Overview of the Simplified Water Allocation Model (SWAM)

South Carolina Surface Water Quantity Model Project

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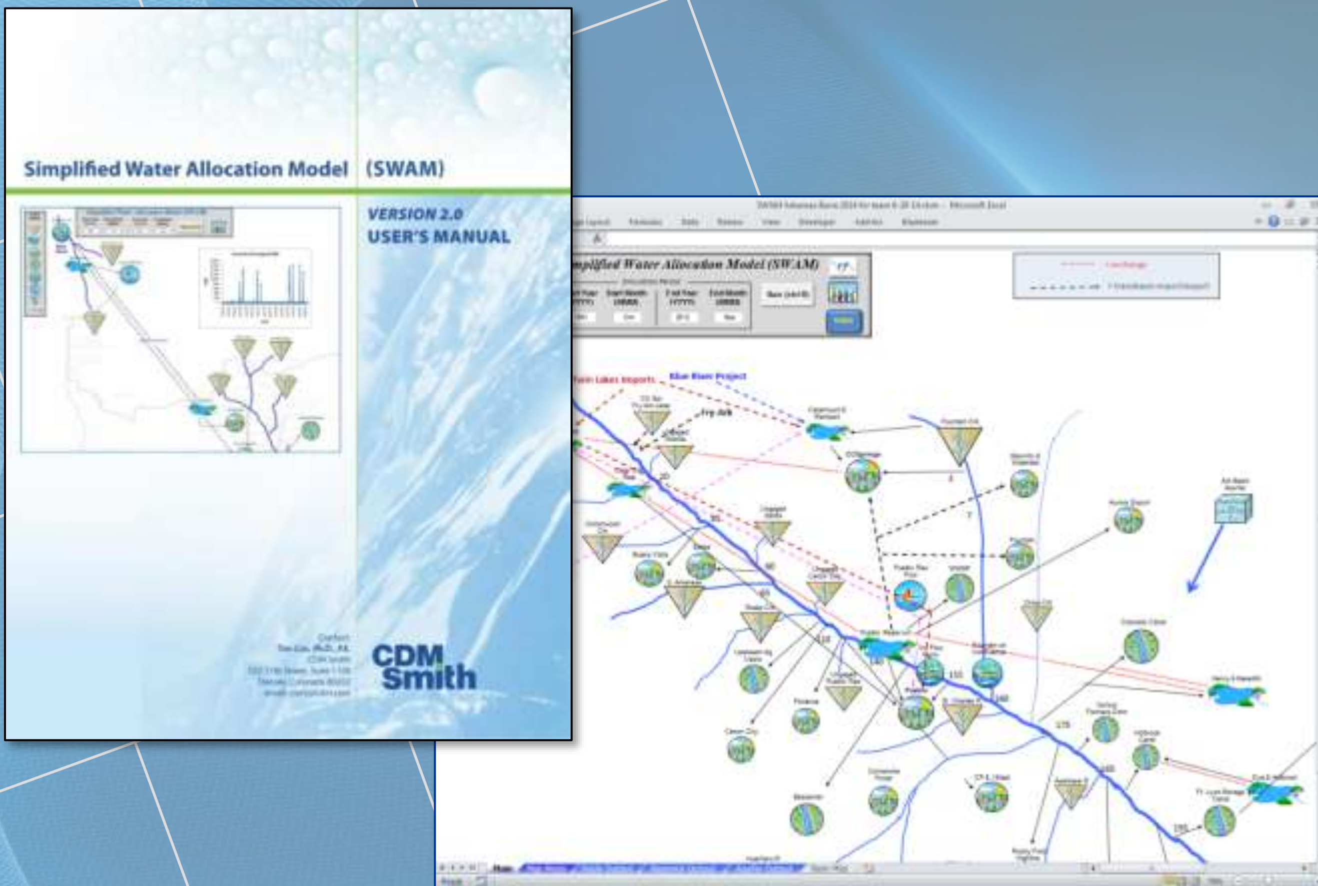
December 3, 2014



CDM Smith

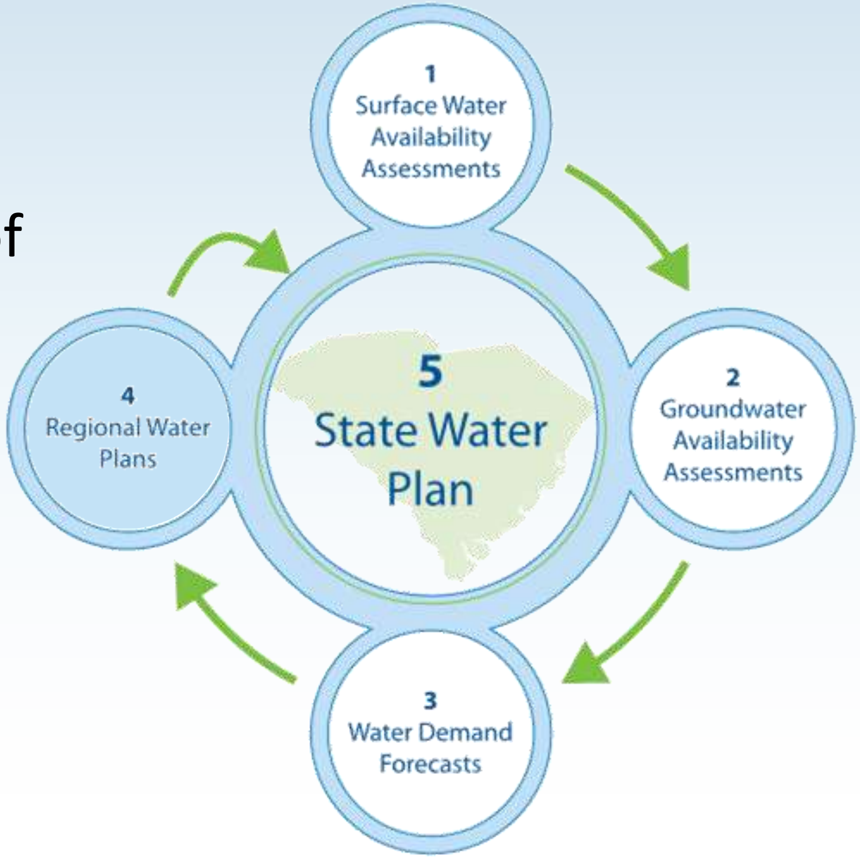
Project Purpose

- Build models surface water quantity models capable of:
  - Accounting for inflows and outflows from a basin
  - Accurately simulating streamflows and reservoir levels over the historical inflow record
  - Conducting "What if" scenarios to evaluate future water demands, management strategies and system performance.
- CDM Smith's contract ends after the models are built and training is conducted

Project Purpose

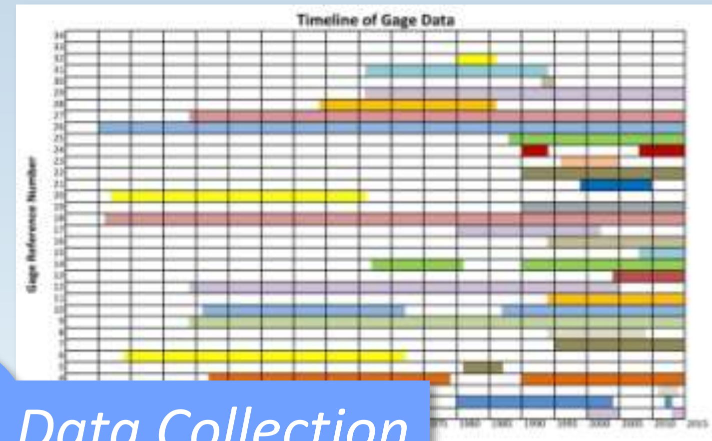
- Once they are built and accepted by DNR/DHEC, the models will be made available for use by water utilities, energy producers, river basin organizations, and other stakeholders.

