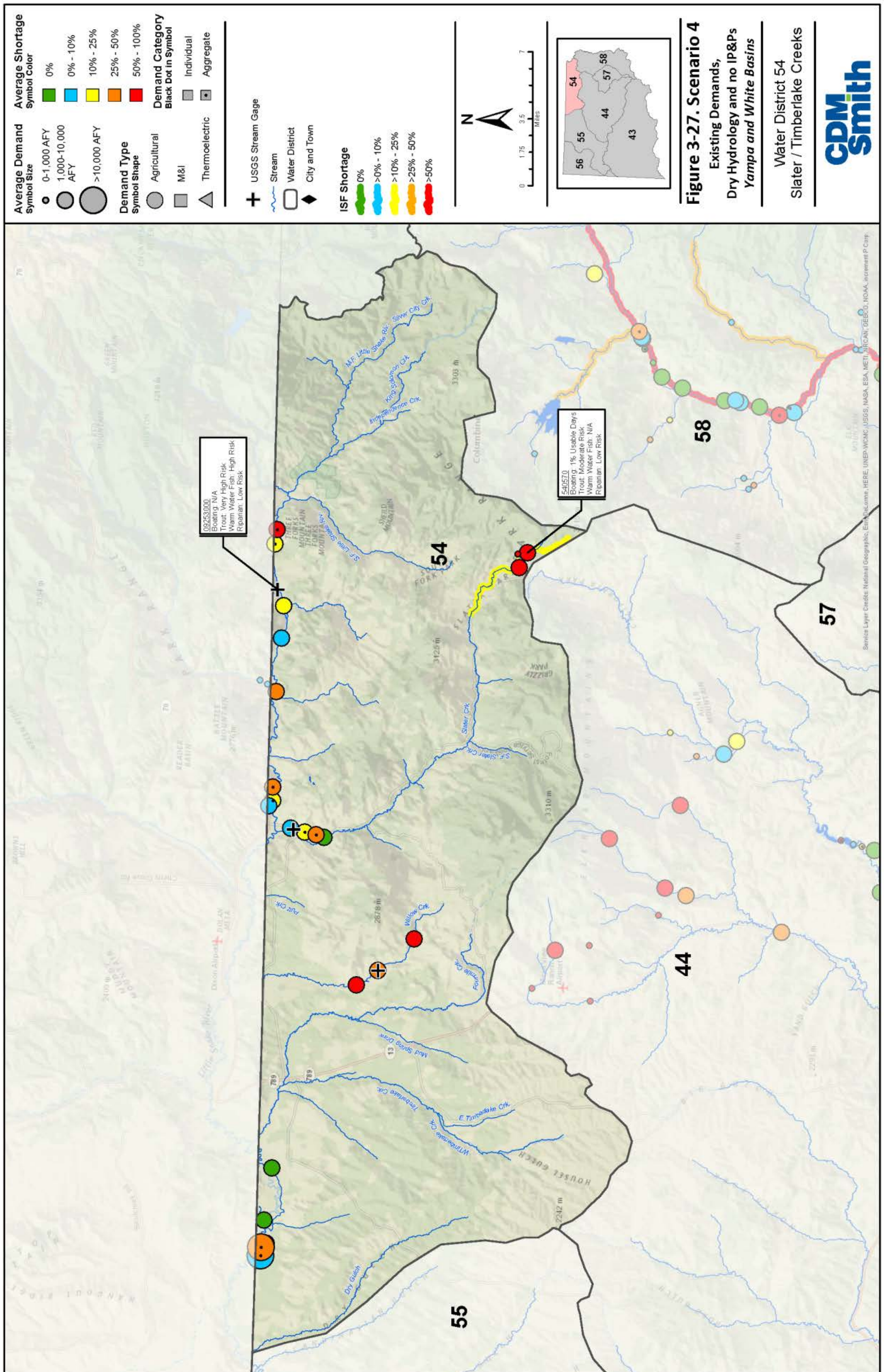
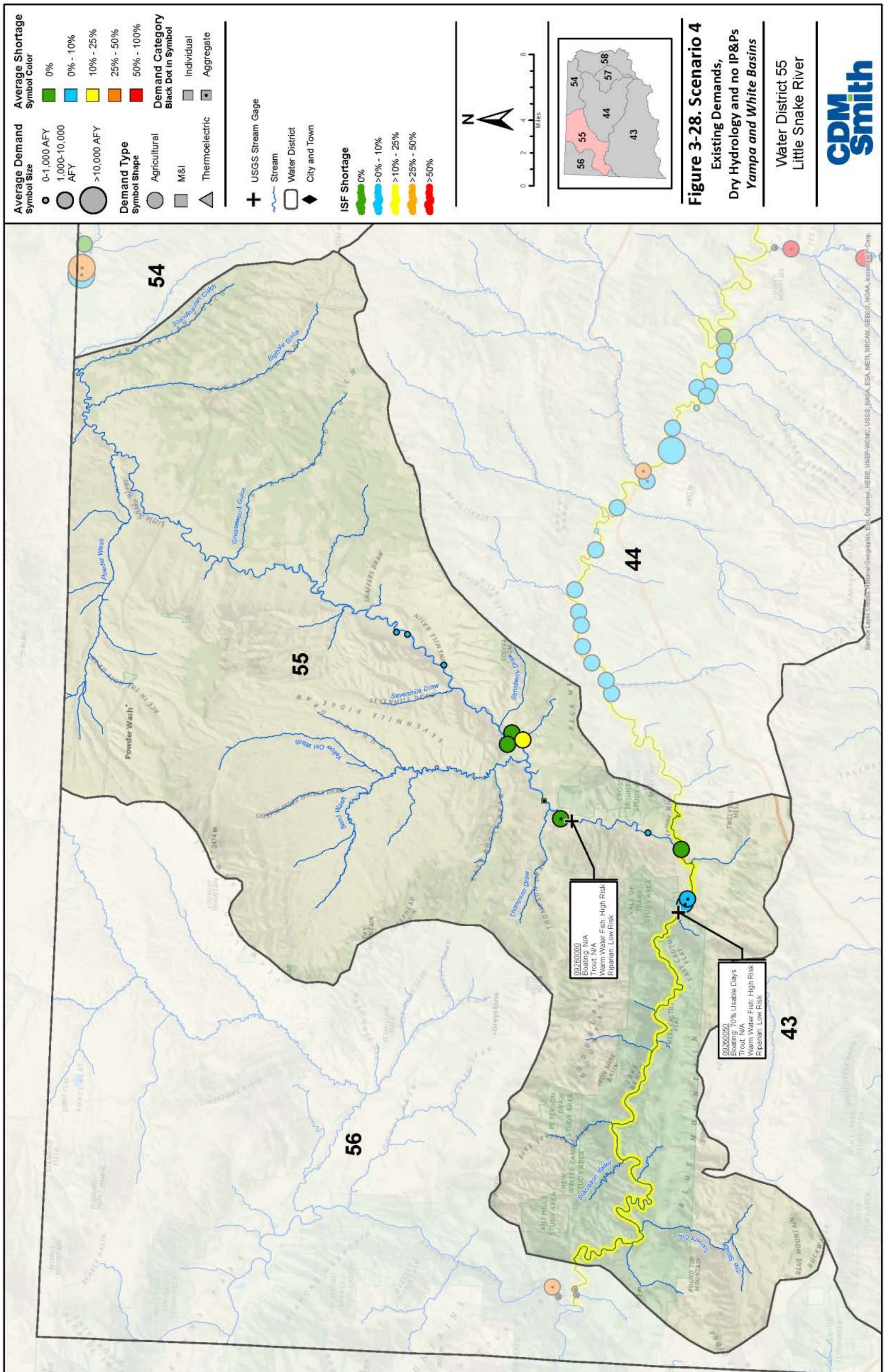


Figure 3-27. Scenario 4
Existing Demands,
Dry Hydrology and no IP&Ps
Yampa and White Basins

Water District 54
Slater / Timberlake Creeks


Average Demand
Symbol Size
0-1,000 AFY
1,000-10,000 AFY
>10,000 AFY
Average Shortage
Symbol Color
0%
0% - 10%
10% - 25%
25% - 50%
50% - 100%
Demand Type
Symbol Shape
Agricultural
M&I
Thermoelectric
Demand Category
Black Dot in Symbol
Individual
Aggregate
USGS Stream Gage
Stream
Water District
City and Town
ISF Shortage
0%
>0% - 10%
>10% - 25%
>25% - 50%
>50%
N
Miles
Figure 3-28. Scenario 4
Existing Demands,
Dry Hydrology and no IP&Ps
Yampa and White Basins
Water District 55
Little Snake River
54
55
44
56
43
09260000
Boating: N/A
Trout: N/A
Warm Water Fish: High Risk
Riparian: Low Risk
09260050
Boating: 70% Usable Days
Trout: N/A
Warm Water Fish: High Risk
Riparian: Low Risk

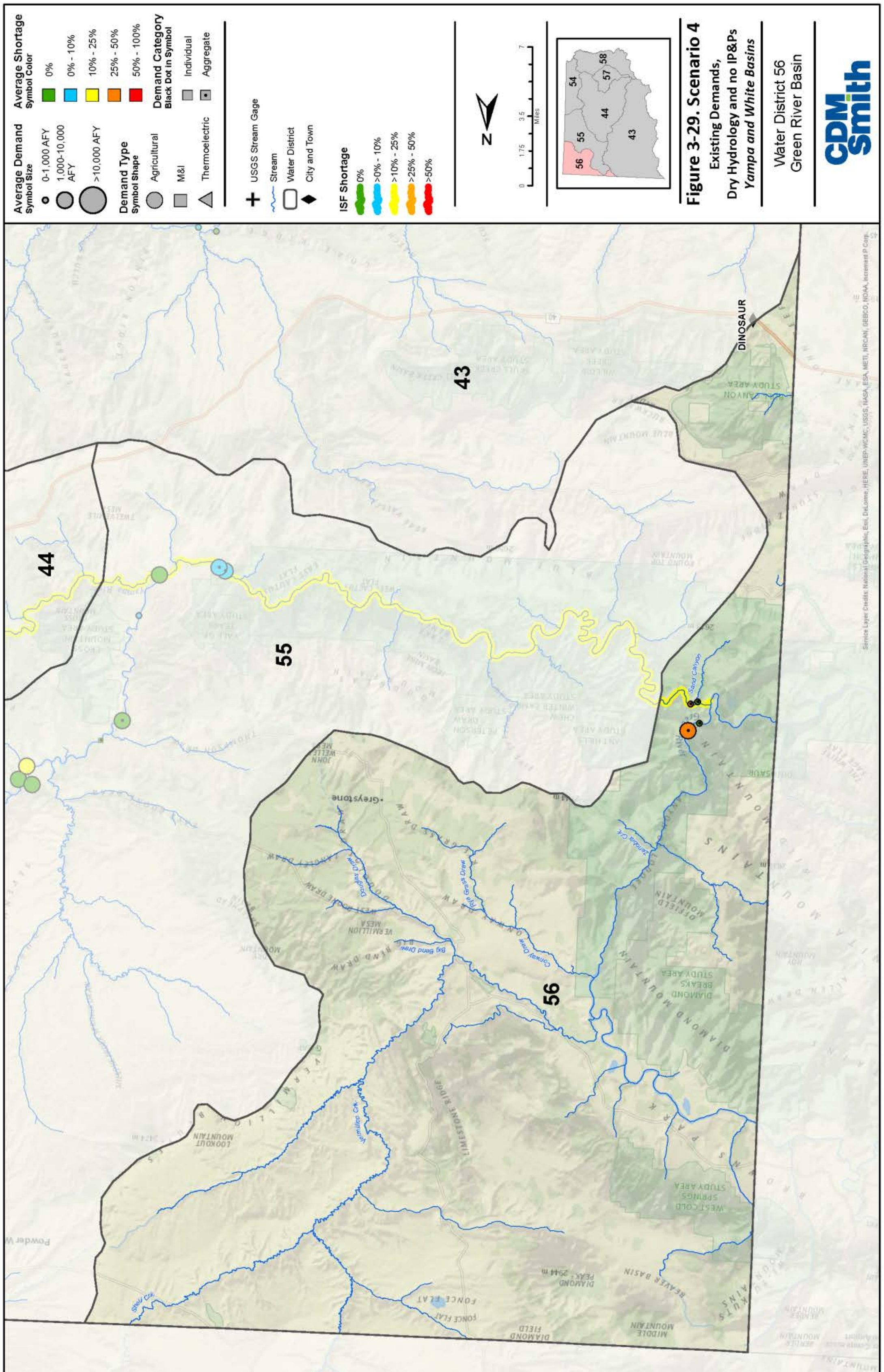


Figure 3-29. Scenario 4
Existing Demands, Dry Hydrology and no IP&Ps
Yampa and White Basins

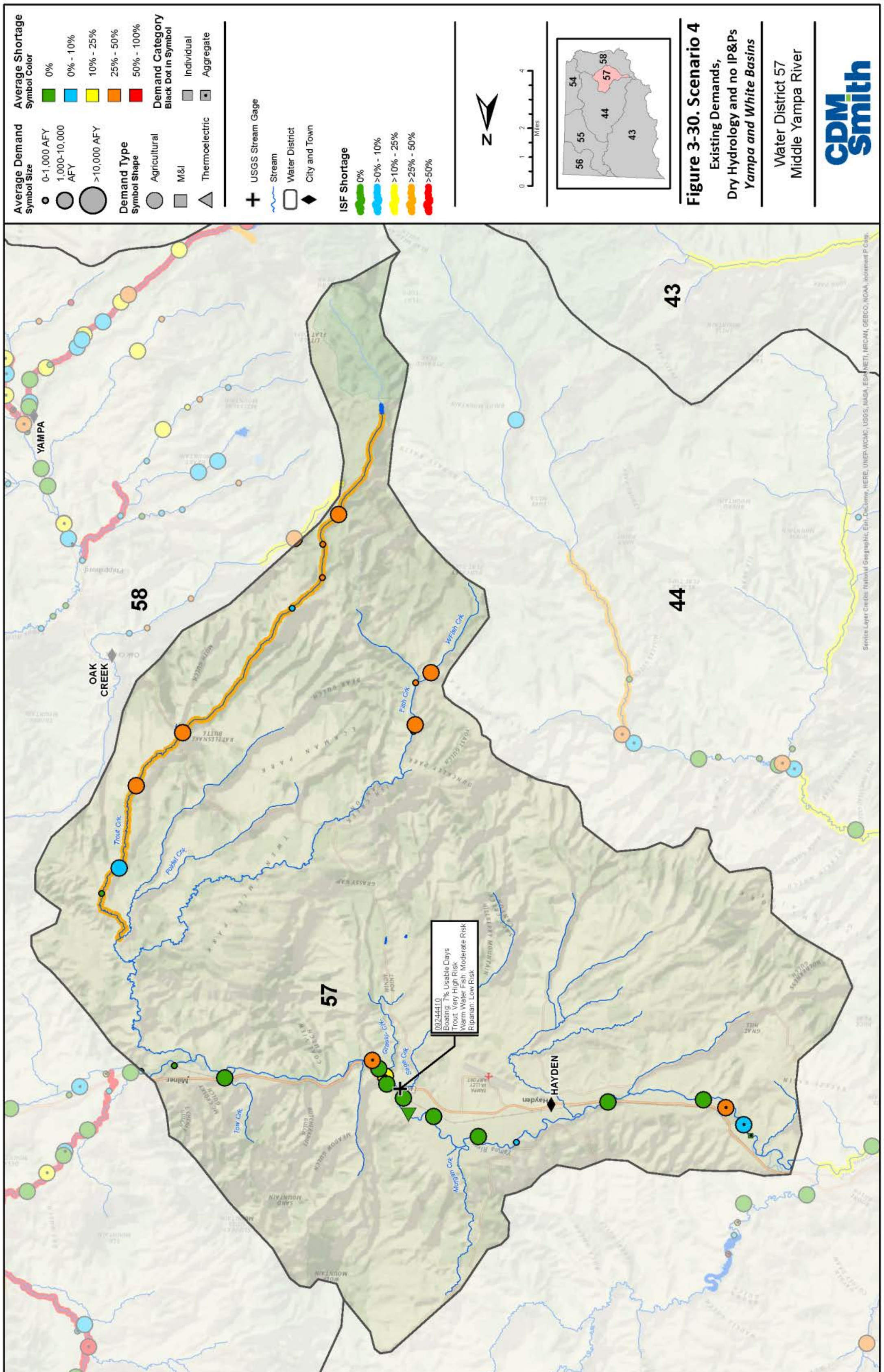


Figure 3-30. Scenario 4
Existing Demands,
Dry Hydrology and no IP&Ps
Yampa and White Basins

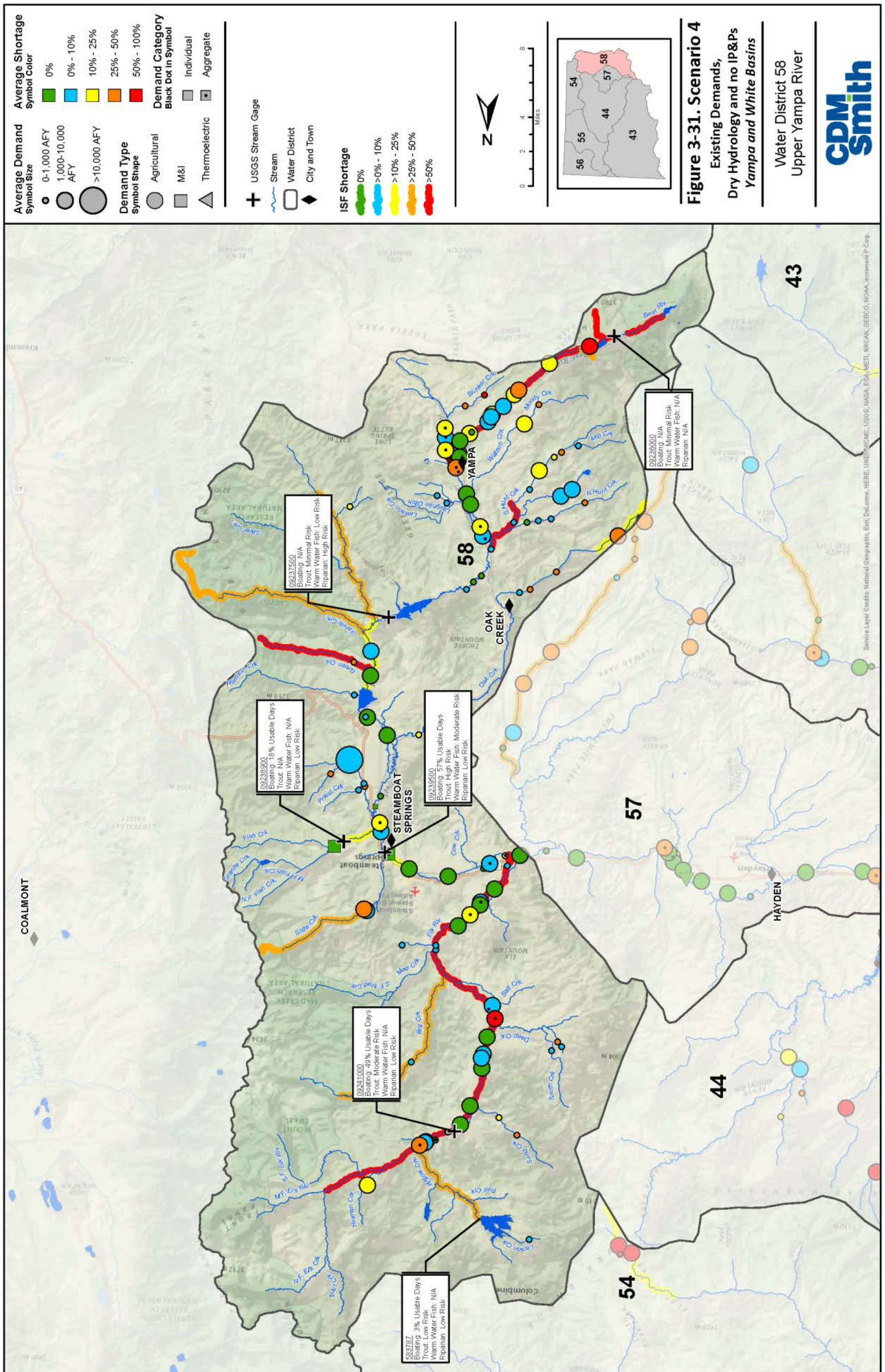


Figure 3-31. Scenario 4
Existing Demands, Dry Hydrology and no IP&Ps
Yampa and White Basins

3.5.5 Scenario 5

Scenario 5 was the second of the three scenarios evaluated after the results from Scenarios 1 through 3 were reviewed by the BRT subcommittee. Scenario 5 was intended to show one of the "bookends" of analysis. In other words, Scenario 5 shows the best case scenario, where the lowest demand is used (existing), the wettest hydrology is used, and all IPPs are turned on.

The model Scenario 5 results are less intuitive than the results from some of the other model scenarios. Due to the shift in streamflow runoff to earlier in the season as shown in Figures 3-1 and 3-2, late irrigation season water availability in the wet scenario is lower than the baseline hydrology. This has the counter-intuitive result of increasing shortages for agricultural diversions in some cases, even though the average annual flow is higher under the wet hydrology. The results of model Scenario 5 are shown graphically in **Figures 3-32 through 3-38**.

