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Water Development Office

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TECHNICAL MEMORANDUM

TO: Water Development Commission **DATE:** July 22, 2011

FROM: Dave K. Myer, P.E. **REFERENCE:** Snake/Salt River Basin Plan Update, 2012

SUBJECT: Spreadsheet Models and Hydrologic Database – *Tab IX (2012)*

Contents

1.0 Introduction

The purpose of this technical memorandum is to provide a summary of the spreadsheet model updates and the development of a hydrologic database produced as part of the 2012 Snake/Salt River Basin Plan Update (2012 Update). This memorandum provides a brief review of the spreadsheet models, describes changes to the models made as part of this work, and documents the new hydrologic database. The database was developed to store and process hydrologic and diversion data for use in the spreadsheet models. The remaining documentation and the results of the spreadsheet models are contained in *Technical Memorandum, Tab X: Available Surface Water Determination*. Additional information pertaining to surface water can be found in *Technical Memorandum, Tab VIII: Surface Water Data Collection and Estimation*.

The spreadsheet models developed for the 2003 Snake/Salt River Basin Plan (previous Basin Plan) were used as a basis for the 2012 Update (Sunrise, 2003). These spreadsheet models were previously documented in *Technical Memorandum: Task 3B Spreadsheet Model Development and Task 3C Surface Water Model Calibration* (Boyle, 2003). Except for updates to input data sets (reflecting a new period of record of 1971 through 2010) and the changes documented within this memorandum, the spreadsheet models remain mostly unchanged from the previous Basin Plan. Because most of the spreadsheet model description and operations remain the same as the previous Basin Plan and rather than repeating information herein, the reader can refer to the previous Technical Memorandum.

The most extensive modification to the spreadsheet models is the development of a hydrologic database that is incorporated directly into the spreadsheet model by being dynamically queried to populate the spreadsheet model input datasets. Previous versions of the spreadsheet models incorporated "cut-and-paste" methods from separate spreadsheet data sources to populate the spreadsheet models. The updated methods provide a much quicker and more reliable method for populating the spreadsheet models while maintaining a historical record of calculation methods.

The new database foundation was originally designed and configured to allow migration to other basin plans by MWH Americas, Inc. as part of the Wind/Bighorn River Basin Plan Update (MWH, 2010). Thus the database established for the Wind/Bighorn River Basin Plan Update was used as a starting point for construction of the database for the 2012 Snake/Salt River Basin Plan Update.

2.0 Hydrologic Database

A hydrologic database, *SnakeSalt Database 2010.mdb*, was developed using the Microsoft Access database platform to house all of the hydrologic datasets required by the spreadsheet models. The calculations required to process datasets use standard Microsoft Access query techniques. A macro written in Visual Basic for Applications (VBA) within the database program develops the dry-average-wet year hydrologic datasets used by the spreadsheet models.

It should be noted that the database has been created in the Microsoft Access 97-2003 format (*.mdb). Conversion to later versions of Microsoft Access may corrupt some of the macro functionality that is built into the database. Therefore, it is recommended that the database be opened and used in Microsoft Access 97-2003 format or ran in "compatibility" mode in later versions of the software.

The database contains the following general datasets which are required by the spreadsheet models:

- Streamflow Data – Includes daily, monthly, and annual USGS gage data.
- Natural Flow Data – Natural flow data nodes, site data, and equations used to estimate ungaged tributary flows (see *Technical Memorandum, Tab VIII: Surface Water Data Collection and Estimation)*
- Diversion Data – Crop Irrigation Requirements (CIR), Irrigation Days, and Irrigated Acres (see *Technical Memorandum, Tab VII: Crop Water Requirements*)
- General Data – Model nodes, descriptions, and dates.

Because of the complex calculations required to compile the input datasets from raw data, the number of tables and queries contained within the database, and the inter-relationship between the tables and queries is rather complicated. Data tables and queries in the database are shown in Tables 1 and 2, respectively. A general schema of the database that shows all tables, queries, and macros is shown in Figure 1.

The following sub-sections describe in more detail the types of data developed by the database, raw datasets required for its construction, and techniques used to develop model input. The text and descriptions included are intended to provide a basic level of instruction for updating datasets in the future and applying the database to other basin planning studies.

Table 1: Snake/Salt Hydro Database Input Data Tables

Type	Table Name	Data Source	Original Source	Data Type[1]	When to Update[2]	Description
General	tblDates	N/A	N/A	Info	N/A	Correlates water years, water months, and water days to calendar years, calendar months, and calendar days through year 2080.
General	tblDates_DaysInMonth	N/A	N/A	Info	N/A	Indicates the number of days in each month as used by the calculations.
General	tblNodes	N/A	Model Setup	Info	With New Model	Contains the master list of model nodes and associated information pertaining to each node. Serves as a master table link to many types of data.
Streamflow	tblHydro_USGS_Daily	SnakeSalt USGS Web Query.xls	USGS Website	Raw	Study Period Update	Contains daily USGS streamflow data. Imported to Access database from macro within the *SnakeSalt USGS Web Query.xls* spreadsheet.
Streamflow	tblHydro_Gages	SnakeSalt USGS Web Query.xls	USGS Website	Info	With New Model	Master list of USGS gages that are included in the study. Contains gage numbers, names, and abbreviations. Also indicates whether the gage is a key gage and what gages depend on it for establishing the Dry-Avg-Wet years.
Streamflow	tblHydro_Streamflow_Month_Salt	MSM Input Export Salt.xlsm	MSM Software	Constr.	Study Period Update	Contains filled monthly streamflow data for the Salt Basin. Constructed by the Mixed Station Method (MSM) software and imported to Access database from *SnakeSalt MSM Files.xlsx* spreadsheet.
Streamflow	tblHydro_Streamflow_Month_Snake	MSM Input Export Snake.xlsm	MSM Software	Constr.	Study Period Update	Contains filled monthly streamflow data for the Snake Basin. Constructed by the Mixed Station Method (MSM) software and imported to Access database from *SnakeSalt MSM Files.xlsx* spreadsheet.
Streamflow	tblHydro_KeyGageDAW_Salt	Access Macro	Macro: BuildDAW	Constr.	Study Period Update	Constructed by the *BuildDAW* macro. Provides the Dry-Avg-Wet year delineation for the key gages in the study period for the Salt Basin. (Note: This table must be built after new data is imported and extended.)
Streamflow	tblHydro_KeyGageDAW_Snake	Access Macro	Macro: BuildDAW	Constr.	Study Period Update	Constructed by the *BuildDAW* macro. Provides the Dry-Avg-Wet year delineation for the key gages in the study period for the Snake Basin. (Note: This table must be built after new data is imported and extended.)
Natural Flow	tblNatFlow_Sites	N/A	GIS and User Setup	Info	With New Model	Lists the ungaged tributary nodes that do not have gage data where mean annual flow is estimated using the Lowham equation. Physical data needed for the equation is entered in this table, along with the required coefficient and exponents. The table also identifies the correlation gages that are used to derive the monthly flow values and mean annual flow for dry, average, and wet hydrologic conditions.
Natural Flow	tblStrawberry_Sites	N/A	GIS and User Setup	Info	With New Model	Lists the sites in the Salt Basin that were correlated with the Strawberry Creek gage site to estimate inflow using the Simple Basin Area Method. The area of each tributary basin is included in the table.
Natural Flow	tblStrawberry_Area	N/A	GIS and User Setup	Info	With New Model	Provides the area of the Strawberry Creek drainage basin, upstream of the USGS gage site 13027000. The area is used in the Simple Basin Area calculation to estimate ungaged tributary inflow within the basins listed in the tblStrawberry_Sites table.
Diversion	tblDiversion_Acres	N/A	Previous Basin Plan	Info	With New Model	Contains a list of all the model nodes within both the Salt and Snake Basins and the irrigated acres associated with each.
Diversion	tblDiversion_CIR	N/A	StateCU Model	Info	With New Model	Provides a list of monthly Consumptive Irrigation Requirements for each established irrigation zone.
Diversion	tblDiversion_Days	N/A	Previous Basin Plan	Info	With New Model	Provides the number of irrigation days per month and the fraction of month in which irrigation takes place for each established irrigation zone.

1. Data Type Key: Info - General Information; Raw - Raw Data; Constr. - Constructed from macro.
2. When to Update Key: With New Model - If a new model is developed or if model is modified; Study Period Update - When study period is updated. (Note: all tables should be updated accordingly when any of the underlying data is modified.)