- The surface water models, and other available tools, can be used to support development of regional water plans

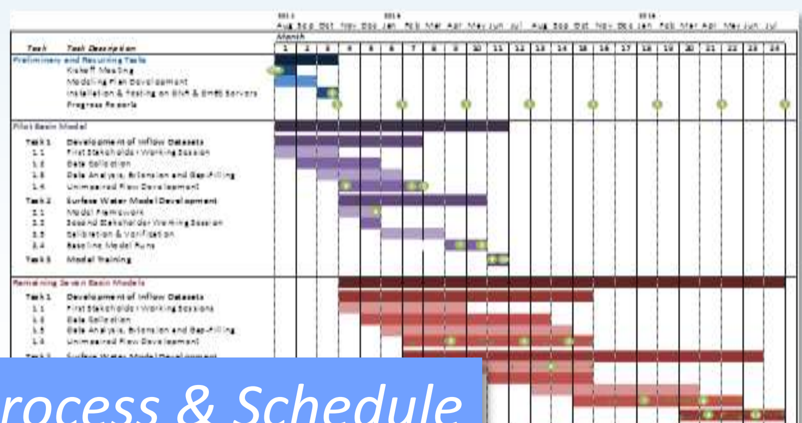


Development of Surface Water Quantity Models

1 *The Tool*



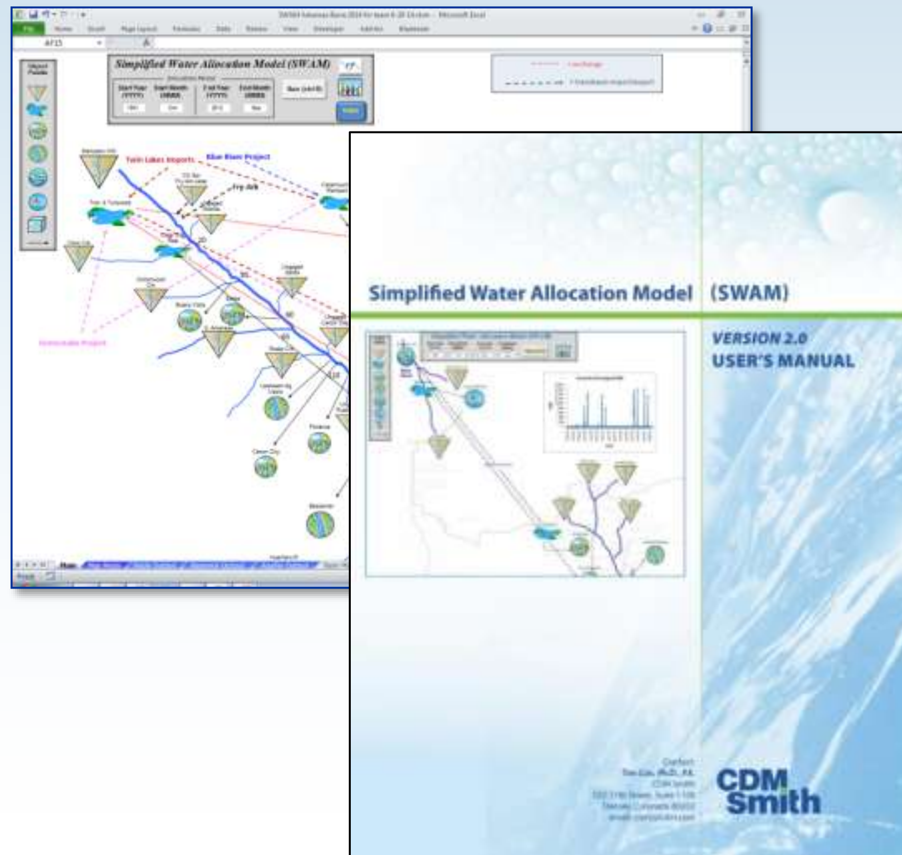
3 *Data Collection*



2 *Process & Schedule*

Simplified Water Allocation Model (SWAM)

- Developed in response to an increasing need for a desktop tool to facilitate regional and statewide water allocation analysis
- Calculates physically and legally available water, diversions, storage consumption and return flows at user-defined nodes
- Used to support large-scale planning studies in Colorado, Oklahoma, Arkansas and Texas



River Basin Flow and Operations Models

Similarities between SWAM, OASIS, CHEOPS, and RiverWare:

- Used in major river basin studies and/or statewide water plans
- Operating Rules of varying complexity
- Monthly and Daily Timesteps
- Visual Depiction of the River Network

Unique Features:

SWAM

- Familiar and adaptable environment: Visual Basic and Spreadsheets
- Built in functions for reservoirs, river operations, discharges, irrigation, return flows, etc.

OASIS

- Built in Probability Analysis for Real-Time Ops
- Optimization toward objectives in each timestep

CHEOPS

- Tailored specifically for hydropower
  - Energy Calculations
  - Reservoir Tracking
- Familiar Visual Basic programming

RiverWare

- Fully linked graphical network development
- 3 modes:
  - Pure simulation
  - Rules-based simulation
  - Optimization

Simplified Water Allocation Model (SWAM)

- Object-oriented tool in which a river basin and all of its influences can be linked into a network with user defined priorities