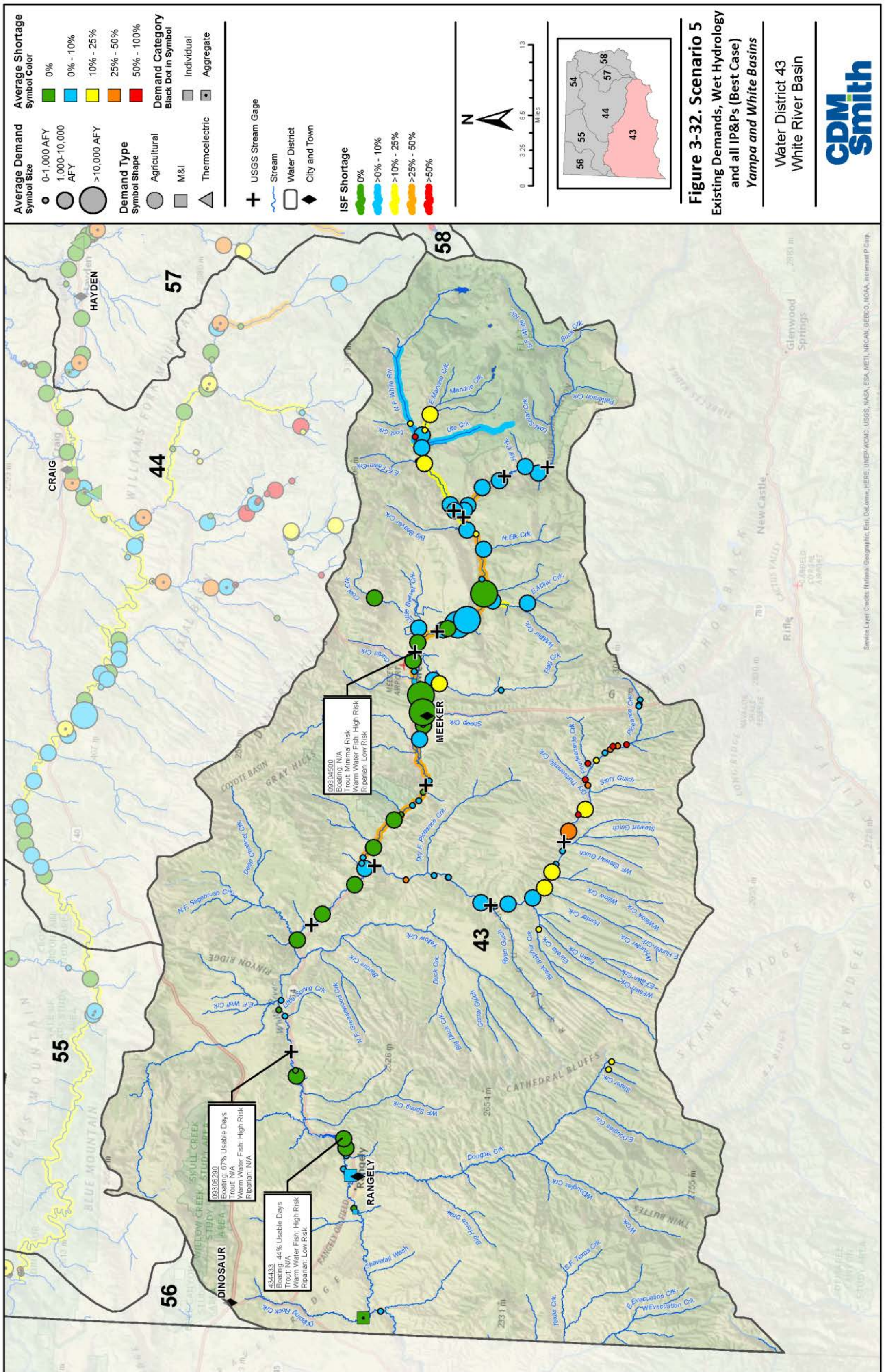


Figure 3-32. Scenario 5
Existing Demands, Wet Hydrology and all IP&Ps (Best Case)
Yampa and White Basins

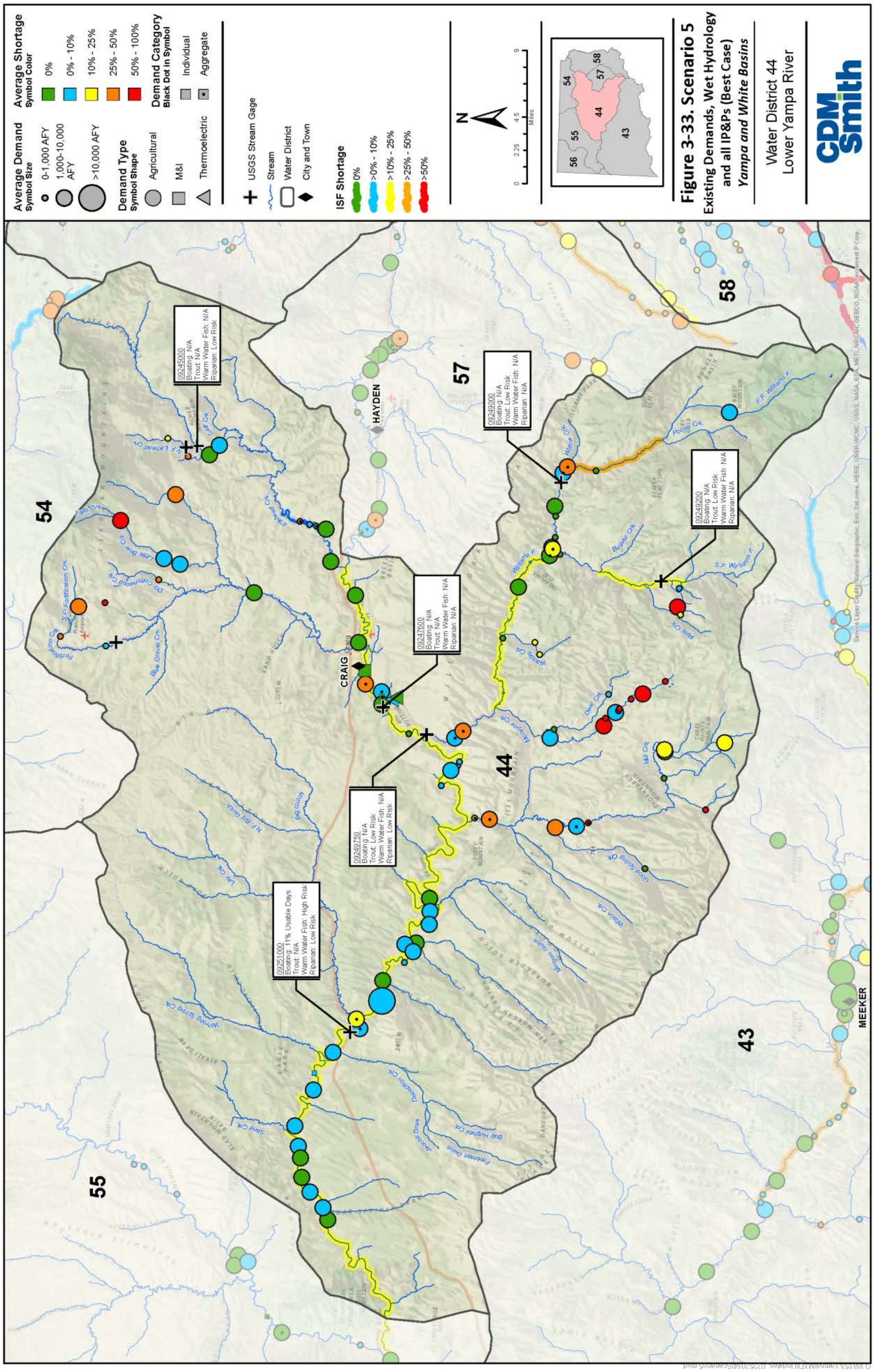


Figure 3-33. Scenario 5
Existing Demands, Wet Hydrology and all IP&Ps (Best Case)
Yampa and White Basins

Water District 44
Lower Yampa River

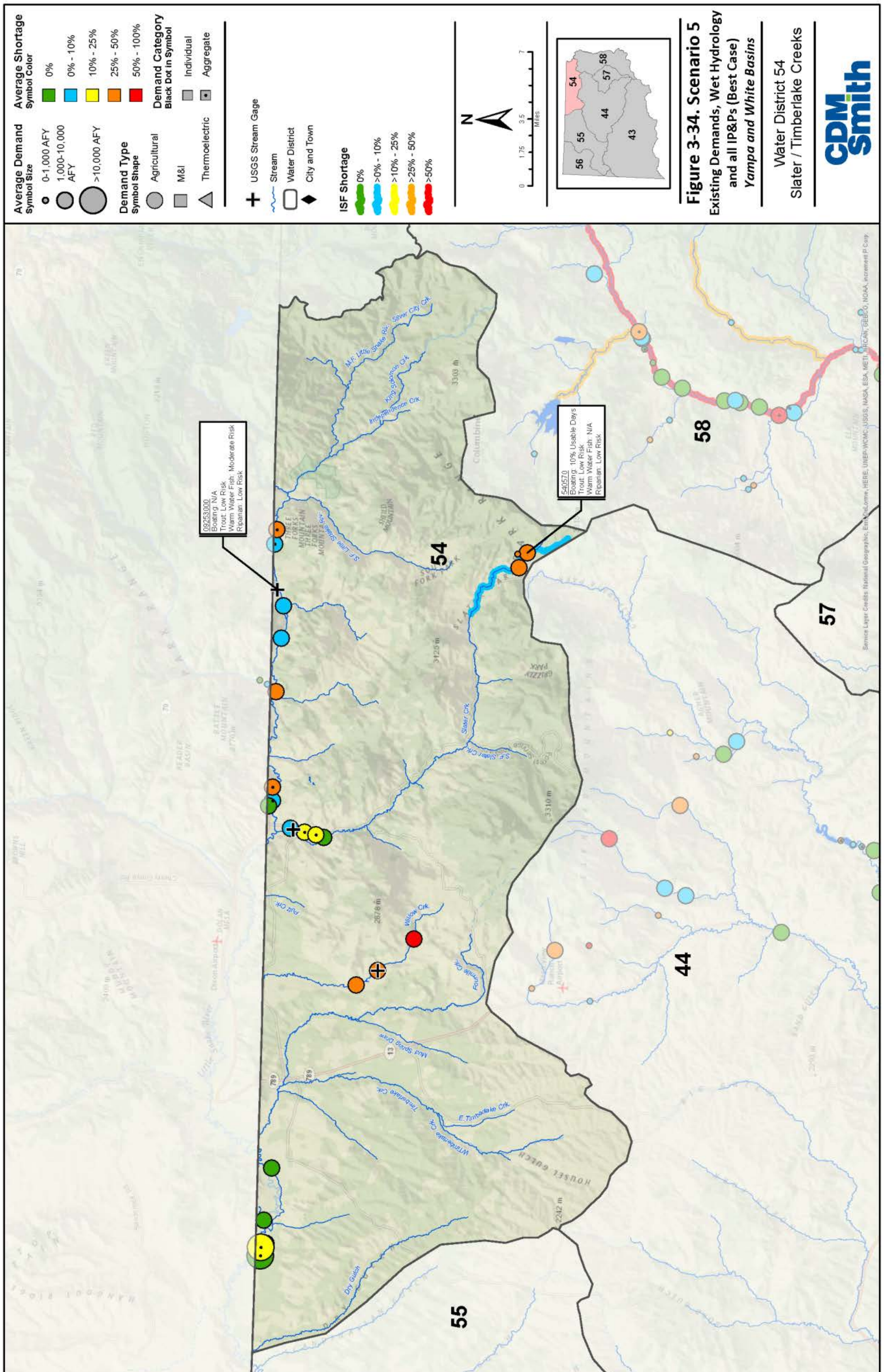


Figure 3-34. Scenario 5
Existing Demands, Wet Hydrology and all IP&Ps (Best Case)
Yampa and White Basins
Water District 54
Slater / Timberlake Creeks

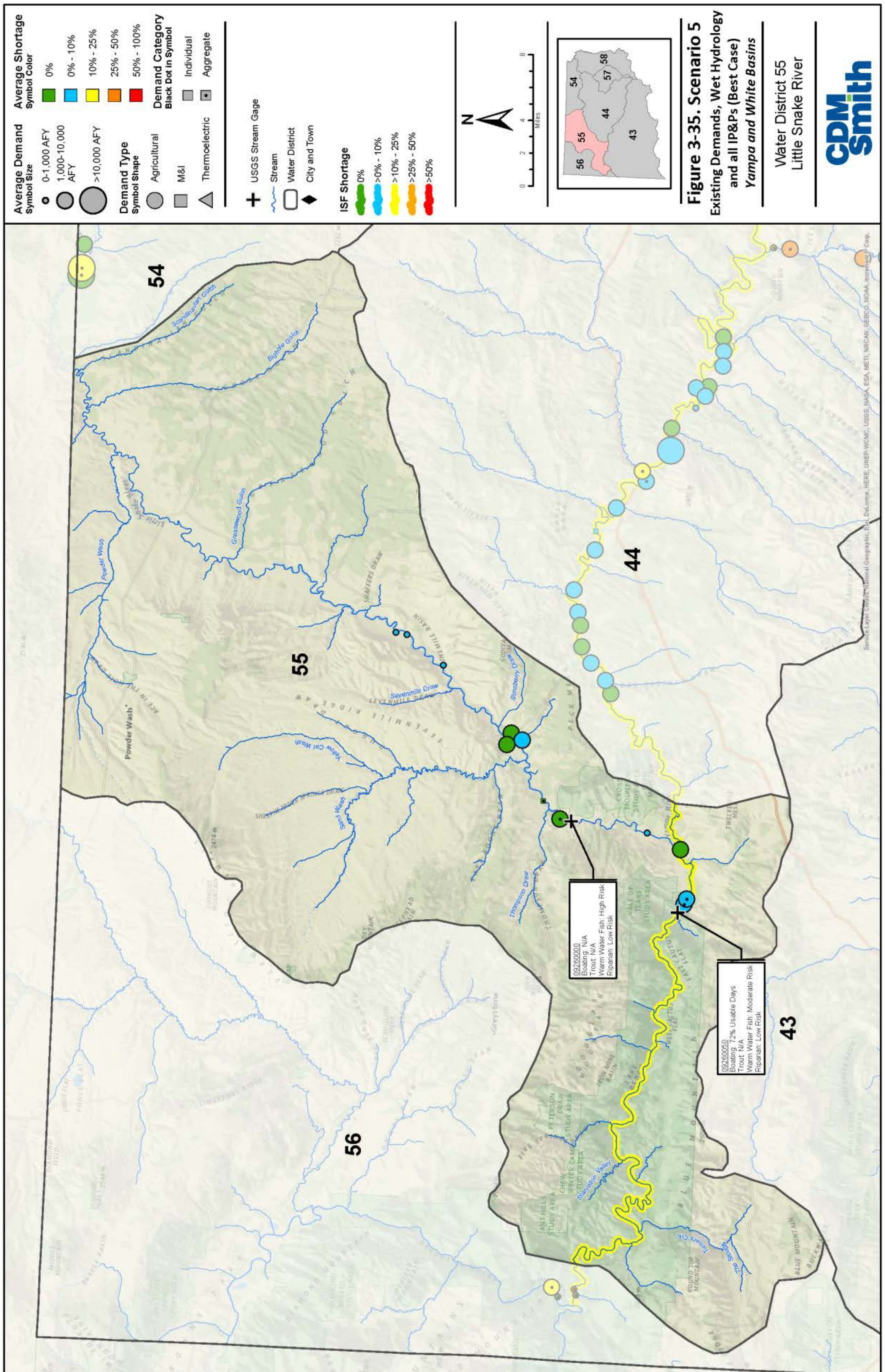


Figure 3-35. Scenario 5
Existing Demands, Wet Hydrology and all IP&Ps (Best Case)
Yampa and White Basins

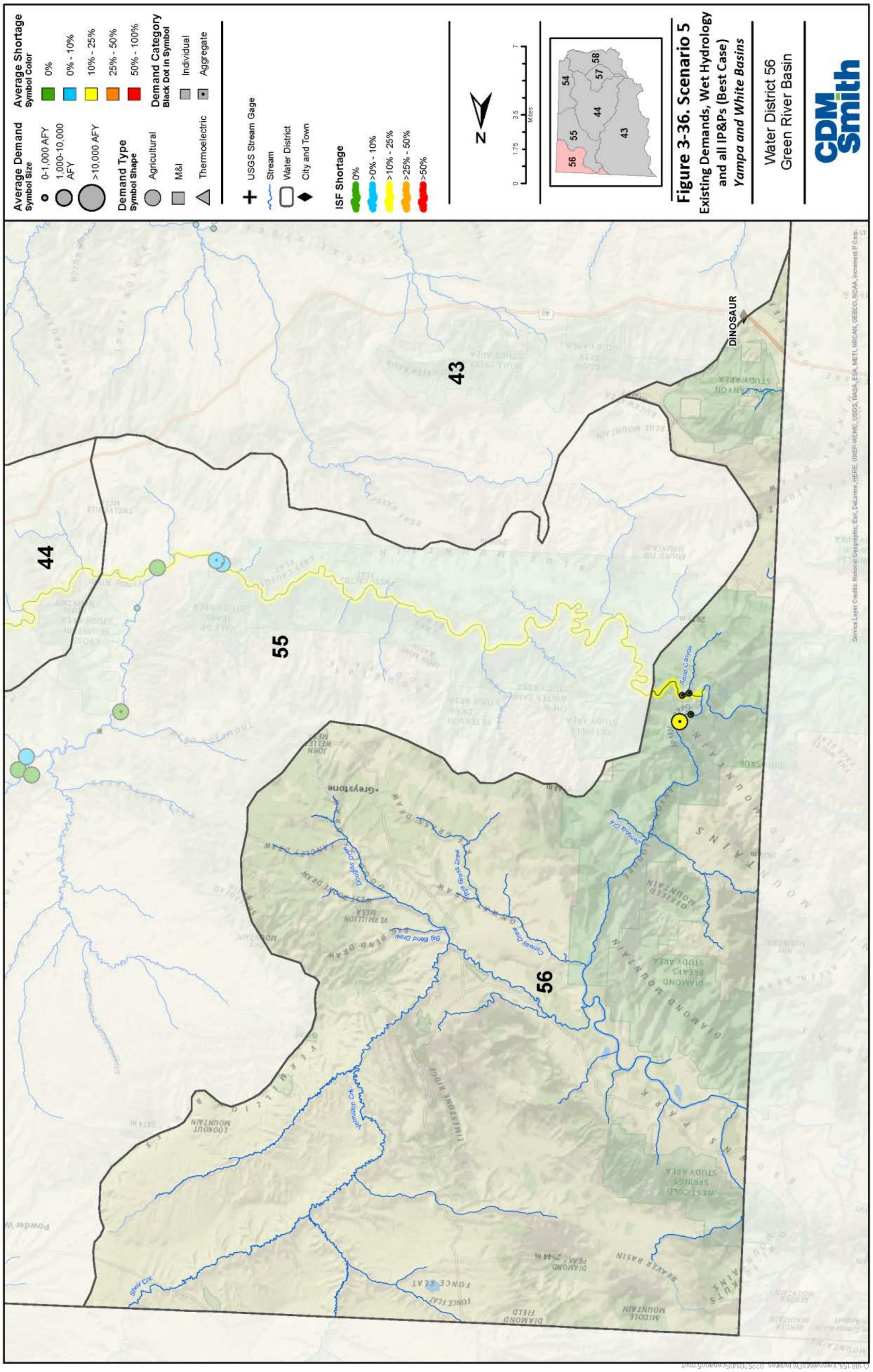


Figure 3-36. Scenario 5
Existing Demands, Wet Hydrology and all IP&Ps (Best Case)
Yampa and White Basins

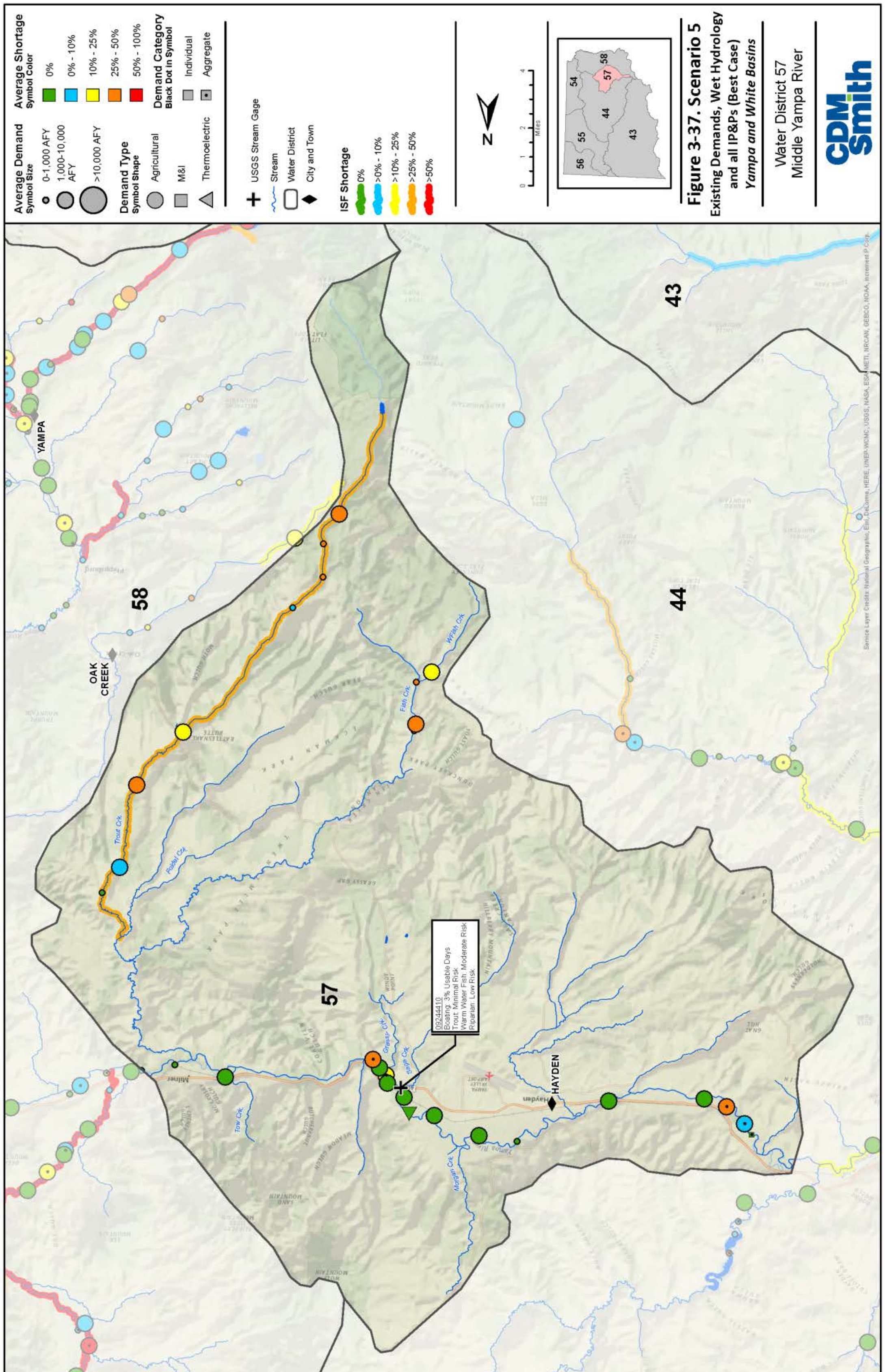


Figure 3-37. Scenario 5
Existing Demands, Wet Hydrology and all IP&Ps (Best Case)
Yampa and White Basins