Table 2: Snake/Salt Hydro Database Queries

Type	Query Name	Database Object Source(s)	Key Output Field(s)[1]	Description
Streamflow	qryHydro_USGS_Month	■ tblHydro_USGS_Daily ■ tblDates ■ tblDates_DaysInMonth	Average of Daily Streamflow (in CFS) for each Gage for each Month within each Year.	This query processes the USGS daily data (from *tblHydro_USGS_Daily*) into monthly data. This is also the query that is used as input to the Mixed Station Method (MSM) software for data filling and extension.
Streamflow	qryHydro_AnnFlow_Salt	■ tblHydro_Gages ■ tblHydro_Streamflow_Month_Salt	Sum of Filled Annual Streamflow for each Gage and for each Year for the Salt Basin	This query calculates the annual flow for each gage site for each year in the Salt Basin using filled data. It is also used as input into the *BuildDAW* macro which establishes the Dry-Avg-Wet years.
Streamflow	qryHydro_AnnFlow_Snake	■ tblHydro_Gages ■ tblHydro_Streamflow_Month_Snake	Sum of Filled Annual Streamflow for each Gage and for each Year for the Snake Basin	This query calculates the annual flow for each gage site for each year in the Snake Basin using filled data. It is also used as input into the *BuildDAW* macro which establishes the Dry-Avg-Wet years.
Streamflow	qryHydro_DAW_Years_Salt	■ tblHydro_KeyGageDAW_Salt	Dry-Average-Wet Years Determination Based on Chosen Key Gage for Salt Basin	Reads data from the *tblHydro_KeyGageDAW_Salt* table, which was generated by the *BuildDAW* macro, and limits the output to just the Salt Basin.
Streamflow	qryHydro_DAW_Years_Snake	■ tblHydro_KeyGageDAW_Snake	Dry-Average-Wet Years Determination Based on Chosen Key Gage for Snake Basin	Reads data from the *tblHydro_KeyGageDAW_Snake* table, which was generated by the *BuildDAW* macro, and limits the output to just the Snake Basin.
Streamflow	qryHydro_Streamflow_DAW_Salt	■ tblHydro_Streamflow_Month_Salt ■ qryHydro_DAW_Years_Salt	Average of Monthly Streamflow for each Gage and by Dry-Avg-Wet Years in Salt Basin	Establishes an average of monthly streamflow data for the Dry years, Average years, and Wet years for each gage site in the Salt Basin.
Streamflow	qryHydro_Streamflow_DAW_Snake	■ tblHydro_Streamflow_Month_Snake ■ qryHydro_DAW_Years_Snake	Average of Monthly Streamflow for each Gage and by Dry-Avg-Wet Years in Snake Basin	Establishes an average of monthly streamflow data for the Dry years, Average years, and Wet years for each gage site in the Snake Basin.
Streamflow	qryModel_Streamflow_Salt	■ tblNodes ■ tblDates_DaysInMonth ■ qryHydro_Streamflow_DAW_Salt	Monthly Streamflow for each Model Node and Hydrologic Condition in the Salt Basin	This query associates streamflow data with specific nodes in the models for the Salt Basin. This is the final query in the Streamflow dataset, and it is linked to the Salt Basin model spreadsheets in pivot table format.
Streamflow	qryModel_Streamflow_Snake	■ tblNodes ■ tblDates_DaysInMonth ■ qryHydro_Streamflow_DAW_Snake	Monthly Streamflow for each Model Node and Hydrologic Condition in the Snake Basin	This query associates streamflow data with specific nodes in the models for the Snake Basin. This is the final query in the Streamflow dataset, and it is linked to the Snake Basin model spreadsheets in pivot table format.
Natural Flow	qryNat1_Ungaged_MeanAnnual	■ tblNatFlow_Sites	Estimated Mean Annual Flow (in CFS) for each Ungaged Tributary	Using the Lowham equation, this query calculates the estimation of mean annual flow for each ungaged tributary site.
Natural Flow	qryNat2_Gaged_Monthly_Salt	■ tblNatFlow_Sites ■ tblHydro_Streamflow_Month_Salt ■ qryHydro_DAW_Years_Salt	Monthly Flow (in CFS) for each year for each Gaged Correlation Site in Salt Basin	This query references streamflow data from the *tblHydro_Streamflow_Month_Salt* table for each gaged correlation site listed in the *tblNatFlow_Sites table*. It also reads from the streamflow query, *qryHydro_DAW_Years_Salt*, to associate each year with the hydrologic condition.
Natural Flow	qryNat2_Gaged_Monthly_Snake	■ tblNatFlow_Sites ■ tblHydro_Streamflow_Month_Snake ■ qryHydro_DAW_Years_Snake	Monthly Flow (in CFS) for each year for each Gaged Correlation Site in Snake Basin	This query references streamflow data from the *tblHydro_Streamflow_Month_Snake* table for each gaged correlation site listed in the *tblNatFlow_Sites table*. It also reads from the streamflow query, *qryHydro_DAW_Years_Snake*, to associate each year with the hydrologic condition.
Natural Flow	qryNat3_Gaged_Monthly_DAW_Salt	■ qryNat2_Gaged_Monthly_Salt	Monthly Flow (in CFS) averaged by Hydrologic Condition for each Gaged Correlation Site in Salt Basin.	For each gaged correlation site, this query averages the monthly flows by hydrologic condition.
Natural Flow	qryNat3_Gaged_Monthly_DAW_Snake	■ qryNat2_Gaged_Monthly_Snake	Monthly Flow (in CFS) averaged by Hydrologic Condition for each Gaged Correlation Site in Snake Basin.	For each gaged correlation site, this query averages the monthly flows by hydrologic condition.
Natural Flow	qryNat4_Gaged_AvgYr_MeanAnnual_Salt	■ qryNat2_Gaged_Monthly_Salt	Mean Annual Flow (in CFS) for the "Average" Hydrologic Condition for each Gaged Correlation Site in Salt Basin	For each gaged correlation site, this query determines the average of the mean annual flow for just the "average" hydrologic condition.
Natural Flow	qryNat4_Gaged_AvgYr_MeanAnnual_Snake	■ qryNat2_Gaged_Monthly_Snake	Mean Annual Flow (in CFS) for the "Average" Hydrologic Condition for each Gaged Correlation Site in Snake Basin	For each gaged correlation site, this query determines the average of the mean annual flow for just the "average" hydrologic condition.
Natural Flow	qryNat5_Gaged_DAW_PercentMeanAnnual_Salt	■ qryNat3_Gaged_Monthly_DAW_Salt ■ qryNat4_Gaged_AvgYr_MeanAnnual_Salt	Gaged Correlation Site Percentage of the "Average" Hydrologic Condition of Mean Annual Flow for Salt Basin	In order to expand the results of the Lowham equation for ungaged tributary mean annual flow into a dry and wet classification (see *qryNat7_Ungaged_DAW_MeanAnnual_Salt*), this query determines the percentage of the "average" hydrologic condition of the mean annual flow for each gaged correlation site and each hydrologic condition. It averages Gaged_Monthly_CFS by hydrologic condition (from *qryNat3_Gaged_Monthly_DAW_Salt*) and divides that number by AvgOfGaged_Monthly_CFS (from *qryNat4_Gaged_AvgYr_MeanAnnual_Salt*).
Natural Flow	qryNat5_Gaged_DAW_PercentMeanAnnual_Snake	■ qryNat3_Gaged_Monthly_DAW_Snake ■ qryNat4_Gaged_AvgYr_MeanAnnual_Snake	Gaged Correlation Site Percentage of the "Average" Hydrologic Condition of Mean Annual Flow for Snake Basin	In order to expand the results of the Lowham equation for ungaged tributary mean annual flow into a dry and wet classification (see *qryNat7_Ungaged_DAW_MeanAnnual_Snake*), this query determines the percentage of the "average" hydrologic condition of the mean annual flow for each gaged correlation site and each hydrologic condition. It averages Gaged_Monthly_CFS by hydrologic condition (from *qryNat3_Gaged_Monthly_DAW_Snake*) and divides that number by AvgOfGaged_Monthly_CFS (from *qryNat4_Gaged_AvgYr_MeanAnnual_Snake*).
Natural Flow	qryNat6_Gaged_PercentMeanAnnual_Salt	■ qryNat3_Gaged_Monthly_DAW_Salt ■ qryNat5_Gaged_DAW_PercentMeanAnnual_Salt	Monthly percentage of Mean Annual Flow for each Gaged Correlation Site in Salt Basin	For each correlation site, for each month, for each hydrologic condition, this query determines the percentage of mean annual flow by using the following formula: *Gaged Monthly Flow / Gaged Mean Annual Flow / 12 Months* Or stated another way:

Type	Query Name	Database Object Source(s)	Key Output Field(s)[1]	Description
				AvgOfGaged_Monthly_CFS (from qryNat3_Gaged_Monthly_DAW_Salt) / AvgOfAvgOfGaged_Monthly_CFS (from qryNat5_Gaged_DAW_PercentMeanAnnual_Salt) / 12
Natural Flow	qryNat6_Gaged_PercentMeanAnnual_Snake	■ qryNat3_Gaged_Monthly_DAW_Snake ■ qryNat5_Gaged_DAW_PercentMeanAnnual_Snake	Monthly percentage of Mean Annual Flow for each Gaged Correlation Site in Snake Basin	For each correlation site, for each month, for each hydrologic condition, this query determines the percentage of mean annual flow by using the following formula: *Gaged Monthly Flow / Gaged Mean Annual Flow / 12 Months* Or stated another way: *AvgOfGaged_Monthly_CFS (from qryNat3_Gaged_Monthly_DAW_Snake) / AvgOfAvgOfGaged_Monthly_CFS (from qryNat5_Gaged_DAW_PercentMeanAnnual_Snake) / 12*
Natural Flow	qryNat7_Ungaged_DAW_MeanAnnual_Salt	■ tblNatFlow_Sites ■ qryNat1_Ungaged_MeanAnnual ■ qryNat5_Gaged_DAW_PercentMeanAnnual_Salt	Mean Annual Flow (in CFS) for each Hydrologic Condition and each Ungaged Tributary in Salt Basin	For each ungaged tributary, this query applies the percentages (from *qryNat5_Gaged_DAW_PercentMeanAnnual_Salt*) to the results of the Lowham Equation (from *qryNat1_Ungaged_MeanAnnual*) in order to obtain the ungaged tributary's mean annual flow for each hydrologic condition.
Natural Flow	qryNat7_Ungaged_DAW_MeanAnnual_Snake	■ tblNatFlow_Sites ■ qryNat1_Ungaged_MeanAnnual ■ qryNat5_Gaged_DAW_PercentMeanAnnual_Snake	Mean Annual Flow (in CFS) for each Hydrologic Condition and each Ungaged Tributary in Snake Basin	For each ungaged tributary, this query applies the percentages (from *qryNat5_Gaged_DAW_PercentMeanAnnual_Snake*) to the results of the Lowham Equation (from *qryNat1_Ungaged_MeanAnnual*) in order to obtain the ungaged tributary's mean annual flow for each hydrologic condition.
Natural Flow	qryModel_Nat_Salt	■ tblNodes ■ tblDates_DaysInMonth ■ qryNat6_Gaged_PercentMeanAnnual_Salt ■ qryNat7_Ungaged_DAW_MeanAnnual_Salt	Estimated Monthly Flow for Ungaged Tributaries in the Salt Basin for each Hydrologic Condition	For each ungaged tributary, this query calculates the monthly flows for each hydrologic condition by multiplying the respective percentage for each month (from *qryNat6_Gaged_PercentMeanAnnual_Salt*) by the product of the tributary's mean annual flow (from *qryNat7_Ungaged_DAW_MeanAnnual_Salt*) times 12 months. This query also converts CFS to Acre-Feet per Month. This is the final query in the procedure for estimating natural flow for the ungaged tributaries and represents input to the spreadsheet models.
Natural Flow	qryModel_Nat_Snake	■ tblNodes ■ tblDates_DaysInMonth ■ qryNat6_Gaged_PercentMeanAnnual_Snake ■ qryNat7_Ungaged_DAW_MeanAnnual_Snake	Estimated Monthly Flow for Ungaged Tributaries in the Snake Basin for each Hydrologic Condition	For each ungaged tributary, this query calculates the monthly flows for each hydrologic condition by multiplying the respective percentage for each month (from *qryNat6_Gaged_PercentMeanAnnual_Snake*) by the product of the tributary's mean annual flow (from *qryNat7_Ungaged_DAW_MeanAnnual_Snake*) times 12 months. This query also converts CFS to Acre-Feet per Month. This is the final query in the procedure for estimating natural flow for the ungaged tributaries and represents input to the spreadsheet models.
Natural Flow	qryStrawberry_DAW	■ tblNodes ■ tblDates_DaysInMonth ■ qryHydro_Streamflow_DAW_Salt	Average of Monthly Flow for Strawberry Creek Gage Site (13027000) for each Hydrologic Condition	This query references the query, *qryHydro_Streamflow_DAW_Salt*, and extracts and averages monthly flow by Dry-Avg-Wet years for just the Strawberry Creek gage site.
Natural Flow	qryModel_Strawberry	■ tblStrawberry_Sites ■ tblStrawberry_Area ■ qryStrawberry_DAW	Monthly Flow for Natural Flow Sites Correlated to Strawberry Ck. Flow for each Hydrologic Condition	This query calculates the monthly inflow estimates for those sites chosen to correlate to Strawberry Creek flows. The calculations use the Simple Basin Area Method given the following equation: *Monthly_Flow_Ungaged_Tributary = StrawberryCk_Monthly_Flow * (Area_StrawberryCk_Drainage / Area_Ungaged_Tributary_Basin)* This is the final query in the Strawberry Creek dataset, and it is linked to the Salt Basin model spreadsheets in pivot table format.
Diversion	qryModel_Diversions	■ tblNodes ■ tblDiversion_Acres ■ tblDiversions_CIR ■ tblDiversions_Days	Monthly Diversion Requirement for each Model Node	This query calculates the monthly diversion requirement for each model node by using the following equation: *Diversion = Acres * CIR * Fraction of Month Irrigated* This is the final query in the Diversion dataset, and it is linked to the Salt and Snake Basin model spreadsheets in pivot table format.

1. All units are in Acre-Feet, unless otherwise noted.

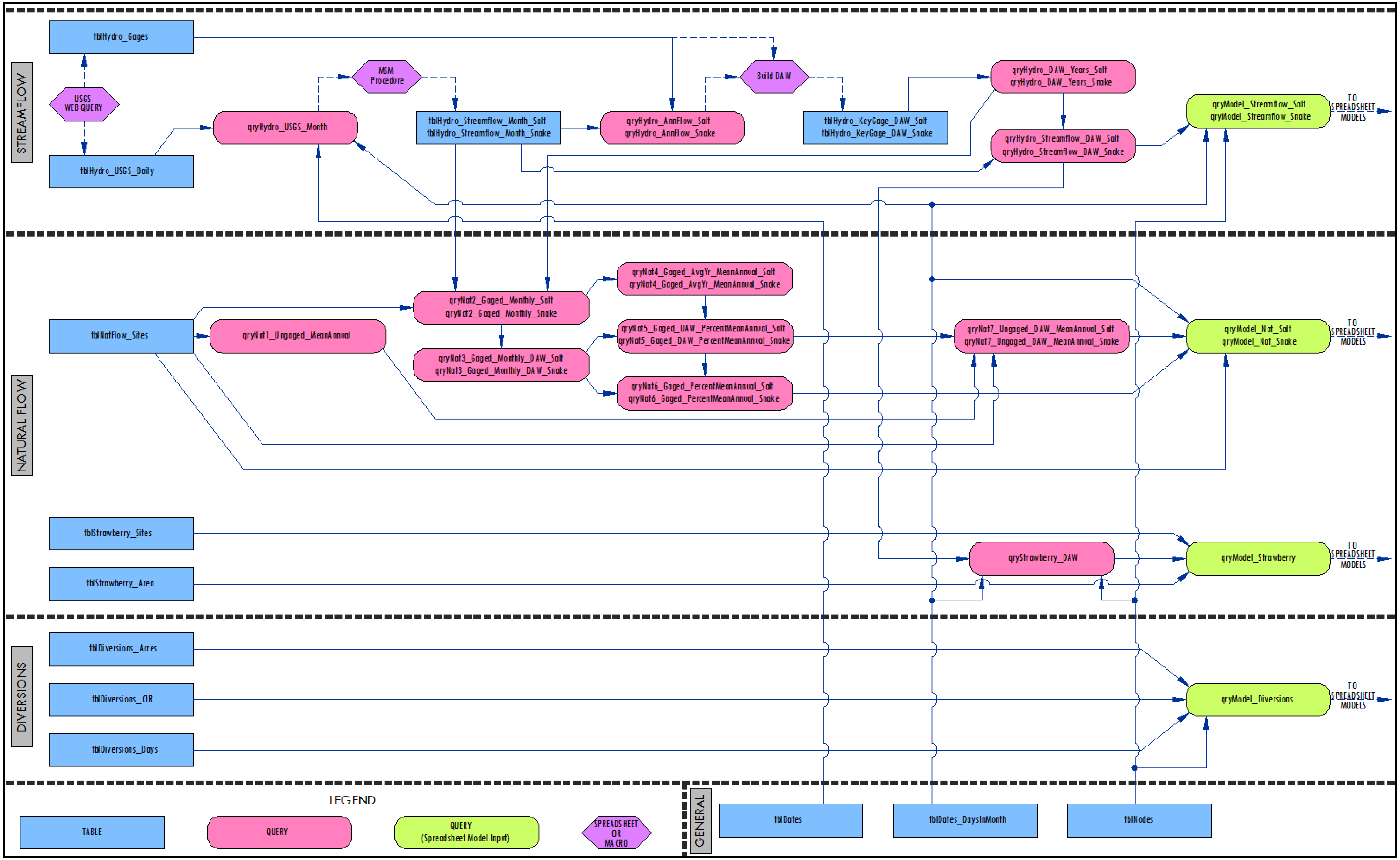


Figure 1: Snake/Salt Hydro Database Schema

2.1 Streamflow Data

The hydrologic models require monthly streamflow data for dry, average, and wet year hydrologic conditions. The primary source of raw streamflow data used to build the streamflow datasets is United States Geological Survey (USGS) National Water Information System (NWIS) daily streamflow data available from the internet. This data is automatically loaded from the internet to the *SnakeSalt Database 2010.mdb* database by running the *USGS Web Query* macro in the Microsoft Excel file, *SnakeSalt USGS Web Query.xls*. Executing this macro also transfers daily data to the database where it is stored in the *tblHydro_USGS* table. Additionally, by running the *Fill Key Gage Table in Database* macro in the same spreadsheet, information pertaining to "Key Gages," or indicator gages that are used to define the dry, average, and wet years, is transferred to the *tblHydro_Gages* table in the database.