Objects

Tributaries

Reservoirs

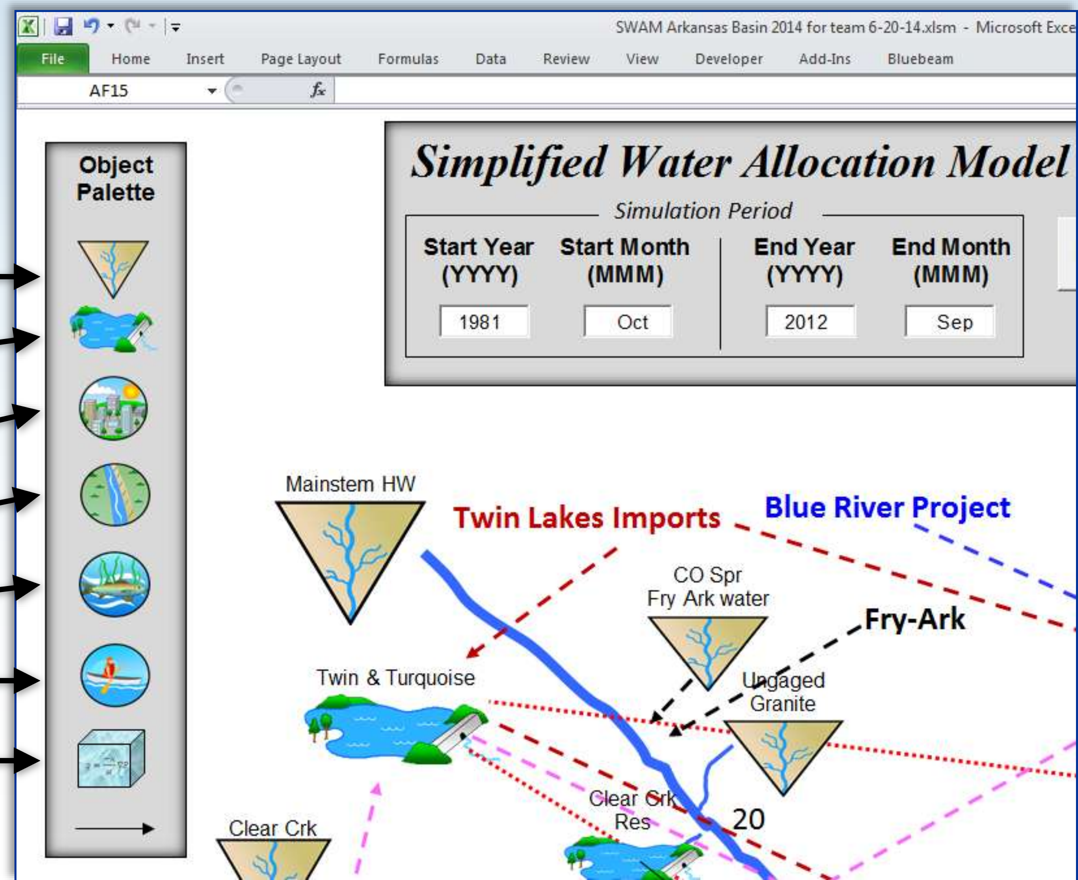
Water Users

Agricultural Users

Instream Flow

Recreational Pool

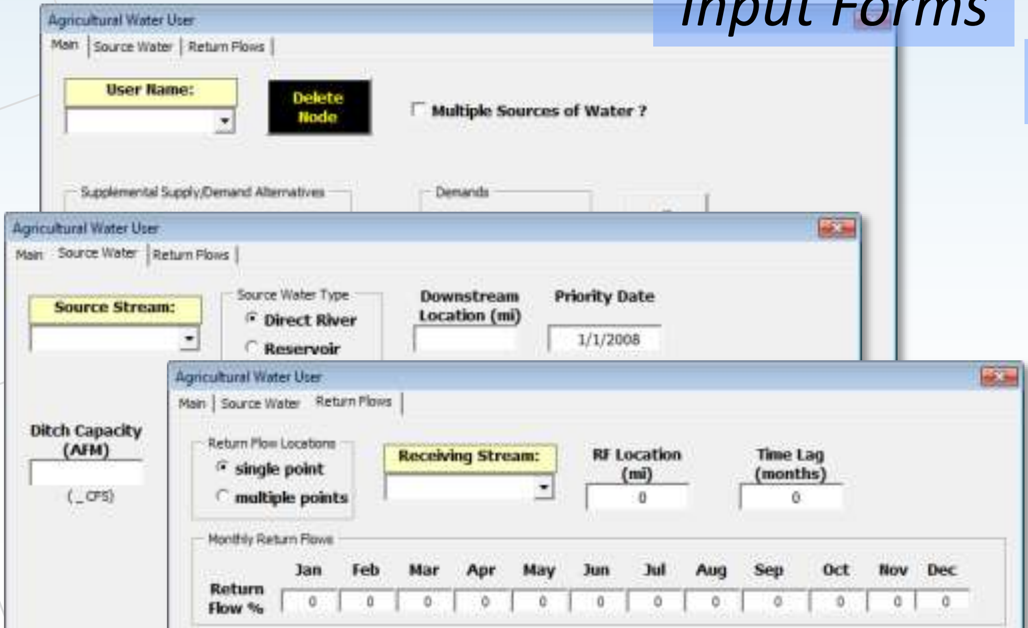
Aquifer



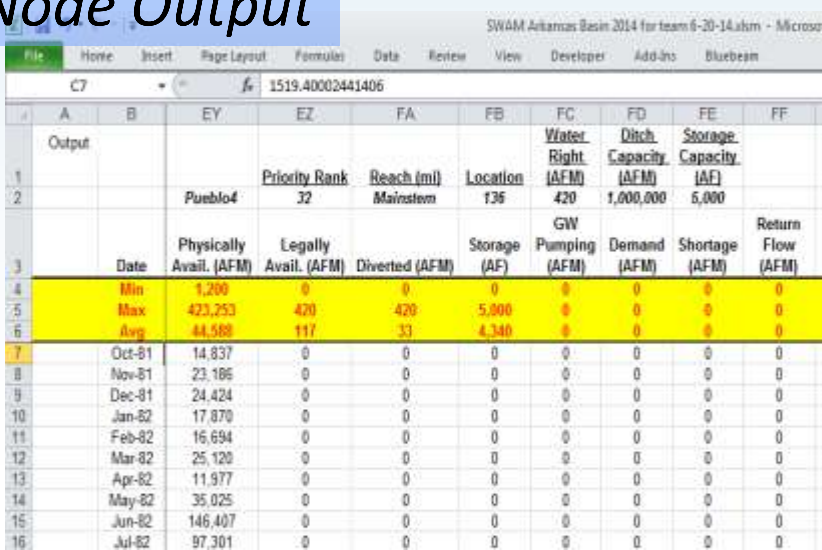
Simplified Water Allocation Model (SWAM)

- **Intuitive & Transparent** Resides within and interfaces directly with Microsoft Excel
- **Ease-of-Use** Point-and-click setup and output access
- **Simple & Robust** Mass balance calculations, but handles operating rules, use priorities, etc.

Input Forms



Node Output



	A	B	EY	EZ	FA	FB	FC	FD	FE	FF
1	Output			Priority Rank	Reach (mi)	Location	Water Right (AFM)	Ditch Capacity (AFM)	Storage Capacity (AF)	
2			Pueblo4	32	Mainstem	136	420	1,000,000	5,000	
3		Date	Physically Avail. (AFM)	Legally Avail. (AFM)	Diverted (AFM)	Storage (AF)	GW Pumping (AFM)	Demand (AFM)	Shortage (AFM)	Return Flow (AFM)
4		Min	1,200	0	0	0	0	0	0	0
5		Max	423,253	420	420	5,000	0	0	0	0
6		Avg	44,588	117	33	4,340	0	0	0	0
7		Oct-81	14,837	0	0	0	0	0	0	0
8		Nov-81	23,186	0	0	0	0	0	0	0
9		Dec-81	24,424	0	0	0	0	0	0	0
10		Jan-82	17,870	0	0	0	0	0	0	0
11		Feb-82	16,694	0	0	0	0	0	0	0
12		Mar-82	25,120	0	0	0	0	0	0	0
13		Apr-82	11,977	0	0	0	0	0	0	0
14		May-82	35,025	0	0	0	0	0	0	0
15		Jun-82	146,407	0	0	0	0	0	0	0
16		Jul-82	97,301	0	0	0	0	0	0	0

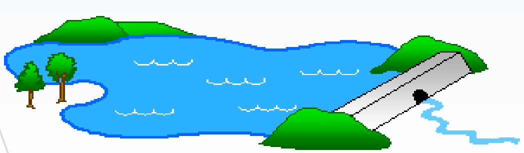
Simplified Water Allocation Model (SWAM)

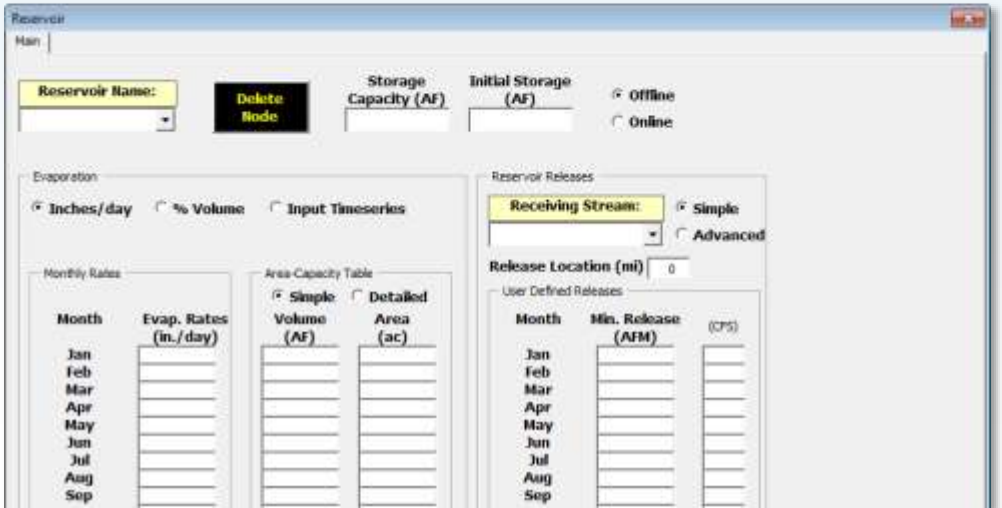
- Supports multiple layers of complexity for development of a range of systems, for example…

A Reservoir Object can include:

1. Basic hydrology dependent calculations
2. Operational rules of varying complexity such as prescribed releases, conditional releases, or hydrology dependent releases.