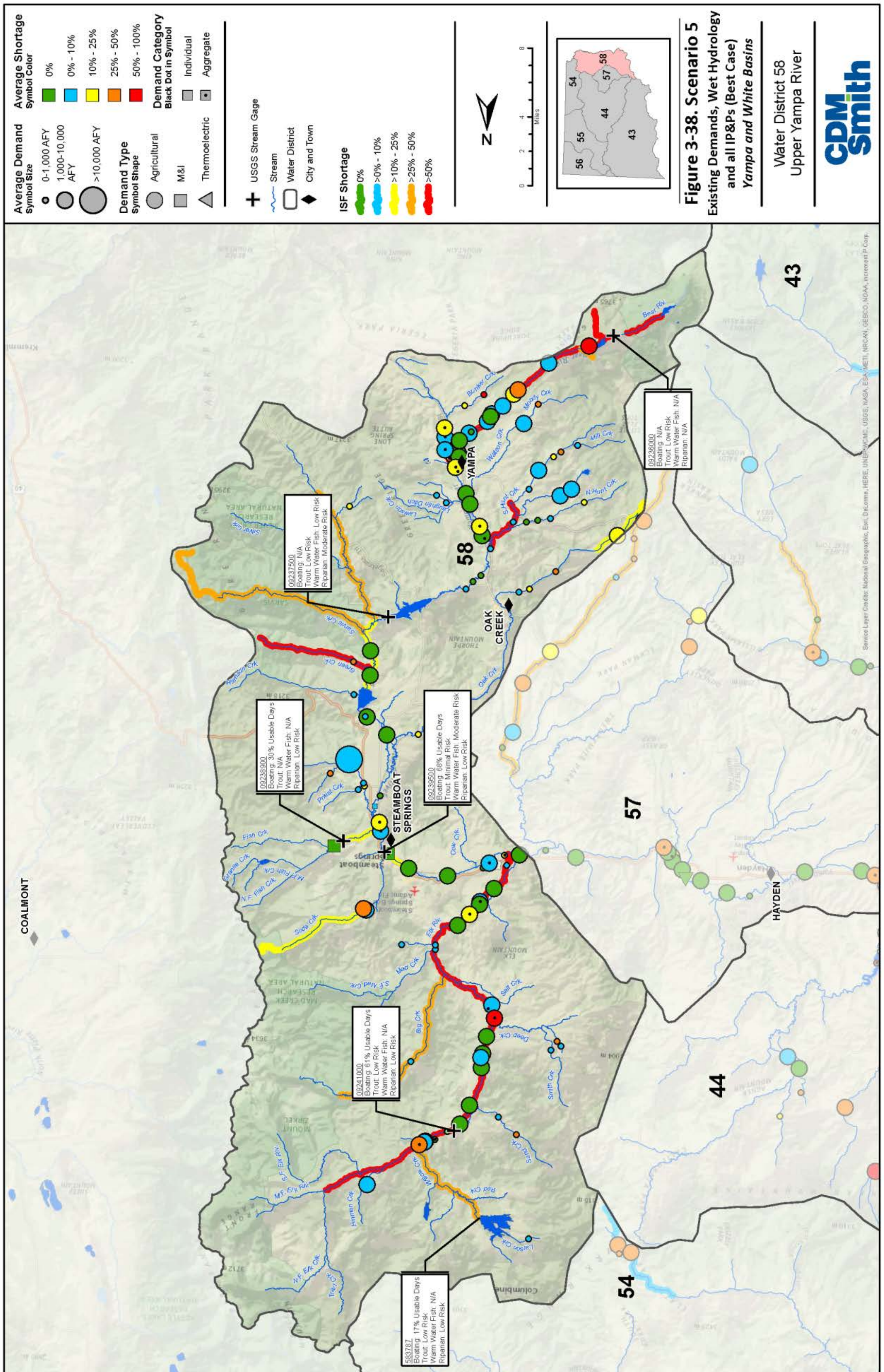


Figure 3-38. Scenario 5
Existing Demands, Wet Hydrology and all IP&Ps (Best Case)
Yampa and White Basins

Water District 58
Upper Yampa River

3.5.6 Scenario 6

Scenario 6 was the last of the three scenarios evaluated after the results from Scenarios 1 through 3 were reviewed by the BRT subcommittee. Scenario 6 was intended to show the other "bookend" of analysis, in contrast to Scenario 5. In other words, Scenario 6 shows the worst case scenario, where the highest demand scenario is used, the driest hydrology is used, and all IPPs are turned off.

As expected, existing gaps for all agricultural diversions basin wide are the same or greater than all other model scenarios. Additionally, due to the high demand, and dry hydrologic conditions, some new shortages also appear in Scenario 6. The results of model Scenario 6 are shown graphically in **Figures 3-39 through 3-45**.

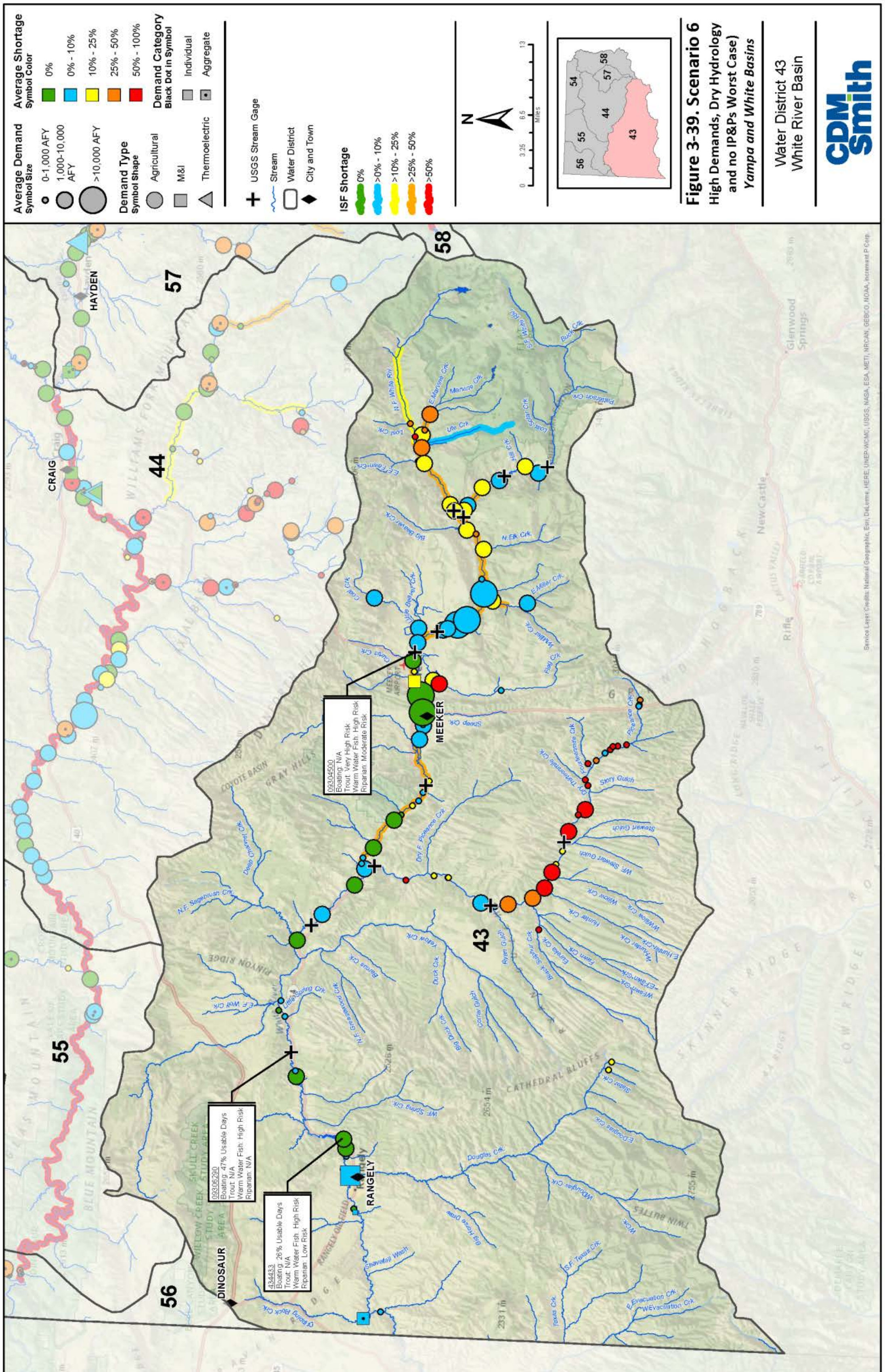


Figure 3-39. Scenario 6
High Demands, Dry Hydrology and no IP&Ps Worst Case)
Yampa and White Basins

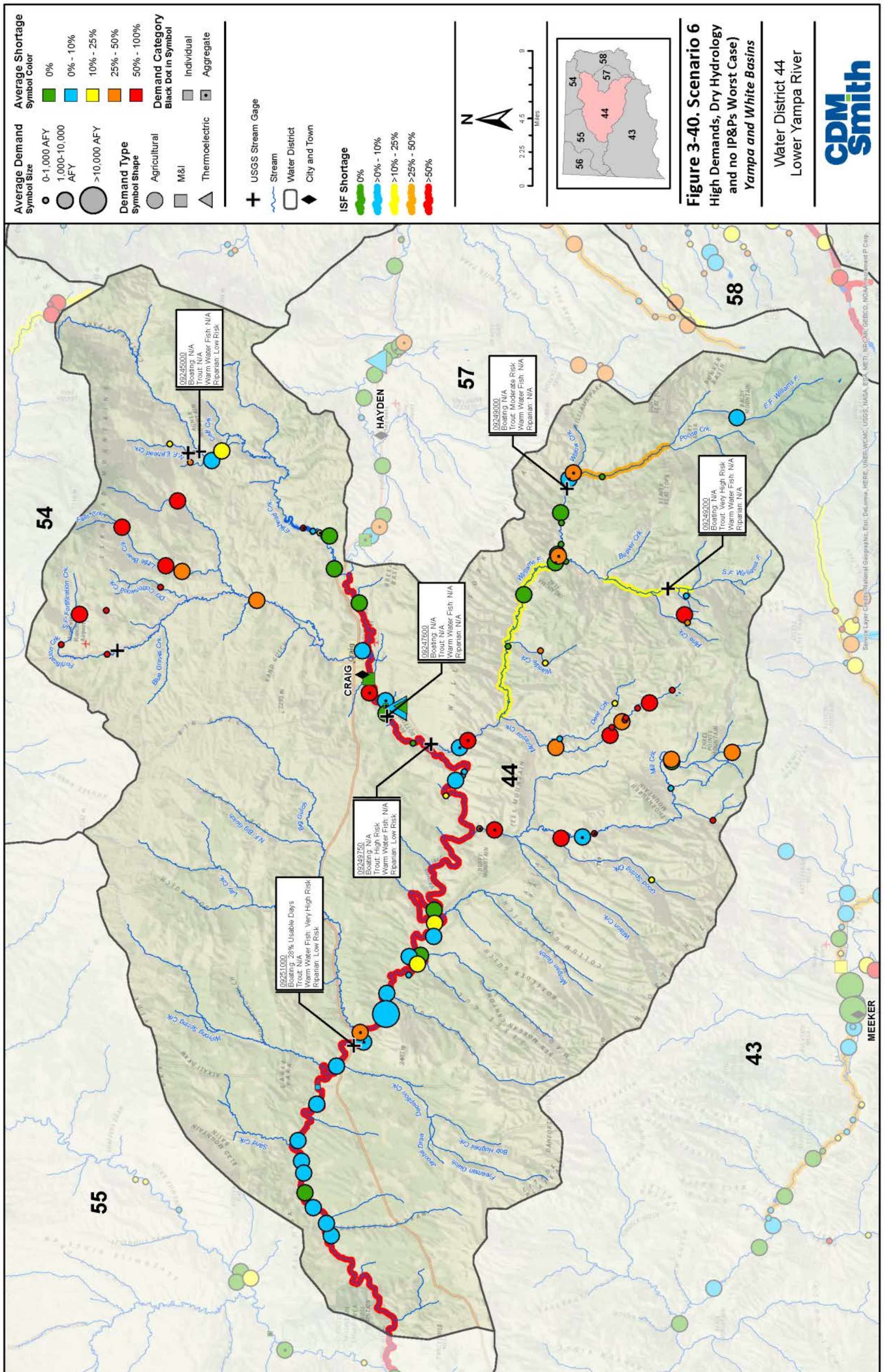


Figure 3-40. Scenario 6
High Demands, Dry Hydrology and no IP&Ps Worst Case)
Yampa and White Basins

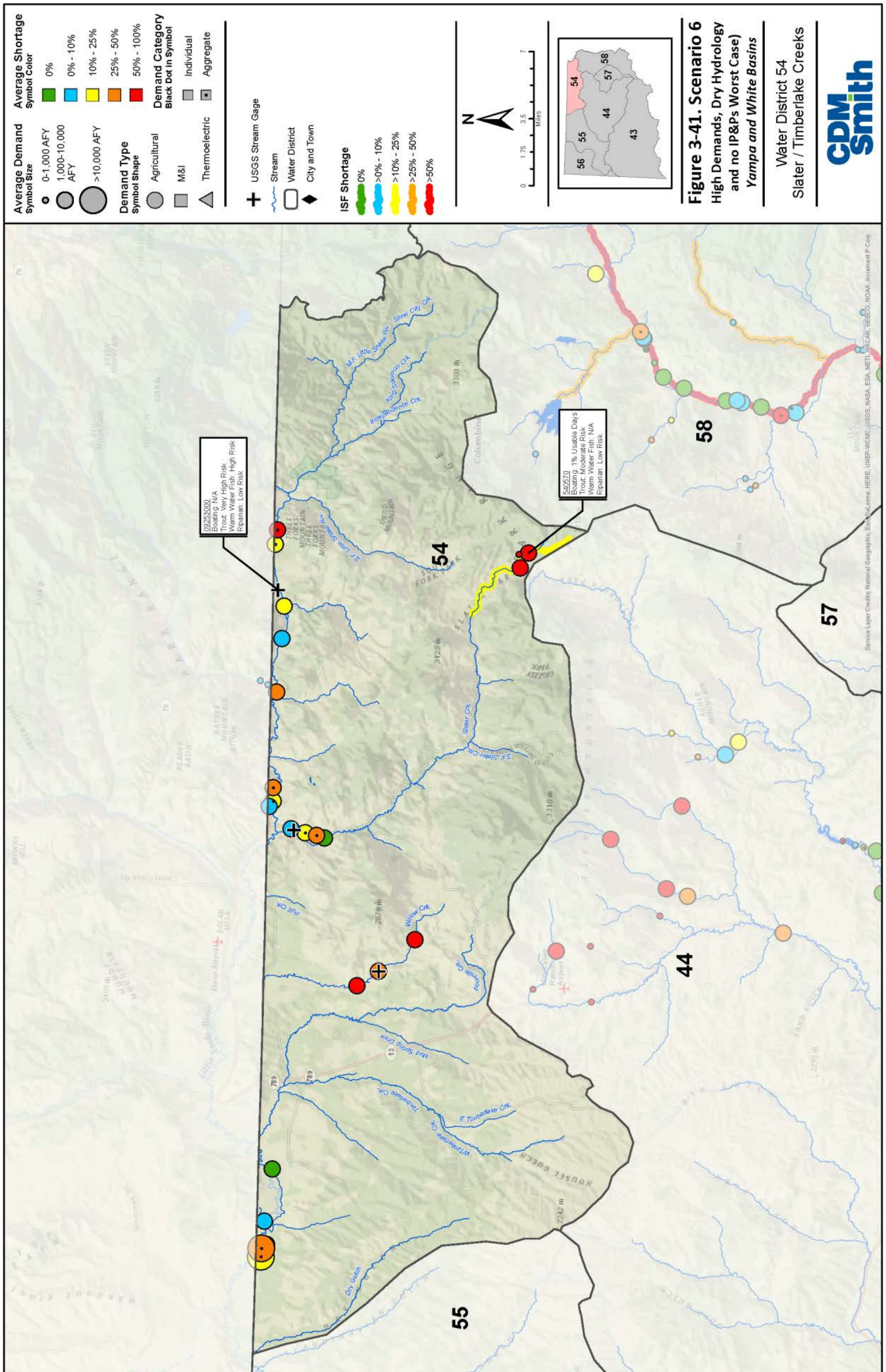


Figure 3-41. Scenario 6
High Demands, Dry Hydrology and no IP&Ps Worst Case)
Yampa and White Basins

Water District 54
Slater / Timberlake Creeks

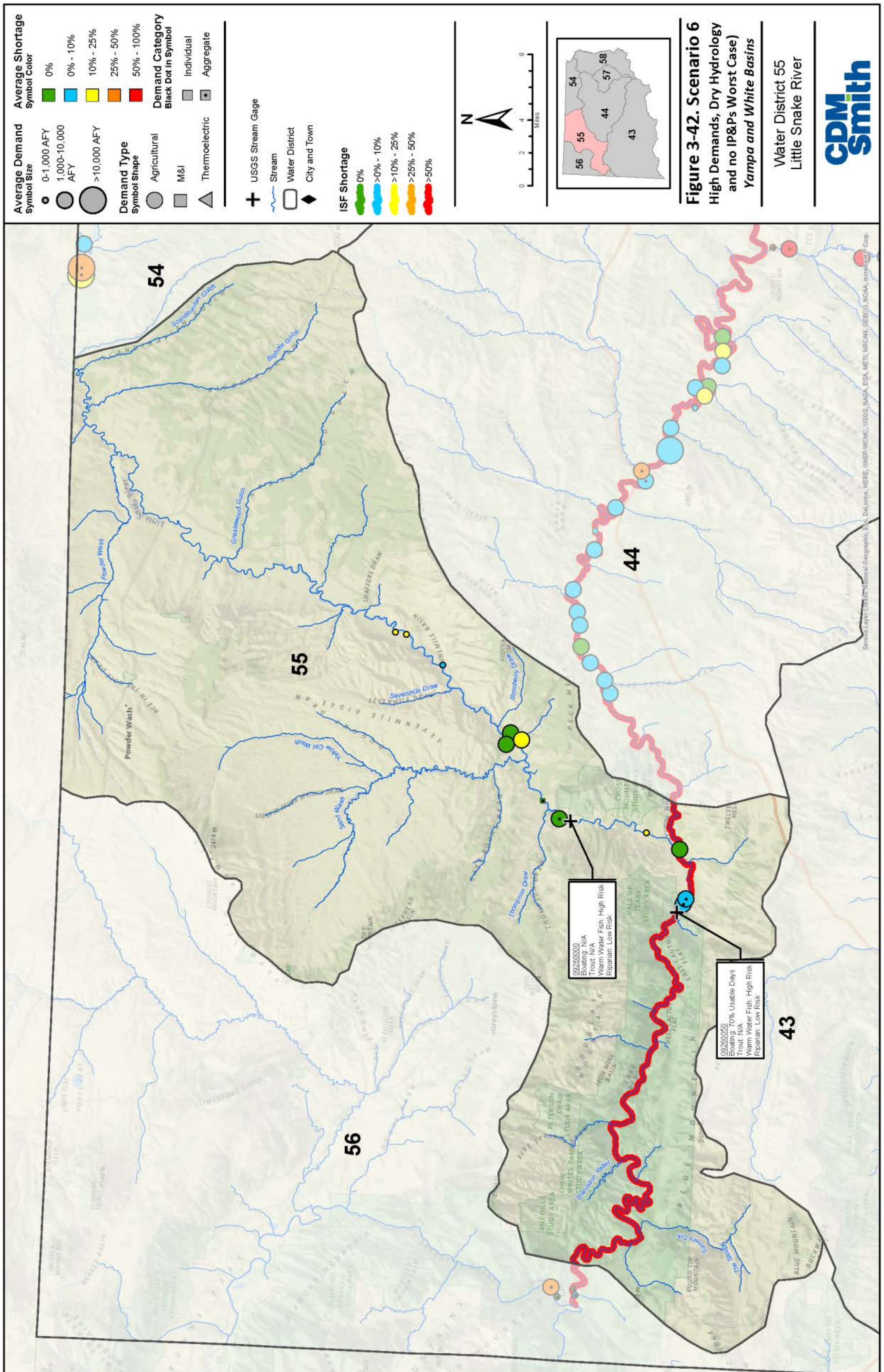


Figure 3-42. Scenario 6
High Demands, Dry Hydrology and no IP&Ps Worst Case)
Yampa and White Basins

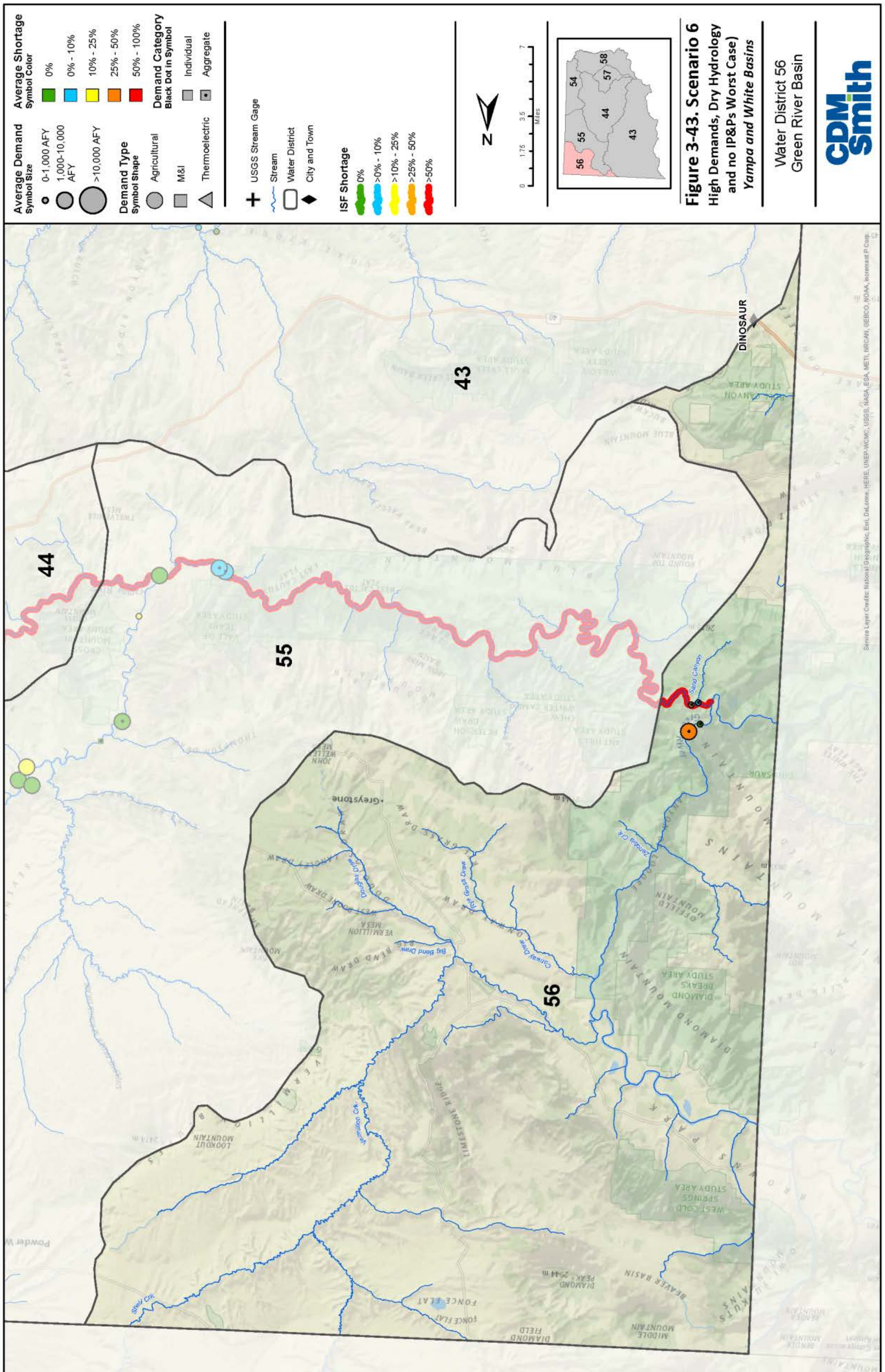


Figure 3-43. Scenario 6
High Demands, Dry Hydrology and no IP&Ps Worst Case)
Yampa and White Basins