The foundation of the *SnakeSalt USGS Web Query.xls* spreadsheet was originally developed by MWH Americas, Inc. as part of the Wind/Bighorn River Basin Plan Update (MWH, 2003). Modifications were made to the spreadsheet to tailor it for the 2012 Snake/Salt River Basin Plan Update. It should be noted that this spreadsheet, along with its macros, have been created in the Microsoft Excel 97-2003 format. (*.xls). Conversion to later versions of Microsoft Excel may corrupt some of the macro functionality that is built into the spreadsheet. Therefore, it is recommended that the spreadsheet be opened and used in Microsoft Excel 97-2003 format or ran in "compatibility" mode in later versions of the software.

After the raw streamflow data is loaded into the database, the query, *qryHydro_USGS_Month*, processes the daily data into monthly data. The next step in compiling the streamflow data is to fill missing data and extend data sets for the entire study period. The data filling and extension process is completed outside of the database by utilizing the Mixed Station Model (MSM) software. The query, *qryHydro_USGS_Month*, serves as the input source to the MSM software, and the tables *tblHydro_Streamflow_Month_Salt* and *tblHydro_Streamflow_Month_Snake* house the resulting output data that consists of filled and extended streamflow data. Note that gage data from the Salt and Snake River Basins are filled and extended separately; therefore, output from the MSM software and subsequent data processing requires separate tables and queries for each sub-basin. For additional information on gage filling and the MSM software, refer to *Technical Memorandum, Tab VIII: Surface Water Data Collection and Estimation*.

The next step in the streamflow data production process is to classify the years within the study period as dry, average, or wet year hydrologic conditions. "Key Gages," or the gages that are used to make these determinations for both the Salt and Snake River Basins, are specified in the "*IAmKeyGage*" field of the *tblHydro_Gages* database table. This table is automatically imported to the database from the *SnakeSalt USGS Web Query.xls* spreadsheet. Classification of each year within the study period for the key gages is performed by running the *BuildDAW* macro within the database. Prior to running the macro, the queries *qryHydro_AnnFlow_Salt* and *qryHydroAnnFlow_Snake* process the filled monthly data into annual flow. These two queries then serve as input to the *BuildDAW* macro. Results from this classification are stored in the *tblHydro_KeyGage_DAW_Salt* and *tblHydro_KeyGage_DAW_Snake* tables.

The final steps in processing streamflow data involve averaging and compiling data for all gages within each of the hydrologic study periods. This is performed automatically using built-in queries once the datasets are built. The queries *qryHydro_DAW_Years_Salt* and *qryHydro_DAW_Years_Snake* separate the dry, average, wet year classifications into individual basins. The *qryHydro_Streamflow_DAW_Salt* and *qryHyrdo_Streamflow_DAW_Snake* queries store the processed monthly streamflow data for each gage and by hydrologic condition. Lastly, *qryModel_Streamflow_Salt* and *qryModel_Streamflow_Snake* queries, which add model node numbers to the previous queries, store the final streamflow data set that is accessed by the spreadsheet models.

For the 2012 Update, all streamflow data sources, periods-of-record, and results are discussed in the *Technical Memorandum, Tab VIII: Surface Water Data Collection and Estimation*.

2.2 Natural Flow Data

Natural flow is used in the basin planning models to estimate natural inflows from ungaged tributaries within the Snake/Salt River Basin. Natural flows are estimated using basin characteristics, including basin area and mean basin elevation. These characteristics used for the calculations are static variables (i.e. the variables don't change over time). Mean annual flow for these catchments was estimated using a regression equation derived for mountainous regions of Wyoming published in *USGS WRIR 88-4045* (Lowham, 1988). Within the database, equation coefficients and exponents are provided in the *tblNatFlow_Sites* table along with a listing of the ungaged tributary sites. Mean annual flow estimates were converted into monthly inflow estimates by correlating each ungaged tributary to a gaged tributary. The correlation gages used for each ungaged tributary site are identified in the *tblNatFlow_Sites* table.

The first step in determining natural inflow to the ungaged tributaries is to estimate mean annual flow. The query *qryNat1_Ungaged_MeanAnnual* accesses the variables from the *tblNatFlow_Sites* table and calculates the mean annual flow for each natural flow site based on the Lowham equation:

Equation 1

$$Q_a = 0.0015A^{1.01}\left(\frac{Elev}{1000}\right)^{2.88}$$

where,
Q_a = *mean annual flow (cfs)*
A = *contributing area* (mi^2)
Elev = *mean basin elevation (feet)*

Because the Lowham equation (Equation 1) only estimates mean annual flow, the majority of the remaining steps involve deriving estimates of monthly flows for the ungaged tributaries for dry, average, and wet hydrologic conditions. With the exception of the methodology for estimating the dry, average, and wet hydrologic conditions, the basic procedure that was used follows an example presented in *USGS WRIR 88-4045, Streamflows in Wyoming* (Example E, page 40) (Lowham, 1988).

The process to derive estimates of monthly flows for dry, average, and wet hydrologic conditions for each ungaged tributary is automated by built-in queries. The queries *qryNat2_Gaged_Monthly_Salt* and *qryNat2_Gaged_Monthly_Snake* retrieve monthly streamflow data for each correlation site from *tblHydro_Streamflow_Month_Salt* and *tblHydro_Streamflow_Month_Snake*, respectively. Then queries *qryNat3_Gaged_Monthly_DAW_Salt* and *qryNat3_Gaged_Monthly_DAW_Snake* average that monthly streamflow by the hydrologic condition (dry, average, or wet).

An assumption was made that the mean annual flow calculated with the Lowham equation (as determined in *qryNat1_Ungaged_MeanAnnual*) represents an "average year" in terms of hydrologic condition for each ungaged tributary. Therefore, in order to broaden the results of the Lowham equation into dry year and wet year classifications, the following steps were taken. Queries *qryNat4_Gaged_AvgYr_MeanAnnual_Salt* and *qryNat4_Gaged_AvgYr_MeanAnnual_Snake* determine the average of the mean annual flow for each gaged correlation site for just the "average year" hydrologic condition. Then the queries *qryNat5_Gaged_DAW_PercentMeanAnnual_Salt* and *qryNat5_Gaged_DAW_PercentMeanAnnual_Snake* determine the percentage of the "average year" hydrologic condition of the mean annual flow for each gaged correlation site and each hydrologic condition. In other words, they average the gaged monthly flow for each hydrologic condition (from the *"qryNat3"* queries) and divide that number by the results from the *"qryNat4"* queries.

The next queries, *qryNat6_Gaged_PercentMeanAnnual_Salt* and *qryNat6_Gaged_PercentMeanAnnual_Salt*, determine the monthly percentage of mean annual flow by following the following general formula:

Gaged Monthly Flow / Gaged Mean Annual Flow / 12 Months

For each ungaged tributary, queries *qryNat7_Ungaged_DAW_MeanAnnual_Salt* and *qryNat7_Ungaged_DAW_MeanAnnual_Snake* apply the percentages (from the *"qryNat5"* queries) to the results of the Lowham Equation (from the *"qryNat1"* query) in order to obtain the ungaged tributary's mean annual flow for each hydrologic condition.

Finally, queries *qryModel_Nat_Salt* and *qryModel_Nat_Snake* calculate the monthly flows for each hydrologic condition by multiplying the respective percentage for each month (from the *"qryNat6"* queries) by the product of the tributary's mean annual flow (from the *"qryNat7"* queries) times 12 months. This query also converts CFS to Acre-Feet per Month. This is the final query in the procedure for estimating natural flow for the ungaged tributaries and represents input to the spreadsheet models.

Additional information pertaining to natural flow estimation and example calculations are presented in *Technical Memorandum, Tab VIII: Surface Water Data Collection and Estimation*.

2.2.1 Correlations to Strawberry Creek

In some cases the annual flow estimated from the equations previously discussed appeared low in comparison to nearby gaged basins. This resulted in shortages to diversions in the spreadsheet model. Under these circumstances, a second estimation method was used involving a simple area weighing of the monthly flows of a similar watershed in close proximity. As in the previous Basin Plan, this was the case in Cedar Creek, Lee Creek, Birch Creek, and Stewart Creek in the Salt River Basin. These tributary flows were estimated by correlating to gaged flows in Strawberry Creek by using the Simple Basin Area Method as defined by Equation 2:

Equation 2

$$Monthly\,Ungaged\,Tributary\,Flow = Strawberry\,Creek\;\;Monthly\,Flow \times \left(\frac{Area\,Ungaged\,Tributary}{Area\,Strawberry\,Creek} \right)$$

where,
"Monthly Ungaged Tributary Flow" is the derived monthly flow estimate for each ungaged tributary.
"Strawberry Creek Monthly Flow" is based on gage records from Strawberry Creek (13027000).
"Area Ungaged Tributary" is the drainage basin area of the ungaged tributary.
"Area Strawberry Creek" is the drainage basin area of Strawberry Creek, upstream of its gage site.

The correlation of these four tributaries to Strawberry Creek flows is automated within the database. The table, *tblStrawberry_Sites*, lists the four tributaries along with their respective drainage basin areas. The table, *tblStrawberry_Area*, simply stores the drainage basin area of the Strawberry Creek watershed. Monthly streamflow data from the Strawberry Creek gage site for dry, average, and wet conditions is acquired by the query, *qryStrawberry_DAW*. Finally, the query, *qryModel_Strawberry*, calculates the estimated inflow for each tributary using Equation 2. This final query stores the estimated natural flow data for these four tributaries and is accessed by the spreadsheet models.

2.3 Diversion Data

The spreadsheet models require monthly diversion data. Surface water diversions in the Snake/Salt River Basin Models are entirely for agricultural use, as municipal use is supplied from groundwater. Because actual diversion records were unavailable in these basins, the model simulates the depletion, that is, the consumptive portion of the diversion, being taken from the stream. Since the model treats this quantity as if it was the diverted amount, and for consistency with other basin spreadsheets, this information is referred to as "diversion data," although it is actually a depletion quantity.

The source of information to compile the diversion data was the StateCU model that was created for this study as discussed in *Technical Memorandum, Tab VII: Crop Water Requirements*. For each node in the spreadsheet models, diversions were calculated as the product of the irrigated acres, the monthly crop irrigation requirement (CIR) determined by the StateCU model, and the fraction of the month in which diversions were practiced:

Equation 3

$$Diversion = CIR * Acres * Fraction$$

where,
Diversion = agricultural depletion quantity (acre-feet per month)
CIR = crop irrigation requirement (feet per month)
Areas = number of irrigated acres
Fraction = fraction of month irrigated

CIR values acquired from the StateCU model were stored in the table, *tblDiversion_CIR*. The table provides monthly CIR values for the following seven irrigation zones that were established as part of this study:

- Zone 1: Teton
- Zone 2: Upper Snake
- Zone 3: Lower Snake
- Zone 4: Hoback
- Zone 5: Lower Salt
- Zone 6: Upper Salt
- Zone 7: Greys

It was assumed that the values for the fraction of month irrigated from the previous Basin Plan were satisfactory for use in the 2012 Update and were not changed. These “Fraction” values are stored in the *tblDiversion_Days* table that lists the previously determined irrigation days. In the table, the "Fraction" field actually represents the fraction of the month when irrigation takes place, or as defined by equation:

Equation 4

$$Fraction = \frac{Irrigation\ Days\ per\ Month}{Number\ of\ Days\ per\ Month}$$

The table, *tblDiversions_Acres*, provides the estimated irrigated acres for each model node. Note that every model node is listed in the table, regardless of whether it has an assigned diversion or not. For information on the quantification of irrigated acreage for this study, refer to *Technical Memorandum, Tab VI: Irrigated Acreage*.

In the database, the query, *qryModel_Diversions*, calculates the monthly diversion requirement for each model node by applying Equation 3. This query stores the estimated diversion data and is accessed by the spreadsheet models.

For the 2012 Snake/Salt River Basin Plan Update, the methodology used to estimate crop water requirements and diversion data is described in *Technical Memorandum, Tab VII: Crop Water Requirements*.

2.4 General Data

The database includes three tables that contain general information utilized by several queries within the database. The primary table is the *tblNodes* table, which serves to tie several of the tables and queries to model nodes used in the spreadsheet models. Fields in this table include the following:

- BasinNodeNo – Provides a unique model node number within each basin where each node number is preceded by the name of the basin where it is located (i.e. “Salt_15.02”).
- Irrigation_Zone – Identifies the irrigation zone where each node is located.
- Node Description – Provides a written description of each model node.
- Model – Identifies the node with either the Salt or Snake River Basin model.
- NodeType – Identifies each node type as either a natural flow node, gage site, diversion node, or a stream confluence.
- Reach – Defines the model reach number that is associated with each node.
- Gage_No – Identifies the USGS gage site when the node represents a gage site.
- Gage_Abbrv – Provides an abbreviation for each UGSG gage site when the node represents a gage site.
- Order – Provides a numerical ordering for each node to facilitate data sorting procedures.

Two other tables are used to track dates within the model. The table, *tblDates*, contains all dates within the study period and several years beyond and relates these dates to calendar years, calendar months, water years and water months. A second table, *tblDates_DaysInMonth*, contains the number of days in each month for use in converting values in cubic feet per second (cfs) to acre-feet (ac-ft).

3.0 Spreadsheet Model Improvements

As previously stated, the spreadsheet model’s methodology and calculations remain mostly the same as the previously developed spreadsheet models. These spreadsheet models were documented in *Technical Memorandum – Task 3B Spreadsheet Model Development and Task 3C Surface Water Model Calibration* (Boyle, 2003). The remaining portion of this section discusses changes that were made to the spreadsheet models as part of this study. The primary changes involve integrating the spreadsheet models with a direct link to the dataset queries contained within the hydrologic database. Other changes include an update to the model map schematics and corresponding calculations that reflect the addition of Greys River into the Salt River Basin spreadsheet model. Basin Node Numbers were also modified in the spreadsheet models to facilitate the connection and relationship to the hydrologic database. Other aesthetic changes made to the spreadsheet models include the following:

- Improvements to background colors and shading.
- Improvements to formatting on tables and charts involving font, text, and line work.
- Color Coding and key on the “GagedFlow” sheet to help distinguish between Natural Flow, Gaged Flow, or Other methods used to estimate inflow.
- Addition and/or improvements to several “popup” comments that help clarify information and note the use of certain assumptions.

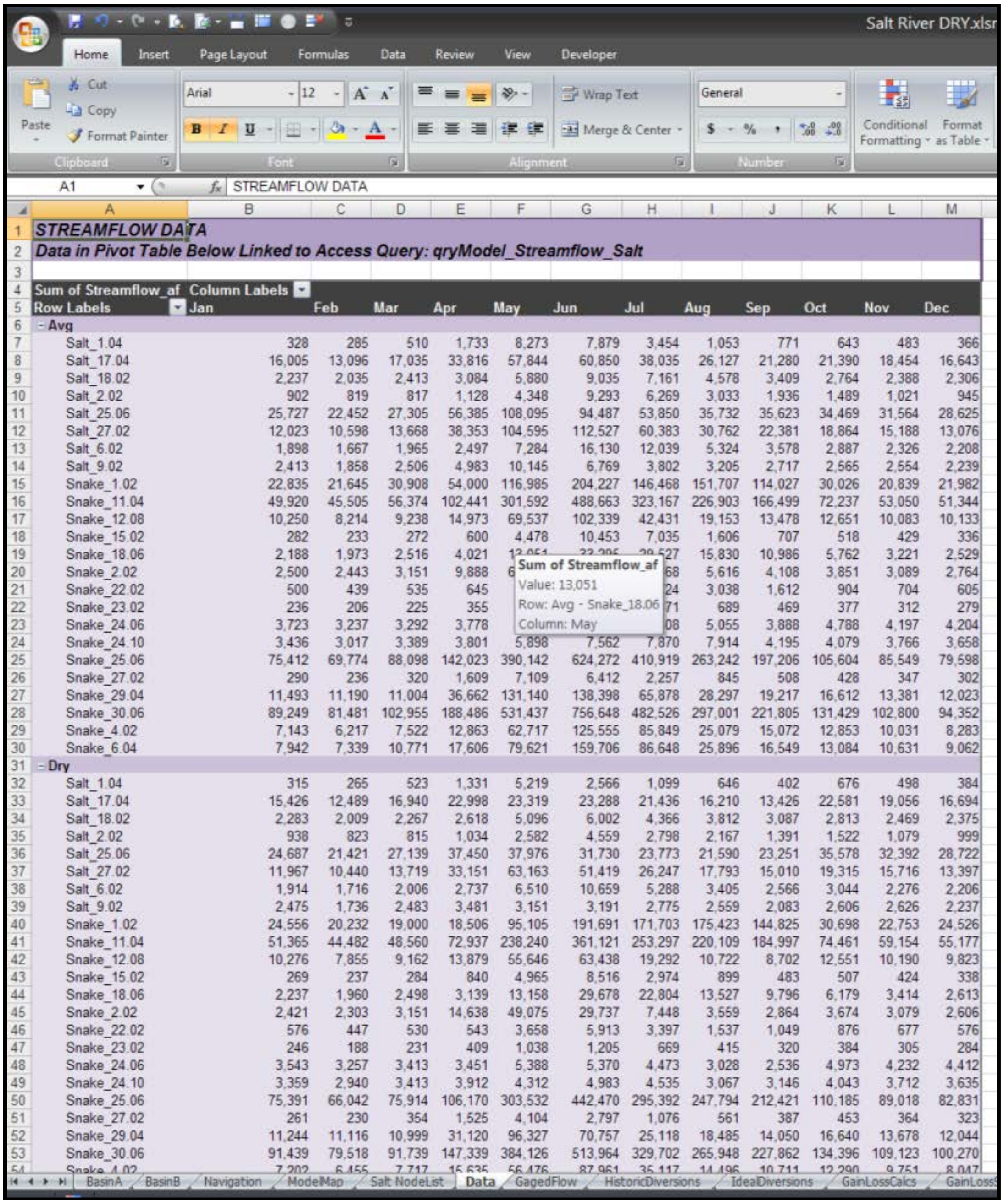
For the 2012 Update, it should be noted that the spreadsheet models have been upgraded to Microsoft Excel 2007 workbooks (*.xlsm), and some of the functions used to make the modifications are only available in this or newer versions. Thus it is recommended that the models be opened and run in Microsoft Excel 2007 or newer versions.