Reservoir

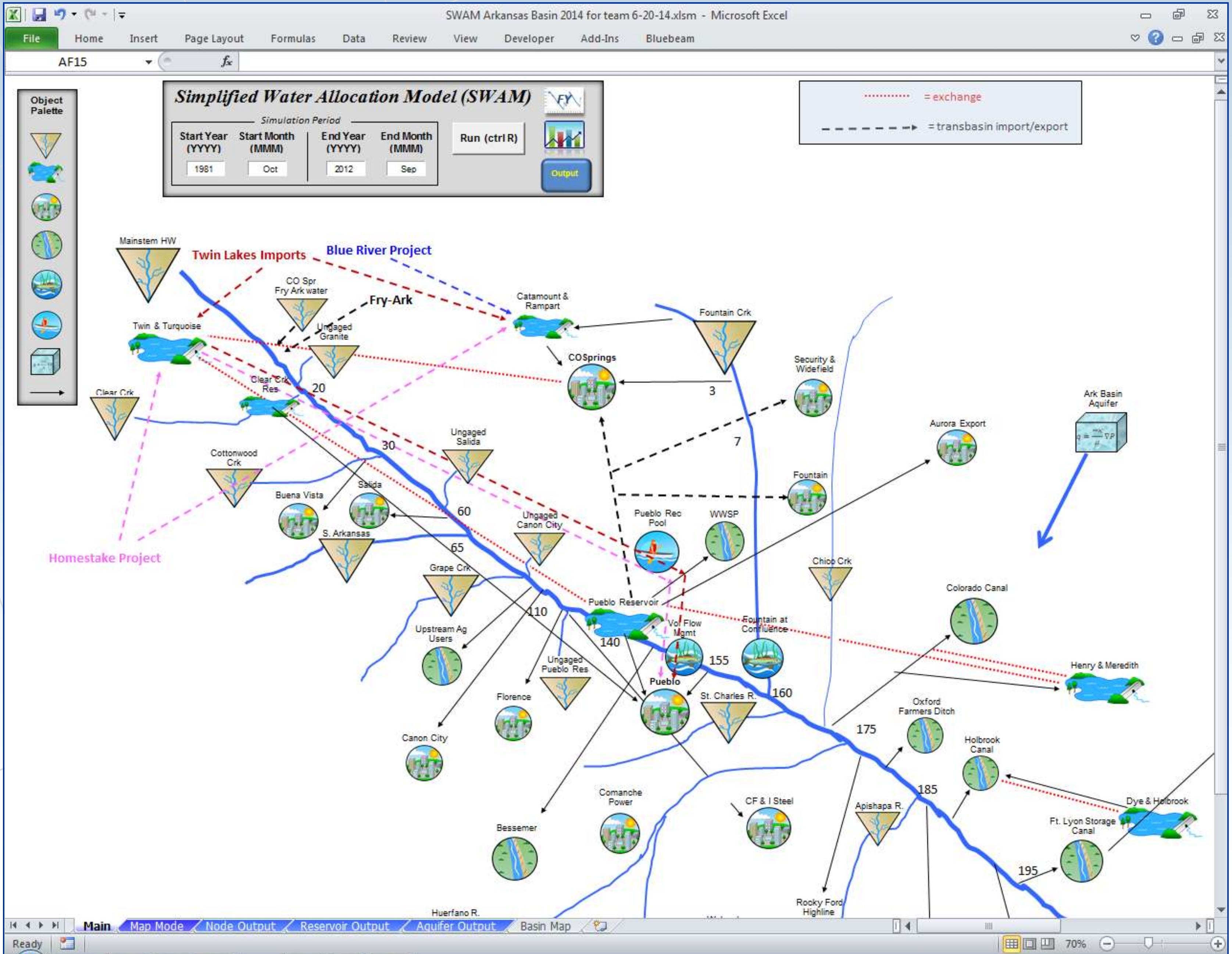




The Models Can Be Used To…

- Determine surface-water availability
- Predict where and when future water shortages would occur
- Test alternative water management strategies, new operating rules, and "what-if" scenarios
- Resolve water disputes
- Consolidate hydrologic data
- Evaluate the impacts of future withdrawals on instream flow needs
- Evaluate interbasin transfers
- Support development of Drought Management Plans
- Compare managed flows to natural flows