Water District 56
Green River Basin

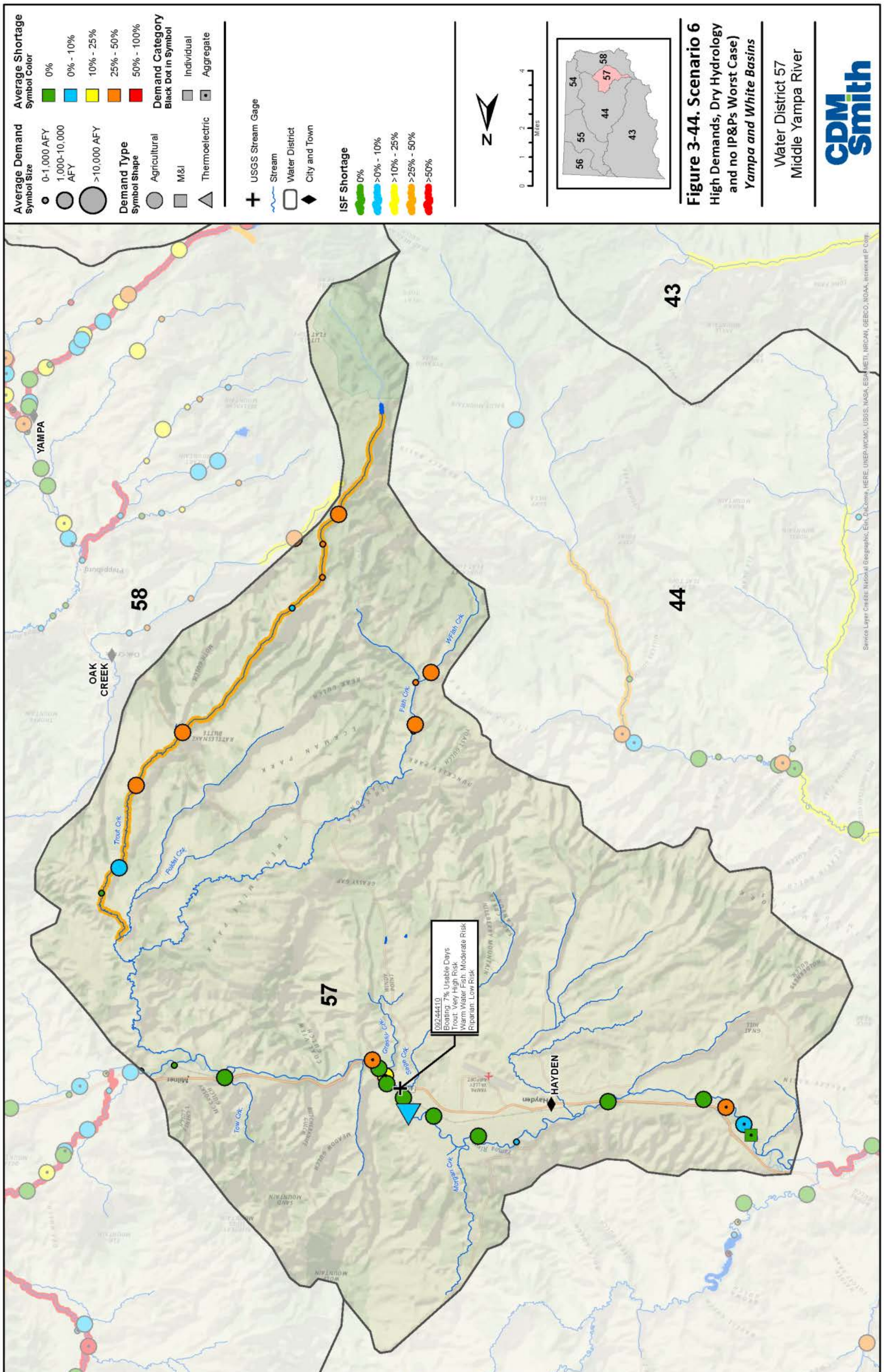


Figure 3-44. Scenario 6
High Demands, Dry Hydrology and no IP&Ps Worst Case)
Yampa and White Basins

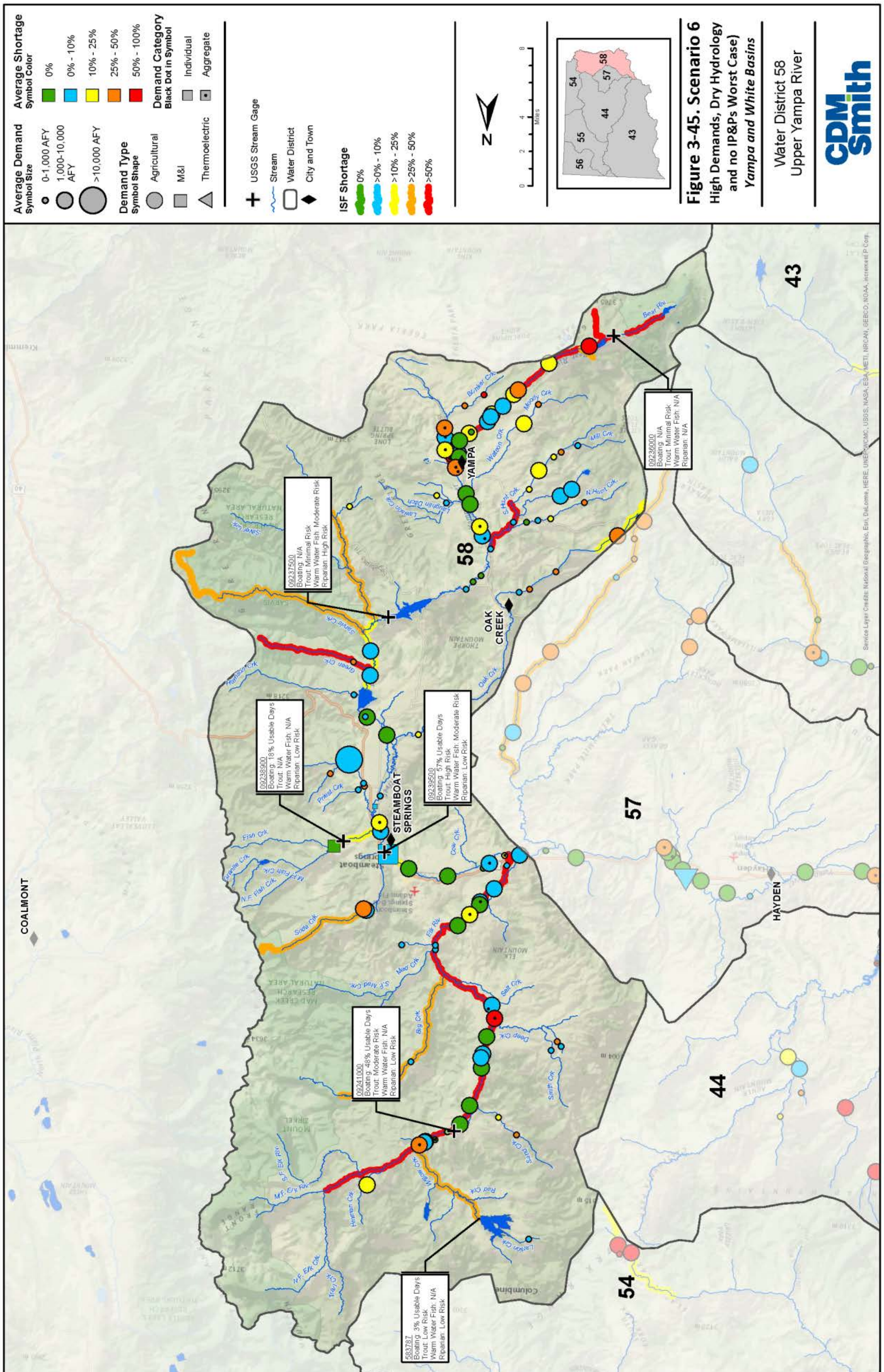


Figure 3-45. Scenario 6
High Demands, Dry Hydrology and no IP&Ps Worst Case)
Yampa and White Basins

3.5.7 Agricultural Results

Agricultural shortages are primarily dependent upon changes in hydrology since the hydrologies affect the entire basin. To a much lesser degree, the demand levels play a role in the agricultural shortages as well, since the only agricultural uses dependent upon the demand scenarios is the Yampa River oxbows agricultural demands, which are discussed separately in Section 3.5.1.2.

Due to the general slight shift earlier in the year of all alternate hydrologies discussed in Section 3.3 and shown in Figures 3-1 and 3-2, late season shortages tend to increase unless there is storage to capture the peak flows. This being said, any upper tributaries without existing storage or an IPP typically observe increased simulated shortages due to decreased late season water availability, even in the wet hydrology simulation.

Agricultural headgate demands for all modeled nodes and shortages as a percentage of total consumptive use are tabulated for each scenario in **Table 3-10**.

Table 3-10. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Baseline Average Annual Total Demand (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
NORT_ADW WhiteNorthF	43_ADW001A	1,560	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NORT_ADW WhiteNorthFB	43_ADW001B	5,040	0.00%	2.74%	2.74%	0.26%	2.10%	0.47%	2.11%
SOUT_ADW WhiteSouthF	43_ADW002A	360	0.00%	5.00%	5.00%	0.00%	3.29%	0.00%	3.29%
SOUT_ADW WhiteSouthFB	43_ADW002B	2,020	0.00%	0.62%	0.62%	0.00%	0.46%	0.00%	0.46%
WHIT_ADW WhiteAbCole	43_ADW003A	1,040	0.00%	4.77%	4.75%	0.99%	4.35%	0.90%	4.35%
WHIT_ADW WhiteAbColeB	43_ADW003B	3,340	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WHITE RIVER NEAR MEEKERB	43_ADW004B	3,110	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WHIT_ADW WhiteNBLMee	43_ADW005A	80	0.00%	0.46%	0.46%	0.00%	0.20%	0.00%	0.20%
WHIT_ADW WhiteNBLMeeB	43_ADW005B	750	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WHIT_ADW WhiteAbPice	43_ADW006A	320	0.00%	3.88%	3.19%	0.81%	1.87%	0.80%	3.02%
WHIT_ADW WhiteAbPiceB	43_ADW006B	480	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PICE_ADW Upper	43_ADW007A	2,900	22.26%	77.10%	77.10%	45.96%	76.98%	37.38%	76.98%
PICE_ADW UpperB	43_ADW007B	930	0.00%	20.91%	20.91%	4.21%	20.91%	1.50%	20.91%
PICE_ADW PicCrBlRioB	43_ADW008A	780	18.70%	53.75%	53.74%	36.61%	53.74%	31.16%	53.74%
PICE_ADW PicCrBlRioBB	43_ADW008B	300	41.37%	91.70%	91.70%	70.40%	91.70%	61.00%	91.70%
PICE_ADW PicCrAbHunt	43_ADW009A	760	54.26%	91.01%	91.01%	74.00%	91.01%	68.03%	91.01%
PICE_ADW PicCrAbHuntB	43_ADW009B	3,260	1.42%	30.24%	30.24%	8.16%	30.24%	5.39%	30.24%
PICE_ADW PicCrBlRyan	43_ADW010B	5,300	4.33%	36.72%	36.70%	13.26%	36.67%	9.60%	36.67%
PICE_ADW Piceance@Wh	43_ADW011A	850	7.78%	19.67%	19.67%	11.13%	19.64%	8.41%	19.64%
PICE_ADW Piceance@WhB	43_ADW011B	1,540	4.44%	12.59%	12.56%	5.62%	12.49%	4.02%	12.49%
WHIT_ADW WhiteBlBois	43_ADW012A	2,230	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WHIT_ADW WhiteBlBoisB	43_ADW012B	4,350	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WHIT_ADW WhiteBlDoug	43_ADW013A	2,310	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WHIT_ADW WhiteBlDougB	43_ADW013B	2,450	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WHIT_ADW WhiteNrStat	43_ADW014A	2,700	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
EVAC_ADW Evac Creek	43_ADW015A	1,990	4.64%	21.94%	21.94%	9.64%	21.94%	8.92%	21.94%
EVAC_ADW Evac CreekB	43_ADW015B	140	8.80%	43.48%	43.48%	19.91%	43.48%	20.05%	43.48%
WHIT_ADW WhiteSBLMee	43_ADW016A	120	39.41%	60.63%	60.63%	52.32%	60.27%	50.80%	60.27%
WHIT_ADW WhiteSBLMeeB	43_ADW016B	870	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WHIT_AMW AggMuni&Ind	43_AMW001	1,100	0.00%	2.53%	1.27%	0.31%	0.00%	0.00%	2.37%
B A & B DITCH NO 1	430511	1,940	0.44%	12.41%	12.41%	2.94%	11.91%	2.32%	11.91%
B M & H DITCH 1	430513	1,250	2.77%	35.60%	35.60%	9.24%	35.53%	5.83%	35.53%
BARBOUR NORTH SIDE D	430526	1,270	0.03%	38.09%	37.76%	9.42%	33.29%	11.84%	33.52%
BECKMAN DITCH	430537	2,220	1.01%	7.33%	7.32%	1.55%	5.46%	1.82%	5.46%
BIG BEAVER DITCH	430539	1,120	3.78%	99.11%	88.07%	79.72%	13.37%	8.35%	13.37%
BLACK EAGLE D NO 1	430543	320	3.74%	52.02%	52.02%	14.86%	52.01%	11.30%	52.01%

Table 3-10. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Baseline Average Annual Total Demand (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
BLACK EAGLE D NO 2	430544	310	5.29%	58.10%	58.10%	16.09%	58.10%	12.73%	58.10%
BLAIR DITCH	430546	1,440	0.00%	1.58%	1.42%	0.00%	1.10%	0.00%	1.14%
CALHOUN DITCH	430563	320	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CALIFORNIA CO WATER	430564	510	0.00%	1.17%	1.17%	0.14%	1.01%	0.36%	1.01%
CALVAT DITCH	430570	860	0.00%	1.74%	1.74%	0.24%	1.74%	0.37%	1.74%
CHARLIE SMITH DITCH	430572	1,680	0.00%	14.87%	14.87%	1.01%	12.59%	1.41%	12.59%
CHASE & COLTHARP D	430573	700	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CLOHERTY DITCH	430575	1,060	0.00%	24.68%	24.44%	0.93%	18.84%	2.59%	19.37%
COAL CREEK MESA DITC	430578	4,650	0.00%	0.09%	0.09%	0.00%	0.09%	0.00%	0.09%
DORRELL DITCH 2	430605	400	0.00%	34.81%	34.25%	8.18%	30.34%	10.74%	30.98%
DREIFUSS DITCH	430607	1,710	0.00%	16.46%	16.43%	0.38%	11.88%	0.91%	12.09%
DREYFUSS DITCH	430608	1,450	5.37%	12.57%	12.57%	8.29%	11.90%	6.51%	11.92%
ELK CREEK DITCH	430623	1,310	2.73%	11.94%	11.94%	4.82%	11.08%	4.20%	11.28%
EMILY DITCH	430625	930	2.53%	23.75%	23.75%	6.69%	23.74%	5.14%	23.74%
FORNEY CORCORAN DITC	430640	1,130	0.00%	2.60%	2.40%	0.40%	1.79%	0.02%	2.09%
G V DITCH	430652	1,290	4.72%	9.37%	9.37%	6.05%	8.97%	5.08%	8.97%
GEORGE S WITTER DITC	430653	1,590	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GREENSTREET DITCH EX	430665	770	0.40%	33.51%	33.51%	8.52%	31.82%	10.91%	32.29%
HANRAHAN DITCH NO 1	430678	100	35.22%	84.57%	84.51%	59.65%	84.51%	47.68%	84.51%
HAY BRETHERTON DITCH	430681	4,290	0.00%	7.32%	7.32%	0.01%	5.79%	0.00%	5.80%
HAY DITCH 2	430684	660	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HEFLEY PUMP PLANT NO	430687	1,110	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HEFLEY PUMP PLANT NO	430688	1,070	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HERWICK DITCH 1	430693	310	43.23%	84.53%	84.53%	61.97%	83.66%	54.65%	83.66%
HIGHLAND DITCH	430694	32,140	0.00%	3.26%	3.25%	0.20%	2.61%	0.25%	2.65%
HILL CREEK NO 3 DITC	430695	750	4.66%	44.58%	44.58%	25.16%	44.14%	30.78%	44.14%
HILL CREEK NO 2 DITC	430696	1,830	0.90%	18.91%	18.91%	2.05%	17.30%	3.89%	17.33%
HOME DITCH	430701	690	1.59%	4.83%	4.83%	2.45%	4.83%	1.17%	4.83%
IMES & REYNOLDS DITC	430710	2,460	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
INDEPENDENT DITCH	430711	730	0.00%	2.36%	2.36%	0.11%	0.94%	0.00%	0.94%
IVO E SHULTS D & PUM	430714	320	0.00%	16.47%	13.72%	3.56%	10.92%	3.08%	14.37%
JAMES HAYES DITCH	430718	1,150	0.16%	2.57%	2.49%	1.31%	2.15%	1.05%	2.20%
JANES DITCH	430719	50	37.11%	82.02%	82.02%	55.70%	75.33%	44.25%	75.33%
LAKE CREEK POOL DITC	430753	330	22.46%	21.10%	21.10%	19.91%	20.80%	19.48%	20.87%
LARSON DITCH	430754	710	4.15%	31.56%	31.56%	7.80%	31.54%	6.34%	31.54%
LAWRENCE DITCH NO 1	430758	610	0.00%	5.93%	3.76%	0.07%	1.19%	0.06%	4.22%
LITTLE DITCH	430769	2,020	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
LOWLAND DITCH	430777	2,520	6.99%	10.27%	10.27%	8.47%	8.47%	8.33%	8.47%
M H M GERMAN CONS D	430782	1,300	2.77%	25.84%	25.84%	9.07%	25.84%	7.53%	25.84%
MARCOTT DITCH	430788	4,240	0.00%	11.20%	11.14%	0.24%	7.59%	1.00%	7.72%
MARTIN DITCH	430789	1,300	0.00%	3.52%	3.50%	0.27%	2.96%	0.35%	3.14%
MARVINE DITCH 1	430790	1,280	0.00%	17.52%	16.87%	0.86%	12.60%	1.45%	12.93%
MARVINE NO 3 DITCH	430791	600	0.96%	46.98%	46.98%	16.09%	43.74%	18.29%	43.76%
MEEKER DITCH	430808	4,310	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
MEEKER POWER DITCH	430809	210	0.00%	29.31%	28.85%	6.51%	24.10%	8.34%	24.60%
MELVIN DITCH	430813	650	1.44%	9.13%	9.13%	4.66%	9.13%	3.59%	9.13%
METZ & REIGAN DITCH	430815	930	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%	0.07%
METZ DITCH	430816	880	6.33%	13.80%	13.75%	9.64%	13.06%	8.40%	13.06%
MIKKELSON DITCH	430818	90	42.78%	85.92%	85.28%	61.55%	79.71%	51.04%	79.71%
MILLER CREEK DITCH	430819	25,630	0.00%	0.82%	0.82%	0.00%	0.25%	0.00%	0.28%
MINER MARTIN DITCH	430823	680	0.00%	2.51%	2.49%	0.50%	2.49%	0.01%	2.49%
MOONEY DITCH	430828	1,360	0.00%	18.75%	18.33%	0.81%	15.59%	1.08%	15.61%
MORGAN DITCH 2	430831	230	25.76%	52.52%	52.45%	33.50%	51.88%	30.23%	51.88%
MORGAN DITCH 1	430832	390	0.14%	6.37%	6.37%	1.28%	6.37%	0.83%	6.37%
NEW ARCHER WARNER DI	430841	980	0.00%	7.05%	7.05%	0.01%	4.29%	0.21%	4.34%
NIBLOCK DITCH	430842	13,560	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 3-10. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Baseline Average Annual Total Demand (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
OAK RIDGE PARK DITCH	430848	21,140	0.00%	3.23%	3.14%	0.00%	1.51%	0.22%	1.63%
OLD AGENCY DITCH	430849	7,780	0.00%	0.23%	0.21%	0.00%	0.01%	0.00%	0.01%
OLDLAND DITCH 1	430850	1,220	10.97%	63.89%	63.89%	26.26%	63.89%	21.02%	63.89%
OLDLAND DITCH 2	430851	770	46.16%	88.06%	88.06%	66.94%	88.06%	58.78%	88.06%
PATTISON DITCH NO 1	430862	800	0.00%	5.72%	5.72%	0.00%	4.80%	0.00%	4.80%
PEASE DITCH	430867	4,230	0.00%	9.28%	9.27%	0.00%	7.10%	0.00%	7.11%
PEDRICK DITCH	430868	3,110	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PICEANCE CREEK DITCH	430873	950	4.05%	20.80%	20.80%	6.84%	20.80%	5.00%	20.80%
POTHOLE DITCH	430881	1,370	5.99%	25.58%	24.49%	10.56%	20.14%	10.51%	20.14%
POWELL PARK DITCH	430883	14,200	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
RANGELY WATER PLANT	430889	1,710	0.00%	4.80%	3.62%	0.58%	2.16%	0.66%	3.92%
REDDIN DITCH	430895	100	39.22%	83.28%	83.18%	57.35%	83.01%	51.54%	83.01%
ROBERT MCKEE DITCH	430903	1,440	11.68%	63.24%	63.24%	27.60%	63.23%	22.51%	63.23%
RYAN DITCH	430908	530	0.25%	0.33%	0.33%	0.33%	0.33%	0.25%	0.33%
RYE GRASS DITCH	430909	1,210	20.66%	76.18%	76.15%	45.08%	76.15%	37.83%	76.15%
SAYER DITCH	430919	310	7.07%	12.46%	12.46%	7.80%	12.46%	7.62%	12.46%
SCHUTTE DITCH	430923	710	15.89%	25.49%	25.49%	20.75%	25.49%	15.89%	25.49%
SHERIDAN & MORTON D	430926	890	0.00%	1.58%	1.58%	0.00%	0.49%	0.00%	0.49%
SIMPSON DITCH	430928	770	0.08%	36.19%	36.15%	8.17%	32.71%	12.89%	33.24%
SIZEMORE DITCH 1	430929	480	43.76%	66.13%	65.92%	57.69%	65.62%	55.43%	65.62%
SKELTON DITCH	430931	1,110	0.00%	25.81%	25.65%	1.27%	19.42%	2.40%	19.57%
SOLDIER CREEK DITCH	430934	570	18.78%	17.63%	17.63%	16.75%	17.35%	15.93%	17.35%
SOUTH SIDE HIGHLINE	430935	6,280	0.00%	0.62%	0.62%	0.13%	0.50%	0.00%	0.50%
SPROD DITCH 1	430944	1,000	11.91%	58.01%	57.98%	26.34%	56.80%	24.59%	56.80%
SQUARE S CONS D SYS	430948	2,280	0.00%	3.82%	3.82%	0.44%	3.82%	0.30%	3.82%
STADTMAN DITCH	430949	970	0.00%	0.15%	0.15%	0.00%	0.00%	0.00%	0.00%
STOREY DITCH 1	430954	590	0.00%	1.42%	1.42%	0.10%	1.42%	0.16%	1.42%
SWEEDE DITCH	430961	2,860	0.00%	11.96%	11.96%	0.08%	8.94%	0.40%	9.20%
THOMAS DITCH	430965	510	0.00%	1.69%	1.57%	0.09%	1.51%	0.00%	1.51%
THOMAS DITCH 2	430966	470	0.00%	3.14%	3.14%	0.56%	3.05%	0.01%	3.05%
UPPER DITCH	430975	170	20.61%	79.50%	79.50%	47.90%	79.22%	37.59%	79.22%
UTE CREEK DITCH	430980	2,160	0.06%	30.22%	30.13%	4.93%	26.76%	8.21%	27.17%
WHITE RIVER MESA DIT	431010	930	27.60%	61.42%	61.40%	38.61%	61.05%	33.60%	61.23%
BELOT MOFFAT DITCH	431027	1,510	11.78%	68.43%	68.41%	32.30%	68.41%	24.43%	68.41%
GORDON DITCH	431031	190	40.00%	81.31%	81.31%	59.79%	81.31%	52.98%	81.31%
LAWRENCE DITCH	431033	670	0.00%	1.62%	1.62%	0.08%	1.04%	0.08%	1.43%
MCDOWELL NO. 1 DITCH	431034	500	0.00%	13.66%	12.53%	2.86%	8.03%	1.50%	10.81%
JACOBS PUMP & PL	431108	510	0.00%	9.35%	9.35%	3.08%	8.21%	1.04%	8.37%
COX PUMP NO 1	431272	1,230	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
REIGAN PUMP NO 1	431273	710	0.00%	0.33%	0.33%	0.00%	0.00%	0.00%	0.06%
GOFF DITCH	431494	670	0.00%	3.70%	3.74%	1.06%	1.99%	0.66%	3.23%
KENNEY PUMP NO 1	432099	820	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
44_ADY012_ElkheadCre	44_ADY012A	740	9.23%	9.29%	9.29%	8.48%	11.05%	9.64%	13.21%
44_ADY012_ElkheadCreB	44_ADY012B	930	61.88%	45.17%	45.07%	44.14%	63.07%	45.18%	63.45%
44_ADY013_YampaRbelC	44_ADY013A	2,710	5.45%	5.45%	5.45%	5.45%	5.45%	5.45%	5.45%
44_ADY013_YampaRbelCB	44_ADY013B	2,150	55.17%	46.70%	46.70%	46.68%	55.17%	46.68%	55.21%
44_ADY014_EFkWilliam	44_ADY014A	2,060	0.00%	0.40%	0.45%	0.00%	0.32%	0.08%	0.06%
44_ADY014_EFkWilliamB	44_ADY014B	4,290	43.47%	29.73%	29.79%	26.18%	45.83%	27.15%	45.78%
44_ADY015_SFkWilliam	44_ADY015A	2,760	0.00%	0.09%	0.09%	0.00%	0.10%	0.00%	0.00%
44_ADY015_SFkWilliamB	44_ADY015B	1,680	33.82%	24.59%	24.70%	22.44%	35.47%	23.01%	35.33%
44_ADY016_WilliamsFo	44_ADY016A	3,850	2.79%	2.79%	2.79%	2.79%	2.79%	2.79%	2.79%
44_ADY016_WilliamsFoB	44_ADY016B	2,220	57.35%	44.49%	44.49%	43.88%	57.71%	44.13%	57.68%
44_ADY017_MilkCrabvG	44_ADY017A	790	14.33%	37.50%	37.71%	24.36%	43.38%	33.08%	43.61%
44_ADY017_MilkCrabvGB	44_ADY017B	490	74.70%	64.18%	64.33%	62.70%	79.15%	64.35%	79.15%
44_ADY018_MilkCreek	44_ADY018A	560	6.60%	31.67%	30.41%	20.68%	28.37%	24.72%	31.31%
44_ADY018_MilkCreekB	44_ADY018B	2,150	51.47%	39.80%	39.80%	39.80%	51.50%	39.80%	51.50%