3.1 Integration of the Hydrologic Database

A new worksheet, "Data," was inserted into each spreadsheet model to house Excel "pivot tables" that query data directly from the *SnakeSalt Database 2010.mdb* database. Separate pivot tables were set up to query each type of data used by the model from the database. Table 3 presents a summary of the pivot table queries contained on the "Data" worksheets in the spreadsheet models while Figure 2 presents a screen capture of the "Data" worksheet.

Table 3: Spreadsheet Model Pivot Tables

Pivot Table Name	SnakeSalt Database Table(s)	Worksheet in Spreadsheet Model where Data is Used
Streamflow Data	qryModel_Streamflow_Salt qryModel_Streamflow_Snake	"GagedFlow"
Natural Flow Data	qryModel_Nat_Salt qryModel_Nat_Snake	"GagedFlow"
Strawberry Creek Correlation Data	qryModel_Strawberry	"GagedFlow" (on Salt Basin models only)
Diversion Data	qryModel_Diversions	"HistoricDiversions"



STREAMFLOW DATA

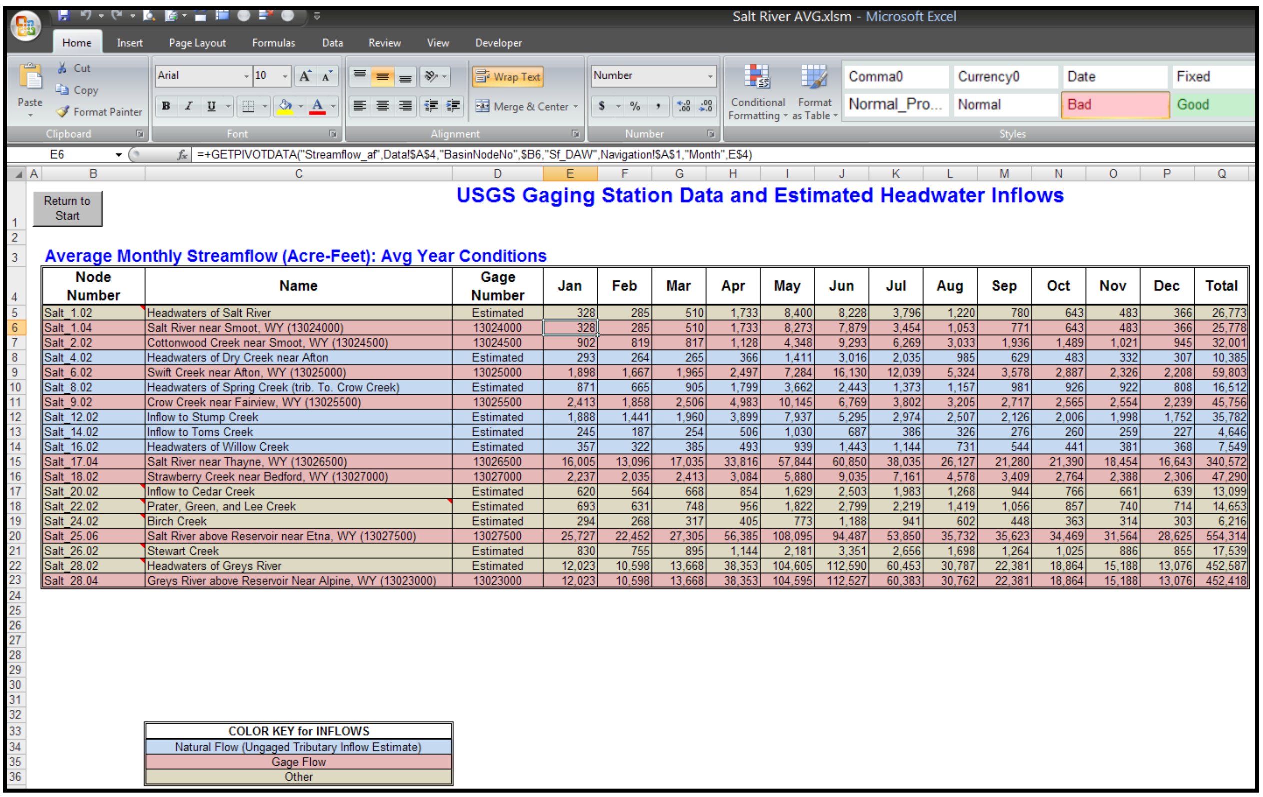
Data in Pivot Table Below Linked to Access Query: qryModel_Streamflow_Salt