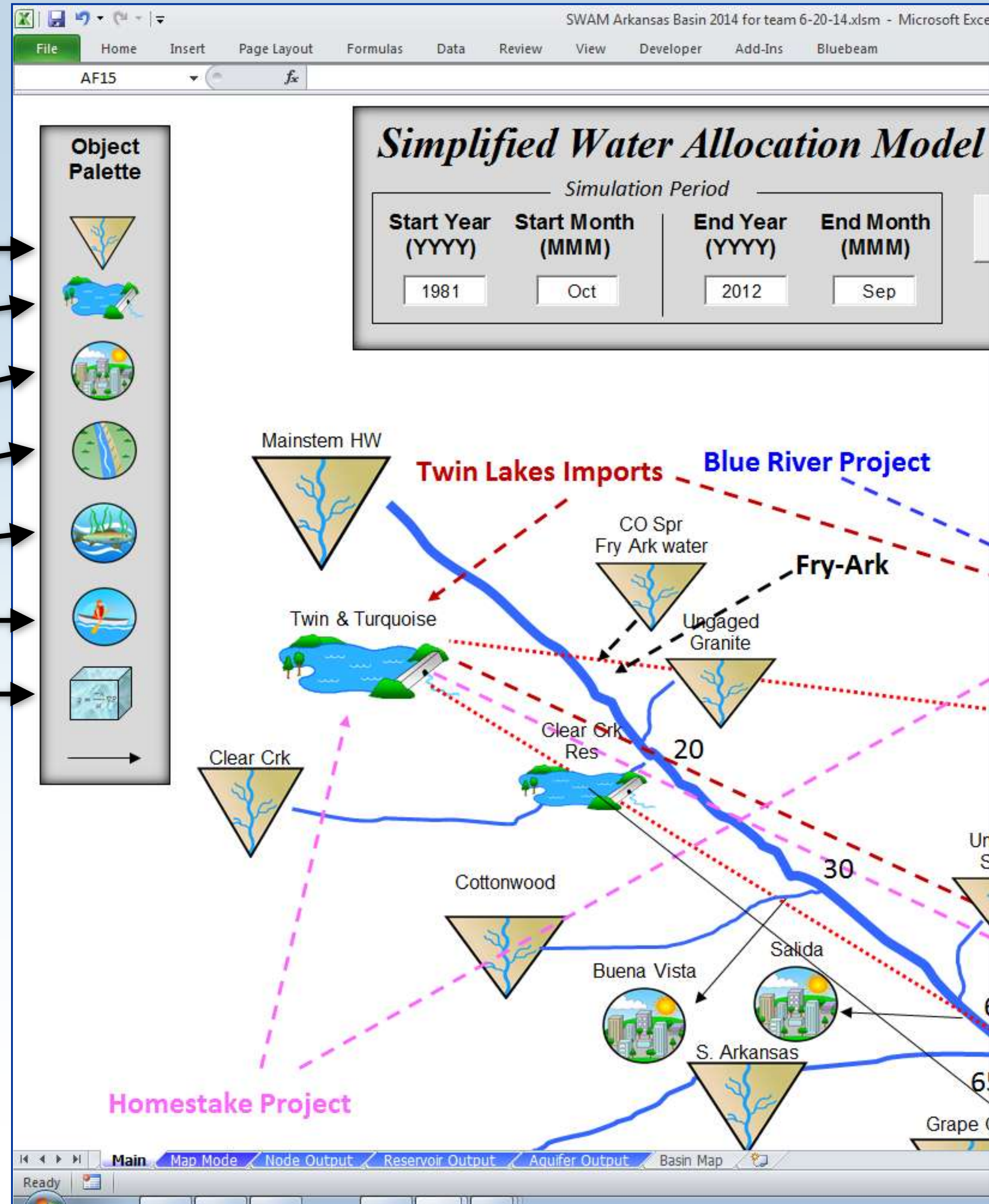
SWAM Model Main Screen



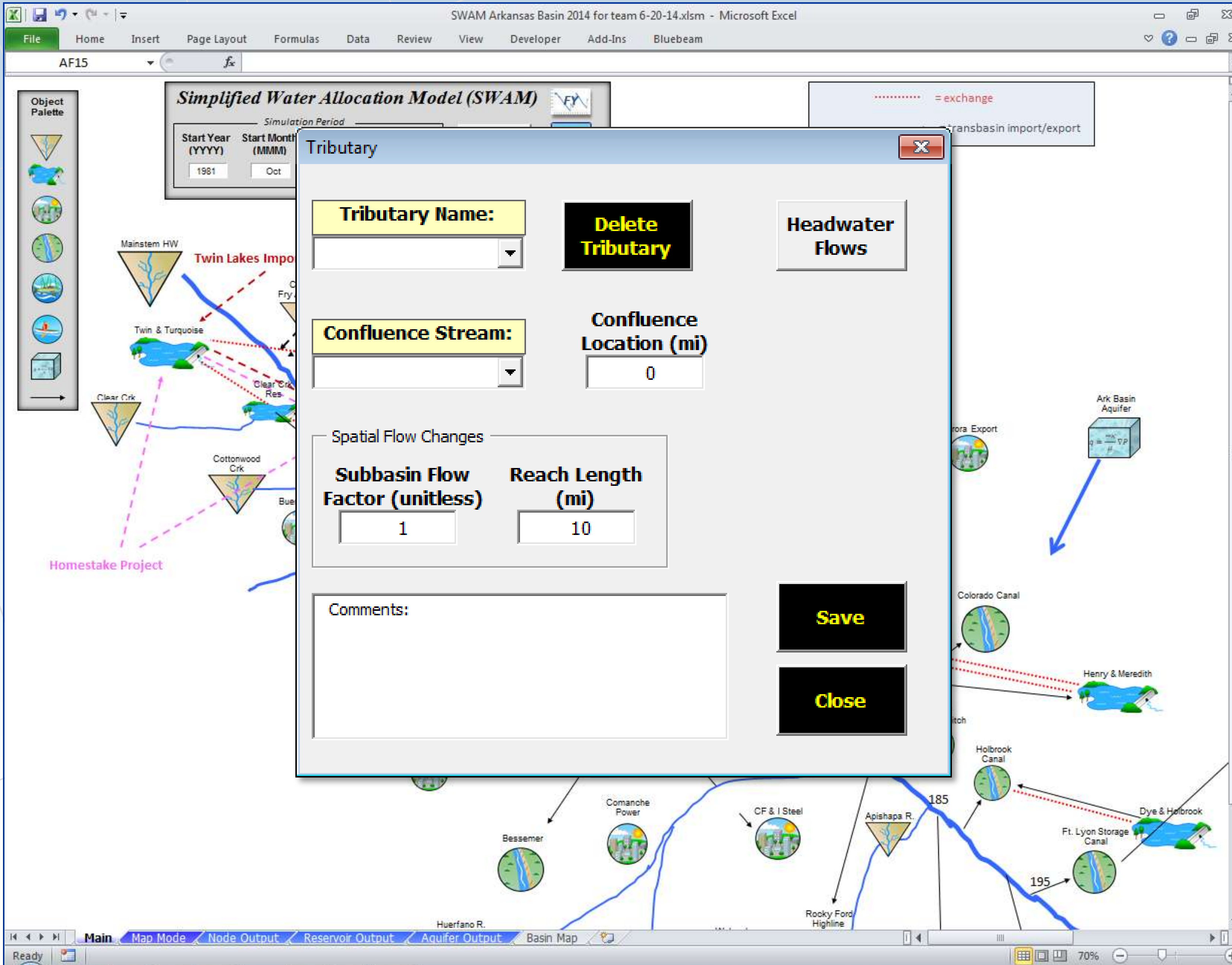
Object Palette

Objects

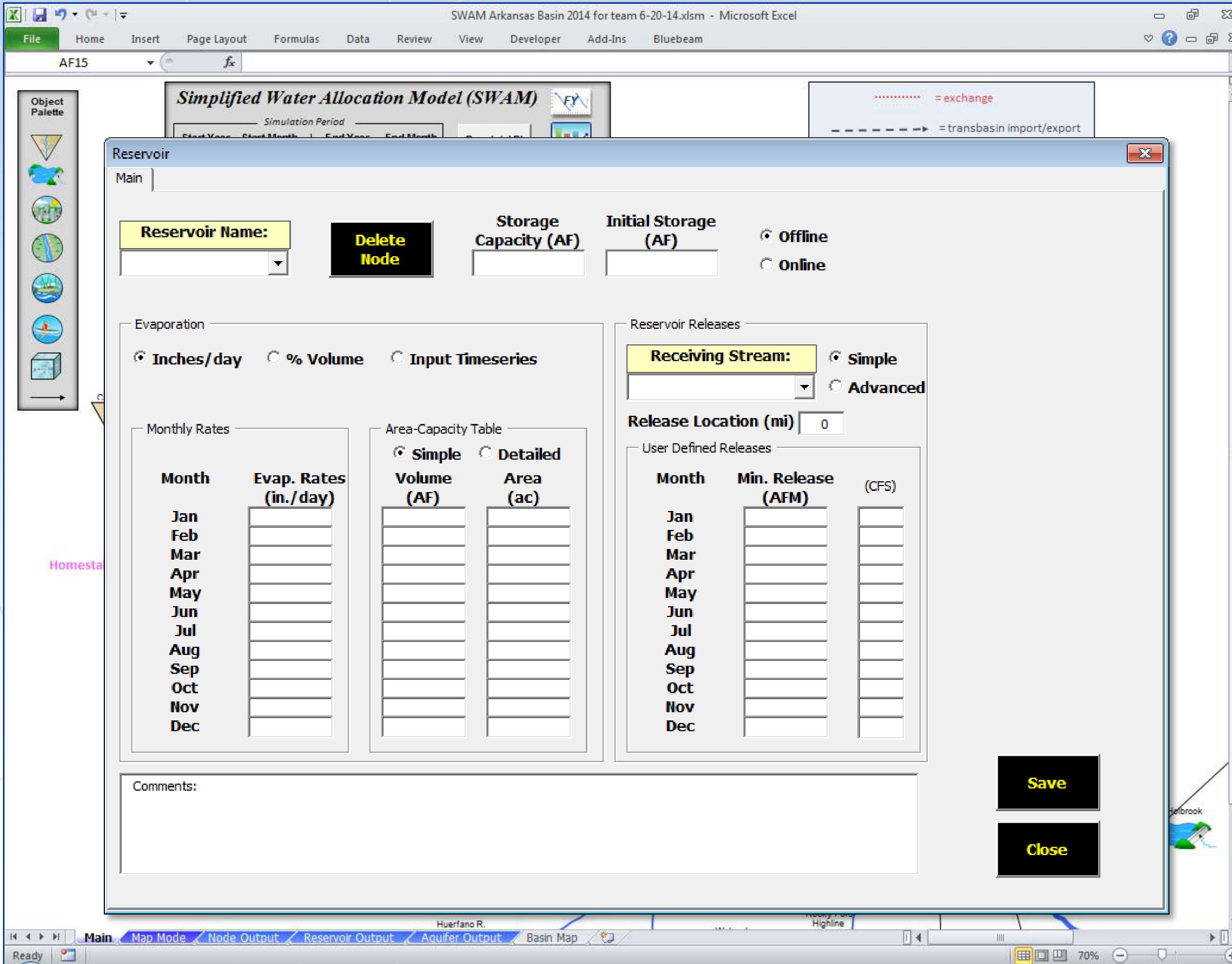
- Tributaries
- Reservoirs
- Water Users
- Agricultural Users
- Instream Flow
- Recreational Pool
- Aquifer