Table 3-10. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Baseline Average Annual Total Demand (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
44_ADY019_YampaRnrMa	44_ADY019A	1,330	1.84%	5.50%	5.34%	2.04%	4.00%	2.77%	5.81%
44_ADY019_YampaRnrMaB	44_ADY019B	2,300	36.68%	23.31%	23.31%	23.31%	36.68%	23.31%	36.68%
44_ADY025_YampaR@Dee	44_ADY025A	3,130	1.70%	1.70%	1.70%	1.70%	1.70%	1.70%	3.18%
44_ADY025_YampaR@DeeB	44_ADY025B	1,190	4.46%	2.68%	2.68%	2.68%	4.46%	2.68%	4.46%
WILSON DITCH	440509	1,470	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WISCONSIN DITCH	440511	4,780	26.40%	0.17%	0.00%	0.00%	39.42%	0.00%	39.42%
WOOLEY & JOHNSON D	440514	710	0.41%	3.02%	2.29%	0.41%	1.72%	1.08%	2.90%
YAMPA VAL STOCK BR C	440517	2,460	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
YELLOW JACKET DITCH	440518	710	35.24%	56.29%	56.29%	44.89%	56.43%	50.76%	56.44%
A Q DITCH 1	440524	280	3.99%	0.29%	0.00%	0.00%	21.41%	0.00%	23.25%
AIR LINE IRR D	440527	840	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ANDERSON DITCH	440533	330	23.40%	43.25%	43.25%	30.11%	43.29%	35.79%	43.25%
BAILEY DITCH	440541	1,000	0.00%	0.14%	0.14%	0.00%	0.40%	0.00%	0.37%
CARD DITCH	440570	1,400	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CARRIGAN-AVERILL D	440572	400	56.46%	78.65%	78.65%	61.08%	78.65%	64.13%	78.65%
CATARACT DITCH	440573	3,860	68.32%	80.02%	80.02%	71.06%	80.02%	75.10%	80.02%
CRAIG WATER SUPPLY P	440581	2,200	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CROSS MTN PUMP - GRO	440583	3,110	0.00%	0.00%	0.00%	0.00%	0.25%	0.00%	0.00%
CROSS MTN PUMP NO 1	440584	2,900	0.00%	0.00%	0.00%	0.00%	0.22%	0.00%	0.22%
CRYSTAL CK DITCH	440585	420	0.42%	13.41%	12.83%	1.69%	7.02%	4.11%	8.92%
D D & E DITCH	440586	3,510	0.00%	2.85%	2.85%	0.27%	3.61%	1.05%	3.61%
D D FERGUSON D NO 2	440587	2,680	5.31%	29.59%	29.59%	11.08%	30.29%	20.32%	30.29%
DEEP CUT IRR D	440589	5,940	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
DEER CK & MORAPOS D	440590	1,730	25.70%	16.98%	16.96%	8.29%	41.22%	0.99%	41.22%
DENNISON & MARTIN D	440593	1,090	52.96%	66.94%	66.94%	56.94%	67.36%	58.60%	67.36%
DUNSTON DITCH	440601	740	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
EGRY MESA DITCH	440607	2,950	0.00%	5.35%	5.33%	0.05%	3.52%	1.22%	3.28%
ELK TRAIL DITCH	440611	1,200	56.95%	75.81%	75.81%	61.18%	75.81%	64.71%	75.81%
ELKHORN IRR DITCH	440612	1,570	55.85%	10.55%	10.55%	5.81%	72.22%	5.87%	72.22%
ELLGEN DITCH	440613	710	0.55%	10.95%	9.45%	1.81%	9.07%	2.85%	12.79%
ELLIS & KITCHENS D	440614	290	11.83%	22.51%	22.51%	15.98%	22.44%	16.34%	22.51%
GIBBONS WILSON JORDA	440628	720	51.98%	71.48%	71.48%	56.03%	71.48%	57.11%	71.48%
GRIESER DITCH	440635	580	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HADDEN BASE DITCH	440638	1,050	69.52%	83.79%	83.79%	72.24%	83.79%	71.38%	83.79%
HARPER DITCH 1	440644	900	3.42%	18.30%	18.30%	7.47%	18.30%	12.18%	18.30%
HARPER DITCH 2	440645	270	4.88%	28.09%	28.09%	13.54%	28.09%	20.73%	28.09%
HAUGHEY IRR DITCH	440647	1,570	50.23%	40.07%	40.07%	24.75%	65.17%	28.83%	65.17%
HIGHLINE MESA BAKER	440650	340	52.49%	13.47%	13.40%	6.81%	69.32%	7.39%	69.32%
HIGHLAND DITCH	440651	3,260	31.50%	18.35%	18.35%	9.24%	48.78%	1.59%	48.78%
HIGHLAND AKA HIGHLIN	440652	1,220	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
J A MARTIN DITCH	440660	740	0.00%	0.07%	0.07%	0.00%	0.29%	0.00%	0.29%
J P MORIN DITCH	440661	760	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
JUNIPER MTN TUNNEL	440675	5,440	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
K DIAMOND DITCH	440677	2,000	0.00%	0.00%	0.00%	0.00%	0.13%	0.00%	0.00%
LAMB IRR DITCH	440681	570	39.44%	38.75%	38.75%	23.42%	53.76%	30.83%	53.76%
LILY PARK D PUMP STA	440687	2,700	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
LITTLE BEAR DITCH	440688	2,270	32.22%	15.69%	15.69%	8.67%	43.58%	8.87%	43.58%
M DITCH	440691	1,210	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.44%
MARTIN CK DITCH	440692	2,760	5.09%	29.98%	29.98%	14.75%	30.13%	22.25%	30.13%
MAYBELL CANAL	440694	13,150	0.00%	1.25%	1.17%	0.25%	1.04%	0.22%	1.63%
MAYBELL MILL PIPELINE	440695	350	0.41%	5.22%	4.49%	1.26%	4.45%	1.82%	6.55%
MCDONALD DITCH	440698	720	58.00%	70.83%	70.84%	61.53%	71.62%	64.85%	71.62%
MCKINLAY DITCH NO 1	440699	1,560	0.04%	0.35%	0.20%	0.00%	0.47%	0.00%	0.35%
MCKINLAY DITCH NO 2	440700	2,480	5.94%	12.80%	12.80%	7.59%	13.02%	9.20%	12.93%
MCINTYRE DITCH	440702	1,990	0.07%	3.58%	3.12%	0.78%	3.45%	0.86%	3.85%
MILK CK DITCH	440706	1,930	19.26%	38.75%	38.72%	29.68%	50.02%	34.55%	50.02%

Table 3-10. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Baseline Average Annual Total Demand (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
MOCK DITCH	440711	1,020	0.06%	2.15%	1.95%	0.06%	2.23%	0.73%	2.40%
MULLEN DITCH	440716	620	0.28%	10.40%	10.40%	1.76%	10.89%	6.42%	10.69%
NICHOLS DITCH NO 1	440723	1,040	0.06%	1.83%	1.62%	0.06%	1.24%	0.64%	1.99%
NORVELL DITCH	440724	2,300	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PATRICK SWEENEY D	440729	1,890	0.55%	4.03%	3.32%	0.62%	2.86%	1.41%	4.16%
PECK IRRIG D	440731	1,350	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PINE CK DITCH	440735	880	6.76%	28.87%	28.86%	12.69%	27.95%	19.44%	27.81%
RATCLIFF DITCH	440740	610	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ROBY D AKA ROBY D NO	440747	970	71.90%	82.27%	82.27%	73.08%	82.27%	72.97%	82.27%
ROBY DITCH NO 2	440748	690	61.65%	75.22%	75.22%	63.77%	75.25%	63.74%	75.25%
ROUND BOTTOM D NO 1	440749	290	0.00%	0.20%	0.20%	0.00%	0.77%	0.21%	0.57%
ROUND BOTTOM D NO 2	440750	360	0.00%	0.30%	0.18%	0.00%	0.71%	0.19%	0.48%
ROUND BOTTOM DITCH	440751	1,020	0.00%	0.31%	0.30%	0.00%	0.20%	0.07%	0.44%
SMITH DITCH	440763	1,770	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
STARR IRRIG DITCH	440770	280	0.10%	0.39%	0.39%	0.05%	1.07%	0.27%	0.89%
SUNBEAM DITCH	440778	1,420	0.06%	3.08%	2.54%	0.25%	2.86%	0.83%	3.31%
TIPTON IRR DITCH	440785	1,840	46.50%	39.62%	39.55%	28.79%	62.32%	33.94%	62.32%
TISDEL D NO 2	440786	1,800	0.00%	0.56%	0.29%	0.00%	0.51%	0.15%	0.59%
UTLEY DITCH	440790	940	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CROSS MTN PUMP - GUE	440801	1,140	0.00%	0.20%	0.00%	0.00%	0.29%	0.00%	0.49%
ELLGEN NO 2 DITCH	440806	410	0.66%	16.06%	13.80%	4.39%	9.83%	3.74%	16.47%
HART DITCH	440812	590	73.25%	80.70%	80.70%	74.03%	80.70%	70.23%	80.70%
HIGHLINE DITCH	440814	800	0.00%	0.35%	0.39%	0.00%	0.74%	0.00%	0.57%
LOWRY SEELEY PUMP	440820	1,450	0.55%	8.62%	7.54%	2.53%	5.66%	2.43%	10.60%
MACK DITCH	440821	520	0.41%	17.35%	15.40%	3.09%	7.91%	3.27%	17.60%
OLD SWEENEY DITCH	440830	1,530	0.64%	8.25%	6.69%	1.56%	6.03%	2.73%	10.74%
HENRY SWEENEY DITCH	440863	1,690	0.55%	5.83%	5.10%	1.33%	4.11%	2.14%	8.03%
DRY COTTONWOOD DITCH	440998	650	53.84%	45.63%	45.60%	33.81%	66.55%	38.90%	66.55%
54_ADY020_LSnakeRnrS	54_ADY020A	1,980	0.45%	17.60%	17.60%	2.32%	15.31%	9.51%	15.68%
54_ADY020_LSnakeRnrSB	54_ADY020B	4,990	39.29%	36.35%	36.35%	22.99%	53.71%	29.54%	53.82%
54_ADY021_LSnakeRabv	54_ADY021A	4,180	0.42%	12.67%	12.67%	1.71%	11.44%	6.88%	11.61%
54_ADY021_LSnakeRabvB	54_ADY021B	1,800	35.87%	34.06%	34.06%	23.91%	45.13%	27.28%	45.13%
54_ADY022_SlaterCreek	54_ADY022A	1,350	2.75%	11.91%	11.91%	6.51%	11.70%	10.27%	11.91%
54_ADY022_SlaterCreekB	54_ADY022B	5,590	28.67%	23.87%	23.87%	16.06%	37.58%	19.39%	37.80%
54_ADY023_LSnakeabvD	54_ADY023A	17,140	0.00%	1.41%	1.41%	0.00%	1.04%	0.00%	13.15%
54_ADY023_LSnakeabvDB	54_ADY023B	12,990	33.77%	16.53%	16.53%	13.10%	36.06%	12.51%	40.09%
BEELER DITCH	540507	1,400	0.00%	3.99%	3.99%	0.00%	3.85%	0.06%	3.85%
HEELEY DITCH	540531	4,500	0.00%	0.47%	0.47%	0.00%	0.24%	0.00%	14.73%
HOME SUPPLY DITCH	540532	1,370	0.15%	13.03%	13.03%	1.01%	10.94%	6.91%	12.33%
LUCHINGER DITCH	540543	1,130	13.74%	42.79%	42.79%	25.42%	41.49%	36.39%	42.73%
MORGAN & BEELER DITCH	540548	1,940	0.00%	0.52%	0.52%	0.00%	0.37%	0.00%	0.37%
MORGAN SLATER DITCH	540549	1,080	0.00%	0.11%	0.11%	0.01%	0.11%	0.01%	0.11%
PERKINS FOX DITCH	540554	2,190	55.47%	76.49%	76.49%	60.47%	76.49%	67.68%	76.49%
PERKINS IRR DITCH	540555	2,670	28.01%	52.33%	52.33%	35.13%	52.33%	41.28%	52.33%
SALISBURY DITCH	540564	610	0.00%	0.07%	0.07%	0.00%	0.01%	0.00%	0.01%
SLATER FORK DITCH	540568	1,670	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SLATER PARK DITCH NO 1	540570	1,880	23.79%	55.65%	55.65%	37.71%	54.66%	49.57%	55.95%
SLATER PARK DITCH NO 2	540571	530	25.13%	55.43%	55.43%	40.55%	55.12%	49.45%	55.52%
TROWEL DITCH	540583	4,940	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WILLOW CK DITCH	540591	3,610	21.64%	40.72%	40.72%	28.09%	40.72%	32.51%	40.72%
WILSON DITCH	540592	550	0.33%	8.22%	8.22%	1.49%	8.16%	3.99%	8.16%
WOODBURY DITCH	540594	1,800	0.00%	0.05%	0.05%	0.00%	0.00%	0.00%	0.06%
55_ADY024_LSnakeRnrL	55_ADY024A	4,570	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
55_ASY003_LSnakeRnrLB	55_ADY024B	410	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
55_ADY026_YampaR@Gre	55_ADY026A	320	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.28%
55_ADY026_YampaR@GreB	55_ADY026B	440	35.20%	27.73%	27.73%	27.73%	35.20%	27.73%	35.61%

Table 3-10. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Baseline Average Annual Total Demand (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
ESCALANTA PUMP 2	550504	1,020	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
MAJORS PUMP NO 2	550506	2,380	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NINE MILE IRR DITCH	550507	970	4.17%	9.82%	9.82%	5.24%	5.64%	3.63%	14.69%
NINE MILE IRR PL	550508	770	8.06%	22.13%	22.13%	9.27%	9.37%	5.77%	22.61%
VISINTAINER DITCH	550513	750	2.98%	6.83%	6.83%	3.73%	3.72%	1.80%	8.46%
RINKER PUMP DITCH	550519	800	5.13%	18.07%	18.07%	6.07%	9.23%	4.25%	17.83%
LEFEVRE NO 1 PUMP	550537	1,690	4.56%	19.44%	19.44%	6.66%	10.78%	5.54%	19.57%
56_027_GreenRiver	56_ADY027A	510	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
56_027_GreenRiverB	56_ADY027B	9,150	28.04%	11.44%	11.44%	11.44%	28.04%	11.44%	28.04%
57_ADY009_TroutCreek	57_ADY009A	3,720	1.12%	13.41%	13.43%	3.64%	17.34%	13.76%	17.38%
57_ADY009_TroutCreekB	57_ADY009B	1,220	38.96%	28.60%	28.60%	27.05%	44.28%	28.17%	44.28%
57_ADY010_YampaRnrHa	57_ADY010A	300	8.69%	18.43%	17.37%	9.63%	17.33%	12.79%	21.84%
57_ADY010_YampaRnrHaB	57_ADY010B	1,890	7.45%	2.95%	2.95%	2.95%	7.45%	2.95%	7.73%
57_ADY011_YampaRabvE	57_ADY011A	1,410	6.72%	8.47%	8.47%	6.73%	8.41%	7.27%	9.40%
57_ADY011_YampaRabvEB	57_ADY011B	1,410	42.81%	29.84%	29.61%	27.90%	44.91%	27.94%	46.33%
BROCK DITCH	570508	2,860	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CARY DITCH CO DITCH	570510	3,670	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
COLO UTILITIES D & PL	570512	4,890	0.00%	0.14%	0.00%	0.00%	0.00%	0.00%	0.14%
DAVID M CHAPMAN DITC	570517	820	5.53%	31.34%	31.32%	12.56%	35.50%	27.63%	35.50%
DENNIS & BLEWITT D	570519	1,080	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
EAST SIDE DITCH	570524	670	13.96%	43.86%	43.86%	27.51%	44.65%	38.47%	44.65%
EAST SIDE DITCH 2	570525	950	21.20%	46.95%	46.90%	30.94%	48.93%	43.74%	48.93%
ERWIN IRRIGATING DIT	570535	590	0.00%	0.66%	0.28%	0.00%	0.39%	0.00%	0.92%
GIBRALTAR DITCH	570539	7,120	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
HIGHLAND DITCH	570544	1,770	1.10%	27.60%	27.51%	7.75%	27.18%	20.20%	27.18%
HOMESTEAD DITCH	570545	1,450	10.20%	35.92%	35.83%	17.25%	40.87%	32.25%	40.87%
LAST CHANCE DITCH	570555	1,280	12.10%	40.35%	39.86%	19.90%	41.52%	34.72%	41.56%
MALE MOORE CO DITCH	570561	480	12.01%	37.46%	37.05%	19.96%	38.59%	32.96%	38.59%
MARSHALL ROBERTS DIT	570563	3,800	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ORNO DITCH	570576	870	0.00%	0.78%	0.78%	0.00%	0.84%	0.44%	0.84%
R E CLARK DITCH	570579	980	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
SADDLE MOUNTAIN DITC	570584	780	0.28%	3.12%	2.81%	0.81%	2.15%	1.00%	3.81%
SHELTON DITCH	570592	7,670	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
TROUT CREEK DITCH 3	570608	1,900	0.00%	2.67%	2.34%	0.00%	1.57%	0.25%	1.93%
TROUT CREEK DITCH 2	570609	580	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WALKER IRRIG DITCH	570611	6,470	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WILLIAMS IRRIG DITCH	570622	2,460	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WILLIAMS PARK DITCH	570623	1,280	7.09%	40.77%	40.74%	21.19%	40.36%	33.56%	40.36%
KOLL DITCH	570635	1,560	3.11%	27.86%	27.86%	11.24%	29.02%	23.14%	29.02%
58_ADY001_UpperBearR	58_ADY001A	1,810	0.00%	4.47%	4.43%	0.62%	2.94%	0.12%	3.60%
58_ADY001_UpperBearRB	58_ADY001B	2,430	14.35%	20.40%	19.72%	11.19%	23.72%	11.80%	25.42%
58_ADY002_ChemneyCre	58_ADY002A	790	13.04%	64.97%	64.97%	38.37%	59.52%	47.62%	64.61%
58_ADY002_ChemneyCreB	58_ADY002B	3,170	13.06%	10.77%	10.76%	6.41%	23.14%	8.14%	23.13%
58_ADY003_BearRabvHu	58_ADY003A	460	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
58_ADY003_BearRabvHuB	58_ADY003B	5,380	23.37%	20.28%	19.66%	13.64%	29.49%	14.48%	30.75%
58_ADY004_BearRabvSt	58_ADY004A	690	20.61%	34.71%	34.71%	27.69%	34.65%	27.98%	34.65%
58_ADY004_BearRabvStB	58_ADY004B	3,430	22.35%	12.39%	12.22%	11.35%	23.44%	11.36%	24.30%
58_ADY005_YampaRabvS	58_ADY005A	1,150	0.00%	4.83%	4.77%	0.76%	1.87%	0.48%	4.70%
58_ADY005_YampaRabvSB	58_ADY005B	6,710	22.39%	13.51%	13.51%	13.26%	22.48%	13.26%	22.93%
58_ADY006_ElkRivernr	58_ADY006A	230	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
58_ADY006_ElkRivernrB	58_ADY006B	1,910	40.99%	37.81%	37.48%	30.35%	45.27%	32.66%	46.27%
58_ADY007_MiddleElkR	58_ADY007A	720	0.63%	1.21%	1.21%	0.63%	0.70%	0.42%	0.94%
58_ADY007_MiddleElkRB	58_ADY007B	3,390	68.79%	55.18%	55.12%	54.78%	68.92%	54.82%	69.00%
58_ADY008_LowerElkRi	58_ADY008A	2,900	0.25%	5.27%	4.99%	0.53%	3.44%	2.11%	4.45%
58_ADY008_LowerElkRiB	58_ADY008B	4,680	18.17%	14.16%	14.02%	8.86%	22.07%	10.05%	23.57%
ACTON DITCH	580500	1,930	0.90%	10.82%	10.64%	3.50%	10.21%	3.25%	10.44%

Table 3-10. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Baseline Average Annual Total Demand (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
ALPHA DITCH	580508	1,540	1.98%	18.49%	18.57%	5.01%	25.15%	19.29%	25.16%
BAXTER DITCH	580530	3,550	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BEAVER CREEK DITCH	580532	780	36.20%	21.53%	21.07%	7.53%	16.31%	12.79%	20.83%
BIG MESA DITCH	580539	5,110	1.98%	19.06%	19.18%	6.27%	18.78%	9.32%	18.80%
BIRD DITCH	580541	2,180	0.00%	0.11%	0.11%	0.00%	0.11%	0.00%	0.11%
BRINKER CREEK DITCH	580556	660	2.21%	26.53%	26.52%	8.69%	25.66%	14.69%	25.92%
BROOKS DITCH	580559	930	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
BRUMBACK DITCH	580561	550	0.00%	1.50%	1.22%	0.01%	1.32%	0.50%	1.50%
BUCKINGHAM MANDALL DITCH	580564	3,500	1.10%	21.55%	21.47%	7.54%	21.48%	10.92%	21.44%
BURNETT DITCH	580568	2,100	0.00%	1.30%	1.28%	0.01%	0.16%	0.01%	1.28%
BURNT MESA DITCH	580569	750	3.81%	38.87%	38.69%	17.77%	38.68%	29.03%	38.70%
C R BROWN MOFFAT COAL DITCH	580574	570	0.44%	9.17%	9.07%	1.20%	5.53%	1.76%	7.93%
CAMPBELL DITCH	580577	1,730	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CHARLES & A LEIGHTON	580582	510	3.65%	29.81%	29.81%	14.43%	31.47%	22.05%	31.47%
CHARLES H KEMMER D	580583	380	0.00%	3.38%	3.08%	0.56%	2.20%	1.03%	2.75%
CLARK & BURKE DITCH	580588	960	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
COLEMAN DITCH	580590	690	0.26%	10.08%	9.92%	1.38%	9.43%	5.56%	9.70%
COLLINS DITCH	580591	1,060	0.10%	2.88%	2.88%	0.46%	2.70%	0.52%	2.88%
CULLEN DITCH 2	580599	780	0.00%	1.08%	1.08%	0.00%	0.12%	0.01%	1.06%
DAY DITCH	580604	820	8.70%	40.77%	40.77%	23.12%	40.52%	33.49%	40.75%
DEVER DITCH	580612	850	0.00%	0.94%	0.61%	0.00%	0.00%	0.00%	0.61%
DUQUETTE DITCH	580618	1,840	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
EGERIA DITCH	580622	2,150	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
EKHART DITCH	580623	1,530	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ELK VALLEY DITCH CO.	580626	3,760	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
ENTERPRISE DITCH	580627	3,150	8.89%	34.59%	34.59%	19.72%	34.59%	28.05%	34.59%
EXCELSIOR DITCH	580628	800	4.12%	25.31%	25.31%	14.19%	25.31%	22.89%	25.31%
FELIX BORGHI DITCH	580633	1,040	0.00%	1.12%	1.00%	0.21%	0.00%	0.00%	0.86%
FERGUSON DITCH	580634	1,370	0.29%	12.23%	12.23%	2.92%	12.14%	7.08%	12.14%
FIRST CHANCE DITCH	580640	740	0.06%	6.33%	5.81%	0.83%	3.18%	0.75%	4.24%
FISH CR MUN WATER INTAK	580642	2,910	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
FIX DITCH	580643	2,270	0.00%	1.50%	1.43%	0.00%	1.23%	0.06%	1.38%
FRANZ DITCH	580649	3,270	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GRAHAM & BENNETT D	580662	2,650	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
GREER DITCH	580663	890	14.13%	46.66%	46.66%	29.96%	46.57%	39.50%	46.66%
GUIDO DITCH	580665	450	2.41%	37.29%	36.20%	11.01%	33.06%	18.07%	35.94%
HERNAGE & KOLBE DITCH	580684	1,100	0.41%	12.20%	12.15%	2.92%	12.35%	5.06%	12.04%
HIGH MESA IRR D	580685	700	0.49%	15.39%	15.08%	0.91%	9.52%	2.79%	13.96%
HIGHLINE BEAVER DITCH	580687	930	15.34%	40.17%	40.17%	28.24%	40.17%	36.32%	40.17%
HOOVER JACQUES DITCH	580694	2,740	0.14%	2.29%	2.29%	0.14%	1.70%	1.34%	2.19%
HOT SPGS CR HIGHLINE	580695	800	0.32%	10.21%	10.21%	1.17%	6.81%	3.71%	8.74%
KELLER DITCH	580714	3,370	0.00%	0.27%	0.25%	0.00%	0.11%	0.00%	0.25%
KINNEY DITCH	580717	1,290	0.34%	10.68%	10.33%	1.08%	7.98%	4.19%	9.51%
L L WILSON D	580721	520	0.00%	7.73%	7.44%	0.63%	4.12%	1.29%	6.37%
LAFON DITCH	580722	680	0.00%	3.07%	2.46%	0.00%	0.46%	0.00%	2.13%
LARSON DITCH	580728	1,070	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%
LATERAL A DITCH	580730	1,250	0.34%	14.20%	14.20%	1.71%	13.92%	5.71%	14.11%
LAUGHLIN DITCH	580731	470	0.00%	12.73%	12.52%	1.40%	9.35%	2.34%	12.34%
LINDSEY DITCH	580738	2,390	5.11%	36.96%	36.92%	17.99%	36.89%	25.40%	36.91%
LOWER PLEASANT VALLEY	580749	1,070	0.00%	0.73%	0.62%	0.00%	0.00%	0.00%	0.62%
LYON DITCH 2	580756	660	1.26%	10.03%	10.05%	3.04%	17.66%	13.22%	17.47%
MANDALL DITCH	580763	5,270	0.00%	9.27%	9.33%	0.51%	9.20%	1.53%	9.14%
MAYFLOWER DITCH	580767	590	1.04%	25.71%	25.36%	5.66%	24.30%	14.90%	24.67%
MILL DITCH 1	580777	650	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

CDM Smith

Table 3-10. Agricultural Consumptive Use Shortages

Diversion Name	WDID	Baseline Average Annual Total Demand (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
MOODY DITCH	580782	630	17.71%	46.89%	46.89%	31.32%	46.86%	40.39%	46.98%
MORIN DITCH	580783	3,240	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NICKELL DITCH	580798	1,450	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
NORTH HUNT CREEK DITCH	580801	670	0.00%	0.17%	0.00%	0.00%	0.00%	0.00%	0.00%
OAK CREEK DITCH	580805	890	0.10%	0.15%	0.15%	0.00%	1.99%	1.29%	1.75%
OAK DALE DITCH	580807	820	3.77%	19.98%	19.98%	8.58%	28.20%	22.07%	28.09%
OAKTON DITCH	580808	1,460	0.00%	0.45%	0.45%	0.00%	0.21%	0.00%	0.28%
OLD CABIN DITCH	580809	560	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
OLIGARCHY DITCH	580811	570	0.00%	2.61%	2.61%	0.21%	0.73%	0.06%	2.31%
PALISADE DITCH	580813	650	0.00%	3.97%	3.03%	0.62%	1.10%	0.44%	2.19%
PENNSYLVANIA DITCH	580821	1,620	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
PONY CREEK D	580826	600	19.88%	73.79%	73.79%	42.32%	73.19%	59.54%	73.79%
PRIEST DITCH	580830	370	0.59%	7.31%	7.31%	2.29%	7.06%	4.20%	7.19%
SAGE HEN DITCH	580844	540	0.00%	0.62%	0.44%	0.00%	0.19%	0.00%	0.44%
SAND CREEK DITCH	580847	700	0.27%	14.24%	14.10%	2.16%	13.19%	8.02%	13.91%
SIMON DITCH	580863	2,650	0.00%	2.63%	2.63%	0.38%	2.57%	0.54%	2.63%
SNOW BANK DITCH	580866	920	0.19%	15.67%	14.43%	0.81%	7.96%	2.77%	13.40%
SODA CREEK DITCH	580868	2,410	1.22%	3.97%	3.97%	1.71%	3.97%	3.11%	3.97%
SOUTH SIDE DITCH	580872	780	0.00%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%
STAFFORD DITCH	580879	2,670	0.00%	0.07%	0.07%	0.00%	0.00%	0.00%	0.00%
SUNNYSIDE DITCH 1	580895	1,280	0.83%	16.98%	16.60%	2.43%	13.72%	7.95%	15.61%
SUTTLE DITCH	580897	4,680	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
TRULL MORIN DITCH	580908	850	0.00%	1.06%	0.86%	0.00%	0.00%	0.00%	0.86%
UNION DITCH	580914	1,360	39.87%	70.48%	70.48%	56.29%	69.89%	51.81%	70.22%
UPPER ELK RIVER D CO	580915	1,300	0.00%	1.57%	1.42%	0.37%	0.76%	0.06%	1.15%
UPPER PLEASANT VALLEY	580916	1,630	0.00%	1.29%	1.29%	0.02%	0.10%	0.00%	1.38%
VAIL SAVAGE DITCH	580917	770	0.18%	10.33%	10.25%	0.89%	7.70%	4.10%	8.82%
WALTON CREEK DITCH	580920	10,240	0.43%	8.66%	8.66%	2.36%	8.66%	6.06%	8.66%
WEISKOPF DITCH	580922	750	0.00%	1.26%	0.98%	0.28%	1.14%	0.28%	1.28%
WELCH & MONSON DITCH	580924	480	0.01%	1.76%	1.76%	0.19%	1.46%	1.03%	1.46%
WHEELER BROS DITCH	580928	680	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WHIPPLE DITCH	580933	1,090	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WINDSOR DITCH	580939	430	0.46%	3.83%	3.71%	1.17%	3.30%	2.22%	3.71%
WOODCHUCK D SODA CK	580943	1,630	10.00%	37.45%	37.45%	22.10%	37.45%	31.02%	37.45%
WOOLERY DITCH	580944	3,870	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
WOOLEY DITCH	580945	1,600	0.00%	1.72%	1.72%	0.00%	1.76%	0.00%	1.73%
GABIOUD DITCH	580980	670	7.03%	43.85%	43.06%	23.74%	37.24%	30.46%	43.10%
LEE IRRIGATION D	581021	950	0.00%	1.31%	1.31%	0.24%	0.63%	0.26%	1.28%
NORTH SIDE DITCH	581035	580	0.44%	9.52%	9.23%	1.37%	5.50%	1.62%	8.55%
ROSSI HIGHLINE DITCH	581074	620	6.28%	29.43%	28.66%	14.69%	32.04%	27.10%	33.35%
MILL CREEK DITCH	581085	690	0.11%	5.11%	5.04%	0.56%	4.65%	0.76%	5.00%
DOME CR DITCH	584630	330	18.41%	46.36%	46.36%	27.09%	46.42%	37.07%	46.36%

3.5.7.1 Agricultural Shortages Affected by IPPs

Fortification Creek

In model Scenarios 1, 2, 3, and 5, Rampart Reservoir, South Fork II Reservoir, and Little Bear I Reservoir are all active. The modeled diversions on Fortification Creek are: Wisconsin Ditch (440511), Cataract Ditch (440573), Elkhorn Irrigation Ditch (440612), Haughey Irrigation Ditch (440647), Highline Mesa Baker Ditch (440650), Lamb Irrigation Ditch (440681), Little Bear Ditch (440688), McDonald Ditch (440698), Tipton Irrigation Ditch (440785), and Dry Cottonwood Ditch 1 (440998). Under the Baseline model scenario, the Fortification Creek average consumptive use shortage is 3,160 AFY. This shortage is reduced to approximately 2,270 AFY in model Scenarios 2 and 3 (dry hydrology scenarios). Under model Scenario 3 (average hydrology scenarios), average annual Fortification Creek Basin shortages are reduced to 1,790 AFY. Under model Scenario 5 (wet hydrology scenarios), average annual Fortification Creek Basin shortages are 1,940 AFY[16].

The fact that greater shortages on Fortification Creek occur for model Scenario 5 than model Scenario 3, draws a very important conclusion regarding the combined effects of the IPPs for augmenting flows on Fortification Creek, as shown in **Figures 3-46 and 3-47**. Figures 3-46 and 3-47 show the monthly average contents of Little Bear I Reservoir and South Fork II Reservoir, respectively.

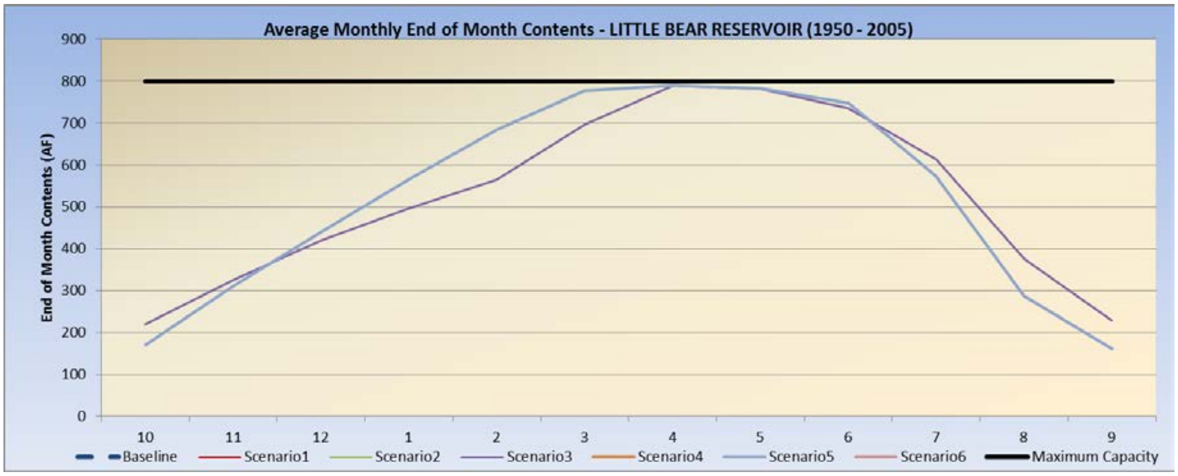


Figure 3-46. Average Monthly Contents of Little Bear I Reservoir for Scenarios 3 and 5

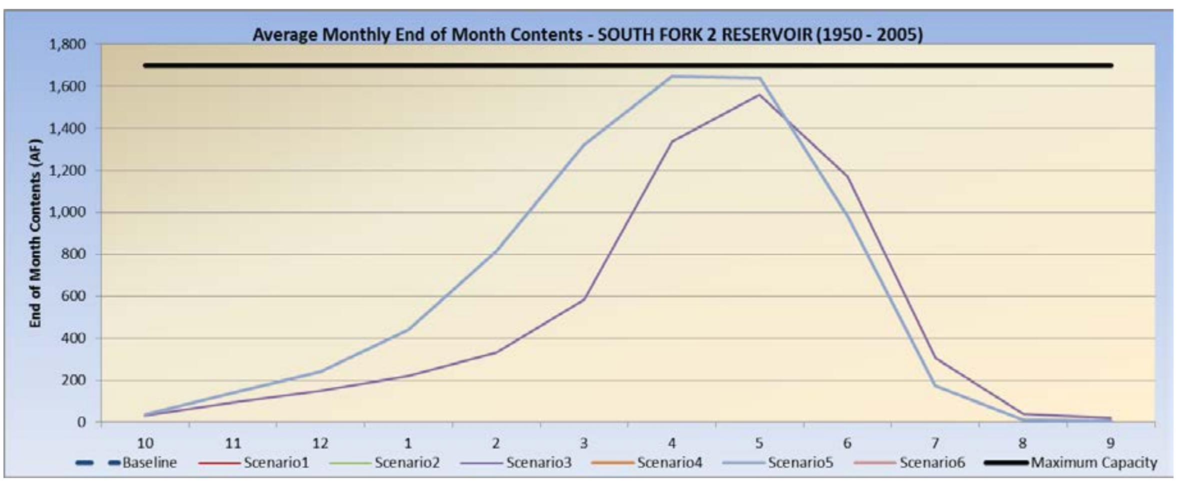


Figure 3-47. Average Monthly Contents of South Fork II Reservoir for Scenarios 3 and 5

[16] Although the wet hydrology scenario used in model Scenario 5, simulated flows on Fortification Creek in June are on average 14 cfs less than the average hydrology scenario.

In both Little Bear I Reservoir and South Fork II Reservoir, the reservoirs both tend to fill earlier in the year for model Scenario 5; however, they also tend to empty faster than model Scenario 3. The important conclusion to draw from this is that these two reservoirs from the Small Reservoir Study might benefit from being even larger to store more water in the early season. Although the simulated shortages decrease in model scenarios with IPPs turned on, a total storage of 2,500 AF between these two reservoirs is not enough to meet late season flows under most hydrologic conditions.

Morapos Creek

In model Scenarios 1, 2, 3, and 5, Morapos Creek supplies are augmented by Monument Butte Reservoir. Diversions on Morapos Creek with direct releases are: Deer Creek and Morapos Ditch (440590), Highland Ditch (440651), Highline Ditch (440814), and the Morapos Creek Aggregate (44_ADY016A). Under the Baseline model scenario, the Morapos Creek Basin average CU shortage is 600 AFY. This shortage is reduced to approximately 370 AFY in model Scenarios 2 and 3 (dry hydrology scenarios). Under model Scenario 3 (average hydrology scenarios), average annual Morapos Creek Basin shortages are reduced to 200 AFY. Under model Scenario 5 (wet hydrology scenarios), average annual Morapos Creek Basin shortages are 60 AFY.

The significant difference between simulated shortages in the Fortification Creek Basin and the Morapos Creek Basin is the size of the reservoir. Under the wet hydrology scenario, the 4,390 AF of storage provided by Monument Butte Reservoir can supply the majority of demands on Morapos Creek for the late season, whereas Fortification Creek modeled storage cannot.

Milk Creek

In model Scenarios 1, 2, 3, and 5, Milk Creek Reservoir is used for two purposes—supplying the Oxbows Agricultural Diversion on the Yampa River mainstem and providing exchange water to upstream diversions on Milk Creek. Therefore, Milk Creek Reservoir can only augment diversion on Milk Creek if a call is administered for a demand by users downstream of Milk Creek Reservoir.

Exchanges are made upstream to A Q Ditch (440524), Milk Creek Ditch (440706), D D & E Ditch (440586), Yellow Jacket Ditch No. 1 (440518), J A Martin Ditch (440660), D D Ferguson Ditch No. 2 (440587), Wilson Ditch (440509), and Martin Creek Ditch (440692). Under the Baseline model scenario, the Milk Creek Basin average consumptive use shortage is 350 AFY. This shortage increases to approximately 1,050 AFY in model Scenarios 2 and 3 (dry hydrology scenarios). Under model Scenario 3 (average hydrology scenarios), average annual Milk Creek Basin shortages are reduced to 600 AFY. Under model Scenario 5 (wet hydrology scenarios), average annual Morapos Creek Basin shortages are 820 AFY.

Similar to the results observed in Fortification Creek, shortages on Milk Creek are highly sensitive to hydrology, especially since water storage in Milk Creek Reservoir is not actually used for direct releases. In other words, if water is not physically available in the late season for exchanges, shortages will occur on Milk Creek, regardless of the storage available in Milk Creek Reservoir.

3.5.7.2 Oxbows Agricultural Shortages

The Yampa River oxbows diversion is augmented by both Rampart Reservoir (as the most junior operating rule[17]) and Milk Creek Reservoir (also using the most junior operating rule). Shortages are dependent on the demand level (since demands increase or decrease on the oxbows depending on the demand level), the hydrology scenario, and whether IPPs are turned on or off. For this reason, the effectiveness of IPPs for the oxbows between scenarios is complex, i.e., do shortages decrease because of decreased demands or due to wetter hydrology.

Future demands of the oxbows were turned on in the following model scenarios:

- Model Scenario 1 – Oxbows 100 percent developed, Milk Creek and Rampart Reservoirs turned on
- Model Scenario 2 – Oxbows 75 percent developed, Milk Creek and Rampart Reservoirs turned on
- Model Scenario 3 – Oxbows 75 percent developed, Milk Creek and Rampart Reservoirs turned on
- Model Scenario 6 – Oxbows 100 percent developed, Milk Creek and Rampart Reservoirs turned off

Figure 3-48 shows the average monthly consumptive use shortages under those conditions.

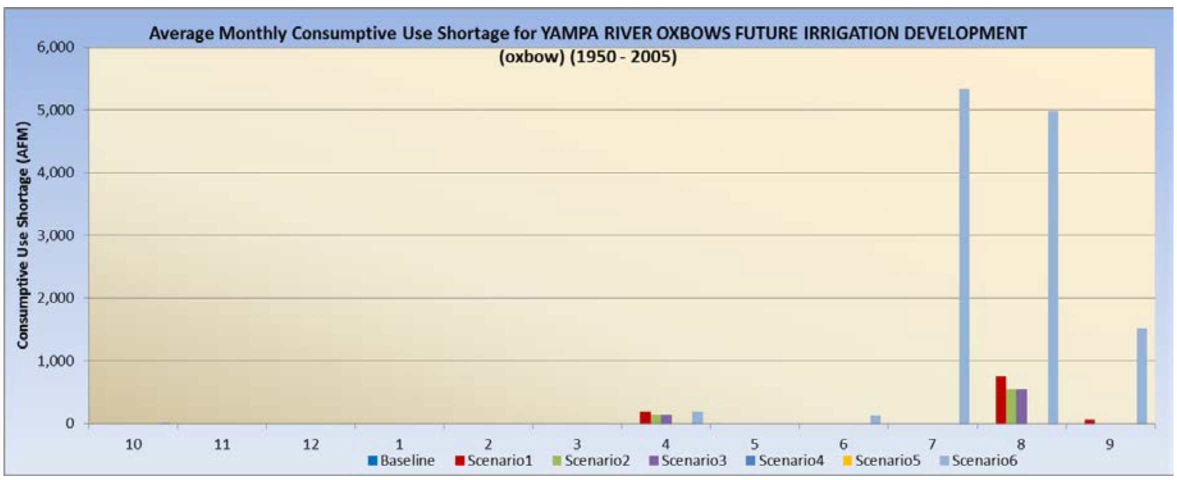


Figure 3-48. Average Monthly Shortages at the Yampa River Oxbows Aggregate Diversion

The most important comparison to observe from Figure 3-48 is the difference in shortages simulated in model Scenario 1 and model Scenario 6. The sole difference between these two model scenarios is that Milk Creek and Rampart Reservoirs are turned on in model Scenario 1 and turned off in model Scenario 6. Oxbows shortages are approximately 990 AFY on average with augmentation from the reservoirs (Scenario 1) and are 12,160 AFY on average without (Scenario 6). This 11,170 AFY average reduction in shortages can be entirely attributed to the two IPPs.

[17] In other words, direct releases to diversion on Fortification Creek occur first, exchanges on Fortification Creek occur second, and releases to the Oxbows occur last if any storage remains.

3.5.8 Municipal and Industrial Results

Increased water shortages may be observed as a result of increases from M&I demand forecasts, per Section 3.2.1.1. None of the IPPs identified augmentation for existing municipal or industrial demand locations; consequently, some model scenarios show increased M&I gaps due to hydrologic conditions and increased demands[18]. **Table 3-11** shows the M&I demand shortages for each scenario.

It should be noted that M&I gaps decrease between Scenarios 1 and 6, which may be unintuitive. The combination of IP&Ps for agricultural use, and the junior water rights held by M&I diversions contribute to this. If IP&Ps were identified for M&I use, this would likely decrease M&I shortages at locations with supply augmentation.

Table 3-11. M&I Demand Shortages

Diversion Name	WDID	Baseline Average Annual Total Demand (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
District 43 M&I	43_AMW001	1,100	0.00%	2.53%	1.27%	0.31%	0.00%	0.00%	2.37%
Rangely Water	430889	1,710	0.00%	3.02%	2.28%	0.37%	1.37%	0.42%	2.48%
Meeker Wells	436045	360	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
District 44 M&I	44_AMY001	740	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Craig Water Supply Plant	440581	2,200	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Maybell Mill Pipeline	440695	350	0.41%	5.22%	4.49%	1.26%	4.45%	1.82%	6.55%
District 55 M&I	55_AMY003	10	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
District 57 M&I	57_AMY001	480	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
District 58 M&I (Steamboat springs)	58_AMY001	1,340	0.00%	0.04%	0.02%	0.00%	0.00%	0.00%	0.06%
Fish Creek Municipal Intake	580642	2,910	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Meeker Demand	950810	370	0.00%	8.35%	8.28%	0.15%	6.84%	0.31%	6.78%

Due to the lack of storage for M&I in the White River Basin, coupled with increasing demands, simulations show that White River Basin M&I diversions may experience large shortages.

3.5.8.1 Municipal and Industrial IPPs

The three M&I IPPs were defined in the Projects and Methods Task 2: Steamboat Supply, the Yampa River – Milk Creek Pipeline, and the White River Oil Shale Production Supply System.

[18] Although the "Steamboat Supply" IP&P is an M&I IP&P, it is modeled as a new demand, which does not augment the supplies at the existing Steamboat Springs demand location.

Steamboat Supply

The Steamboat Supply was modeled along with the low, medium, and high demand scenarios. Average monthly shortages over the study period are shown in **Figure 3-49**.

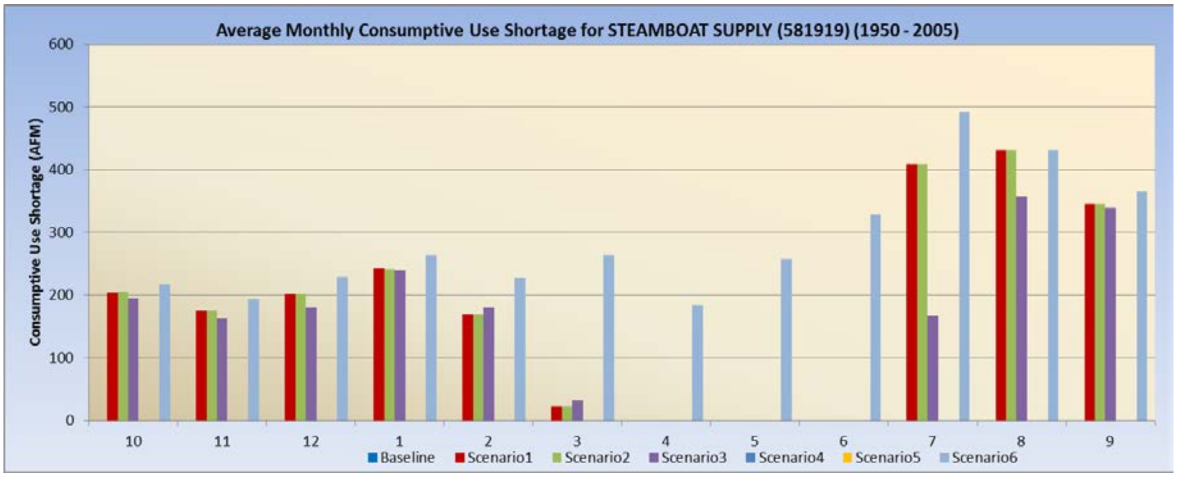


Figure 3-49. Monthly Average Shortages at "Steamboat Supply"

Figure 3-49 shows that without augmentation, the Steamboat Supply on Elk River will only reliably yield diversions from March through June (except in the worst case model Scenario 6). Average monthly shortages in all other months represent either most or all of the demands shown in Table 3-8.

Yampa River - Milk Creek Pipeline

The Yampa River - Milk Creek Pipeline was modeled with both a junior agricultural irrigation water right of 200 cfs and a senior industrial water right of 200 cfs, which acts as the primary source of supply for Milk Creek Reservoir. The Yampa River - Milk Creek Pipeline is not used for industrial purposes due to fact that no industrial operations were assigned to Milk Creek Reservoir; subsequently, the industrial account for Milk Creek remains full year round (with the exception of losses to evaporation). However, for the agricultural portion, generally the Yampa River - Milk Creek Pipeline comes into priority on the mainstem, which fills the reservoir before the agricultural storage right on Milk Creek comes into priority. The yield from the direct storage right from Milk Creek is typically low or nothing throughout the period of record. If the IPPs for the Yampa River - Milk Creek Pipeline were altered and were only used to fill the industrial account, Milk Creek Reservoir may not be as effective in meeting agricultural needs. **Figure 3-50** shows the reservoir contents for the last 10 years of simulation for the Milk Creek Reservoir agricultural account.

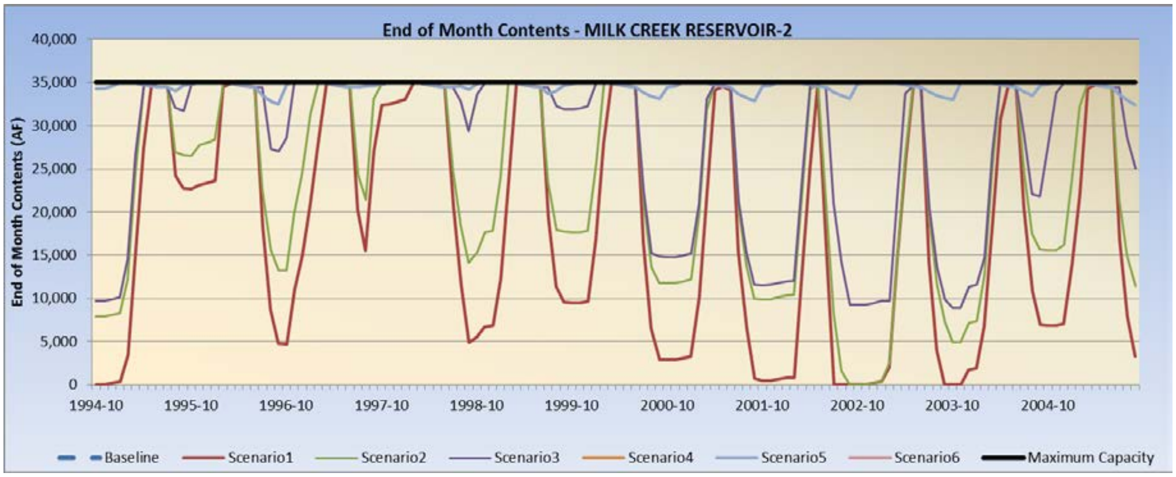


Figure 3-50. Milk Creek Reservoir Simulated End of Month Contents

Due to the high peak flows seen in all hydrology scenarios on the mainstem of the Yampa River, the agricultural account in Milk Creek Reservoir is able to fill. Under model Scenarios 1, 2, and 3, the majority of reservoir releases are made to reduce water shortages at the Yampa River oxbows, whereas a much smaller percentage is used to exchange water and reduce shortages on Milk Creek.

White River Oil Shale Production Supply System

The White River Oil Shale Production Supply System (Wolf Creek Reservoir, Lake Avery Enlargement, and White River Supply for Lake Avery Enlargement) for existing hydrology is covered in greater depth in the Energy Development Water Needs Assessment. The primary factor driving the effectiveness of the Oil Shale Production Supply system is the hydrology. Under Scenarios 2 and 3 of the Energy Development Water Needs Assessment, all Oil Shale Demands can be met with undecreed water rights and without storage in Wolf Creek.

Under Scenario 3, using medium demands (Oil Shale production demands are 54,000 AFY), and an average hydrology, up to 77,000 AF of Wolf Creek Reservoir storage is used to meet oil shale production demands in the most severe drought conditions.

Under Scenario 2, using medium demands (Oil Shale production demands are 54,000 AFY), and a dry hydrology, up to 148,000 AF of Wolf Creek Reservoir storage is used to meet oil shale production demands in the most severe drought conditions.

Under Scenario 1, using high demands (Oil Shale production demands are 110,000 AFY), and a dry hydrology, Wolf Creek Reservoir completely drains multiple times throughout the study period and oil shale production demands are not fully met. **Figure 3-51** shows the end of month contents of Wolf Creek Reservoir.

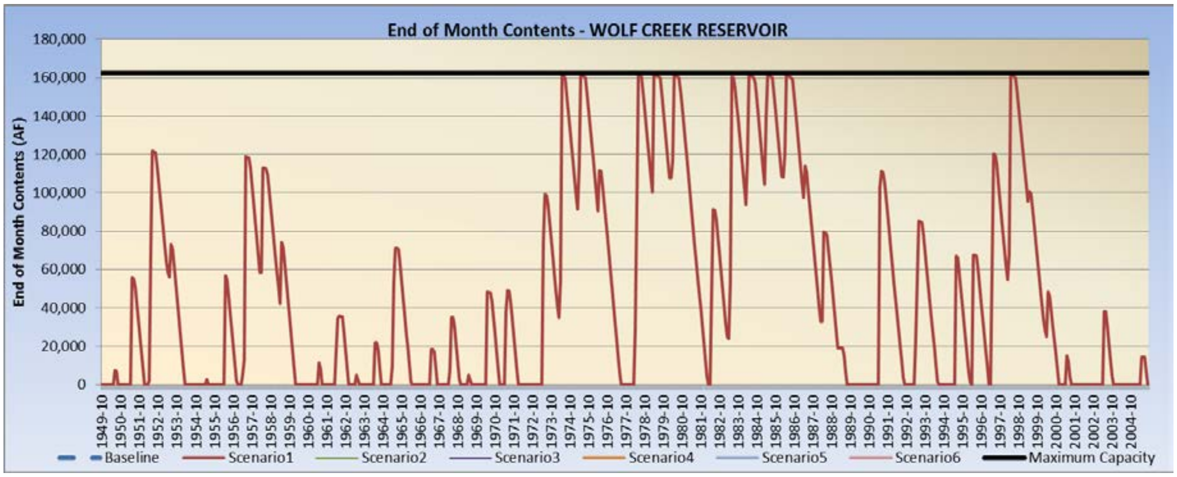


Figure 3-51. Wolf Creek Reservoir End of Month Contents

3.5.9 Thermoelectric Results

Thermoelectric demands (Hayden Station (570512) and Craig Station (440522 and 440522b)) are not augmented by any IPPs. Model Scenarios 1 through 6 evaluate thermoelectric power generation demands using augmentation from Steamboat Lake for Hayden Station and Elkhead and Stagecoach Reservoirs for Craig Station.

Thermoelectric Power Generation Water Demand shortages are shown in **Table 3-12**.

Table 3-12. Thermoelectric Power Generation Water Demand Shortages

Diversion Name	WDID	Average Annual Simulated Diversion (AFY)	Average Annual Percent Short						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
COLO UTILITIES D&PL	570512	4,890	0%	0%	0%	0%	0%	0%	0%
CRAIG STATION D&PL	440522	8,040	0%	0%	0%	0%	0%	0%	0%
TriState	440522b	4,020	0%	0%	0%	0%	0%	0%	0%

Shortages occur in both Hayden and Craig Stations in dry hydrology, high demand model scenarios for a dry month in March of 1961; however, when averaged over the entire 56-year period of record, that 1-month shortage becomes a negligible percentage of the total demand.

3.5.10 Nonconsumptive Shortages

Neither demand scenarios nor IPPs were defined for nonconsumptive uses. For this reason, all affects seen in the model scenarios with regards to increased or decreased nonconsumptive shortages occur depending on the specific model scenario. For this reason nonconsumptive shortages may be significantly impacted by IPPs, hydrology, and demand projections. For each of the WFET flow-ecology risk metric calculations, simulated flows were compared to their natural version, i.e., model Scenario 1 uses a dry hydrology, metrics were calculated from model Scenario 1 simulated flows, and naturalized dry hydrology scenario flow, not historical naturalized flows.

Generally, nonconsumptive uses are affected in much the same way as agricultural demands. Trout flow-ecology relationships are sensitive to September and August flows; if the model scenario configuration causes flows to decrease in September and August, it is likely that the risk will increase. Warm water fish flow–ecology relationships are sensitive to the average minimum monthly flows, if those minimum flows decrease from baseline, risk increases. Cottonwood abundance risk is based on maximum 90-day flows during wet years; if the model scenario configuration decreases 90-day flows, the subsequent risk will increase.

3.5.10.1 Trout Flow-Ecology Risk Metric

Table 3-13 shows the Trout Flow-Ecology Risk Metric at each location for which it was evaluated. Hydrologies have a large impact on the risk level assigned to each Trout Flow-Ecology Node, especially since the Trout Flow-Ecology Metric is calculated from the August and September flows relative to natural annual flows; i.e., if August and September flows are low, the Trout Flow-Ecology risk increases.

Table 3-13. Trout Flow Risk Metric

Diversion Name	Evaluation Node	WFET Trout Flow Risk						
		Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Yampa River from Pump Station to confluence of Elkhead Creek	09244410	Moderate Risk	Very High Risk	Very High Risk	High Risk	Very High Risk	Minimal Risk	Very High Risk
Elk River from headwaters to the County Road 129 bridge at Clark; including the North, Middle and South Fork as well as the mainstem of the Elk	09241000	Minimal Risk	Moderate Risk	Moderate Risk	Minimal Risk	Moderate Risk	Low Risk	Moderate Risk
White River from headwaters to Meeker; including the North and South Fork and mainstem of the White	09304500	Minimal Risk	Very High Risk	Very High Risk	High Risk	Very High Risk	Minimal Risk	Very High Risk
Slater Creek from headwaters to the Beaver Creek confluence	540570	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	Low Risk	Moderate Risk
South Fork of the Little Snake from headwaters to confluence of Johnson Creek	09253000	High Risk	Very High Risk	Very High Risk	Very High Risk	Very High Risk	Low Risk	Very High Risk
East Fork of the Williams Fork from headwaters to the confluence of the Forks	09249000	Minimal Risk	High Risk	High Risk	Moderate Risk	Moderate Risk	Low Risk	Moderate Risk
South Fork of the Williams Fork from headwaters to the confluence of the Forks	09249200	High Risk	Very High Risk	Very High Risk	Very High Risk	Very High Risk	Low Risk	Very High Risk
Williams Fork - from South Fork to confluence of the Yampa River	09249750	Moderate Risk	High Risk	High Risk	High Risk	High Risk	Low Risk	High Risk

Table 3-13. Trout Flow Risk Metric

Diversion Name	Evaluation Node	WFET Trout Flow Risk						
		Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Yampa River from Stagecoach Reservoir "Tailwaters" to northern boundary of Sarvis Creek State Wildlife area	09237500	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Minimal Risk	Low Risk	Minimal Risk
Yampa River from Chuck Lewis Wildlife Area to Pump Station	09239500	Moderate Risk	High Risk	High Risk	High Risk	High Risk	Minimal Risk	High Risk
Willow Creek below Steamboat Lake to confluence with the Elk	583787	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Bear River from headwaters to USFS boundary	09236000	Low Risk	Minimal Risk	Minimal Risk	Low Risk	Minimal Risk	Low Risk	Minimal Risk

3.5.10.2 Warm Water Fish Flow-Ecology Risk Metric

In contrast to the Trout Flow-Ecology Risk Metric, the Warm Water Fish Flow-Ecology Risk is associated with a comparison between natural and "current" conditions minimum 30-day flows. If minimum 30-day flows are reduced due to increased use, or IPP operations, the Warm Water Fish Flow-Ecology risk may potentially increase. **Table 3-14** shows the Warm Water Fish Flow-Ecology Risk Metric at each location for which it was evaluated.

Table 3-14. Warm Water Fish Flow Risk Metric

Diversion Name	Evaluation Node	Warm Water Fish Flow Risk						
		Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Yampa River from entrance of Cross Mountain Canyon (East Cross Mountain) to confluence with Green River	09260050	Moderate Risk	High Risk	High Risk	High Risk	High Risk	Moderate Risk	High Risk
Yampa River from Pump Station to confluence of Elkhead Creek	09244410	Low Risk	Moderate Risk	Moderate Risk	Low Risk	Moderate Risk	Moderate Risk	Moderate Risk
White River from headwaters to Meeker; including the North and South Fork and mainstem of the White	09304500	Low Risk	High Risk	High Risk	High Risk	High Risk	High Risk	High Risk
White River below Kenney Reservoir dam to Utah State line	434433	Low Risk	High Risk	High Risk	High Risk	High Risk	High Risk	High Risk
White River from Rio Blanco dam to Kenney Reservoir	09306290	Low Risk	High Risk	High Risk	High Risk	High Risk	High Risk	High Risk
South Fork of the Little Snake from headwaters to confluence of Johnson Creek	09253000	Low Risk	Moderate Risk	Moderate Risk	Moderate Risk	High Risk	Moderate Risk	High Risk

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Table 3-14. Warm Water Fish Flow Risk Metric

Diversion Name	Evaluation Node	Warm Water Fish Flow Risk						
		Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Little Snake River from Moffat County Road 10 to confluence of the Yampa River	09260000	High Risk	High Risk	High Risk	High Risk	High Risk	High Risk	High Risk
Yampa River from Craig (Hwy 394 Bridge) to mouth of Cross Mountain Canyon	09251000	Moderate Risk	Moderate Risk	Moderate Risk	Moderate Risk	High Risk	High Risk	Very High Risk
Yampa River from Stagecoach Reservoir "Tailwaters" to northern boundary of Sarvis Creek State Wildlife area	09237500	Low Risk	Moderate Risk	Moderate Risk	Low Risk	Low Risk	Low Risk	Moderate Risk
Yampa River from Chuck Lewis Wildlife Area to Pump Station	09239500	Low Risk	Moderate Risk	Moderate Risk	Low Risk	Moderate Risk	Moderate Risk	Moderate Risk

3.5.10.3 Cottonwood Abundance Risk Metric

Since the Projects and Methods Study did not calculate the model using a daily time step, cottonwood abundance was calculated using a comparison between natural and "current" conditions wet year 90-day flows. **Table 3-15** shows the Cottonwood Abundance Risk Metric at each location for which it was evaluated.

Table 3-15. Cottonwood Abundance Risk Metric

Reach Name	Evaluation Node	Cottonwood Abundance Risk						
		Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Yampa River from entrance of Cross Mountain Canyon (East Cross Mountain) to confluence with Green River	09260050	Low Risk	Low Risk	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk
Yampa River from Pump Station to confluence of Elkhead Creek	09244410	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Elk River from headwaters to the County Road 129 bridge at Clark; including the North, Middle and South Fork as well as the mainstem of the Elk	09241000	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
White River from headwaters to Meeker; including the North and South Fork and mainstem of the White	09304500	Low Risk	Moderate Risk	High Risk	Moderate Risk	Moderate Risk	Low Risk	Moderate Risk

Table 3-15. Cottonwood Abundance Risk Metric

Reach Name	Evaluation Node	Cottonwood Abundance Risk						
		Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
White River below Kenney Reservoir dam to Utah State line	434433	Moderate Risk	Very High Risk	Very High Risk	Moderate Risk	Low Risk	Low Risk	Low Risk
Slater Creek from headwaters to the Beaver Creek confluence	540570	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Elkhead Creek from headwaters to confluence of North Fork of Elkhead Creek	09245000	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
South Fork of the Little Snake from headwaters to confluence of Johnson Creek	09253000	Low Risk	Low Risk	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk
Williams Fork - from South Fork to confluence of the Yampa River	09249750	Low Risk	Low Risk	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk
Little Snake River from Moffat County Road 10 to confluence of the Yampa River	09260000	Low Risk	Low Risk	High Risk	Low Risk	Low Risk	Low Risk	Low Risk
Yampa River from Craig (Hwy 394 Bridge) to mouth of Cross Mountain Canyon	09251000	Low Risk	Low Risk	Moderate Risk	Low Risk	Low Risk	Low Risk	Low Risk
Yampa River from Stagecoach Reservoir "Tailwaters" to northern boundary of Sarvis Creek State Wildlife area	09237500	High Risk	High Risk	High Risk	High Risk	High Risk	Moderate Risk	High Risk
Fish Creek from Fish Creek Falls to confluence of the Yampa River	09238900	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Yampa River from Chuck Lewis Wildlife Area to Pump Station	09239500	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Willow Creek below Steamboat Lake to confluence with the Elk	583787	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk

3.5.10.4 Recreational Whitewater Boating Flows

Whitewater boating flow targets from the WFET are not affected by the comparison between natural and "current" conditions flows. Therefore, boating flows are generally more sensitive to the hydrology scenarios than the demand projection level and IPPs. **Table 3-16** shows the Recreational Whitewater Boating Flows Risk Metric at each location for which it was evaluated.

Table 3-16. Recreational Whitewater Boating Nonconsumptive Results

Reach Name	Evaluation Node	Percentage of Boating Season with Usable Flows						
		Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Yampa River from entrance of Cross Mountain Canyon (East Cross Mountain) to confluence with Green River	09260050	87% Usable Days	69% Usable Days	69% Usable Days	75% Usable Days	70% Usable Days	72% Usable Days	70% Usable Days
Yampa River from Pump Station to confluence of Elkhead Creek	09244410	20% Usable Days	7% Usable Days	7% Usable Days	13% Usable Days	7% Usable Days	3% Usable Days	7% Usable Days
Elk River from headwaters to the County Road 129 bridge at Clark; including the North, Middle and South Fork as well as the mainstem of the Elk	09241000	48% Usable Days	48% Usable Days	48% Usable Days	46% Usable Days	49% Usable Days	61% Usable Days	48% Usable Days
White River below Kenney Reservoir dam to Utah State Line	434433	33% Usable Days	25% Usable Days	25% Usable Days	34% Usable Days	26% Usable Days	44% Usable Days	26% Usable Days
White River from Rio Blanco Lake dam to Kenney Reservoir	9306290	58% Usable Days	25% Usable Days	32% Usable Days	48% Usable Days	47% Usable Days	67% Usable Days	47% Usable Days
Slater Creek from headwaters to the Beaver Creek confluence	540570	1% Usable Days	1% Usable Days	1% Usable Days	2% Usable Days	1% Usable Days	10% Usable Days	1% Usable Days
Yampa River from Craig (Hwy 394 Bridge to mouth of Cross Mountain Canyon, including Little Juniper Canyon	09251000	43% Usable Days	29% Usable Days	29% Usable Days	29% Usable Days	27% Usable Days	11% Usable Days	28% Usable Days
Fish Creek from Fish Creek Falls to confluence with Yampa River	09238900	12% Usable Days	18% Usable Days	18% Usable Days	13% Usable Days	18% Usable Days	30% Usable Days	18% Usable Days

Table 3-16. Recreational Whitewater Boating Nonconsumptive Results

Reach Name	Evaluation Node	Percentage of Boating Season with Usable Flows						
		Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Yampa River form Chuck Lewis Wildlife Area to Pump Station	09239500	55% Usable Days	57% Usable Days	57% Usable Days	58% Usable Days	57% Usable Days	68% Usable Days	57% Usable Days
Willow Creek below Steamboat Lake to confluence with the Elk	583787	0% Usable Days	3% Usable Days	3% Usable Days	4% Usable Days	3% Usable Days	17% Usable Days	3% Usable Days

3.5.10.5 Colorado Water Conservation Board Instream Flows

All three factors (hydrology, demand level, and IPPs) affect the flows through ISF reaches. Since ISFs have more junior water rights, increased demands and IPPs may directly impact ISF reaches. For obvious reasons hydrologies will also have an effect on ISF reaches. **Table 3-17** shows the results of the ISFs for each scenario.

Table 3-17. ISF Target Flow Shortages

Diversion Name	WDID	Average Annual Target Flow (cfs)	Simulated Average Annual Minimum Flow Along Reach (cfs)						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Bear River (Middle)	582404	7.9	4.1	2.9	2.9	3.1	2.8	3.1	2.9
Bear River (Lower)	582202	12.0	5.8	3.3	3.3	3.5	3.2	4.9	3.3
Big Creek	582206	15.0	10.7	8.8	8.8	9.7	8.8	11.1	8.8
Coal Creek	582214	5.0	3.4	2.8	2.8	3.1	2.8	3.6	2.8
Dome Creek	582216	2.0	0.3	0.4	0.4	0.3	0.4	0.6	0.4
East Fork Williams Fork	441452	14.2	12.2	8.7	8.7	10.3	8.7	10.3	8.7
Elk River (Lower)	581355	65.0	26.9	24.5	24.4	24.5	23.3	29.8	24.4
Elk River (Upper)	582219	65.0	27.3	26.0	25.6	25.1	24.0	30.5	25.8
Green Creek	582245	5.0	2.1	2.1	2.1	2.0	2.0	2.4	2.1
Hunt Creek	582519	5.0	2.4	1.8	1.8	1.9	1.8	2.3	1.8
Marvine Creek	432334	40.0	39.0	27.4	27.4	34.3	27.3	33.1	27.3
Miller Creek	432337	10.0	8.4	7.1	7.1	8.0	7.1	8.1	7.1
North Fork Fish Creek	582287	5.0	4.3	4.2	4.2	4.2	4.2	4.4	4.2
North Fork White River	432339	70.0	69.7	52.9	52.9	65.3	52.9	63.0	52.9
North Fork White River	432338	120.0	117.5	84.0	84.0	105.5	84.0	102.2	84.0
Oak Creek	582290	2.0	1.9	1.8	1.8	1.9	1.8	1.8	1.8
Phillips Creek	582409	6.0	2.4	1.4	1.4	1.8	1.3	2.1	1.3
Service Creek	582306	6.0	3.9	3.6	3.6	3.7	3.5	4.1	3.6
Slater Creek	542076	3.0	2.9	2.8	2.8	2.8	2.6	2.8	2.6
Soda Creek	582311	5.0	4.1	3.2	3.2	3.6	3.2	3.8	3.2
South Fork White River	432344	80.0	74.8	47.1	47.1	60.8	47.0	57.3	47.0
South Fork Williams Fork	441456	5.9	5.4	4.8	4.8	5.1	4.7	5.2	4.7
Trout Creek (Lower)	571009	5.0	3.8	1.6	1.5	1.7	2.9	3.1	2.9
Ute Creek	432372	6.0	6.0	5.7	5.7	6.0	5.7	6.0	5.7
White River	431845	200.0	190.8	111.9	112.0	151.1	113.8	145.0	113.6

Table 3-17. ISF Target Flow Shortages

Diversion Name	WDID	Average Annual Target Flow (cfs)	Simulated Average Annual Minimum Flow Along Reach (cfs)						
			Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Williams Fork River	441448	20.7	20.3	15.8	15.8	18.7	16.2	17.2	16.2
Willow Creek	582332	7.0	4.0	3.8	3.8	3.8	3.8	4.6	3.8
Willow Creek	581461	5.0	3.0	2.8	2.9	2.8	2.8	3.4	2.9
Willow Spring & Pond	582162	13.0	6.7	5.9	5.9	6.2	5.6	7.0	5.6
Yampa River	582164	56.9	52.5	43.6	43.4	47.7	42.8	49.4	43.6

3.5.10.6 Colorado Water Conservation Board Yampa River Endangered Species Flow Target Operations

Operations for releases from Elkhead Reservoir to the Endangered Species Flow Reach on the Yampa River downstream of Maybell were not modified for any of the model scenarios. The flow target was primarily met by native water and then augmented by up to 50 cfs of releases from Elkhead Reservoir. If the combined native and released water could not meet the target, a shortage would occur. **Figure 3-52** shows the minimum flows along the reach. The solid thick black line shows the flow target for each month of the year, i.e. the closer the minimum model scenario flows are to the target, the fewer shortages are simulated.

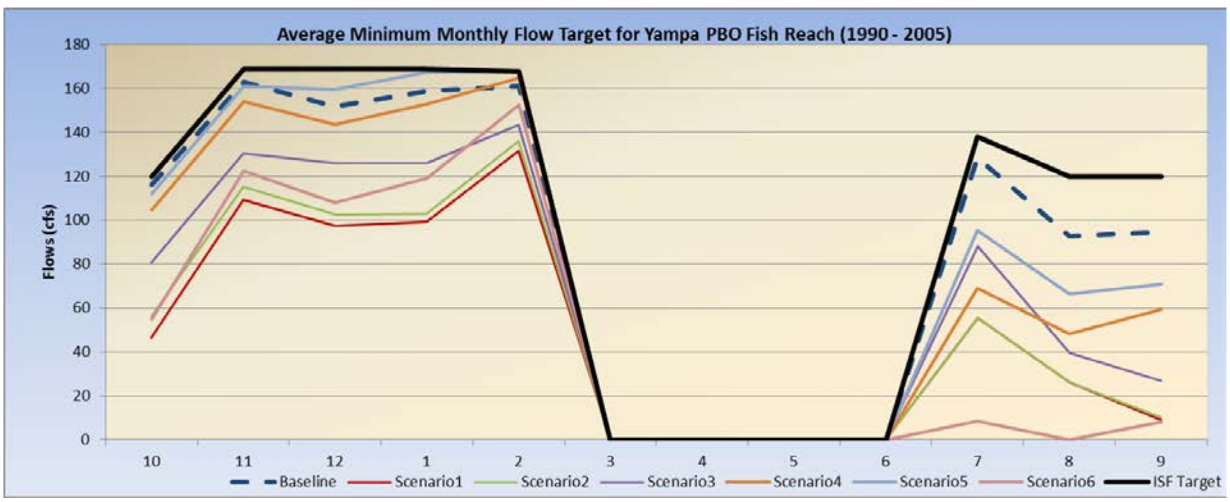

Figure 3-52. Average Minimum Monthly Flow through the Yampa River Endangered Species Flow Reach

3.6 Summary and Recommendations

3.6.1 Key Findings

This section describes primary findings from the Projects and Methods Study. IPPs tended to be tied to the critical stream reaches found in the Agricultural Water Needs Assessment (Fortification Creek, Morapos Creek, and the Yampa River oxbows).

Fortification Creek

In model Scenarios 1, 2, 3, and 5, Rampart Reservoir, South Fork II Reservoir, and Little Bear I Reservoir are active. Under the Baseline model scenario, the Fortification Creek average consumptive use shortage is 3,160 AFY, which may be reduced to approximately 2,270 AFY in dry hydrology scenarios, 1,790 AFY under average hydrology scenarios, and 1,940 AFY under wet hydrology scenarios. Rampart Reservoir, South Fork II Reservoir, and Little Bear I Reservoir have a significant effect on shortages on Fortification Creek; however, they cannot be eliminated under the current configuration. For the majority of shortages, only South Fork II and Little Bear I can directly release to them. Since both of these reservoirs frequently empty to meet shortages, a possible solution is to increase the size of both reservoirs if feasible.

Morapos Creek

In model Scenarios 1, 2, 3, and 5, Morapos Creek supplies are augmented by Monument Butte Reservoir. Under the Baseline model scenario, the Morapos Creek Basin average consumptive use shortage is 600 AFY. This shortage is reduced to approximately 370 AFY under dry hydrology scenarios, 200 AFY under average hydrology scenarios, and 60 AFY wet hydrology scenarios.

The significant difference between simulated shortages in the Fortification Creek Basin and the Morapos Creek Basin is the size of the reservoir. Under the wet hydrology scenario, the 4,390 AF of storage provided by Monument Butte Reservoir can supply the majority of shortages on Morapos Creek for the late season, whereas Fortification Creek cannot.

Oxbows

Demand at the oxbows that can be met are highly sensitive to hydrology, demand levels, and if IPPs are active. As model Scenario 6 shows, significant gaps can occur under the "worst case scenario." The cause of these gaps is mostly due to the undecreed water right not coming into priority often to meet the large demands. No model scenarios were developed with high demands and wet hydrology with IPPs turned off to evaluate how oxbows high demands can be met without the augmentation water from IPPs.

Steamboat Supply Pipeline

The Steamboat Supply on Elk River demands cannot be met in a majority of years under most conditions. To effectively use the Steamboat Supply, augmentation water would be needed.

Milk Creek Project (Milk Creek Reservoir and Yampa River – Milk Creek Pipeline)

Industrial uses have not been defined for the Milk Creek Project, although it may be effective for that purpose. For existing agricultural uses, Milk Creek Reservoir is most effective under wetter conditions, since gaps are legally driven by the junior rights on Milk Creek. The Milk Creek Project also helps effectively meet a significant amount of demands at the Oxbows that cannot be met directly under an undecreed water right.

3.6.2 Further Development of the Projects and Methods Modeling

3.6.2.1 Additional Modeling

Funding for creating additional modeling scenarios was secured through the BRT subcommittee. With the key findings in Section 3.6.1 and after reviewing the entire report, the BRT subcommittee can recommend additional scenarios with a better understanding of what to expect.

In addition to generating additional model scenarios, the BRT subcommittee may take this as an opportunity to further develop new IPPs that were not identified as a part of the Projects and Methods Study and add them to new model scenarios.

Lastly, alternative hydrologies may be evaluated in the Yampa River Basin such as the paleo- record flows evaluated in the UYWCD study.

3.6.2.2 Optimized Existing Reservoir Operations

One option that was not explored during the Projects and Methods Study was evaluating optimized operations of existing reservoirs. Some additional modeling scenarios may take advantage of this by exploring new operations such as:

- Additional modeling could also revolve around reviewing beneficial uses of storage in Stagecoach and determining optimized operations such as exchanges and releases that could legally help meet shortages.
- Examining existing temporary reservoir releases and evaluating whether they could be made permanent.
  - In the existing model, a methodology was developed to make releases from the Elkhead Reservoir CWCB 5,000 AF account to the Endangered Species Fish flow target. The current agreement allows CWCB to lease additional storage from the Elkhead Reservoir CRWCD account to be used for the Endangered Species Fish flow target. In some additional model runs, the impacts of permanently leasing additional storage from CRWCD would have on meeting the Endangered Species Fish flows.
  - Section 2.5.5 indicates that the UYWCD Planning Study makes releases through a temporary lease to the CWT. This lease could be included in future modeling scenarios.
  - Determine if the BRT subcommittee recommend other leasing agreements in the basin that need to be evaluated.
- Refining operations of Steamboat Lake to ISF reaches.
- Identifying additional IP&Ps that the BRT subcommittee would like to be evaluated.

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Section 4

Comparison of Statewide Alternatives Water Right Priority Dates with those of the Yampa-White-Green Basins

4.1 Introduction

This section summarizes the analysis completed to accomplish the objective of Task 3, which is a "Comparison of water right priorities associated with the various SWSI Transbasin Alternatives on the Yampa-White-Green Basin" as stated in the Statement of Work. The purpose of this task is to examine potential statewide transbasin alternatives water rights, if they have been adjudicated, and examine how their potential implementation compares to existing water rights in the Yampa, White, and Green River Basins.

4.2 Projects and Associated Water Rights

The projects that have been identified for comparison with Yampa-White-Green River Basin water rights in the SWSI Transbasin Alternatives are as follows:

- Blue Mesa Pumpback
- Flaming Gorge-Green River Pumpback
- Green Mountain-Blue River Pumpback
- Yampa Pumpback

The Blue Mesa Pumpback would operate under the priority of the Aspinall Unit water rights that store water for project purposes in Blue Mesa Reservoir. The proposal would pump project water under a contract with the Bureau of Reclamation and the Upper Gunnison River Water Conservancy District from Blue Mesa Reservoir to the Front Range. The appropriation date of the project as granted in Civil Action No. 6981 for Water District 62 is November 13, 1957.

The Flaming Gorge-Green River Pumpback could operate under the priority of the Flaming Gorge Project water rights stored in Flaming Gorge Reservoir. The appropriation date for the Flaming Gorge Project is August 7, 1958 according to Kent Jones, Utah State Engineer, in an electronic communication dated September 19, 2011. The proponents for this pumpback project have stated publicly that it would not operate under the senior appropriation date of the Flaming Gorge Project. The proponents have filed for a water right on the Green River in Wyoming above Flaming Gorge Reservoir with an appropriation date of December 28, 2007 according to Patrick Tyrrell, Wyoming State Engineer, in an electronic communication dated September 19, 2011. This task will consider both appropriation dates in the comparison.

The Green Mountain-Blue River does not have an appropriation date since no water right application has been filed by Denver Water to obtain a water right for this possible pumpback from Green Mountain Reservoir to Dillon Reservoir for delivery to the Denver Water Service area. The Yampa

Pumpback does not have an appropriation date since no water right application has been filed by any potential proponent.

When this project began, the Juniper Project, which was a large conditional water right for storage of 844,294 AF less 19,000 AF conveyed to Colorado-Ute Electric Association, with an appropriation date of June 8, 1954, was included in the evaluation. A portion of this water right, along with some other conditional direct and storage rights, was cancelled in a recent diligence case for the conditional water rights in Case No. 04CW27. The Juniper Project was sponsored by the CRWCD and in the above water court case; the River District requested that the conditional water rights for the Juniper Project be abandoned.

4.3 Analysis

In order to compare the water rights of various transbasin alternatives with those in the Yampa-Green-White Basins, the appropriation dates of the water rights for the alternative transbasin projects and the appropriation dates of the various water rights in the Yampa-White-Green River Basins were used as the basis for comparison. The tabulation of water rights prepared by the Colorado DWR uses both the appropriation date and the date of adjudication of the water right to establish a priority for the water right in order to be able to administer the water rights in a water division on a common basis. Since the various transbasin alternatives are in different water divisions and in other states such as Utah and Wyoming, the only reasonable way to compare the water rights is to use the appropriation date. Therefore, the listing of water rights in HydroBase 2010 for Water Division 6 for the Yampa-White-Green River Basins was sorted on the basis of appropriation date to establish a modified ranking of water rights based on appropriation dates.

In order to compare what water rights could be affected by a possible curtailment demand from the Lower Basin in order to increase deliveries to Lee Ferry in the event the 10-year moving total at Lee Ferry is less than 75,000,000 AF, the listing of water rights based on appropriation date is also appropriate. The method in which a curtailment demand would be administered is being evaluated in the Colorado River Compact Study funded by the CWCB. The results are not available at this time. It most likely will include the appropriation date of the water rights in the four water divisions in the Colorado River Basin in Colorado. The Colorado River Compact contains a provision that water rights perfected by use on or before November 24, 1922 will not be curtailed. Therefore, the appropriation date of the water right is important in establishing if it is a pre-compact water right that would not be curtailed by a compact curtailment demand. However, it should be pointed out that a pre-compact water right could be curtailed by a senior downstream water right call in Colorado and often is curtailed by such a call, especially in a drought year.

This ranking of water rights was moved into an Excel spreadsheet [Div6_Curtailments.xlsx] and is attached as an appendix to this report (Appendix B). The spreadsheet contains other useful information on the individual water right such as source, location, county, adjudication date, appropriation date, uses, and amounts. The spreadsheet ranks the water rights from the oldest appropriation date to the newest as shown in the HydroBase 2010 database. A break at the appropriation date of a project or for the November 24, 1922 Colorado River Compact date is included in the curtailments worksheet and is shown in a red shaded row. For example, the break for the Colorado River Compact is on row 4147. All water rights above this row are senior to November 24, 1922.

Table 4-1 contains a summary of the number of water rights impacted by a specific priority for each of the alternatives. It also includes the amount of water affected either by cfs or AF for absolute and conditional water rights. For example, 10,548 water rights are junior (post-compact) to the date of the Colorado River Compact, November 24, 1922 in the Yampa-White-Green River Basins. Additional detail is provided in the Excel spreadsheet [Div6_Curtailments.xlsx] contained in Appendix B.

Table 4-1. Summary of the Affected Water Rights by Project/Compact

Project/Compact	Date	Number Water Rights	Absolute Direct Flow Water Right Rates Impacted (cfs)	Absolute Storage Water Right Amounts Impacted (AF)	Conditional Direct Flow Water Right Rates Impacted (cfs)	Conditional Storage Water Right Volumes Impacted (AF)
Colorado Compact	11/24/1922	10,548	8,120	172,119	43,100	1,807,129
Blue Mesa Pumpback	11/13/1957	7,414	5,652	143,957	41,999	1,714,014
Flaming Gorge Reservoir (1958)	8/7/1958	7,259	5,626	143,883	40,169	1,714,014
Flaming Gorge Reservoir (2007)	12/28/2007	12	3	2	1	30
Yampa Pumpback	No Date	0	0	0	0	0
Green Mountain Pumpback	No Date	0	0	0	0	0

Table 4-2 contains a summary of water rights not affected by a specific priority for each of the alternatives shown in the table. In other words, it shows the number of water rights senior to the appropriation date of each of the alternatives listed in the table. It includes the amount of water not affected either by cfs or AF. For example, 4,145 water rights are senior (pre-compact) to the date of the Colorado River Compact in the Yampa-White-Green River Basins.

Table 4-2. Summary of the Water Rights Not Affected by Project/Compact

Project/Compact	Date	Number Water Rights	Absolute Direct Flow Water Right Rates Unaffected (cfs)	Absolute Storage Water Right Volume Unaffected (AF)	Conditional Direct Flow Water Right Rates Unaffected (cfs)	Conditional Storage Water Right Volume Unaffected (AF)
Colorado Compact	11/24/1922	4,145	5,602	14,509	12	12
Blue Mesa Pumpback	11/13/1957	7,279	8,069	42,671	1,112	93,127
Flaming Gorge Reservoir (1958)	8/7/1958	7,434	8,095	42,746	2,942	93,127
Flaming Gorge Reservoir (2007)	12/28/2007	14,681	13,719	186,627	43,110	1,807,111
Yampa Pumpback	No Date	14,693	13,721	186,629	43,111	1,807,141
Green Mountain Pumpback	No Date	14,693	13,721	186,629	43,111	1,807,141

This section and the accompanying Excel spreadsheet were provided to the BRT subcommittee for review. A meeting was conducted on January 5, 2012 in Craig to receive feedback and direction on additional analysis required in order to complete the objective of Task 3. The addition of Table 4-2 was the primary recommendation of the subcommittee.

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