Sum of Streamflow_af / Row Labels	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg												
Salt_1.04	328	285	510	1,733	8,273	7,879	3,454	1,053	771	643	483	366
Salt_17.04	16,005	13,096	17,035	33,816	57,844	60,850	38,035	26,127	21,280	21,390	18,454	16,643
Salt_18.02	2,237	2,035	2,413	3,084	5,880	9,035	7,161	4,578	3,409	2,764	2,388	2,306
Salt_2.02	902	819	817	1,128	4,348	9,293	6,269	3,033	1,936	1,489	1,021	945
Salt_25.06	25,727	22,452	27,305	56,385	108,095	94,487	53,850	35,732	35,623	34,469	31,564	28,625
Salt_27.02	12,023	10,598	13,668	38,353	104,595	112,527	60,383	30,762	22,381	18,864	15,188	13,076
Salt_6.02	1,898	1,667	1,965	2,497	7,284	16,130	12,039	5,324	3,578	2,887	2,326	2,208
Salt_9.02	2,413	1,858	2,506	4,983	10,145	6,769	3,802	3,205	2,717	2,565	2,554	2,239
Snake_1.02	22,835	21,645	30,908	54,000	116,985	204,227	146,468	151,707	114,027	30,026	20,839	21,982
Snake_11.04	49,920	45,505	56,374	102,441	301,592	488,663	323,167	226,903	166,499	72,237	53,050	51,344
Snake_12.08	10,250	8,214	9,238	14,973	69,537	102,339	42,431	19,153	13,478	12,651	10,083	10,133
Snake_15.02	282	233	272	600	4,478	10,453	7,035	1,606	707	518	429	336
Snake_18.06	2,188	1,973	2,516	4,021	[illegible]	[illegible]	[illegible]	15,830	10,986	5,762	3,221	2,529
Snake_2.02	2,500	2,443	3,151	9,888	[illegible]	[illegible]	[illegible]	5,616	4,108	3,851	3,089	2,764
Snake_22.02	500	439	535	645	[illegible]	[illegible]	[illegible]	3,038	1,612	904	704	605
Snake_23.02	236	206	225	355	[illegible]	[illegible]	[illegible]	689	469	377	312	279
Snake_24.06	3,723	3,237	3,292	3,778	[illegible]	[illegible]	[illegible]	5,055	3,888	4,788	4,197	4,204
Snake_24.10	3,436	3,017	3,389	3,801	5,898	7,562	7,870	7,914	4,195	4,079	3,766	3,658
Snake_25.06	75,412	69,774	88,098	142,023	390,142	624,272	410,919	263,242	197,206	105,604	85,549	79,598
Snake_27.02	290	236	320	1,609	7,109	6,412	2,257	845	508	428	347	302
Snake_29.04	11,493	11,190	11,004	36,662	131,140	138,398	65,878	28,297	19,217	16,612	13,381	12,023
Snake_30.06	89,249	81,481	102,955	188,486	531,437	756,648	482,526	297,001	221,805	131,429	102,800	94,352
Snake_4.02	7,143	6,217	7,522	12,863	62,717	125,555	85,849	25,079	15,072	12,853	10,031	8,283
Snake_6.04	7,942	7,339	10,771	17,606	79,621	159,706	86,648	25,896	16,549	13,084	10,631	9,062
Dry												
Salt_1.04	315	265	523	1,331	5,219	2,566	1,099	646	402	676	498	384
Salt_17.04	15,426	12,489	16,940	22,998	23,319	23,288	21,436	16,210	13,426	22,581	19,056	16,694
Salt_18.02	2,283	2,009	2,267	2,618	5,096	6,002	4,366	3,812	3,087	2,813	2,469	2,375
Salt_2.02	938	823	815	1,034	2,582	4,559	2,798	2,167	1,391	1,522	1,079	999
Salt_25.06	24,687	21,421	27,139	37,450	37,976	31,730	23,773	21,590	23,251	35,578	32,392	28,722
Salt_27.02	11,967	10,440	13,719	33,151	63,163	51,419	26,247	17,793	15,010	19,315	15,716	13,397
Salt_6.02	1,914	1,716	2,006	2,737	6,510	10,659	5,288	3,405	2,566	3,044	2,276	2,206
Salt_9.02	2,475	1,736	2,483	3,481	3,151	3,191	2,775	2,559	2,083	2,606	2,626	2,237
Snake_1.02	24,556	20,232	19,000	18,506	95,105	191,691	171,703	175,423	144,825	30,698	22,753	24,526
Snake_11.04	51,365	44,482	48,560	72,937	238,240	361,121	253,297	220,109	184,997	74,461	59,154	55,177
Snake_12.08	10,276	7,855	9,162	13,879	55,646	63,438	19,292	10,722	8,702	12,551	10,190	9,823
Snake_15.02	269	237	284	840	4,965	8,516	2,974	899	483	507	424	338
Snake_18.06	2,237	1,960	2,498	3,139	13,158	29,678	22,804	13,527	9,796	6,179	3,414	2,613
Snake_2.02	2,421	2,303	3,151	14,638	49,075	29,737	7,448	3,559	2,864	3,674	3,079	2,606
Snake_22.02	576	447	530	543	3,658	5,913	3,397	1,537	1,049	876	677	576
Snake_23.02	246	188	231	409	1,038	1,205	669	415	320	384	305	284
Snake_24.06	3,543	3,257	3,413	3,451	5,388	5,370	4,473	3,028	2,536	4,973	4,232	4,412
Snake_24.10	3,359	2,940	3,413	3,912	4,312	4,983	4,535	3,067	3,146	4,043	3,712	3,635
Snake_25.06	75,391	66,042	75,914	106,170	303,532	442,470	295,392	247,794	212,421	110,185	89,018	82,831
Snake_27.02	261	230	354	1,525	4,104	2,797	1,076	561	387	453	364	323
Snake_29.04	11,244	11,116	10,999	31,120	96,327	70,757	25,118	18,485	14,050	16,640	13,678	12,044
Snake_30.06	91,439	79,518	91,739	147,339	384,126	513,964	329,702	265,948	227,862	134,396	109,123	100,270
Snake_4.02	7,202	6,455	7,717	15,635	56,476	87,961	35,117	14,496	10,711	12,290	9,751	8,047

Figure 2: Spreadsheet Model Pivot Table on "Data" Worksheet

To update the pivot tables, they first must be connected back to the database on the local computer. Once this connection is established, it remains intact unless the database file is moved. Furthermore, each individual pivot table contains a separate connection to the database, so the connection must be set for each pivot table. The connections can be examined by using the Excel menu sequence "Data\Connections\Properties\Definition." Should the connection need to be updated, the same Excel menu sequence can be used, followed by browsing for the correct location of the database. The user must ensure that the table (or in this case, query) is being referenced correctly from the database file. The name of the query for each pivot table connection can be confirmed by examining the readouts that are displayed in the same Excel menu sequence. Once the connections are established, the data in the pivot tables can be updated by simply selecting either "Refresh" or "Refresh All" from the "Data" menu. Connections only need to be refreshed if data in the database has been modified.

Data from the pivot tables is loaded into the appropriate worksheet cells in each spreadsheet model by using the "GETPIVOTDATA" function in Microsoft Excel. This function is formatted to automatically load the correct data for the model node, month, and hydrologic condition as needed for input. All of these references are automatically tied to the proper pivot table. An example of where this function is utilized to retrieve gaged flow data from the Streamflow pivot table in the "Salt River Avg" spreadsheet model can be seen in Figure 3.



Node Number	Name	Gage Number	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Salt_1.02	Headwaters of Salt River	Estimated	328	285	510	1,733	8,400	8,228	3,796	1,220	780	643	483	366	26,773
Salt_1.04	Salt River near Smoot, WY (13024000)	13024000	328	285	510	1,733	8,273	7,879	3,454	1,053	771	643	483	366	25,778
Salt_2.02	Cottonwood Creek near Smoot, WY (13024500)	13024500	902	819	817	1,128	4,348	9,293	6,269	3,033	1,936	1,489	1,021	945	32,001
Salt_4.02	Headwaters of Dry Creek near Afton	Estimated	293	264	265	366	1,411	3,016	2,035	985	629	483	332	307	10,385
Salt_6.02	Swift Creek near Afton, WY (13025000)	13025000	1,898	1,667	1,965	2,497	7,284	16,130	12,039	5,324	3,578	2,887	2,326	2,208	59,803
Salt_8.02	Headwaters of Spring Creek (trib. To. Crow Creek)	Estimated	871	665	905	1,799	3,662	2,443	1,373	1,157	981	926	922	808	16,512
Salt_9.02	Crow Creek near Fairview, WY (13025500)	13025500	2,413	1,858	2,506	4,983	10,145	6,769	3,802	3,205	2,717	2,565	2,554	2,239	45,756
Salt_12.02	Inflow to Stump Creek	Estimated	1,888	1,441	1,960	3,899	7,937	5,295	2,974	2,507	2,126	2,006	1,998	1,752	35,782
Salt_14.02	Inflow to Toms Creek	Estimated	245	187	254	506	1,030	687	386	326	276	260	259	227	4,646
Salt_16.02	Headwaters of Willow Creek	Estimated	357	322	385	493	939	1,443	1,144	731	544	441	381	368	7,549
Salt_17.04	Salt River near Thayne, WY (13026500)	13026500	16,005	13,096	17,035	33,816	57,844	60,850	38,035	26,127	21,280	21,390	18,454	16,643	340,572
Salt_18.02	Strawberry Creek near Bedford, WY (13027000)	13027000	2,237	2,035	2,413	3,084	5,880	9,035	7,161	4,578	3,409	2,764	2,388	2,306	47,290
Salt_20.02	Inflow to Cedar Creek	Estimated	620	564	668	854	1,629	2,503	1,983	1,268	944	766	661	639	13,099
Salt_22.02	Prater, Green, and Lee Creek	Estimated	693	631	748	956	1,822	2,799	2,219	1,419	1,056	857	740	714	14,653
Salt_24.02	Birch Creek	Estimated	294	268	317	405	773	1,188	941	602	448	363	314	303	6,216
Salt_25.06	Salt River above Reservoir near Etna, WY (13027500)	13027500	25,727	22,452	27,305	56,385	108,095	94,487	53,850	35,732	35,623	34,469	31,564	28,625	554,314
Salt_26.02	Stewart Creek	Estimated	830	755	895	1,144	2,181	3,351	2,656	1,698	1,264	1,025	886	855	17,539
Salt_28.02	Headwaters of Greys River	Estimated	12,023	10,598	13,668	38,353	104,605	112,590	60,453	30,787	22,381	18,864	15,188	13,076	452,587
Salt_28.04	Greys River above Reservoir Near Alpine, WY (13023000)	13023000	12,023	10,598	13,668	38,353	104,595	112,527	60,383	30,762	22,381	18,864	15,188	13,076	452,418

Figure 3: Spreadsheet Model "GagedFlow" Worksheet

3.2 Revised Model Map Network

A model map network was developed in the previous Basin Plan to mathematically represent the Snake and Salt River Basin systems. The river systems were divided into reaches based primarily on the location of major tributary confluences. Each reach was then sub-divided by identifying a series of individual nodes representing diversions, tributary confluences, gages, or other significant water resources features. The resulting model map network is the simplification of the real world the model represents.

Illustrated within each spreadsheet model, model map networks have been revised for this study to include a representation of Greys River in the Salt River Basin along with minor improvements to line work, color, and readability. The revised model map networks for both the Snake and Salt River Basins are shown on Figures 4 and 5, respectively.

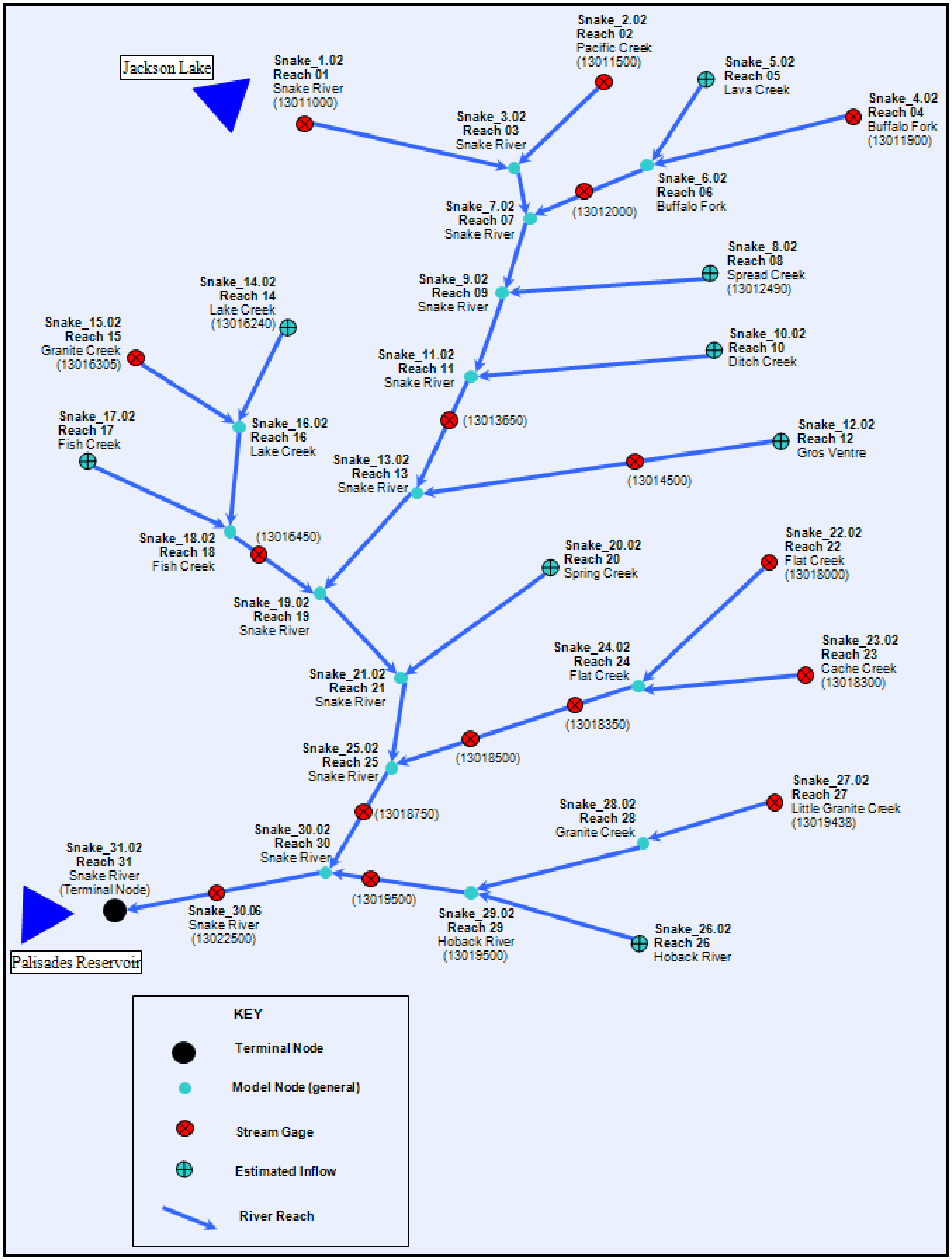


Figure 4: Snake River Basin Model Map Network

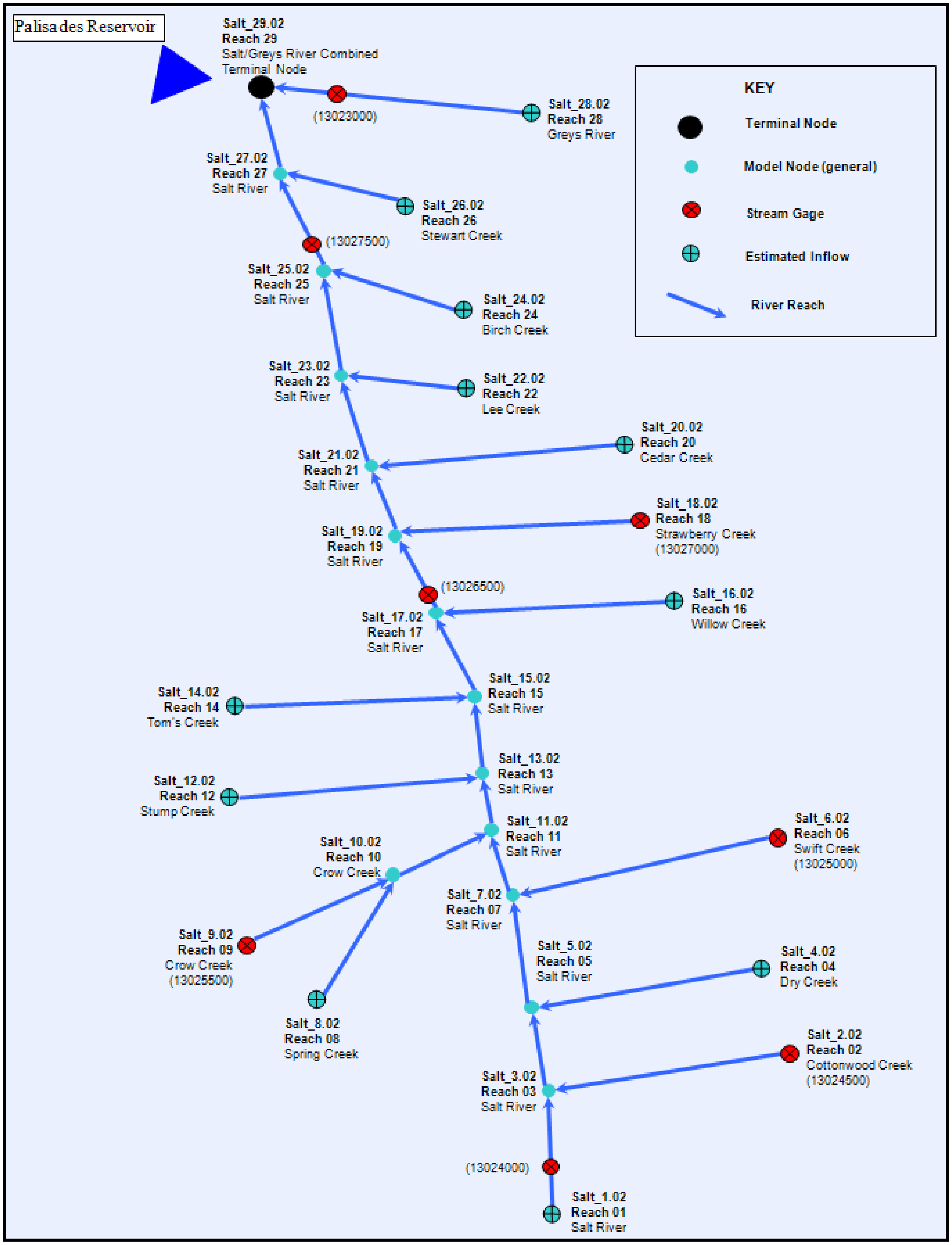


Figure 5: Salt River Basin Model Map Network

4.0 Summary

The spreadsheet models developed as part of the previous Basin Plan were used as a basis for the work completed in the 2012 Update. The models were revised to include updated hydrology, improvements in data storage, and access to that data. Other minor improvements were made to the spreadsheet models as described in this memorandum. Streamflow data was updated to a study period of 1971 through 2010.

The most extensive modification to the spreadsheet models was the development of a hydrologic database entitled *SnakeSalt Database 2010.mdb* using the Microsoft Access database platform to house all of the hydrologic datasets required by the spreadsheet models. A macro coded in Visual Basic for Applications (VBA) was developed within the database program to develop the dry-average-wet year hydrologic datasets used by the spreadsheet models. The remainder of the calculations required to process datasets use standard Microsoft Access query techniques. The database contains historical streamflow, natural flow estimations, and historical diversion data. The database is linked directly into the spreadsheet models using external "pivot table" links.

Results of the models are contained in *Technical Memorandum, Tab X: Available Surface Water Determination*.

References

Boyle Engineering Corporation. Frantz, Meg and Bandy, Jeff. Technical Memorandum – Task 3B Spreadsheet Model Development and Task 3C Surface Water Model Calibration. Snake/Salt River Basin Plan (http://waterplan.state.wy.us/plan/snake/techmemos/spread.html). February 14, 2003.

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