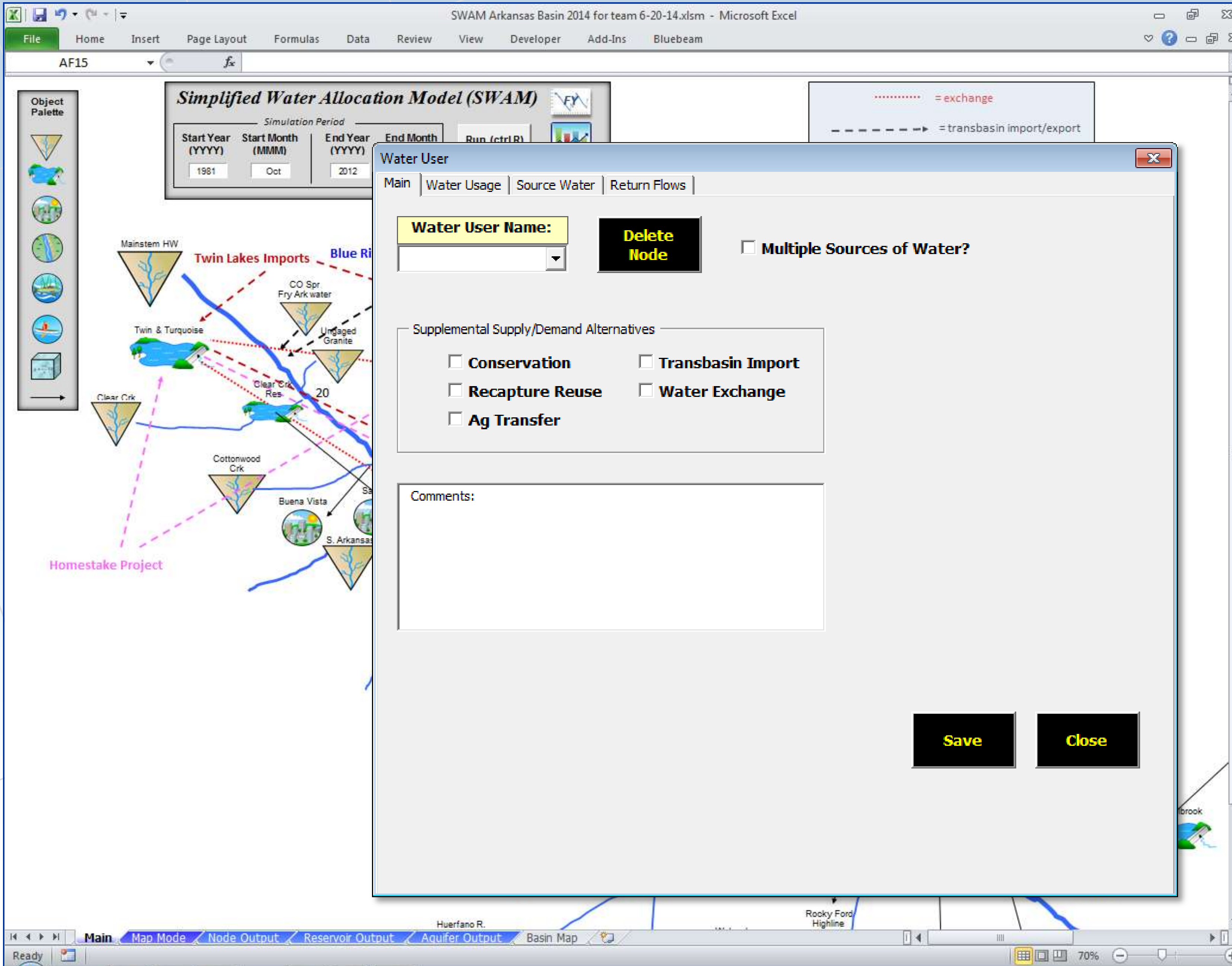
Tributary Input Form



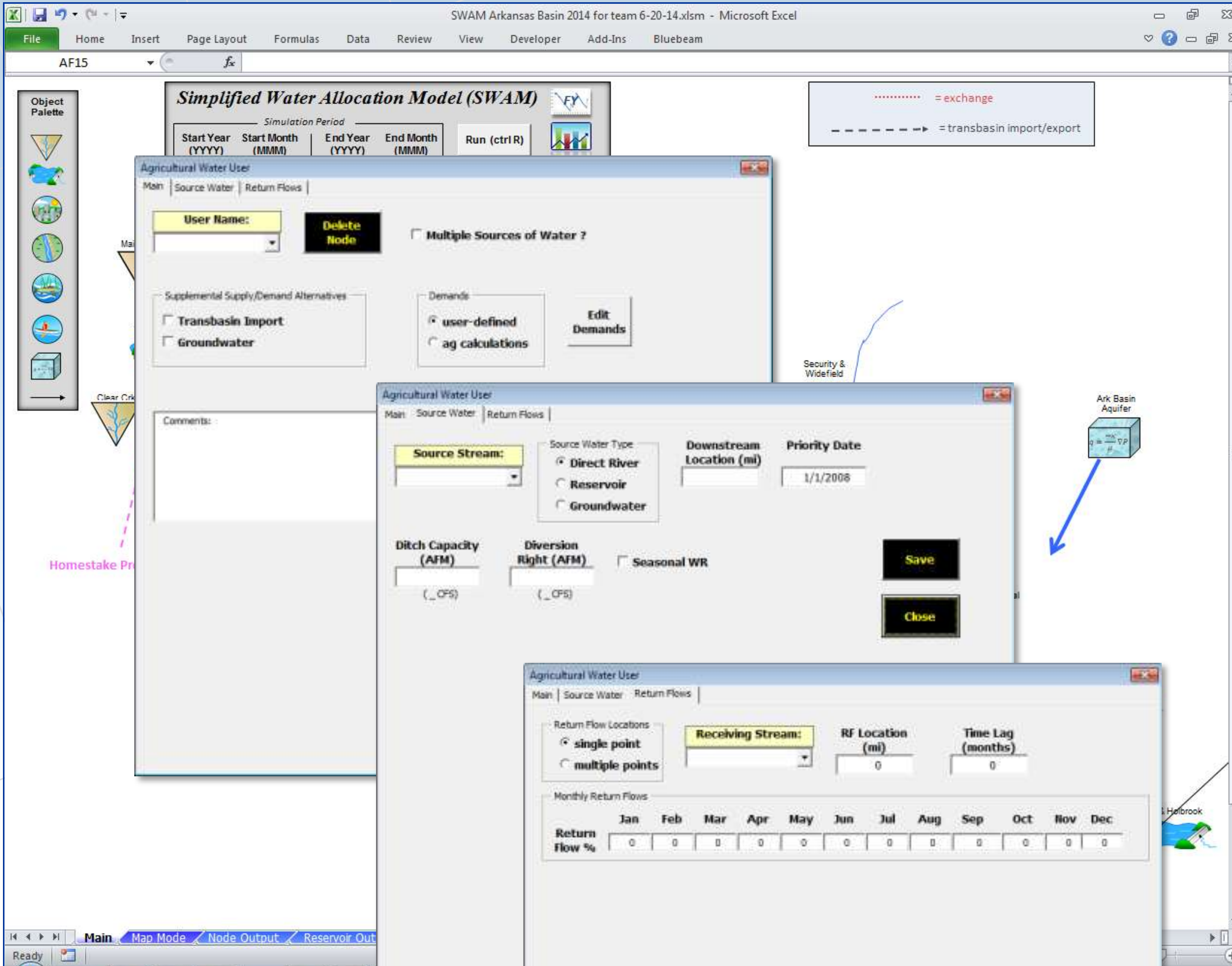
Reservoir Input Form



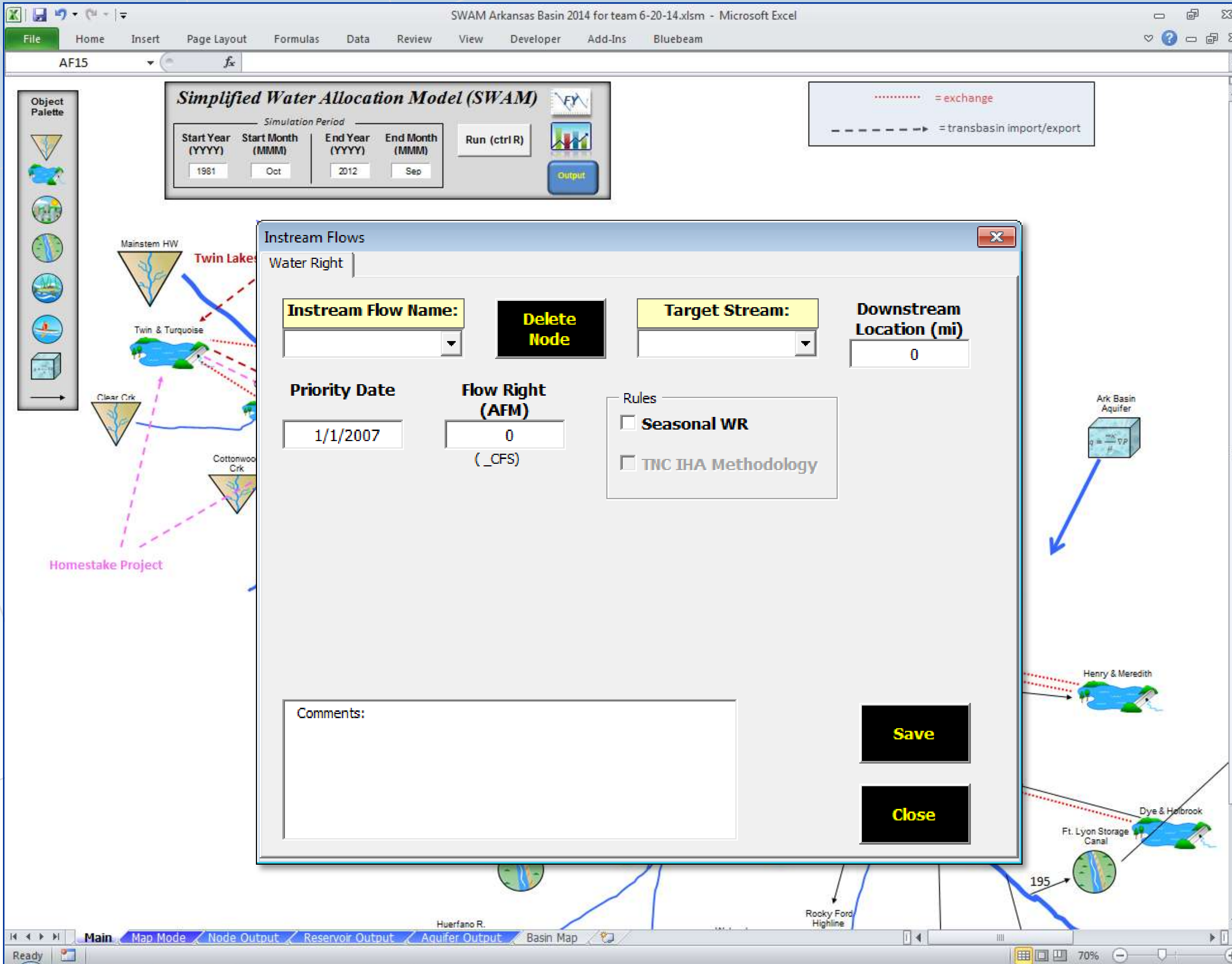
Water User Input Form – Main



Agricultural Water User Input Forms



Instream Flow Input Form



Output Tables

Node Output

SWAM Arkansas Basin 2014 for team 6-20-14.xlsm - Microsoft Excel

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	A	B	EY	EZ	FA	FB	FC	FD	FE	FF	FG	FH	FI	FJ	FK	FL
1	Output			Priority Rank	Reach (mi)	Location	Water Right (AFM)	Ditch Capacity (AFM)	Storage Capacity (AF)						Priority Rank	Reach (mi)
2			*Pueblo4*	*32*	*Mainstem*	*136*	*420*	*1,000,000*	*5,000*					*Fountain2*	*44*	*Mainstem*
3		Date	Physically Avail. (AFM)	Legally Avail. (AFM)	Diverted (AFM)	Storage (AF)	GW Pumping (AFM)	Demand (AFM)	Shortage (AFM)	Return Flow (AFM)	Release (AFM)	Evap Losses (AFM)		Physically Avail. (AFM)	Legally Avail. (AFM)	Diverted (AFM)
4		Min	1,200	0	0	0	0	0	0	0	0	0		1,200	0	0
5		Max	423,253	420	420	5,000	0	0	0	0	0	52		423,201	0	0
6		Avg	44,588	117	33	4,340	0	0	0	0	0	21		44,555	0	0
7		Oct-81	14,837	0	0	0	0	0	0	0	0	0		14,837	0	0
8		Nov-81	23,186	0	0	0	0	0	0	0	0	0		23,186	0	0
9		Dec-81	24,424	0	0	0	0	0	0	0	0	0		24,424	0	0
10		Jan-82	17,870	0	0	0	0	0	0	0	0	0		17,870	0	0
11		Feb-82	16,694	0	0	0	0	0	0	0	0	0		16,694	0	0
12		Mar-82	25,120	0	0	0	0	0	0	0	0	0		25,120	0	0
13		Apr-82	11,977	0	0	0	0	0	0	0	0	0		11,977	0	0
14		May-82	35,025	0	0	0	0	0	0	0	0	0		35,025	0	0
15		Jun-82	146,407	0												
16		Jul-82	97,301	0												
17		Aug-82	75,150	0												
18		Sep-82	73,884	420												
19		Oct-82	39,997	420												
20		Nov-82	4,595	0												
21		Dec-82	4,215	0												
22		Jan-83	16,663	420												
23		Feb-83	15,069	420												
24		Mar-83	26,208	420												
25		Apr-83	42,386	420												
26		May-83	47,647	420												
27		Jun-83	349,601	420												
28		Jul-83	178,891	420												
29		Aug-83	93,139	420												
30		Sep-83	21,418	0												
31		Oct-83	13,990	0												
32		Nov-83	1,200	0												
33		Dec-83	1,200	0												
34		Jan-84	18,621	420												
35		Feb-84	17,647	420												
36		Mar-84	40,025	420												
37		Apr-84	61,011	420												
38		May-84	224,609	420												
39		Jun-84	261,443	420												
