DUPAGECOUNTY

STORMWATER MANAGEMENT

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DuPage County Stormwater Management

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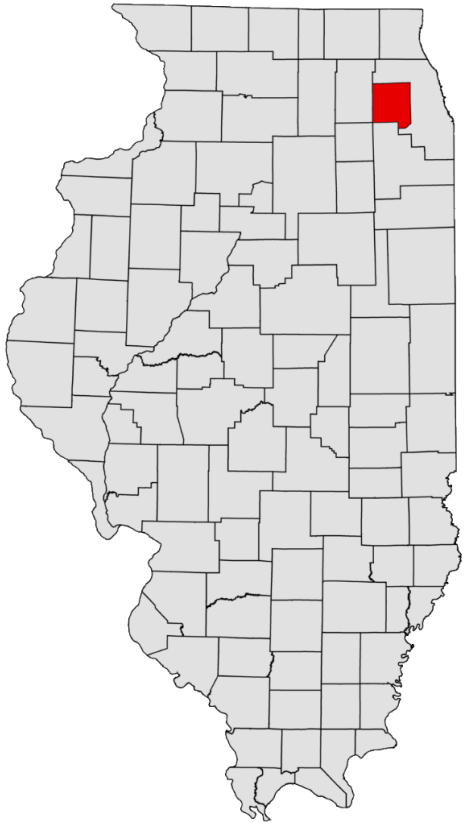
Automation of HSPF Procedures for Event Selection and Model Calibration

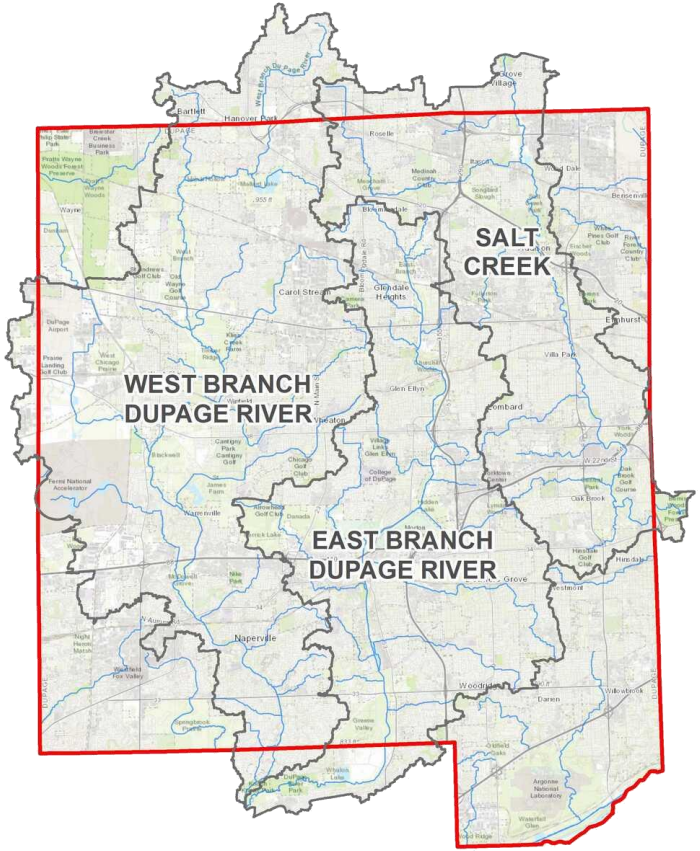
IAFSM Conference 2022 – March 8th, 2022

Jack T. Knuepfer Administration Building, 421 N. County Farm Rd., Wheaton, IL 60187

(630) 407-6700 • www.dupageco.org/swm

1. County Overview
2. History of the Department
3. Watershed Characteristics
4. Hydraulic & Hydrologic Methodology
5. Hydrology Procedures
6. Automation





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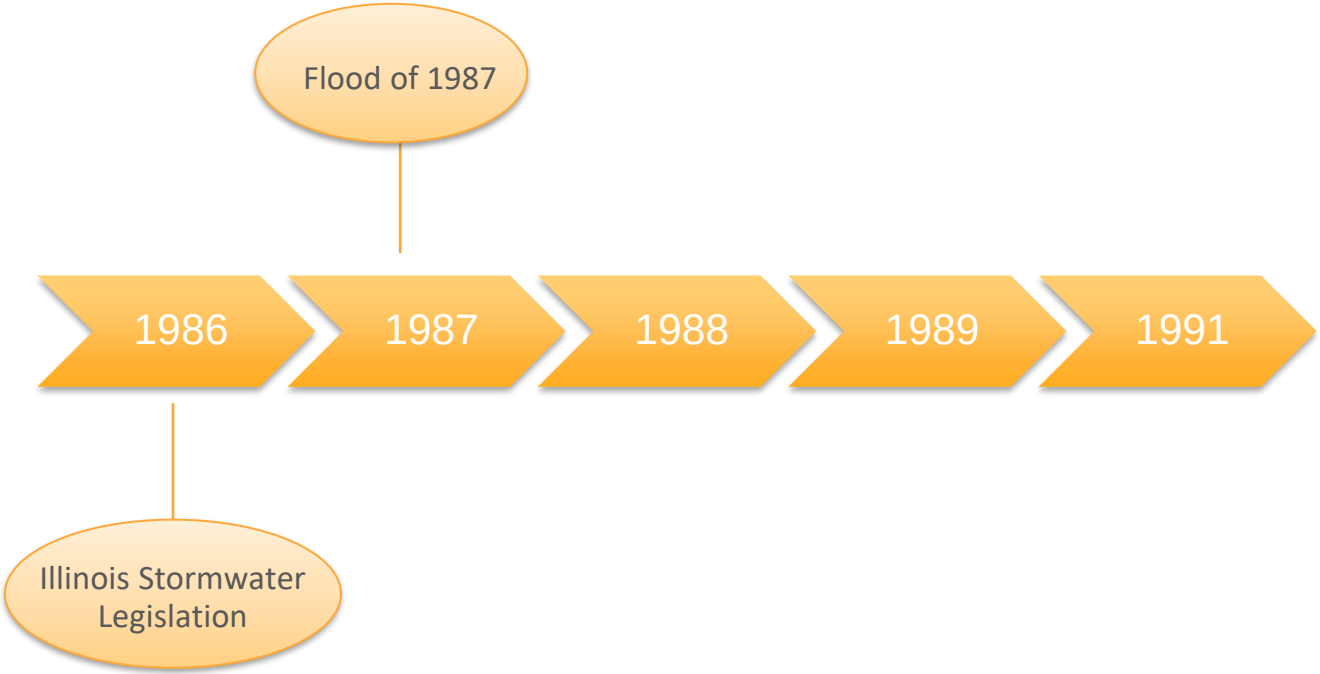

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History of our Department

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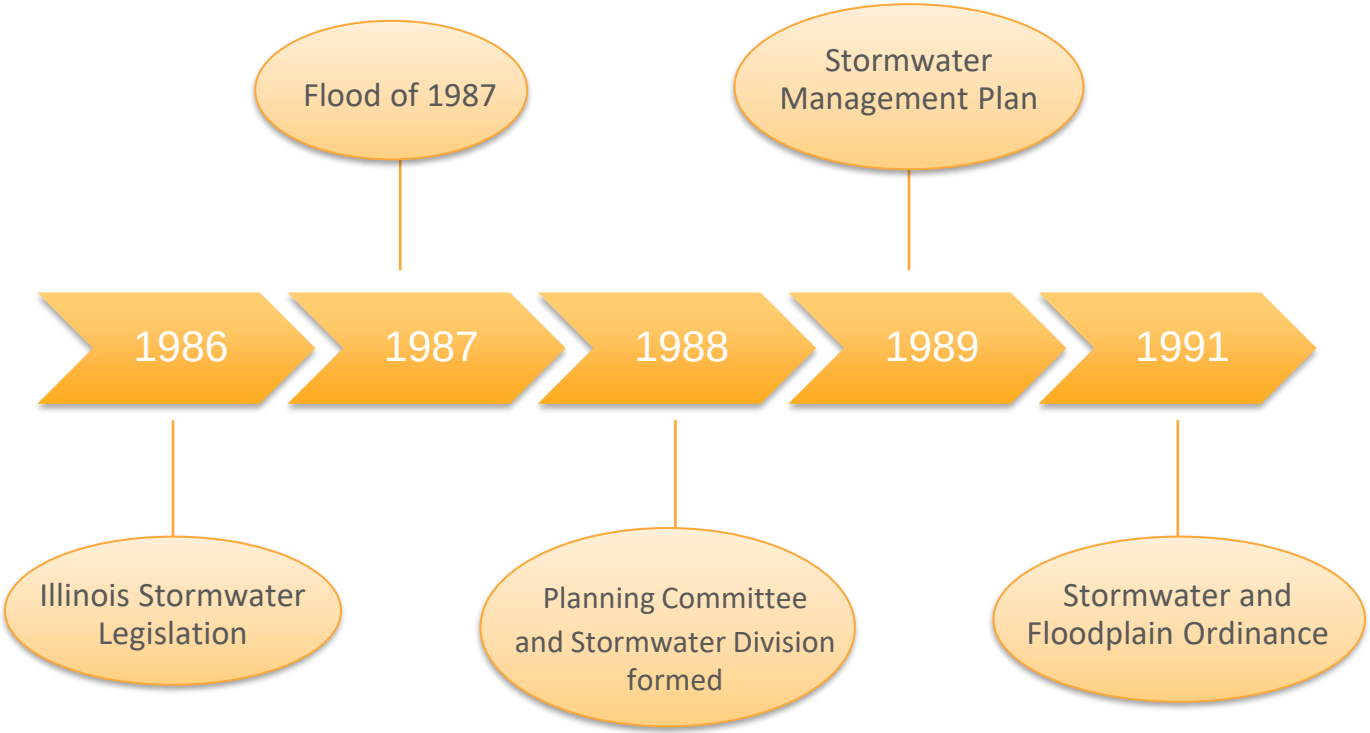
THE FLOOD OF '87


13FT 10IN



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History of our Department

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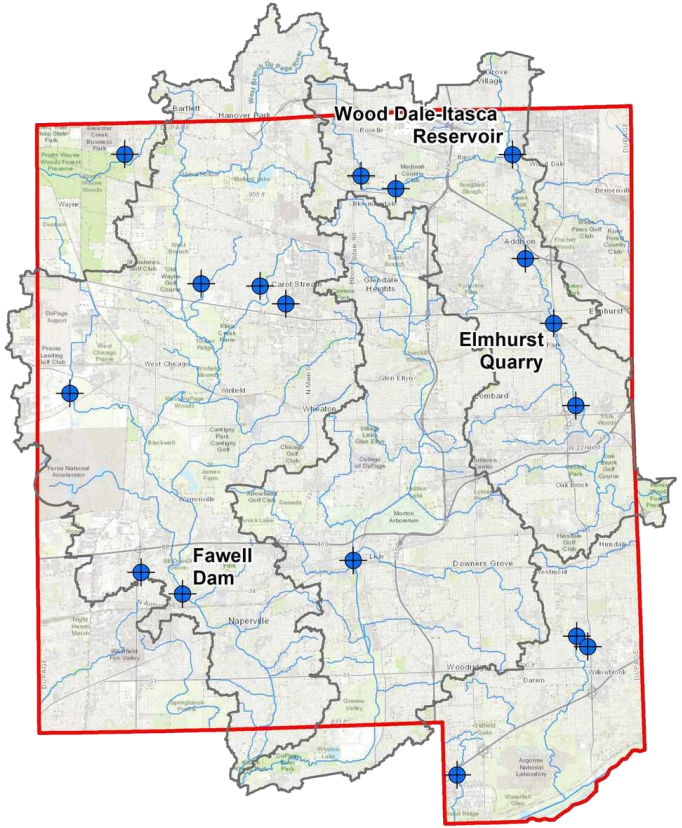
Watershed Characteristics

- Urbanized
- Very flat, numerous flow paths
- Backwater effects
- Flood control facilities – pump & gate operations
- Offline storage



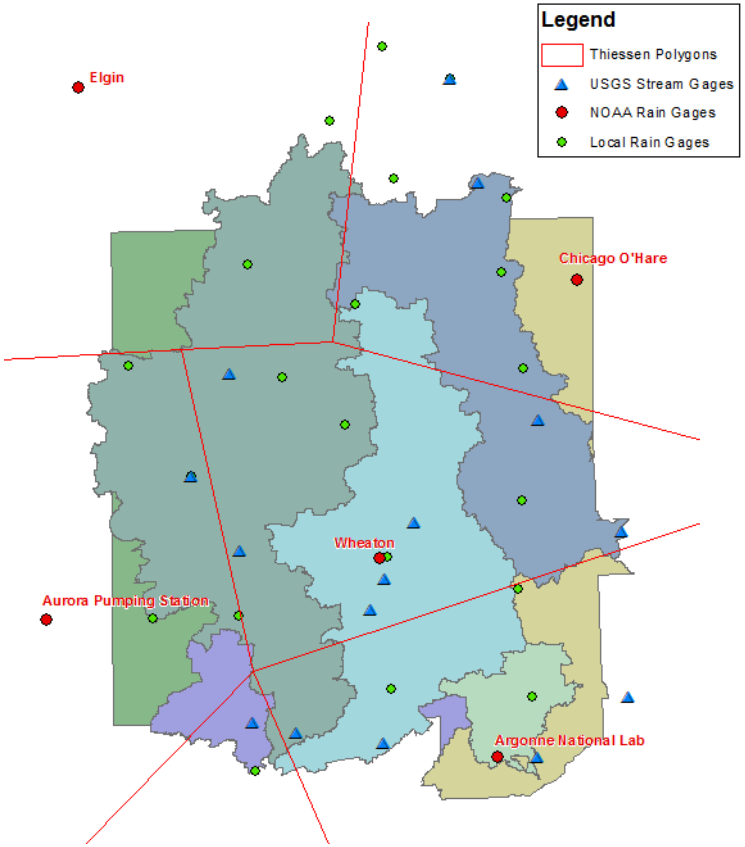
Hydrology

Hydrological Simulation Program - FORTRAN (HSPF)

- Continuous simulation
- Land cover types (eg. Impervious, grass, forest, agriculture)
- Recalibrated approximately every 10 years

Rain & Stream Gage Network

- Used to drive the hydrology model
- NOAA Gages: Wheaton, O'Hare, Elgin, Aurora, Argonne
    * Continuous rainfall record since 1949
    * Thiessen Polygons
- 28 additional rain gages
- 12 streamflow gages



Hydraulics

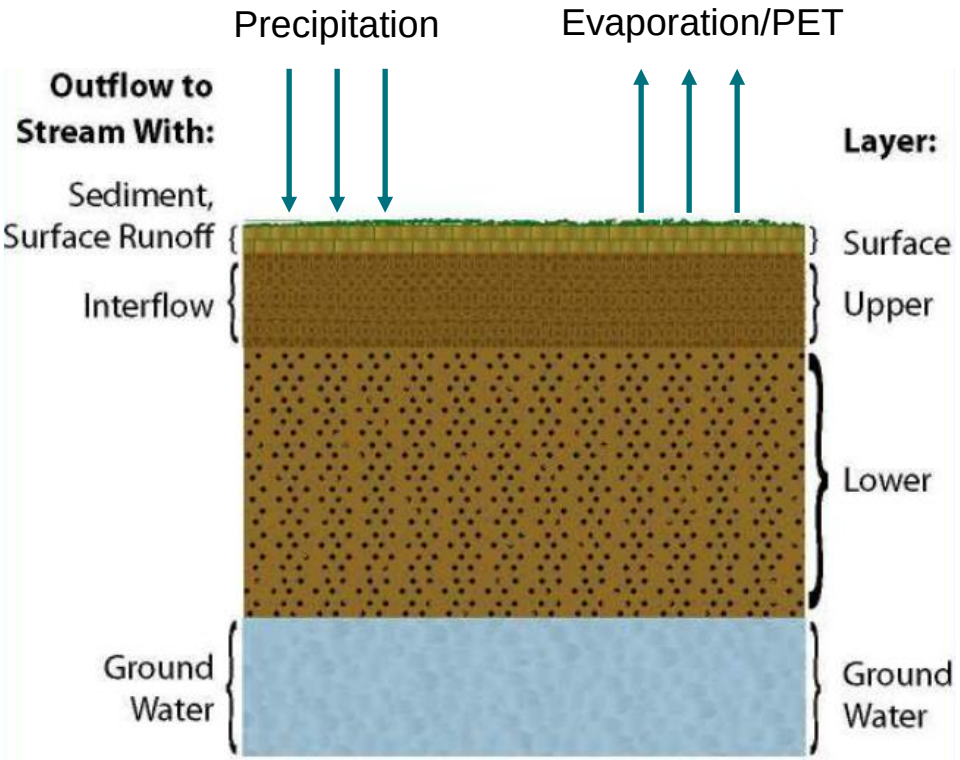
Full Equations (FEQ)

- 1-D, Unsteady flow
- Historical storm data – 157 Events
- Regulatory model

(Credit: Lake County Stormwater Management Commission)

Hydrology Procedures

- Continuous simulation vs design storm
- Data collection & Processing
- HSPF modeling
- Calibration
    - *Event selection
    - *FEQ modeling



Adapted from AquaTerra

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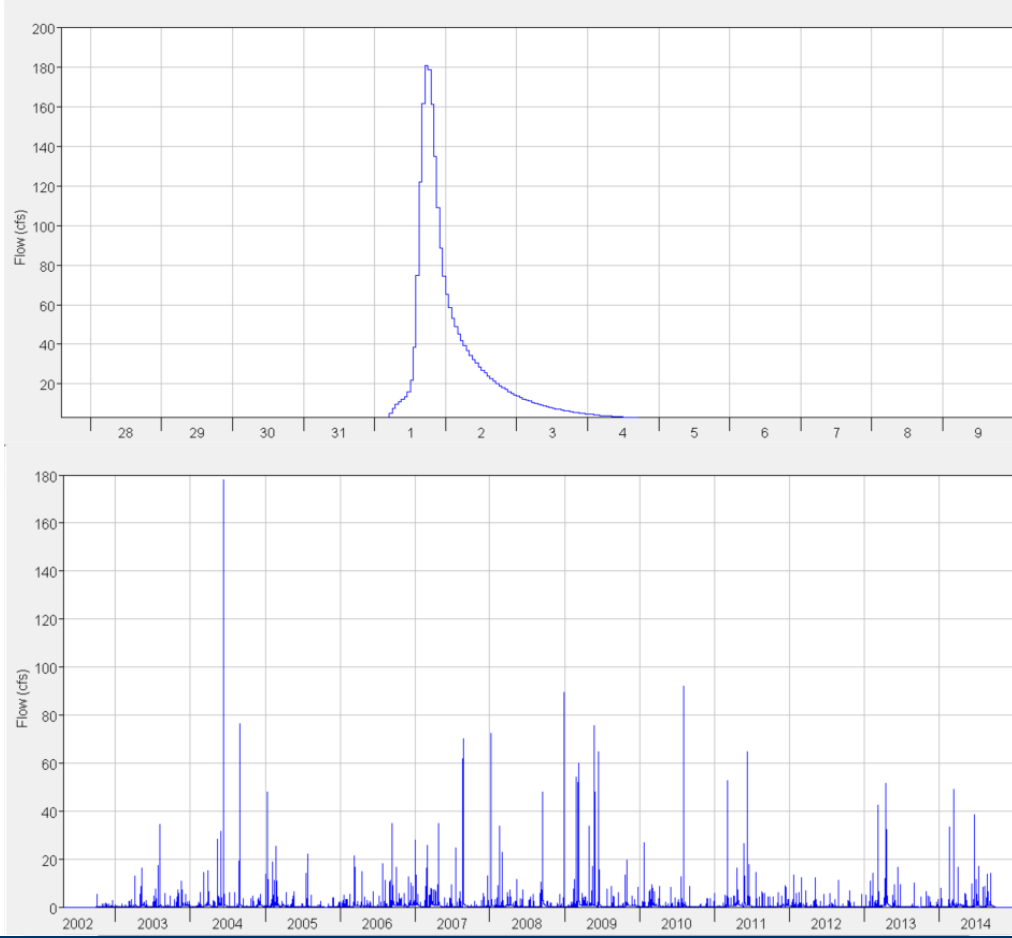

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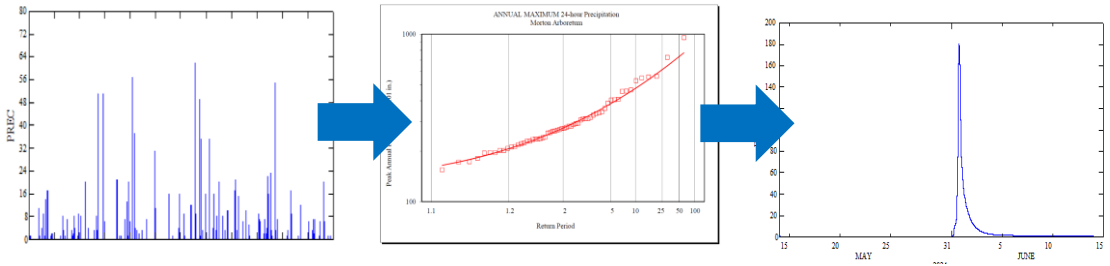
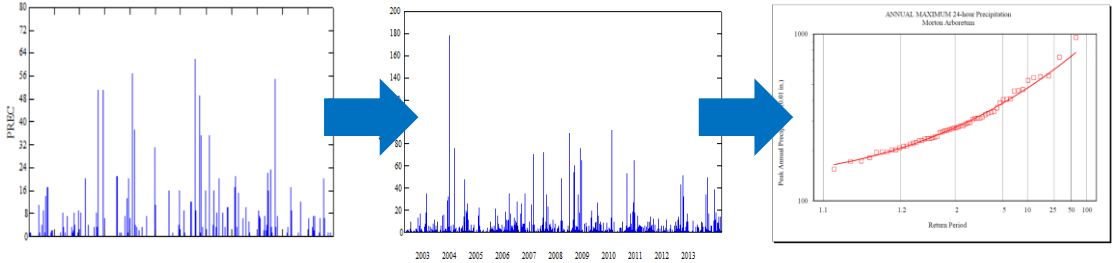
Design Storm



Rainfall record | Frequency Analysis | Modeling

Continuous Simulation



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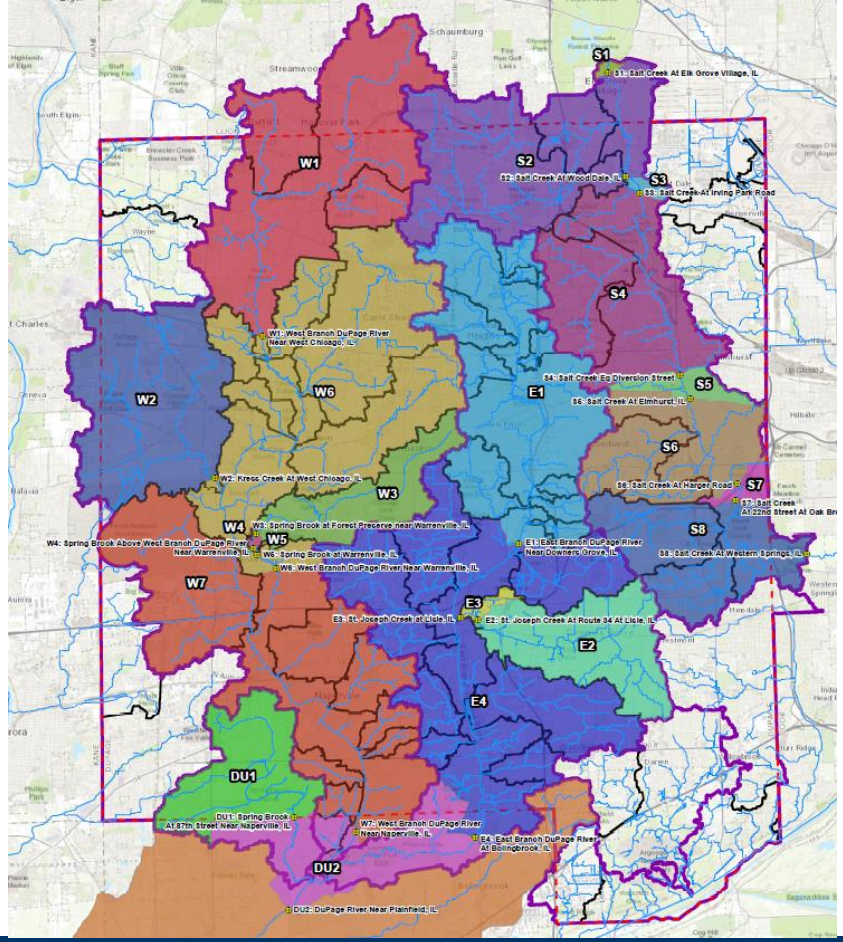

Data Collection & Processing

- NOAA precipitation
- USGS precipitation
- Argonne meteorology
- Wastewater facility discharge
- USGS Streamflow
- Precipitation Disaggregation

Data Collection & Processing

USGS Streamflow

agency_cd	site_no	datetime	02_00060_00003	02_00060_00003_cd
5s	15s	16d	14n	10s
USGS	05540091	1991-10-01	8.8	Ae
USGS	05540091	1991-10-02	10	Ae
USGS	05540091	1991-10-03	15	Ae
USGS	05540091	1991-10-04	28	Ae

Argonne Meteorologic Data

1	4	20	0030	E	3.4	3.9	11.1	2.3	7.4	2.4	20.0	2.5	0.8	86.4	-0.4	0.0	0.00	-11.00	99.44
1	4	20	0130	F	350.4	3.6	11.5	2.3	347.3	2.4	20.0	2.5	0.7	86.3	-0.4	0.0	0.00	-12.60	99.43
1	4	20	0230	E	344.2	3.6	9.3	2.1	346.3	2.4	19.1	2.3	0.7	86.5	-0.4	0.0	0.00	-13.60	99.42
1	4	20	0330	F	348.5	3.2	10.4	2.1	350.2	2.2	18.3	2.2	0.5	86.4	-0.4	0.0	0.00	-13.70	99.44
1	4	20	0430	F	356.9	3.6	9.3	2.1	4.7	2.1	19.6	2.2	0.5	86.3	-0.3	0.0	0.00	-13.70	99.46
1	4	20	0530	D	11.4	3.1	9.6	2.2	18.2	2.0	21.0	2.3	0.5	85.9	-0.3	0.0	3.00	-10.50	99.48
1	4	20	0630	D	9.0	2.9	11.4	2.4	15.8	2.1	20.6	2.7	0.7	85.1	-0.5	0.0	38.60	15.90	99.53
1	4	20	0730	C	9.0	2.6	18.8	2.9	11.7	2.4	23.2	3.3	1.1	83.2	-0.8	0.0	109.10	64.30	99.60
1	4	20	0830	C	5.1	2.9	15.6	3.6	11.3	2.6	20.0	4.0	1.4	81.2	-0.9	0.0	197.50	124.10	99.68

NOAA Daily Precipitation

DSET	COOPID	WBNID	STATION NAME	CD	ELEM	UN	YEARMO	DAHR	DAY01	F	F	DAHR	DAY02	F	F	DAHR	DAY03	F	F	DAHR	DAY04	F	F	DAHR	DA
3210	111549	94846	CHICAGO OHARE INTL AP	02	PRCP	HI	200001	0124	00000	T	0	0224	00001		0	0324	00025		0	0424	00000	T	0	0524	00
3210	111549	94846	CHICAGO OHARE INTL AP	02	PRCP	HI	200002	0124	00000		S	0224	00000	T	0	0324	00000	T	0	0424	00000	T	0	0524	00
3210	111549	94846	CHICAGO OHARE INTL AP	02	PRCP	HI	200003	0124	00005		0	0224	00000		0	0324	00000		0	0424	00000		0	0524	00
3210	111549	94846	CHICAGO OHARE INTL AP	02	PRCP	HI	200004	0124	00000	T	0	0224	00000	T	0	0324	00000		0	0424	00000	T	0	0524	00
3210	111549	94846	CHICAGO OHARE INTL AP	02	PRCP	HI	200005	0124	00016		S	0224	00000		0	0324	00000	T	0	0424	00000		0	0524	00
3210	111549	94846	CHICAGO OHARE INTL AP	02	PRCP	HI	200006	0124	00036		S	0224	00001		0	0324	00000		0	0424	00003		0	0524	00
3210	111549	94846	CHICAGO OHARE INTL AP	02	PRCP	HI	200007	0124	00000		0	0224	00146		S	0324	00012		S	0424	00000	T	0	0524	00

USGS Hourly Precipitation

Precip	1999	12	31	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Precip	1999	12	31	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Precip	2000	01	01	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Precip	2000	01	01	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Precip	2000	01	02	1	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0

Precipitation Disaggregation

	A	B	C	D	E	F	G	H	I
1		Daily			Disaggregation Gages				
2		Wheaton		DISAG	Lisle	Whtn Sewer	Whtn Water	Wooddale	Argonne
314	10/14/2014 4:00			0.00	0.00	0.00	0.00	0.00	0.00
315	10/14/2014 5:00			0.00	0.00	0.00	0.00	0.00	0.00
316	10/14/2014 6:00	0.77	Fractional dist. w/ DSN	0.01	0.00	0.00	0.00	0.01	0.00
317	10/14/2014 7:00			0.05	0.05	0.05	0.05	0.05	0.05
318	10/14/2014 8:00			0.02	0.06	0.02	0.02	0.02	0.02
319	10/14/2014 9:00			0.00	0.00	0.01	0.01	0.00	0.08
320	10/14/2014 10:00			0.00	0.03	0.00	0.00	0.00	0.00
321	10/14/2014 11:00			0.00	0.01	0.00	0.00	0.00	0.00
322	10/14/2014 12:00			0.01	0.00	0.18	0.18	0.01	0.01
323	10/14/2014 13:00			0.30	0.00	0.05	0.05	0.31	0.05
324	10/14/2014 14:00			0.00	0.01	0.00	0.00	0.00	0.00
325	10/14/2014 15:00			0.24	0.00	0.00	0.00	0.25	0.00
326	10/14/2014 16:00			0.23	0.40	0.09	0.09	0.24	0.07
327	10/14/2014 17:00			0.04	0.32	0.45	0.26	0.04	0.06
328	10/14/2014 18:00			0.10	0.06	0.29	0.29	0.10	0.05
329	10/14/2014 19:00			0.12	0.10	0.11	0.11	0.12	0.10
330	10/14/2014 20:00			0.05	0.07	0.07	0.07	0.05	0.16
331	10/14/2014 21:00			0.03	0.01	0.02	0.02	0.03	0.03
332	10/14/2014 22:00			0.00	0.00	0.00	0.00	0.00	0.01
333	10/14/2014 23:00			0.00	0.00	0.00	0.00	0.00	0.00
334	10/15/2014 0:00			0.00	0.00	0.00	0.00	0.00	0.00
335	10/15/2014 1:00			0.00	0.00	0.00	0.00	0.00	0.00
336	10/15/2014 2:00			0.00	0.00	0.00	0.00	0.00	0.01
337	10/15/2014 3:00			0.01	0.01	0.02	0.02	0.01	0.02
338	10/15/2014 4:00			0.02	0.01	0.01	0.01	0.02	0.01
339	10/15/2014 5:00			0.01	0.00	0.00	0.00	0.01	0.01
340	10/15/2014 6:00	1.23	Fractional dist. w/ DSN	0.02	0.00	0.00	0.00	0.02	0.00
341	10/15/2014 7:00			0.03	0.00	0.00	0.00	0.00	0.02
342	10/15/2014 8:00			0.00	0.00	0.00	0.00	0.00	0.00

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DuPage County Stormwater Management

HSPF Modeling

- Six Land Covers
- Two parameter sets
- Five Precipitation gages
- Flow accumulation at streamflow gag

Table 3: Land Use to Land Cover Conversion

Land Use Category	% Impervious	% Grass	% Forest
Single family residential, storm sewered; average lot size:			
< 0.15 acre	23.0	70.5	6.5
> 0.15 acre	23.0	70.5	6.5
> 0.2 acre	15.6	77.9	6.5
> 0.3 acre	9.4	84.1	6.5
> 0.4 acre	5.7	87.8	6.5
> 0.5 acre	3.2	90.3	6.5
> 0.6 acre	1.6	91.9	6.5
> 0.7 acre	0.7	92.8	6.5
> 0.8 acre	0.5	93.0	6.5
> 1 acre	0.3	93.2	6.5
Single family residential, non storm sewered; average lot size:			
> 0.15 acre	20.7	72.8	6.5
> 0.15 acre	20.7	72.8	6.5
> 0.2 acre	14.0	79.5	6.5
> 0.3 acre	5.6	87.9	6.5
> 0.4 acre	3.4	90.1	6.5
> 0.5 acre	1.9	91.6	6.5
> 0.6 acre	0.5	93.0	6.5
> 0.7 acre	0.2	93.3	6.5
> 0.8 acre	0.2	93.3	6.5
> 1 acre	0.1	93.4	6.5
Mulit-family residential			
Low Density	40	50	10
High Density	50	40	10
Commercial/Industrial	85	15	0
Roadway - sewered	65	35	0
Roadway - unsewered	50	50	0
Office Research - General	40	55	5
Business Park			

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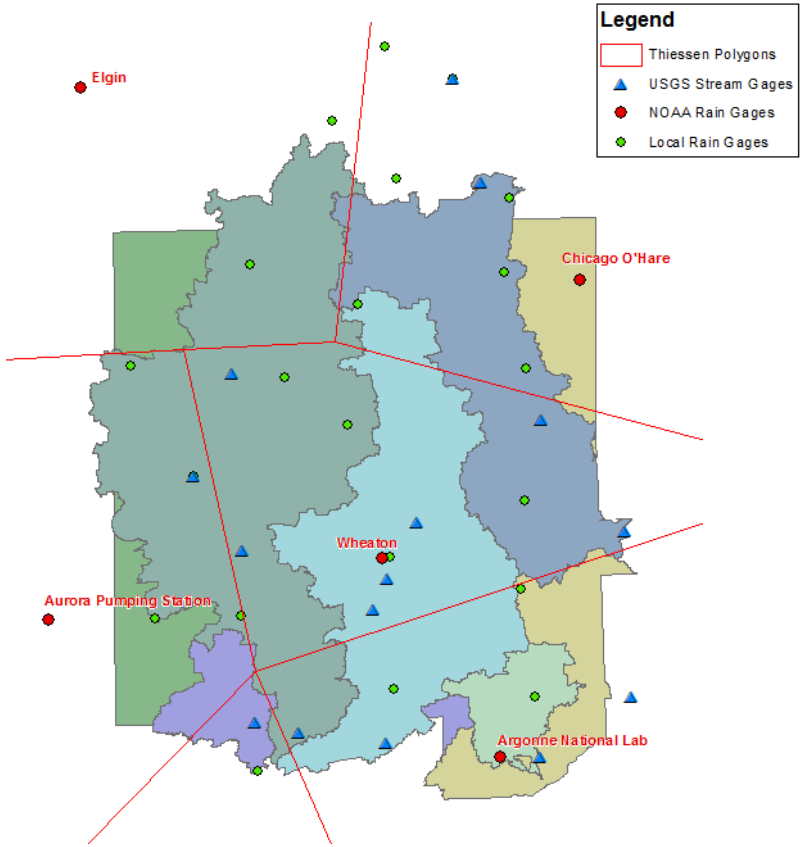
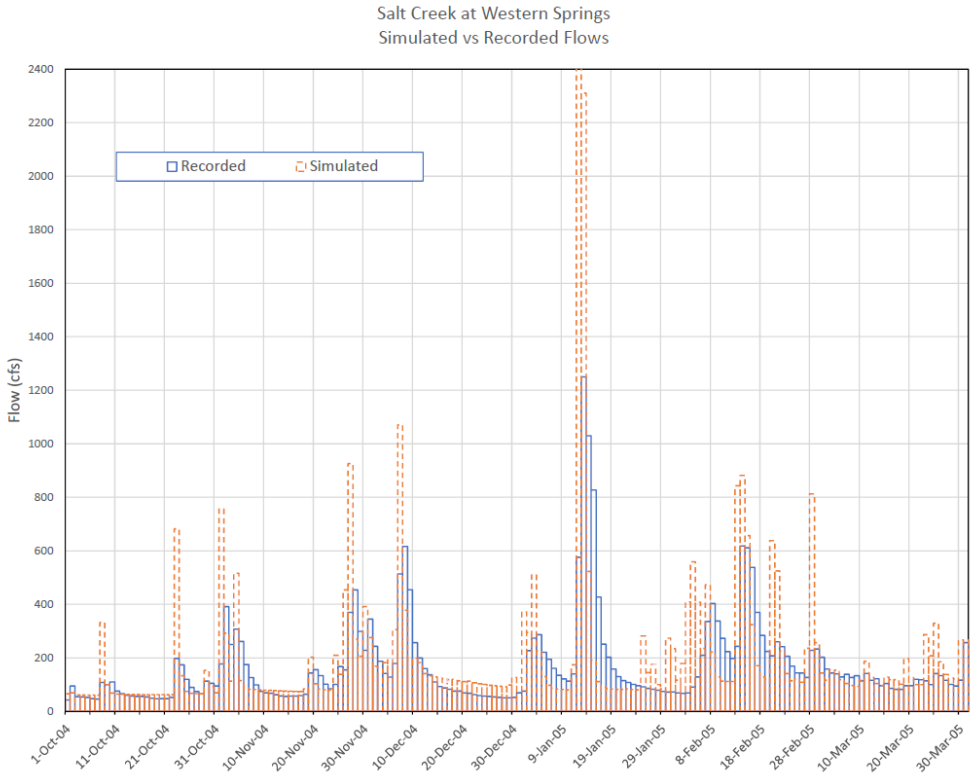


Calibration

- Hydrograph Output
- Annual & Monthly runoff comparison
- Event Calibration
    - Event selection
    - Event runoff comparison
    - Event Peak flow and stage comparison
    - FEQ modeling



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Average Monthly Flows			
Month	Simulated Flow (cfs)	Recorded Flow (cfs)	S/R
October	121.89	110.39	1.10
November	111.30	103.26	1.08
December	149.45	131.17	1.14
January	107.56	115.50	0.93
February	174.93	154.75	1.13
March	164.41	174.87	0.94
April	165.95	200.40	0.83
May	176.55	224.95	0.78
June	146.89	180.54	0.81
July	129.35	133.38	0.97
August	112.79	118.85	0.95
September	88.13	92.14	0.96

Monthly Flow Statistics	
Coefficient of Model Fit Efficiency	0.82
Correlation Coefficient	0.91
Average Absolute Percent Error*	16.8%
Average Absolute Error**	16.6%
Percent of Errors Less than 10 Percent	40.9%
Percent of Errors Less than 25 Percent	76.5%

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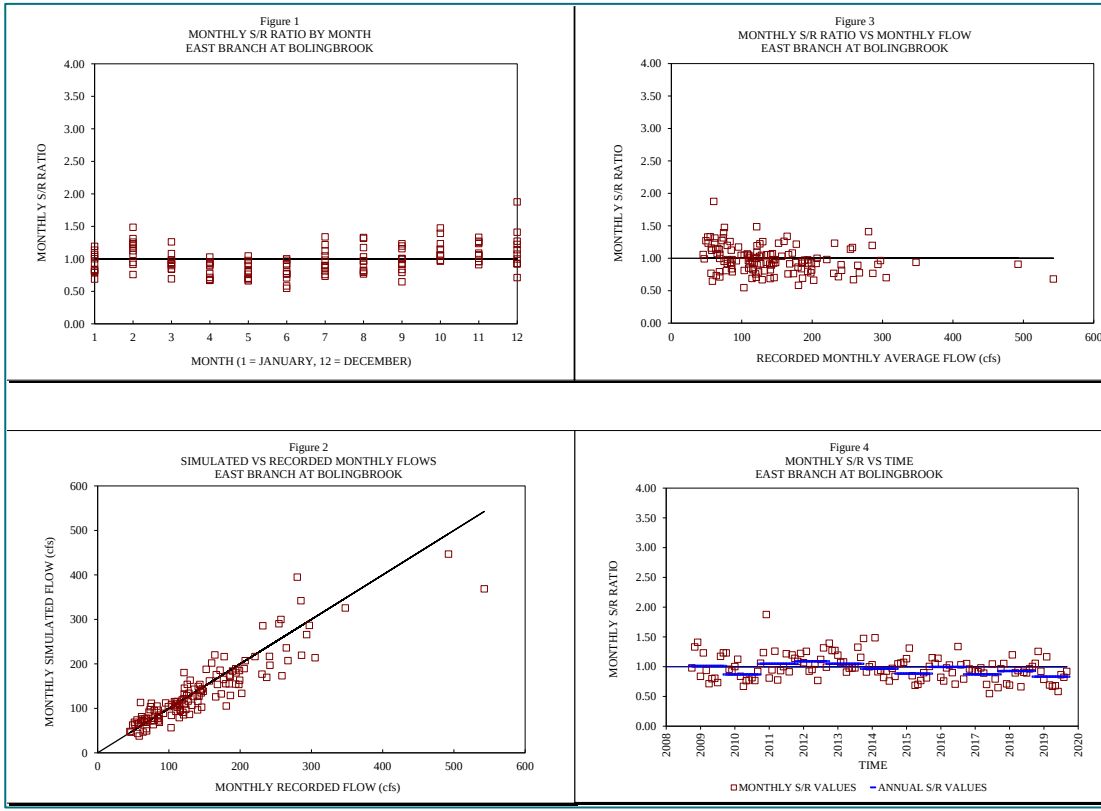

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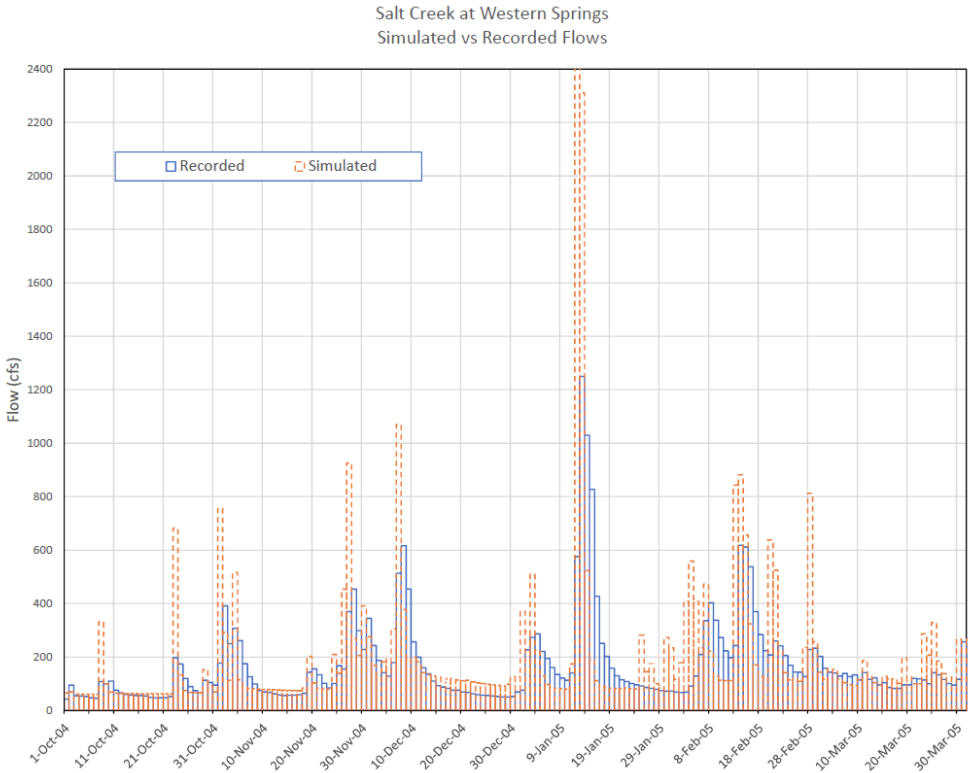

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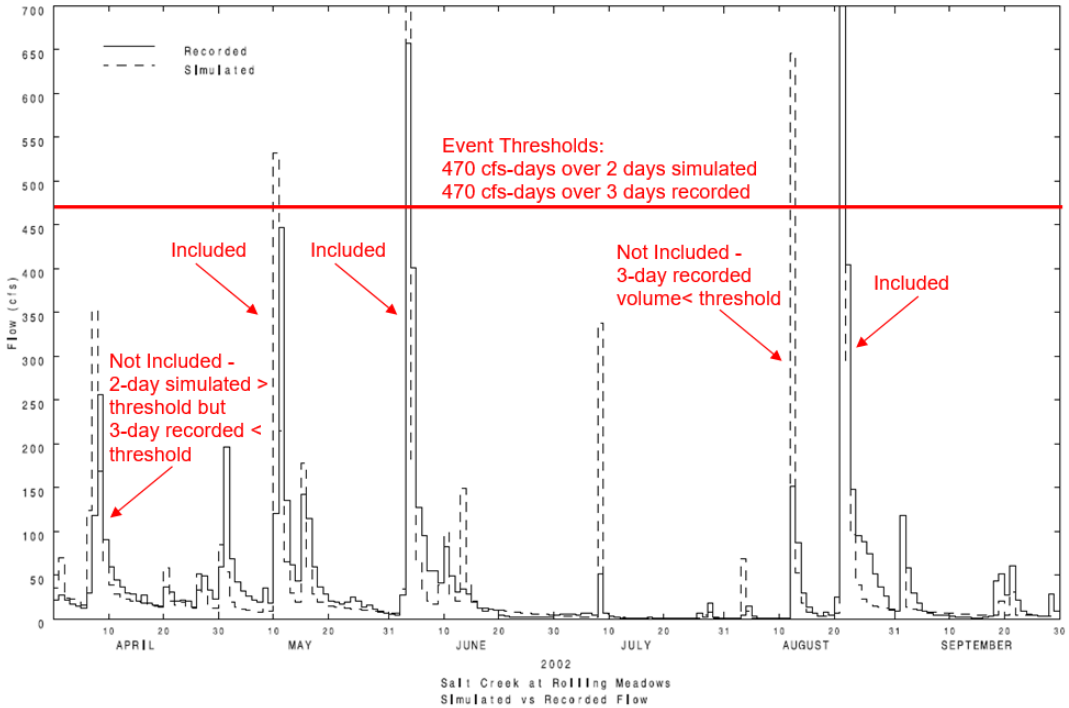

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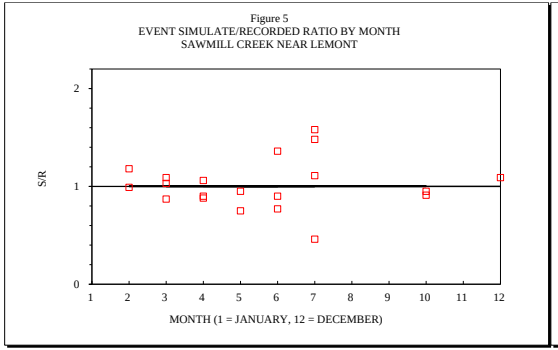

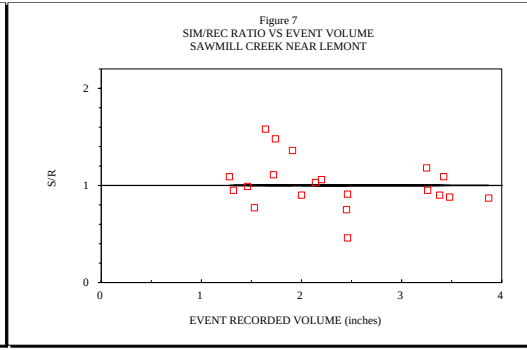

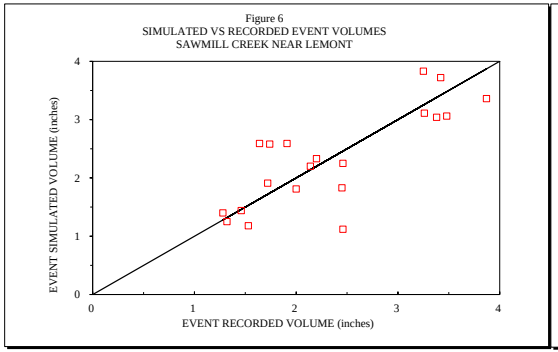

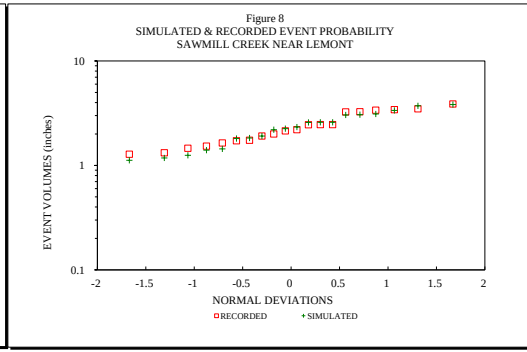

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Sawmill Creek near Lemont Event Runoff Volumes
Runoff Volume Statistics

Number of Events	20
Number of Events Simulated High	9
Number of Events Simulated Low	11
Average Simulated/Recorded Ratio	0.99
Correlation Coefficient	0.79
Average Absolute Error	18.2%
Number of Events within 10%	45.0%
Number of Events within 25%	75.0%

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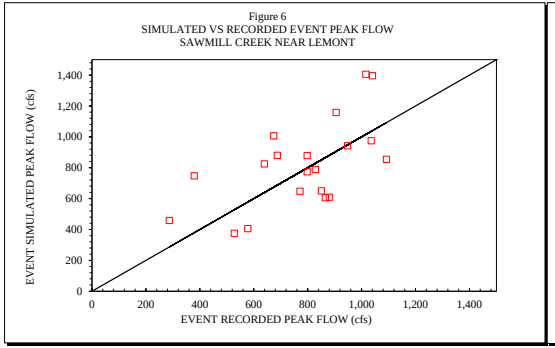
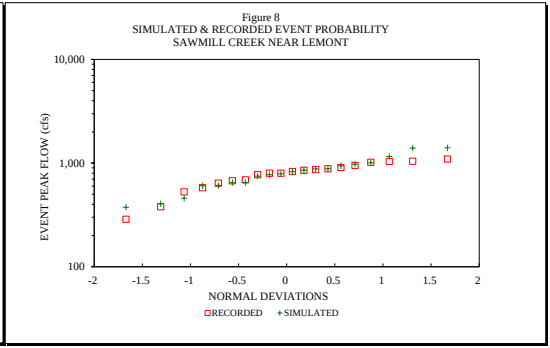
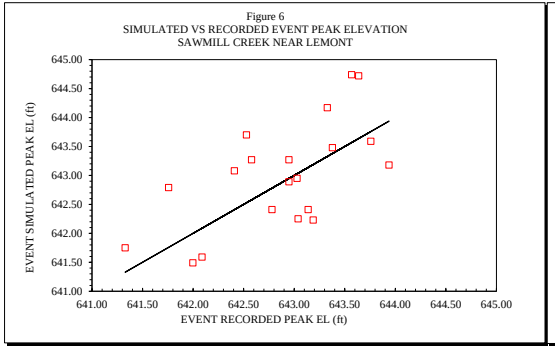
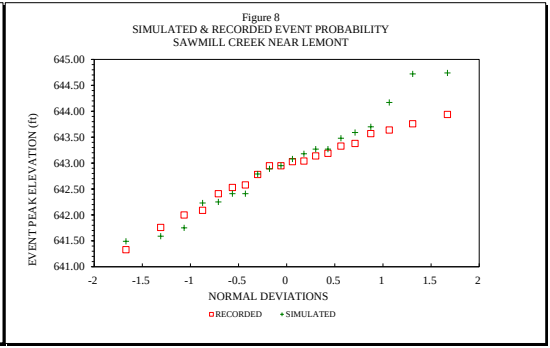
Peak Flows





Peak Stages



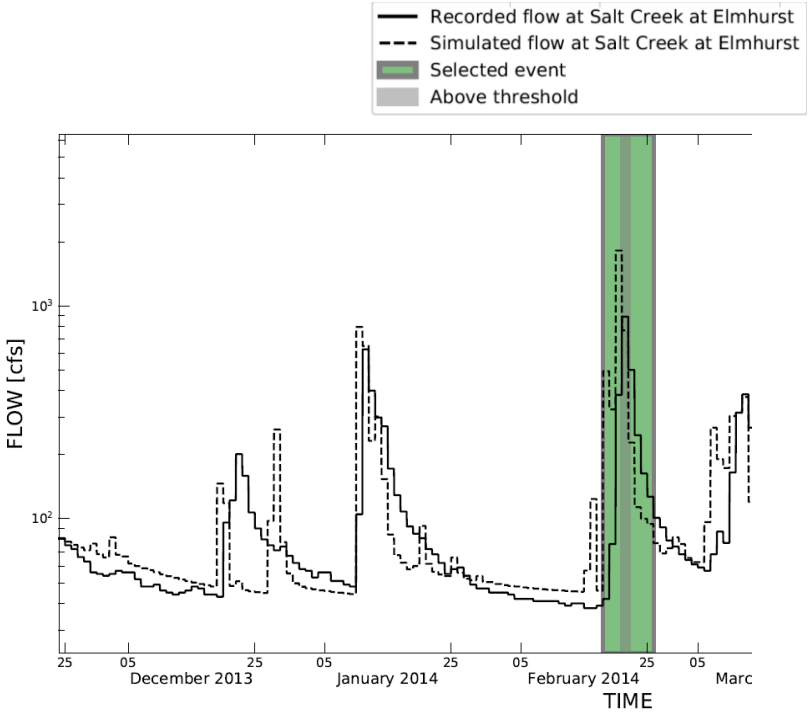


Decision to Automate

- Obsolete, unsupported programs
- Data formatting
- Allow DPC to update the TSF more frequently
- Complete work in-house

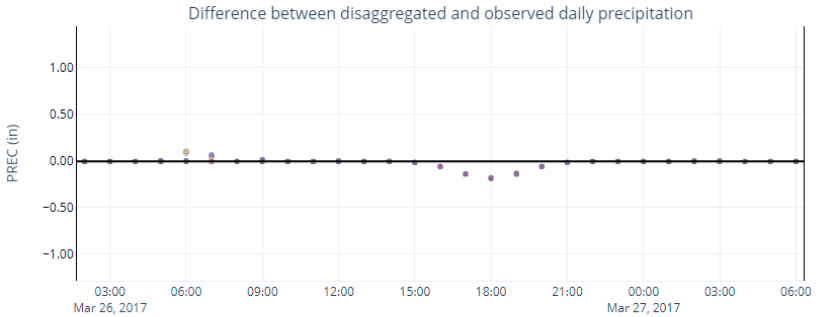
Automation Overview

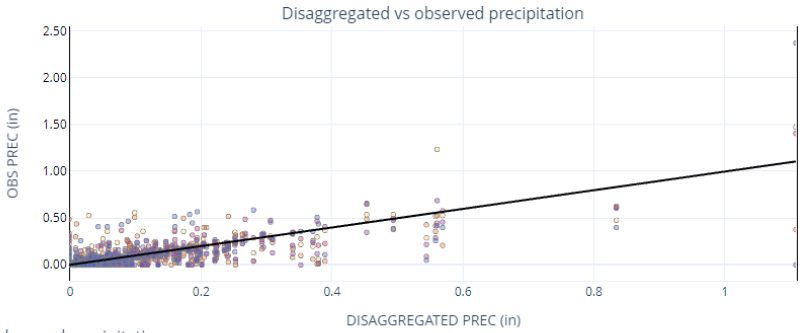
- Collaborative effort with ECT and USGS
- Command-line interface utilizing python scripts and input files
- Generated graphs
- *Next steps:* Graphical User Interface (GUI)

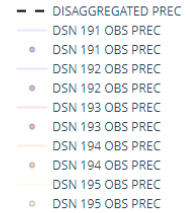


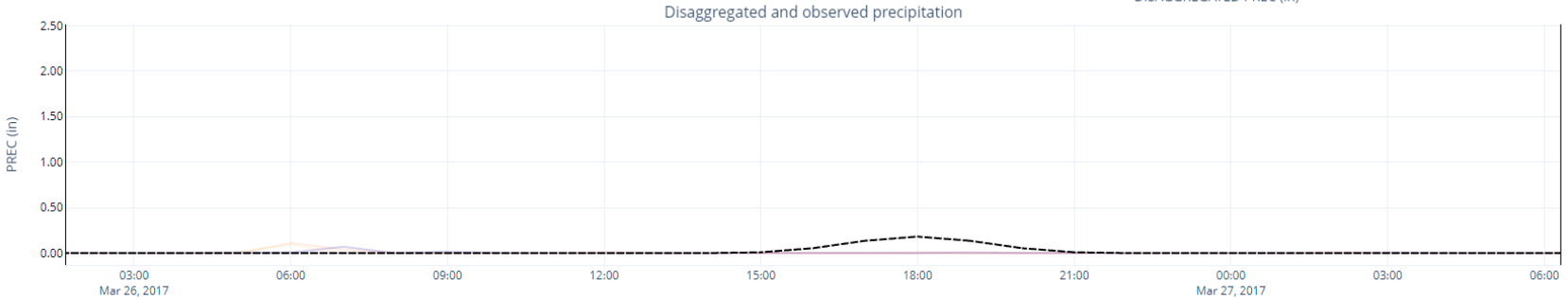
Event Hydrographs Auto-Generated at Stream Gage

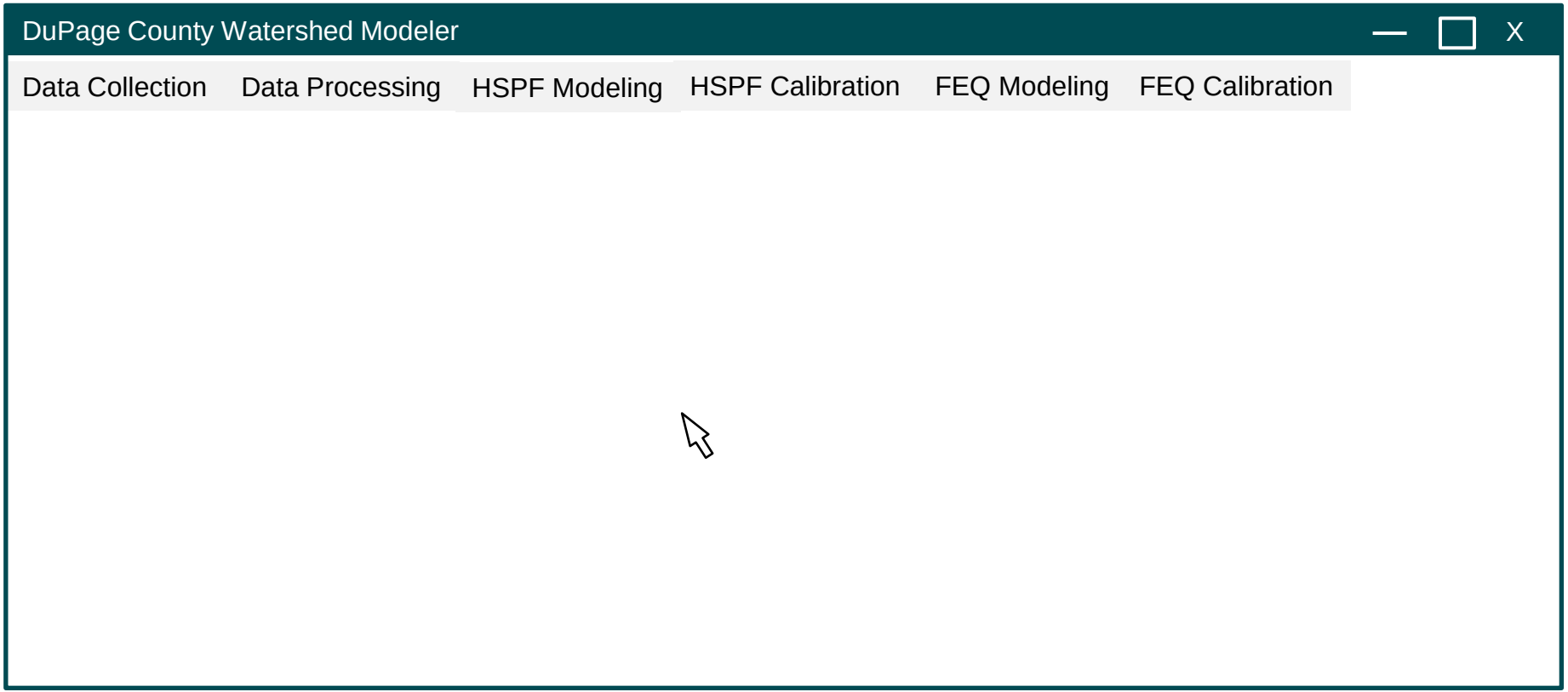
WATER YEAR 2017 NCDC-WHEATON HOURLY PRECIPITATION











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Interface Mockup

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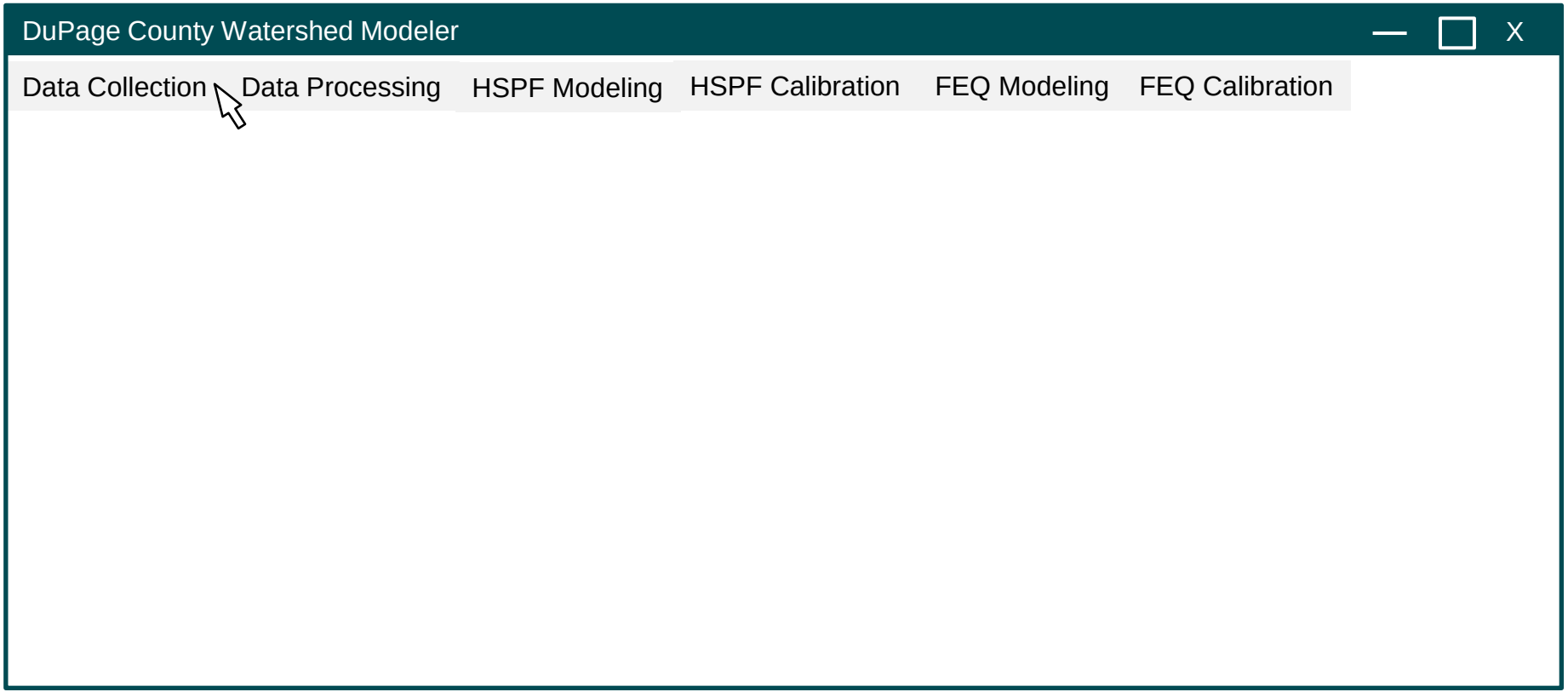

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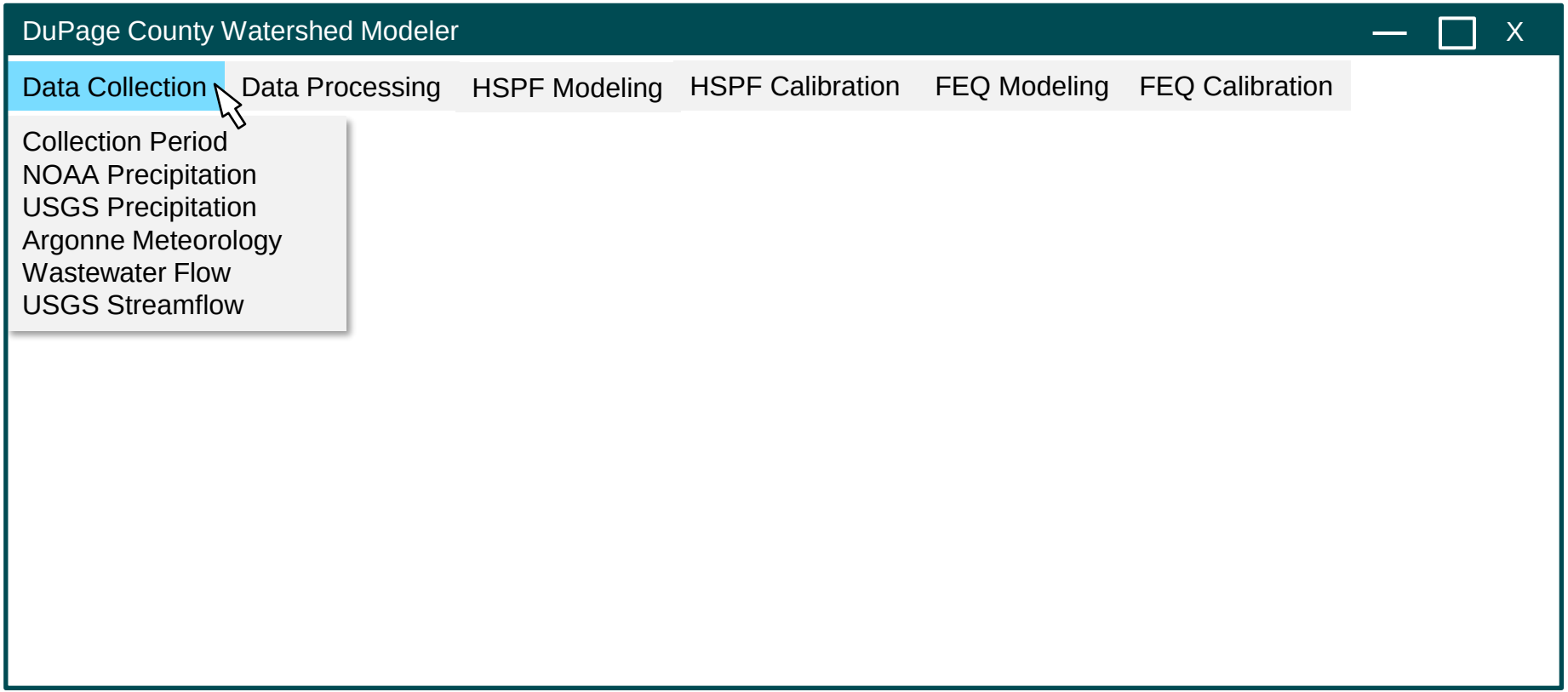

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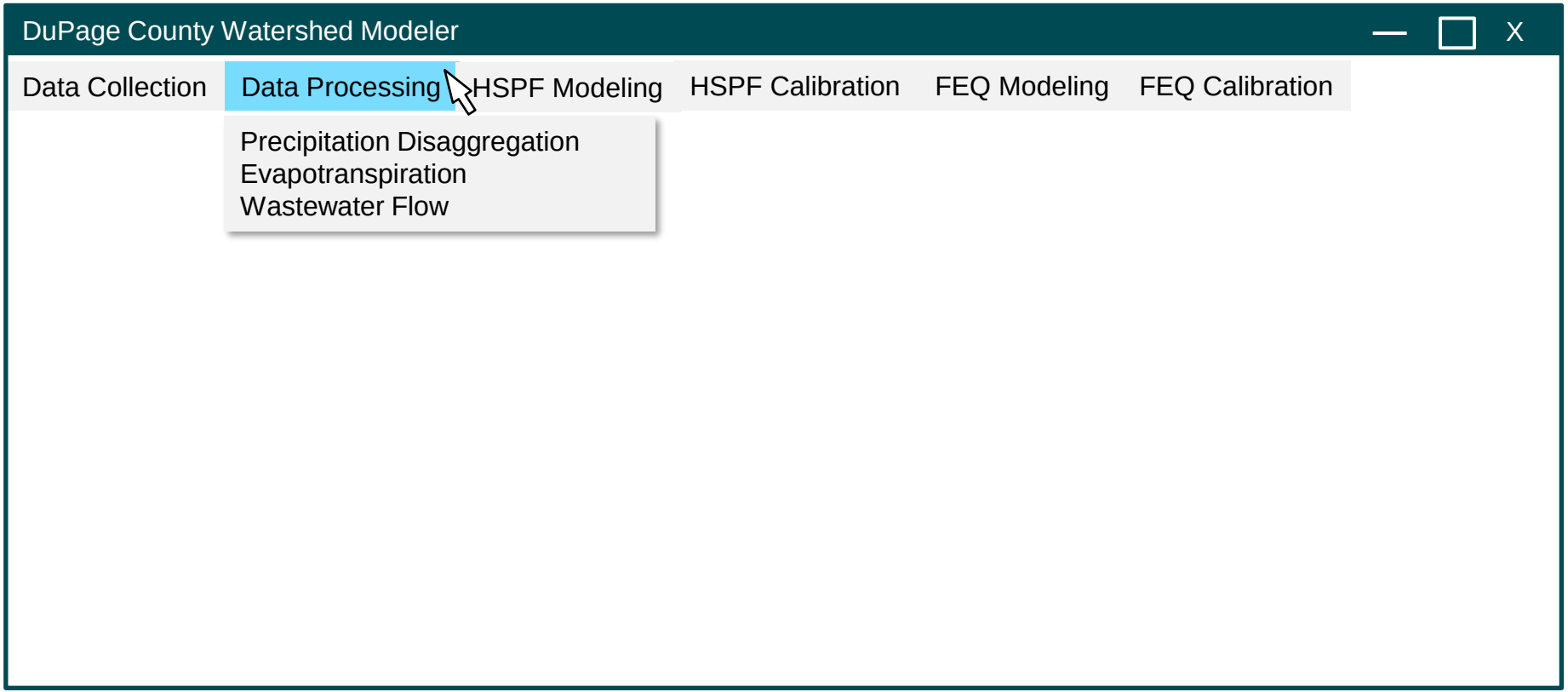

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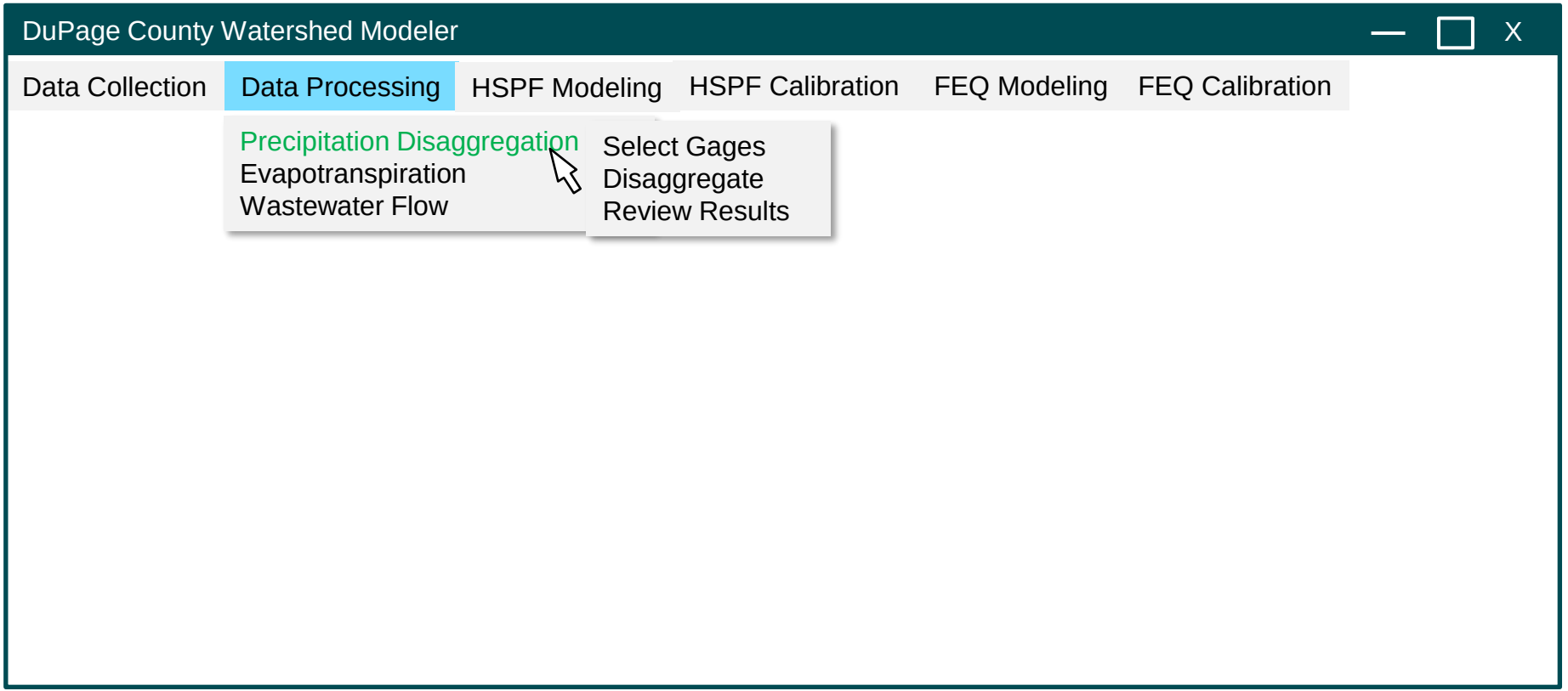

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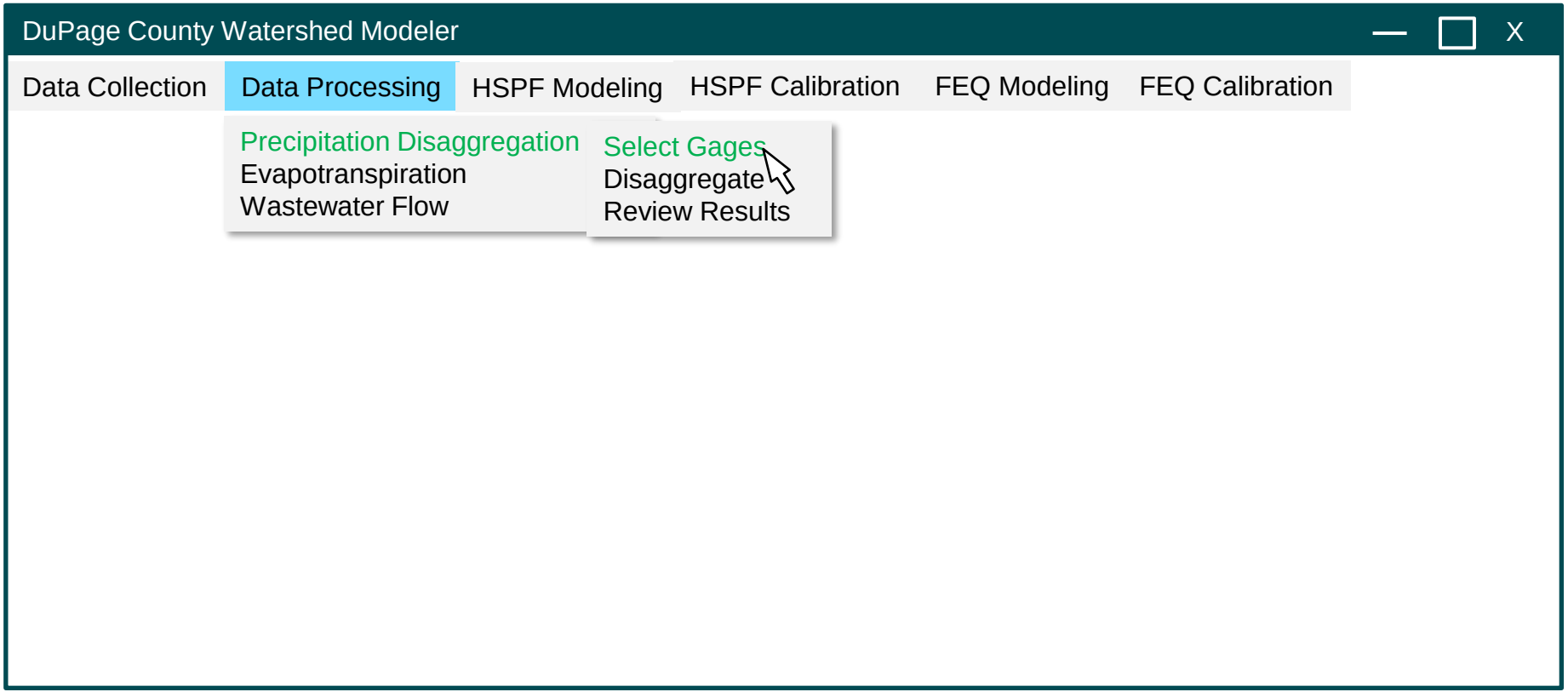

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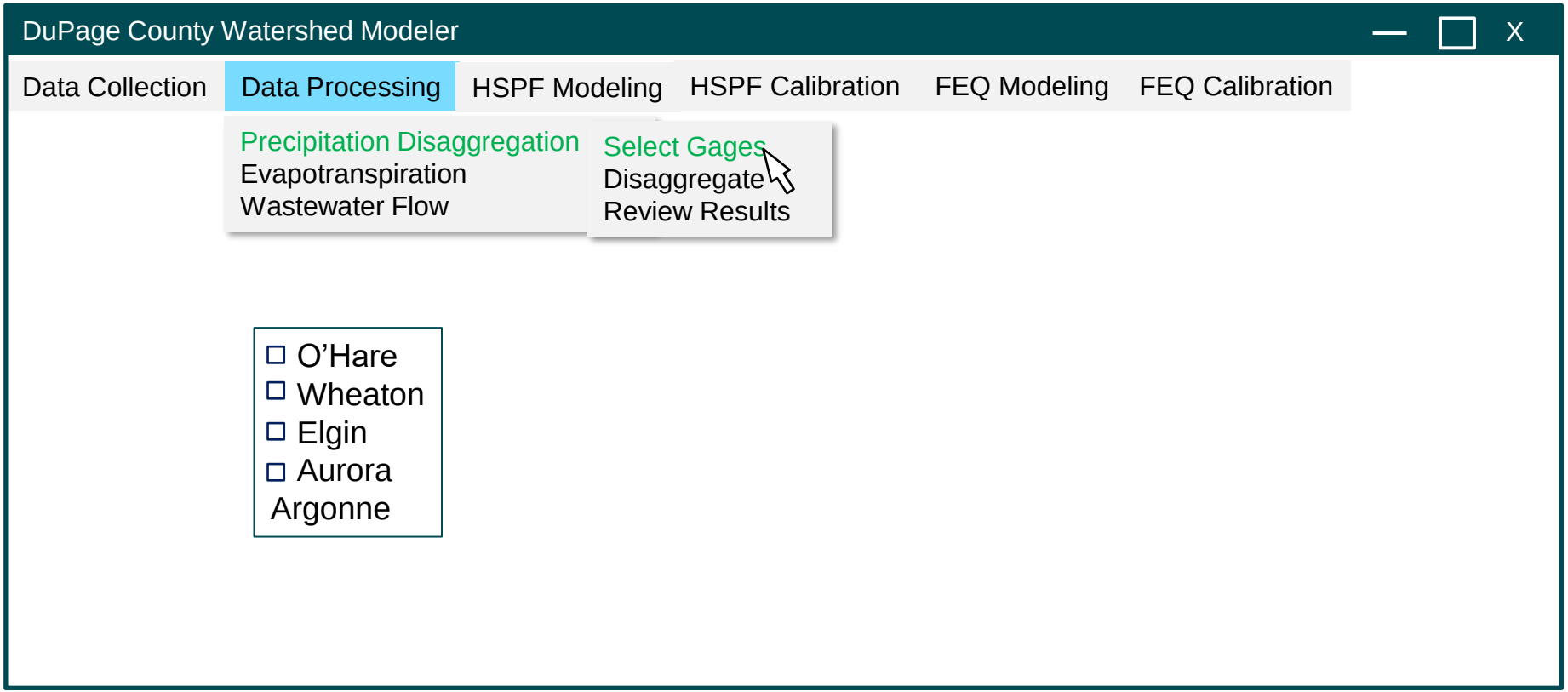
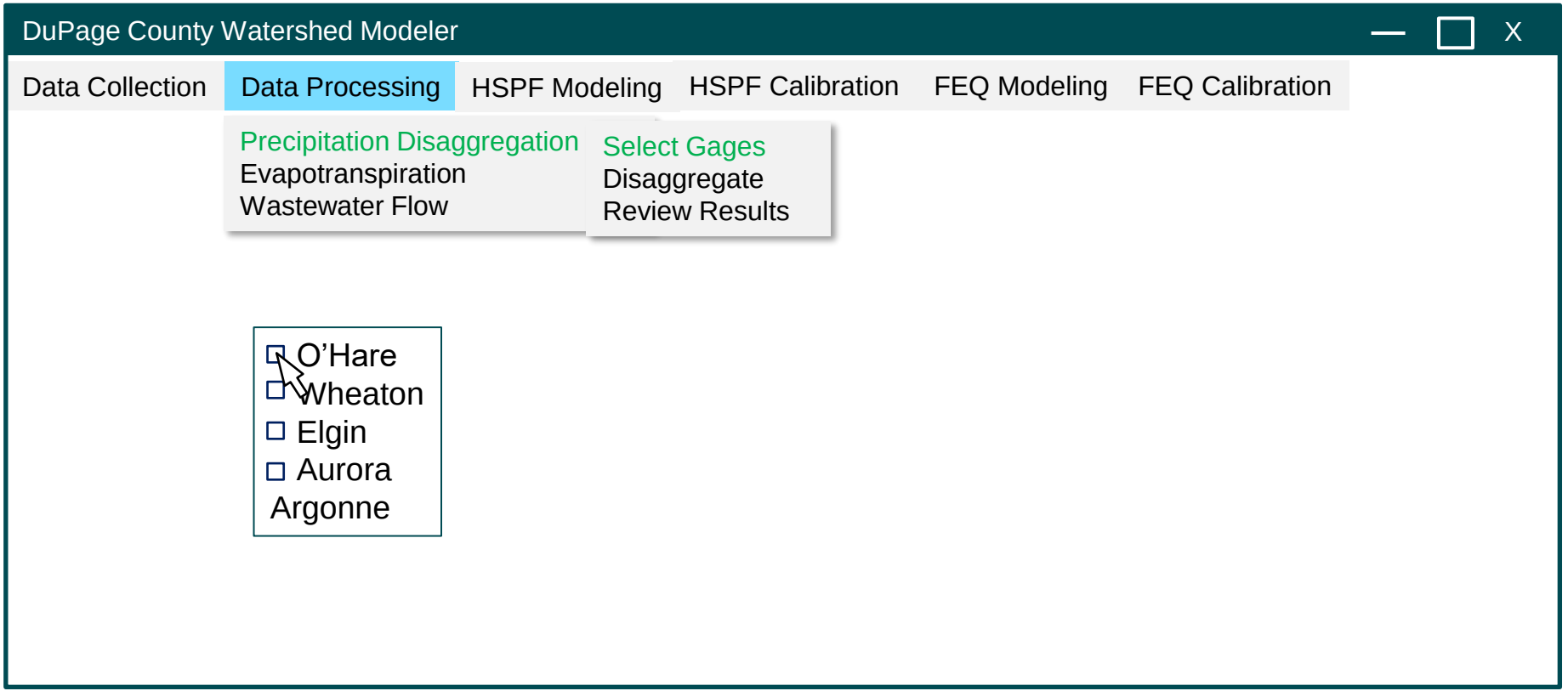

DuPage County Watershed Modeler
X
Data Collection
Data Processing
HSPF Modeling
HSPF Calibration
FEQ Modeling
FEQ Calibration
Precipitation Disaggregation
Evapotranspiration
Wastewater Flow
Select Gages
Disaggregate
Review Results
O'Hare
Wheaton
Elgin
Aurora
Argonne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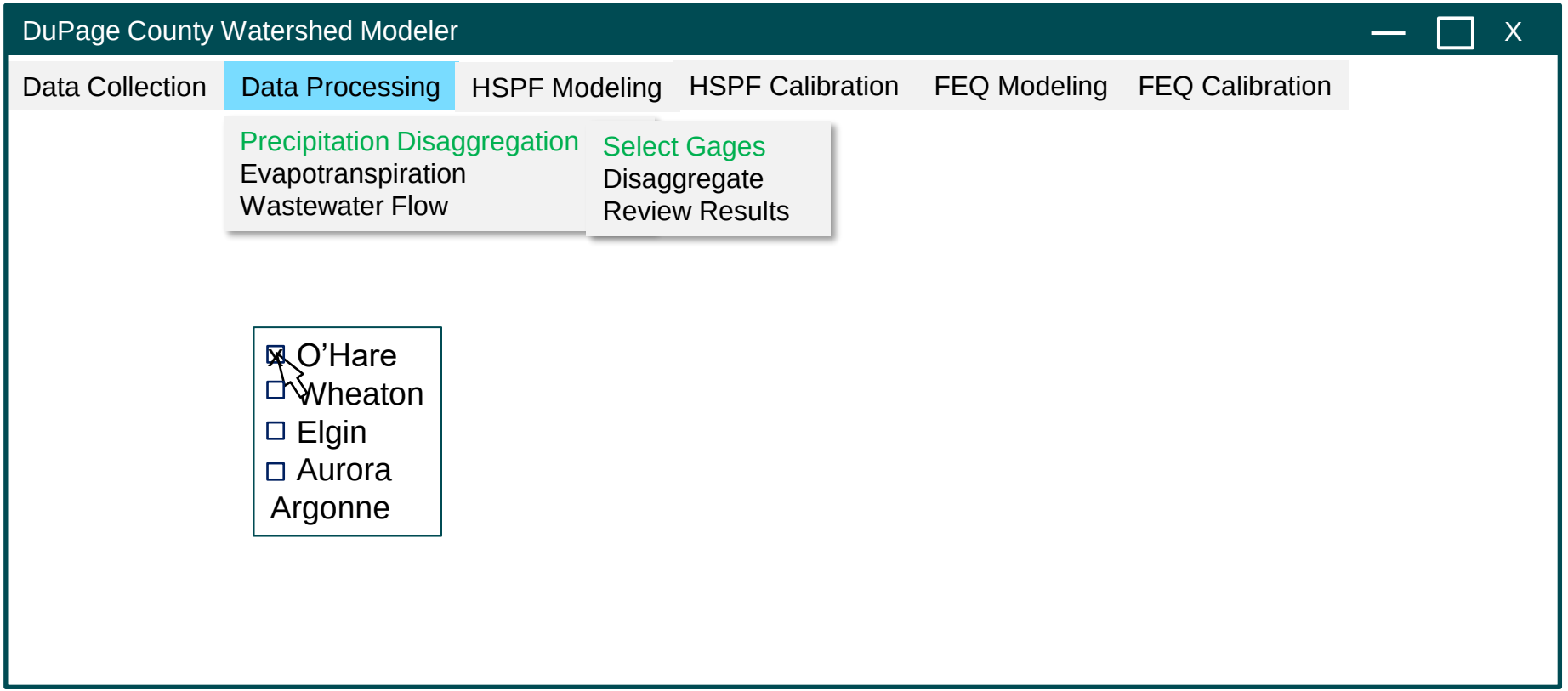
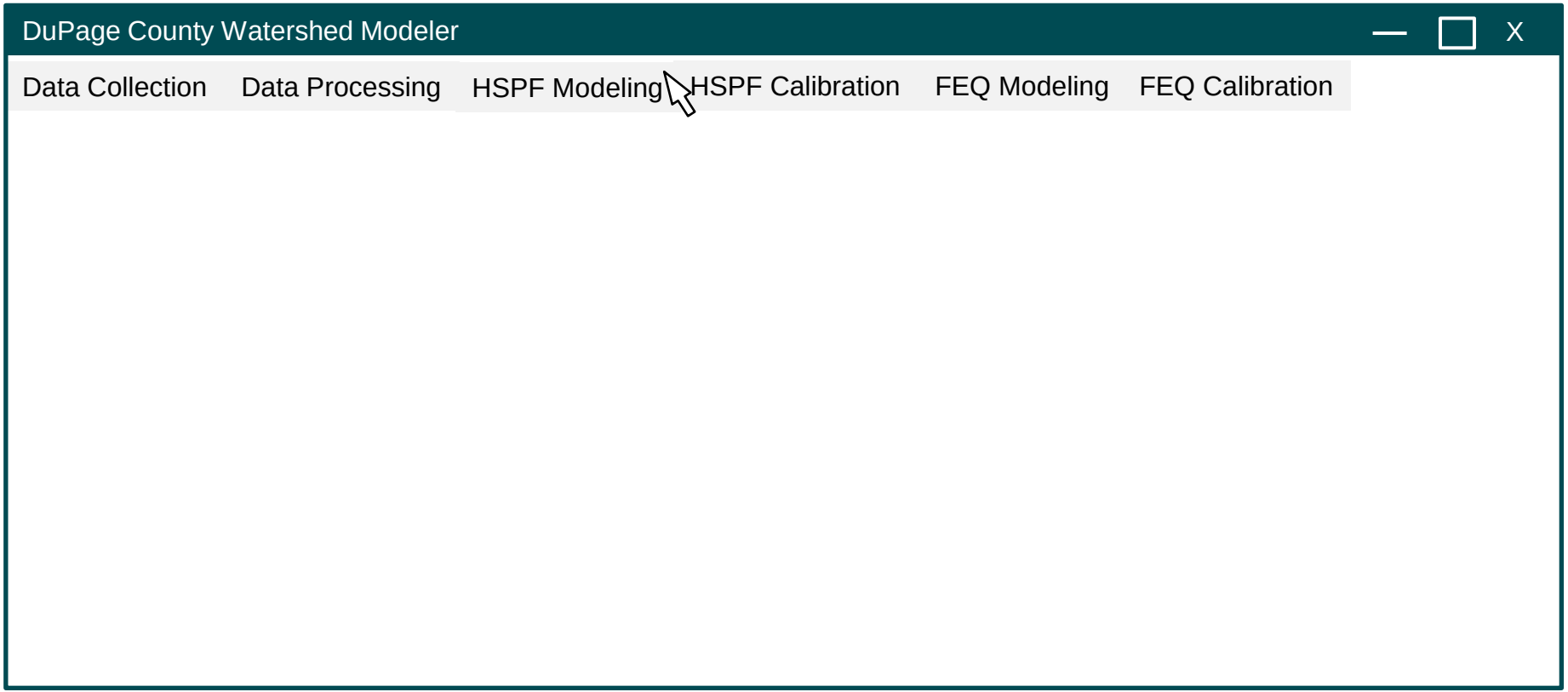


Interface Mockup



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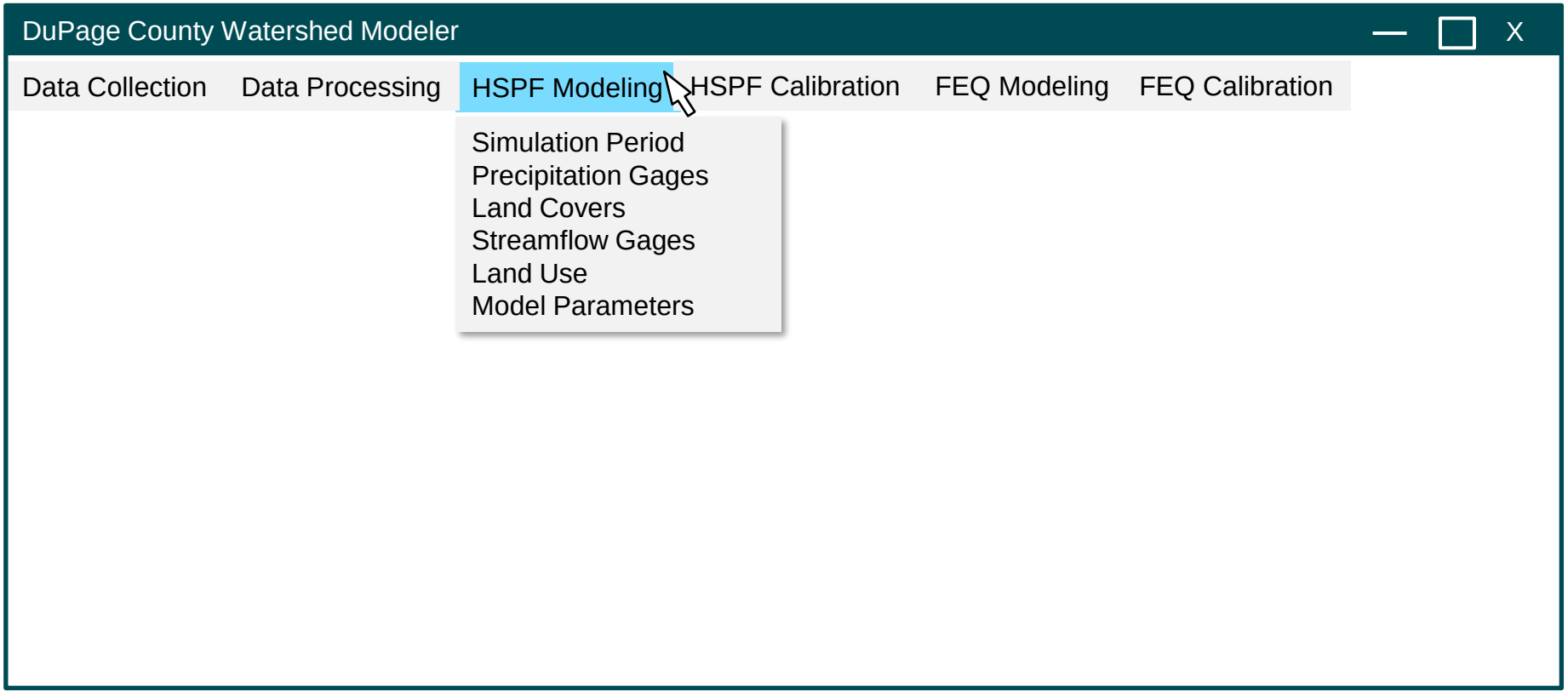

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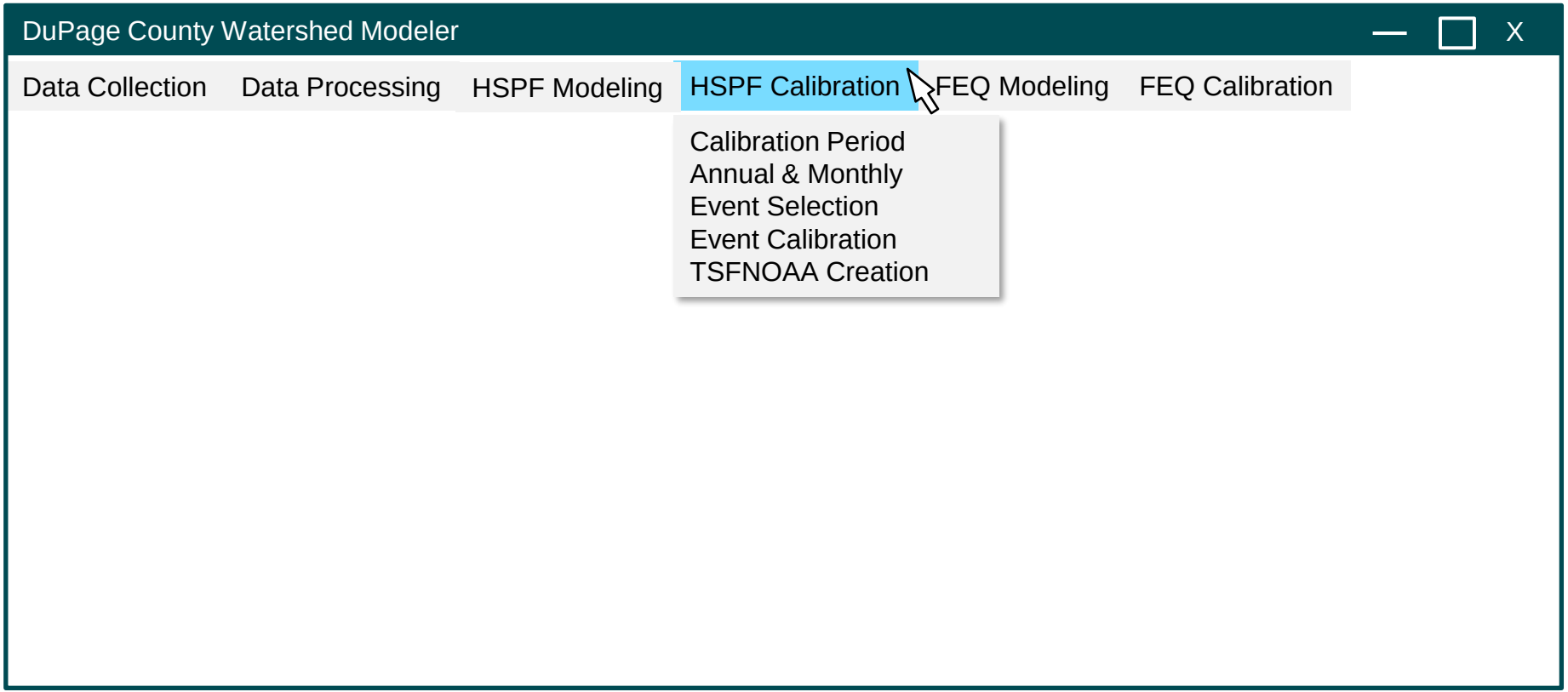

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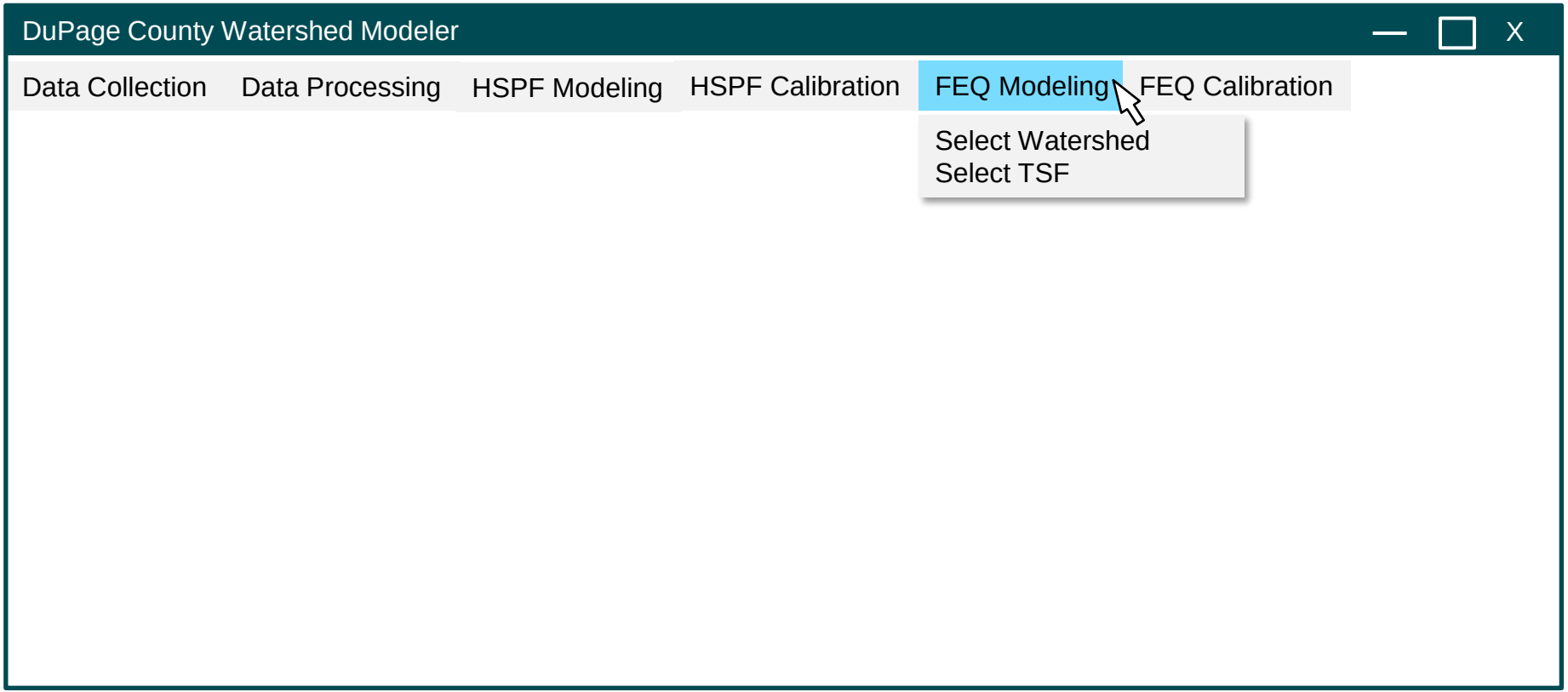

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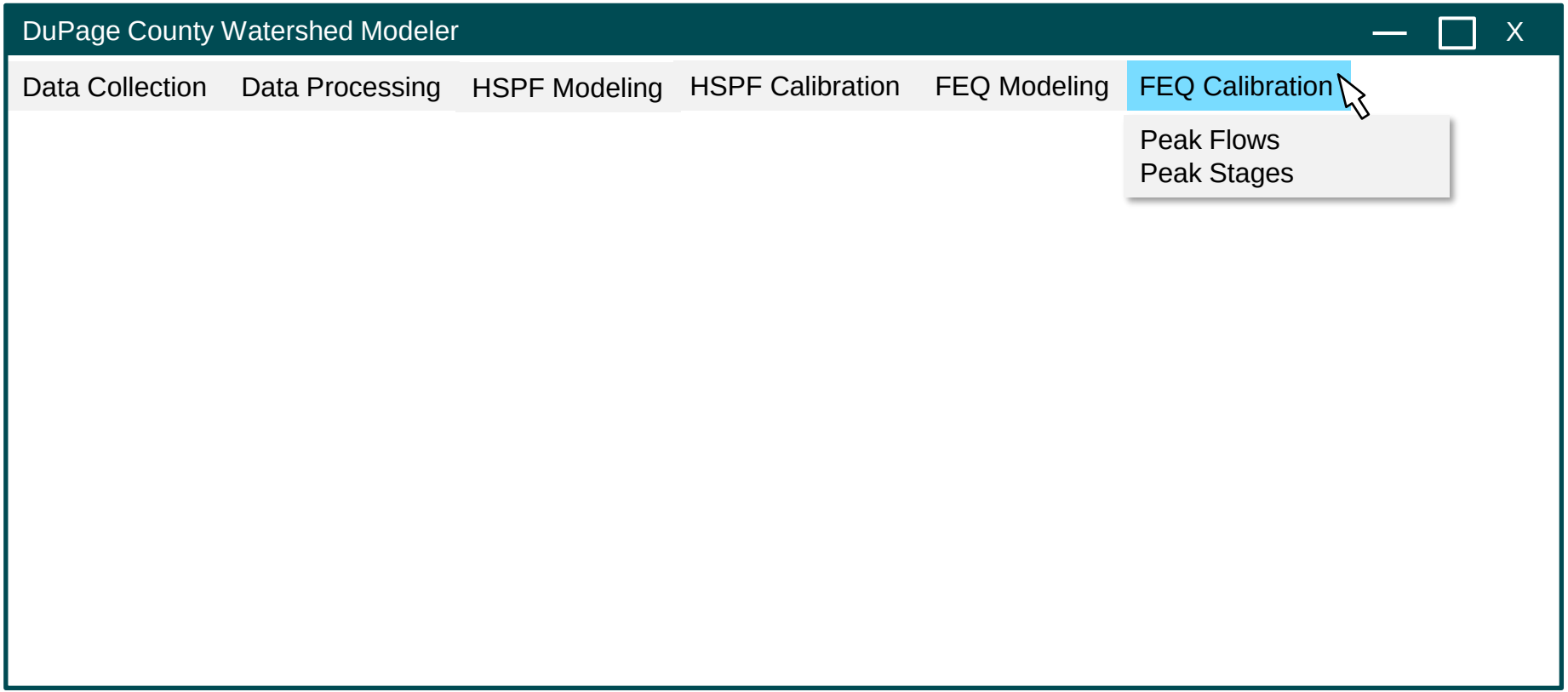

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Questions?

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