40		Jul-84	147,595	420												
41		Aug-84	99,322	420												
42		Sep-84	30,073	0												
43		Oct-84	37,219	420												
44		Nov-84	1,200	0												
45		Dec-84	4,940	420												
46		Jan-85	22,847	420												

Node Output

Reservoir Output

SWAM Arkansas Basin 2014 for team 6-20-14.xlsm - Microsoft Excel

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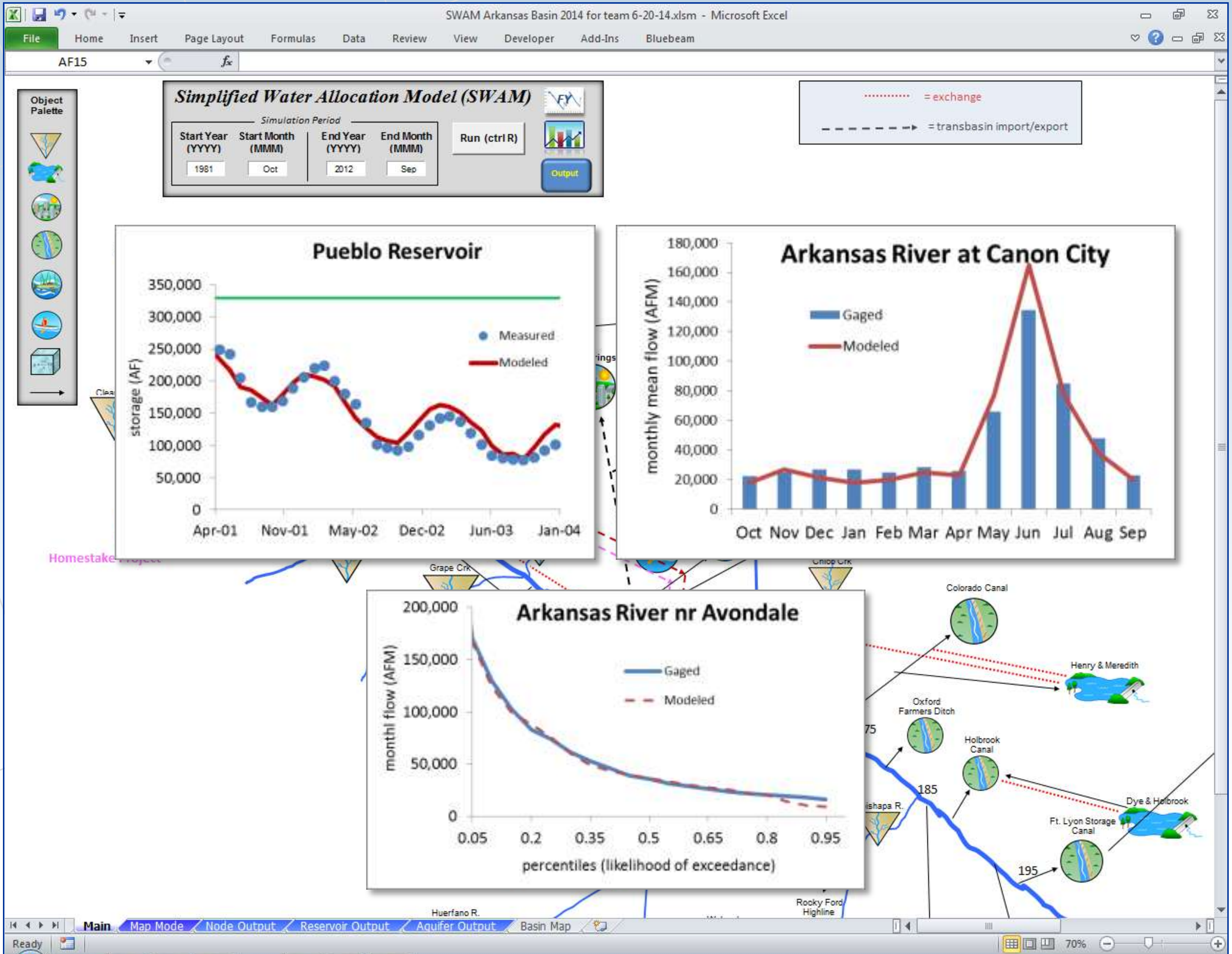
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Output					Total Capacity (AF)	Release Location						
2				*Pueblo Reservoir*		*330000.0*	*143.0*						*JMR*
3		Date		Storage (AF)	Excess Volume (AF)	Overflow (AFM)	Total Inflow (AFM)	Total Withdrawl (AFM)	Release (AFM)	Outflow (AFM)	Evap (AFM)		Storage (A
4		Min		37,367	0	0	2,862	4,373	0	0	0		7,545
5		Max		330,000	0	19,692	303,831	101,197	0	7,000	3,451		450,000
6		Avg		212,993	0	1,352	46,753	39,940	0	4,281	1,009		132,387
7		Oct-81		92,749	0	0	40,265	46,985	0	0	532		200,277
8		Nov-81		90,783	0	240	14,646	16,371	0	0	0		176,741
9		Dec-81		88,111	0	680	11,817	13,808	0	0	0		154,539
10		Jan-82		86,610	0	680	8,105	8,927	0	0	0		134,969
11		Feb-82		87,315	0	680	7,549	6,165	0	0	0		119,018
12		Mar-82		88,019	0	680	10,218	8,834	0	0	0		107,688
13		Apr-82		82,264	0	614	24,650	29,220	0	0	571		98,144
14		May-82		64,852	0	624	55,732	71,830	0	0	690		90,661
15		Jun-82		62,620	0	728	98,054	98,922	0	0	637		95,890
16		Jul-82		52,251	0	525	79,954	89,142	0	0	655		94,416
17		Aug-82		42,029	0	600	61,795	70,950	0	0	466		102,863
18		Sep-82		38,780	0	810	50,284	52,424	0	0	299		110,282
19		Oct-82		53,544	0	1,087	56,442	40,384	0	0	206		107,965
20		Nov-82		82,590	0	1,384	44,561	12,995	0	1,136	0		97,376
21		Dec-82		100,657	0	1,384	31,635	10,432	0	1,752	0		87,514
22		Jan-83		110,347	0	1,384	19,931	6,721	0	2,135	0		90,684
23		Feb-83		118,421	0	1,384	17,965	6,165	0	2,341	0		83,248
24		Mar-83		127,482	0	1,384	22,397	9,440	0	2,512	0		89,077
25		Apr-83		136,429	0	1,213	43,943	30,270	0	2,687	827		97,669
26		May-83		132,169	0	936	74,268	73,580	0	2,870	1,144		108,757
27		Jun-83		330,000	0	728	303,831	101,197	0	2,776	1,299		258,390

Calibration Result Graphs



Major Tasks

Task 1

Data Collection
- Streamflow, M&I and ag withdrawals, discharges, precipitation, reservoir operations, interconnections, facility operation dates, etc.

Stakeholder Input

Data Analysis
- Gap filling and record extension

Unimpaired Flow Development
- Daily mean UIFs

Task 2

Basin Schematic
- Model framework development

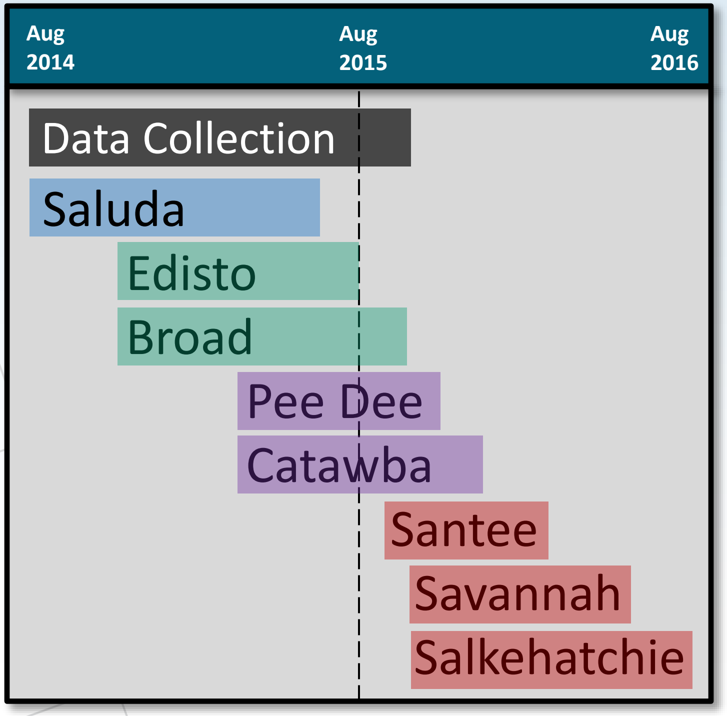
Stakeholder Input

Model Calibration
- Reproduce actual conditions

Baseline Model Runs
- Simulate current conditions

Schedule for Developing the Models

- ***Pilot Model*** of the Saluda River Basin
- Other models to follow, with order based on data availability
- 2-year schedule requires that groups of models be constructed in parallel



Schedule for Developing the Pilot Model

Task/Deliverable	Date
• Unimpaired Flow (UIF) Methodology	Dec 1, 2014
• Model Framework	Jan 15, 2015
• UIF Dataset	Mar 1, 2015
• Baseline Model Runs	May 1, 2015
• Final Calibrated Model	June 1, 2015
• Model Training and Users Manual	July 1, 2015

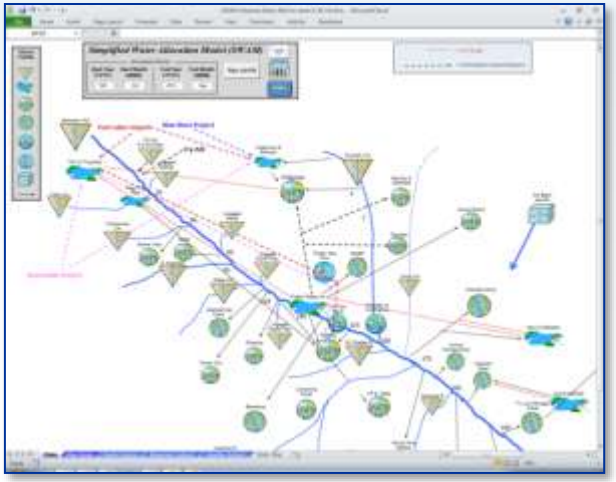
Data is Needed to Support…

1. Development of Unimpaired Flows (UIFs)

UIF Definitions: - Flow in a river as it would be in a completely unaltered state
- Historically observed flows with human influences removed

UIFs Provide: A baseline for evaluating impacts of human use by allowing analysts to compare altered flows to UIFs

2. Development of each baseline model
   - A. Withdrawal and return amounts and locations
   - B. Current reservoir operating rules
   - C. Drought Management Plans and Requirements
   - D. Instream flow requirements

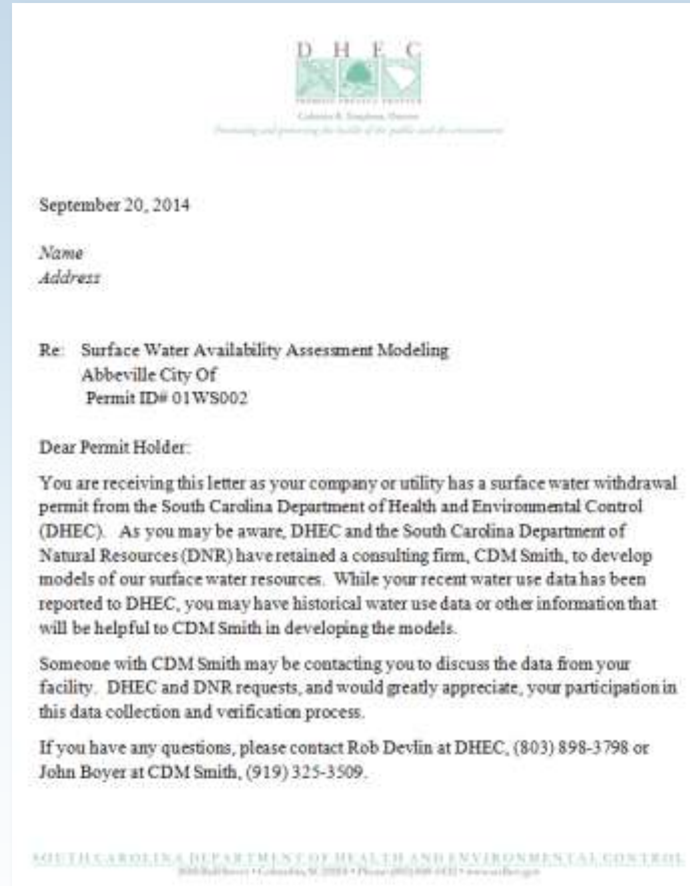


Data Needed to Support Unimpaired Flows

- Streamflow, dating back to earliest continuous gage data
- Historical withdrawals (>100,000 gpd) and discharges for M&I, thermoelectric, agriculture, hydropower
- Reservoirs
  - a) Operating rules and elevation-storage-area curves
  - b) Historical elevation release data
  - c) Precipitation and evaporation records
- Interconnections

Data Collection

1. Permitted surface water users will be contacted by CDM Smith to:
   - A. Confirm the history of your water source(s) and operation
   - B. Collect additional data that may be useful to characterize and quantify historical water withdrawals and discharges for UIF development
2. CDM Smith will follow-up with an e-mail confirming our understanding of your data



D H E C

September 20, 2014

Name
Address

Re: Surface Water Availability Assessment Modeling
Abbeville City Of
Permit ID# 01WS002

Dear Permit Holder:

You are receiving this letter as your company or utility has a surface water withdrawal permit from the South Carolina Department of Health and Environmental Control (DHEC). As you may be aware, DHEC and the South Carolina Department of Natural Resources (DNR) have retained a consulting firm, CDM Smith, to develop models of our surface water resources. While your recent water use data has been reported to DHEC, you may have historical water use data or other information that will be helpful to CDM Smith in developing the models.

Someone with CDM Smith may be contacting you to discuss the data from your facility. DHEC and DNR requests, and would greatly appreciate, your participation in this data collection and verification process.

If you have any questions, please contact Rob Devlin at DHEC, (803) 898-3798 or John Boyer at CDM Smith, (919) 325-3509.

SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL