Overview of Climate Impact Assessment Framework and Implementation

Gary Shenk CBPO

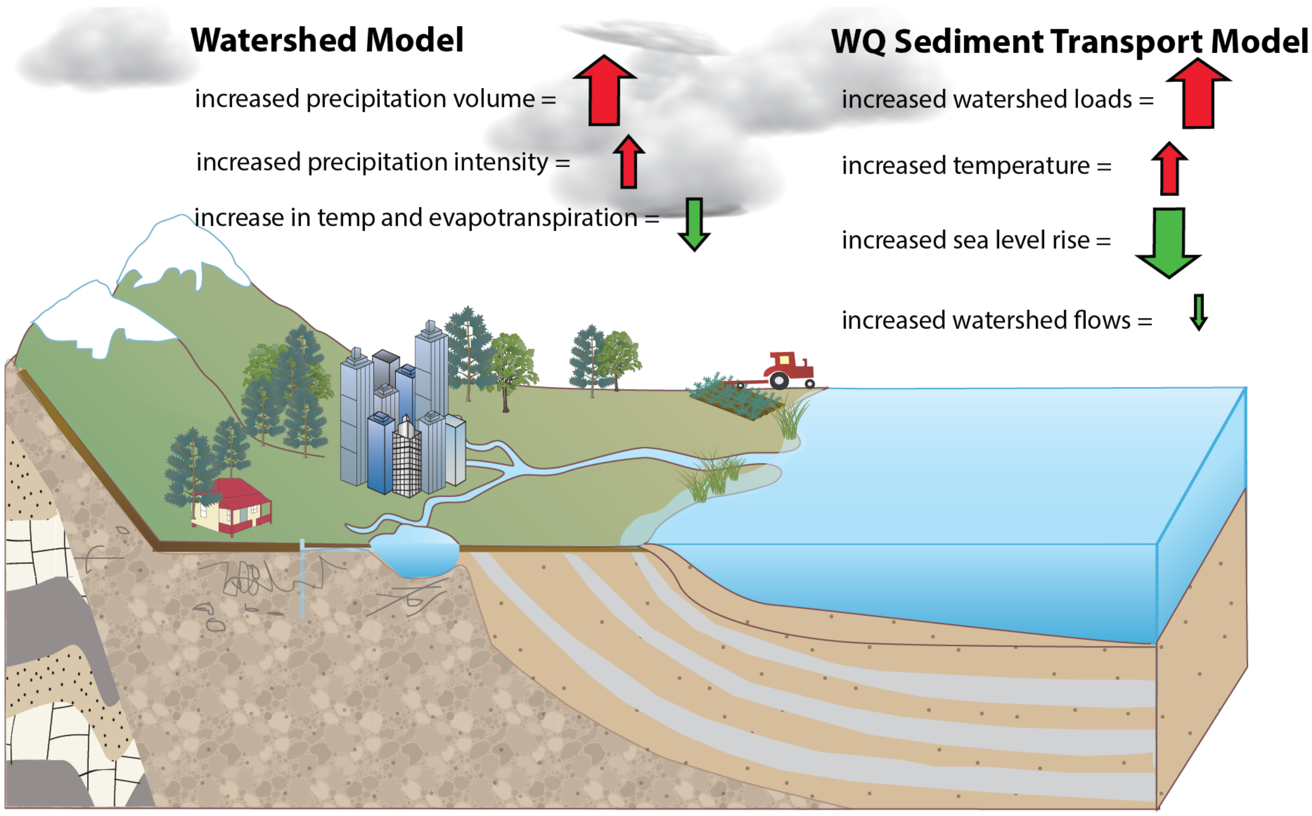
STAC Workshop

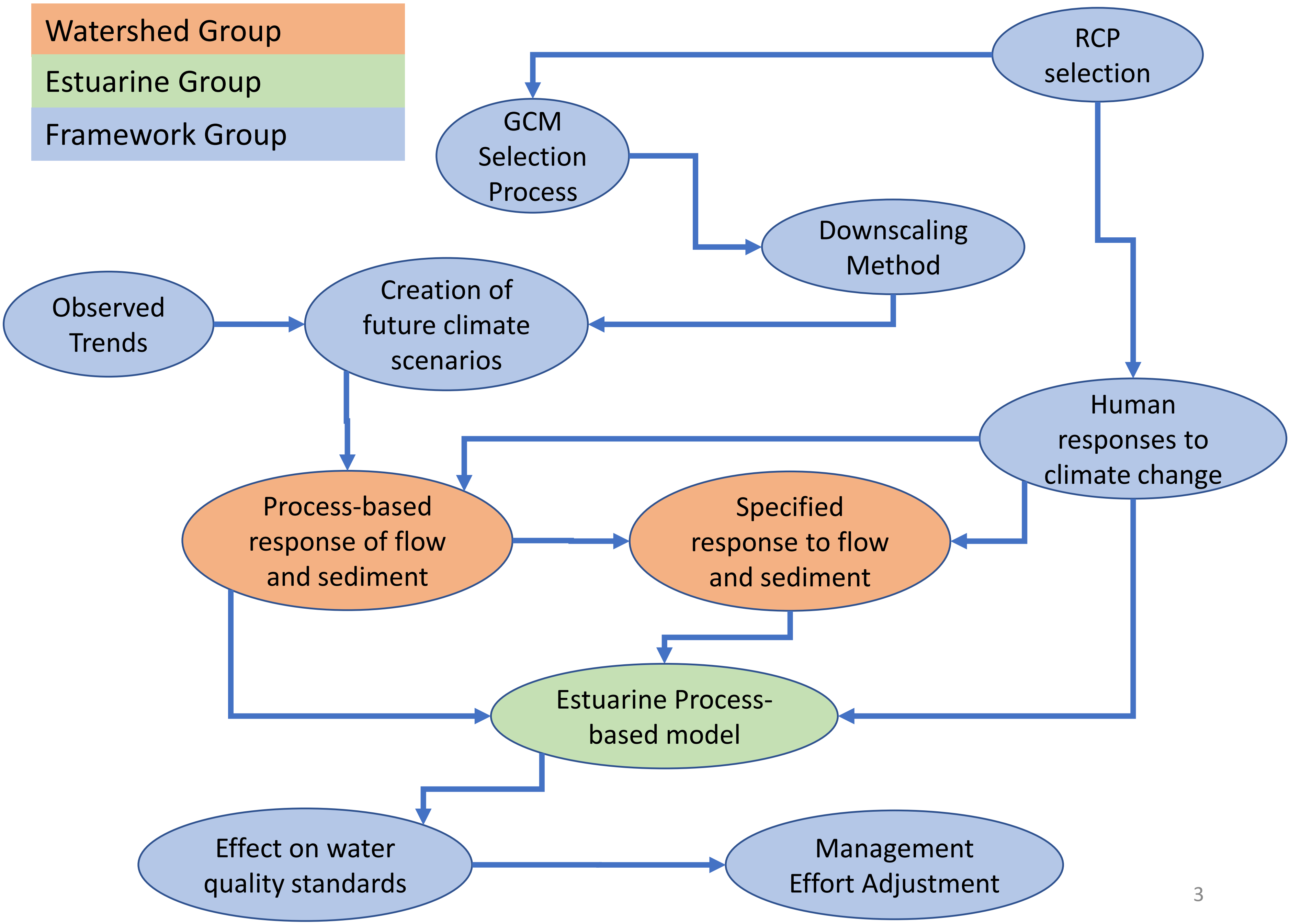
Chesapeake Bay Program Climate Change Modeling 2.0

9/24/2018

Accounting for Changing Conditions

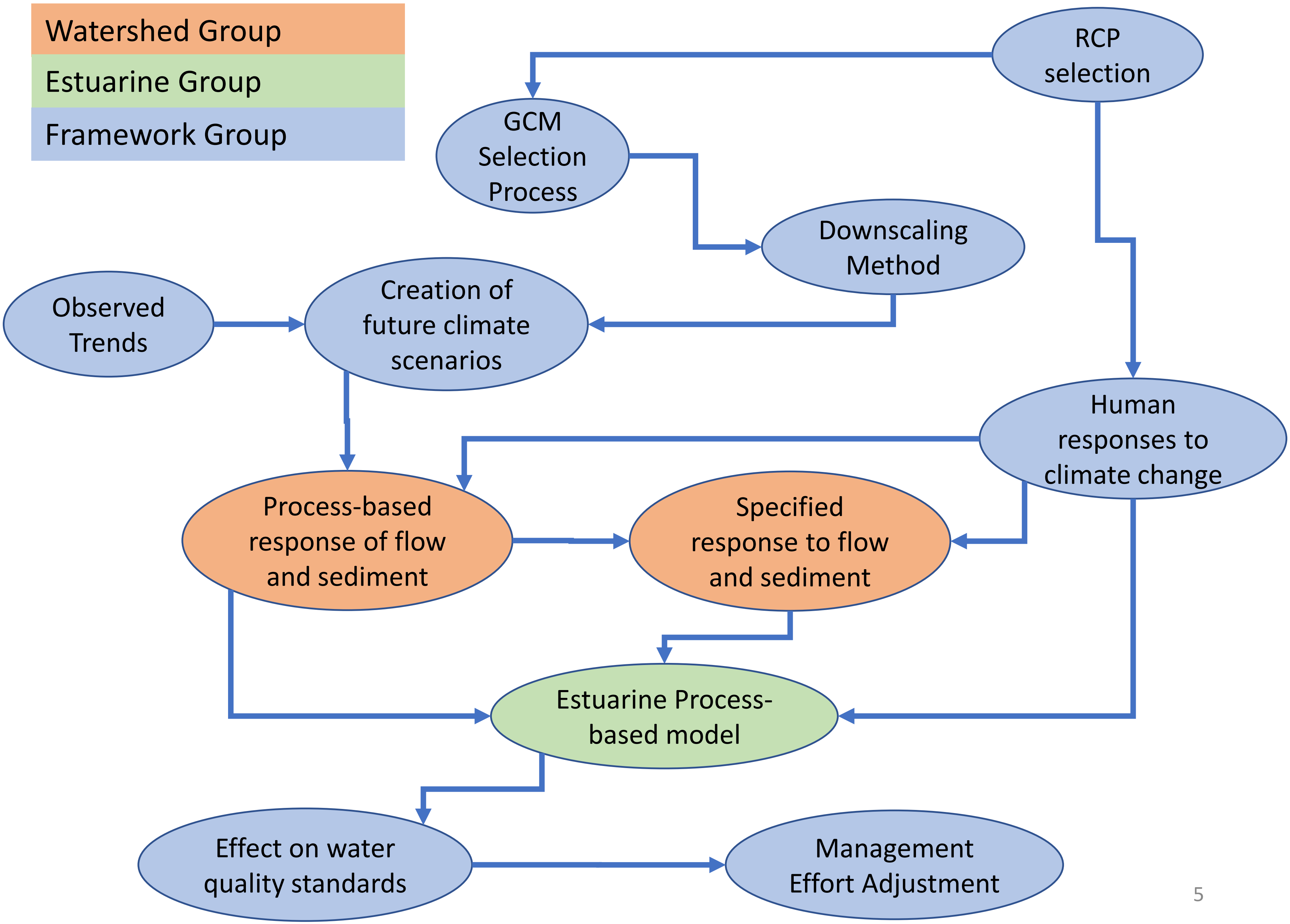
Cumulative Assessment of Bay Low Dissolved Oxygen Impacts




Watershed Group
Estuarine Group
Framework Group
RCP selection
GCM Selection Process
Downscaling Method
Observed Trends
Creation of future climate scenarios
Human responses to climate change
Process-based response of flow and sediment
Specified response to flow and sediment
Estuarine Process-based model
Effect on water quality standards
Management Effort Adjustment

Chesapeake Bay Program

- Modeling for TMDL Water Quality Standards based on 1991-2000 hydrology
- Project to 2025 (30 years) and 2050 (55 years)
- Presented to Principals' Staff Committee in 2017. PSC asked for additional analysis to be completed in 2019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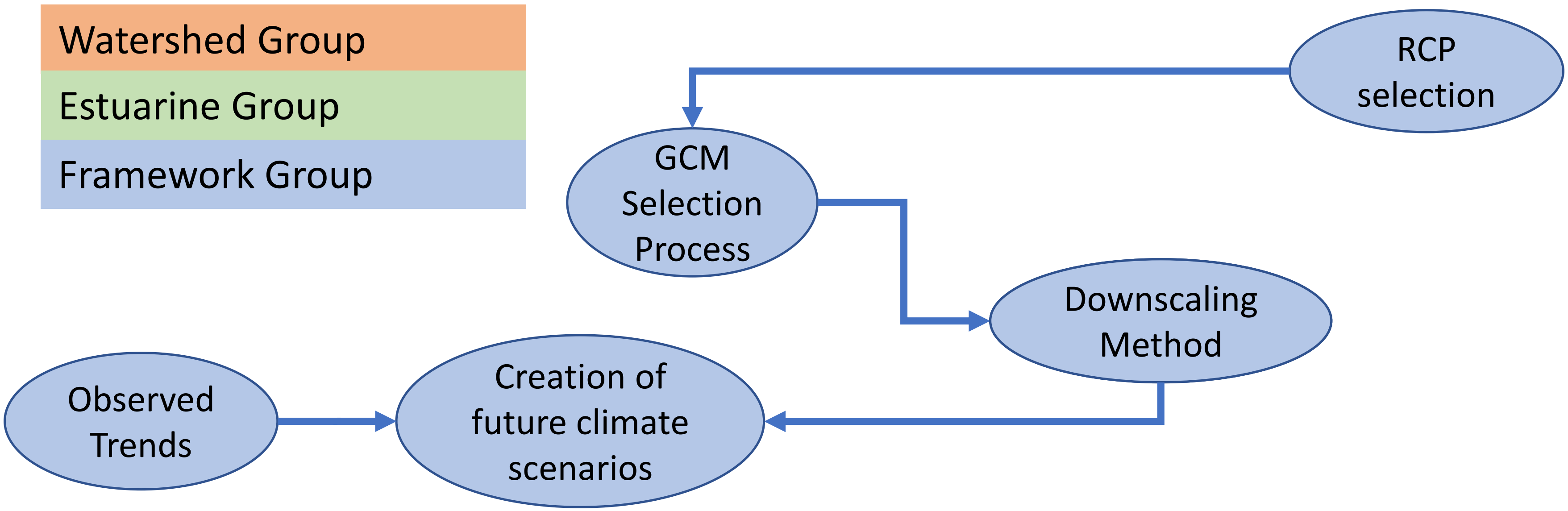
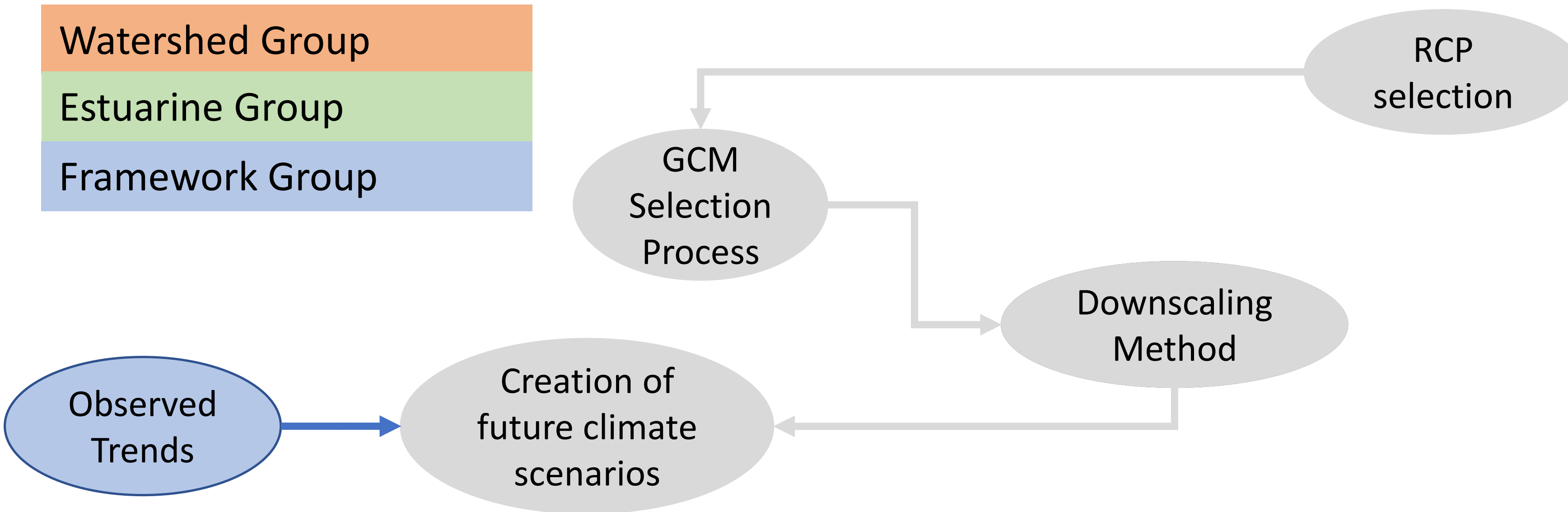


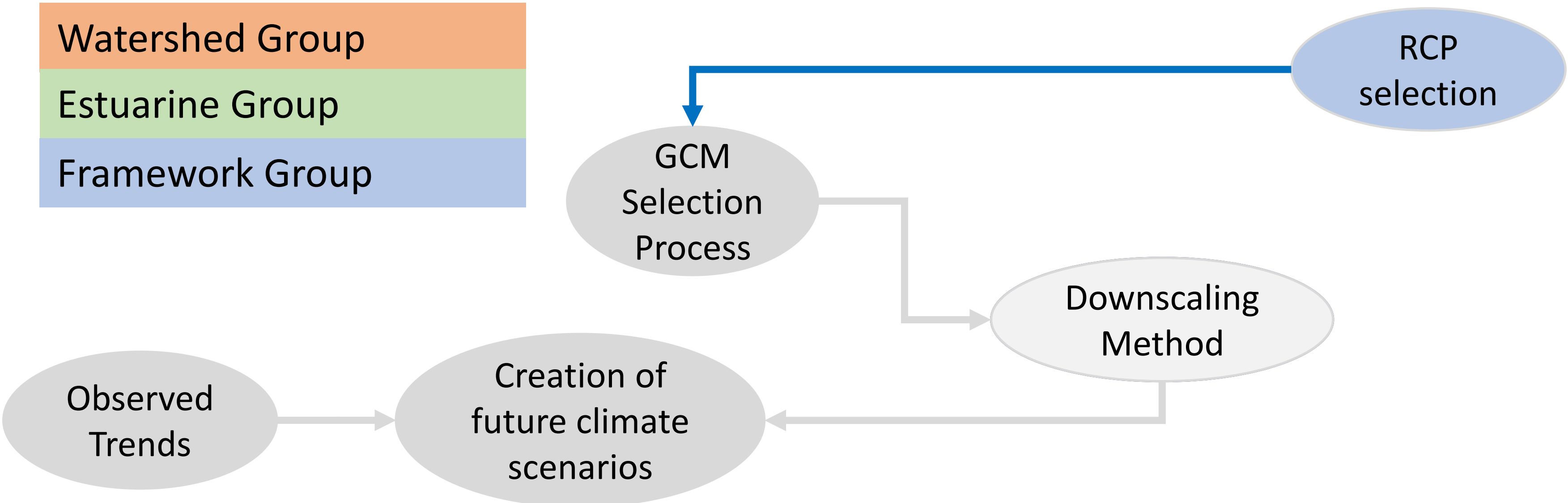
2016 STAC workshop *The Development of Climate Projections for Use in Chesapeake Bay Program Assessments* (Johnson et al. 2016).

- 2025: Use long-term observed trends for precipitation
- 2050 precipitation and all temperature: Use an ensemble of existing downscaling of CMIP5 models
- Carefully consider evapotranspiration
- Use RCP 2.6, 4.5, and 8.5

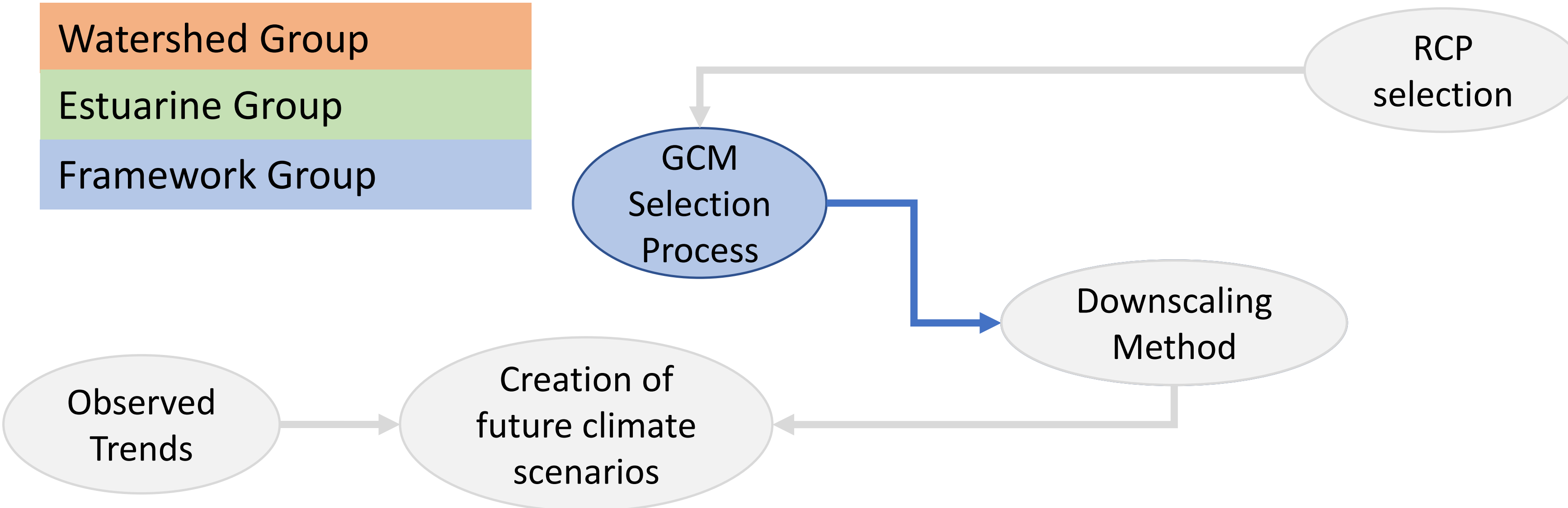


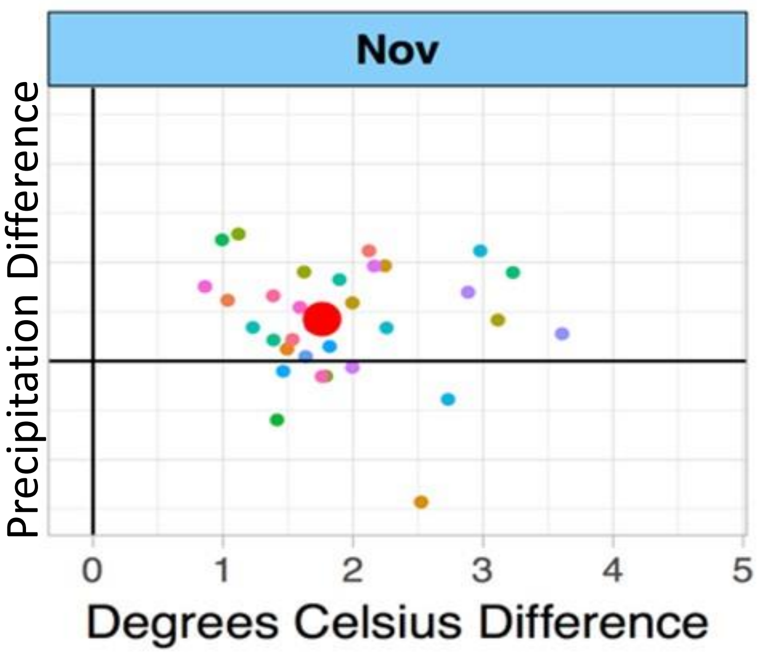
Observed Precipitation Trends

- 1927-2014 PRISM precipitation data
- Aggregated to annual values of a county
- OLS regression to determine slope
- 30 years of slope applied to each month of 1991-2000 rainfall data



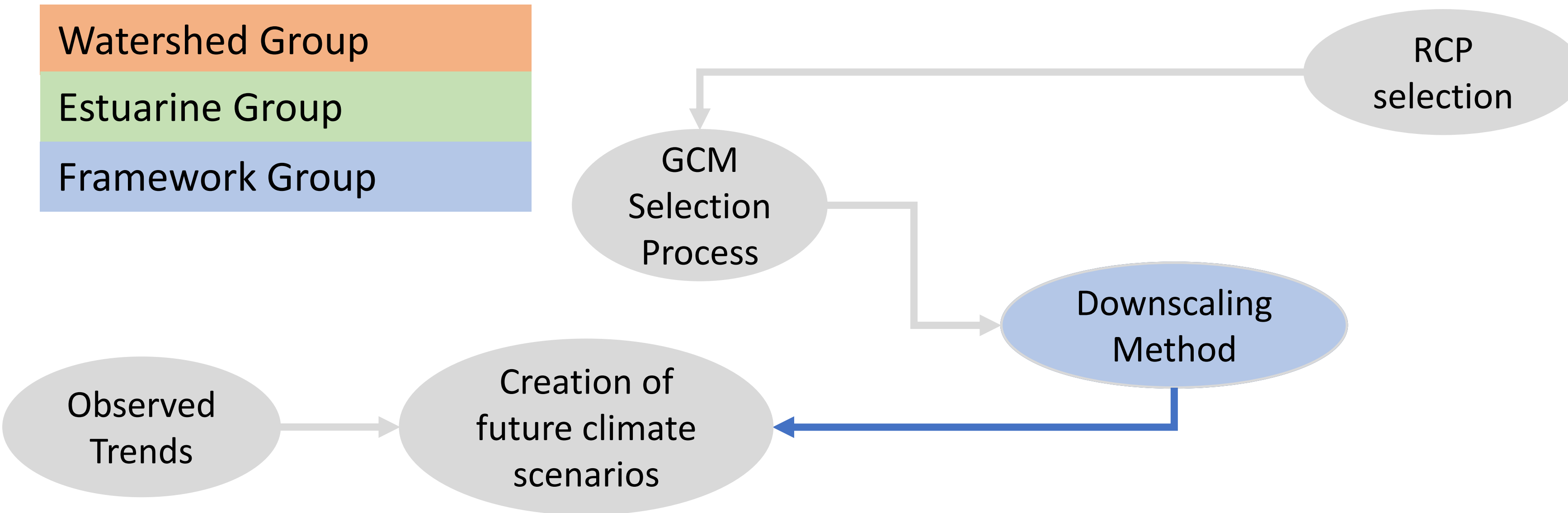
- Used RCP 4.5 for scenario run through the full modeling system and shown to PSC
- Found significant overlap with RCP 2.6 and 8.5





GCM selection

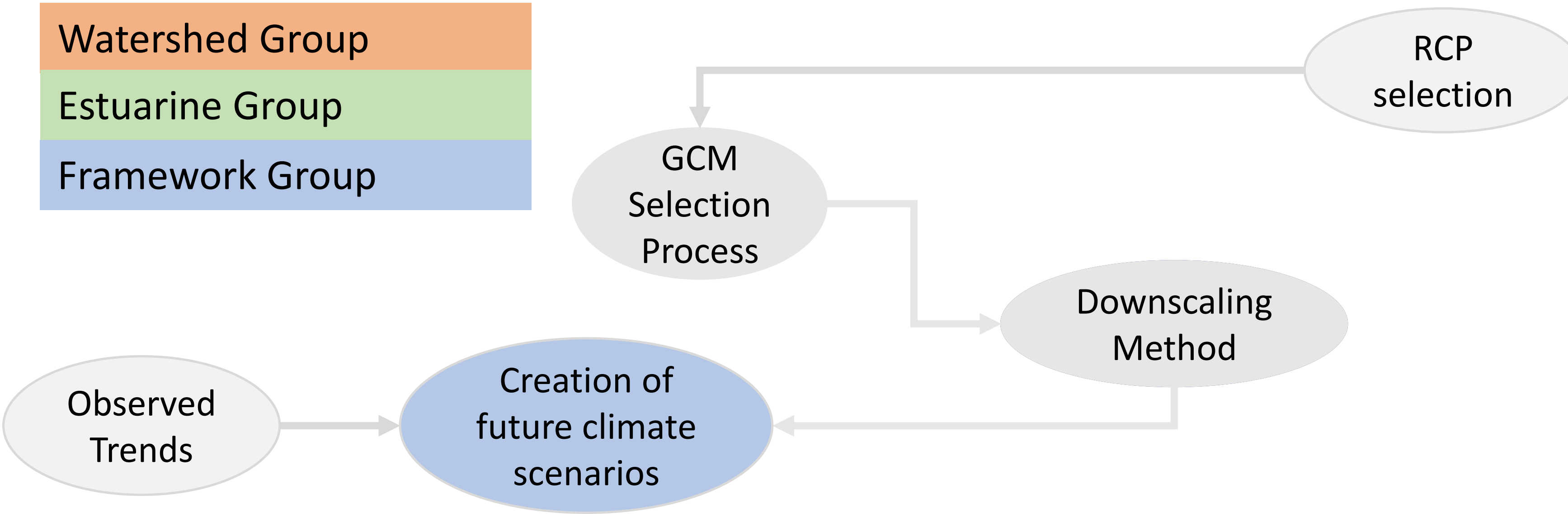
- Used the same group of models and model runs that were used in NOAA's Climate Resilience Toolkit

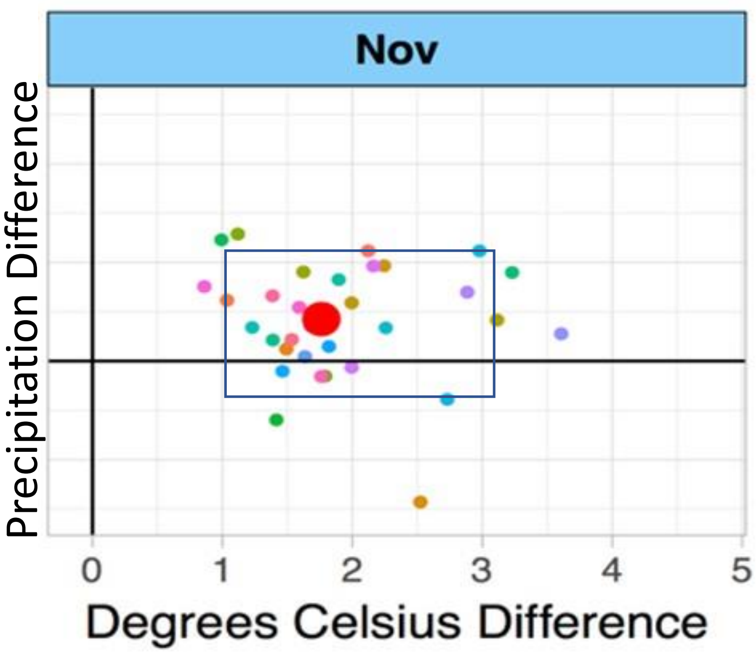


Downscaling methods:

- Bias Corrected Spatial Disaggregation (BCSD) - used for runs in 2017
- Investigating Multivariate Adaptive Constructed Analogs (MACA)
- Investigating Localized Constructed Analogs (LOCA)

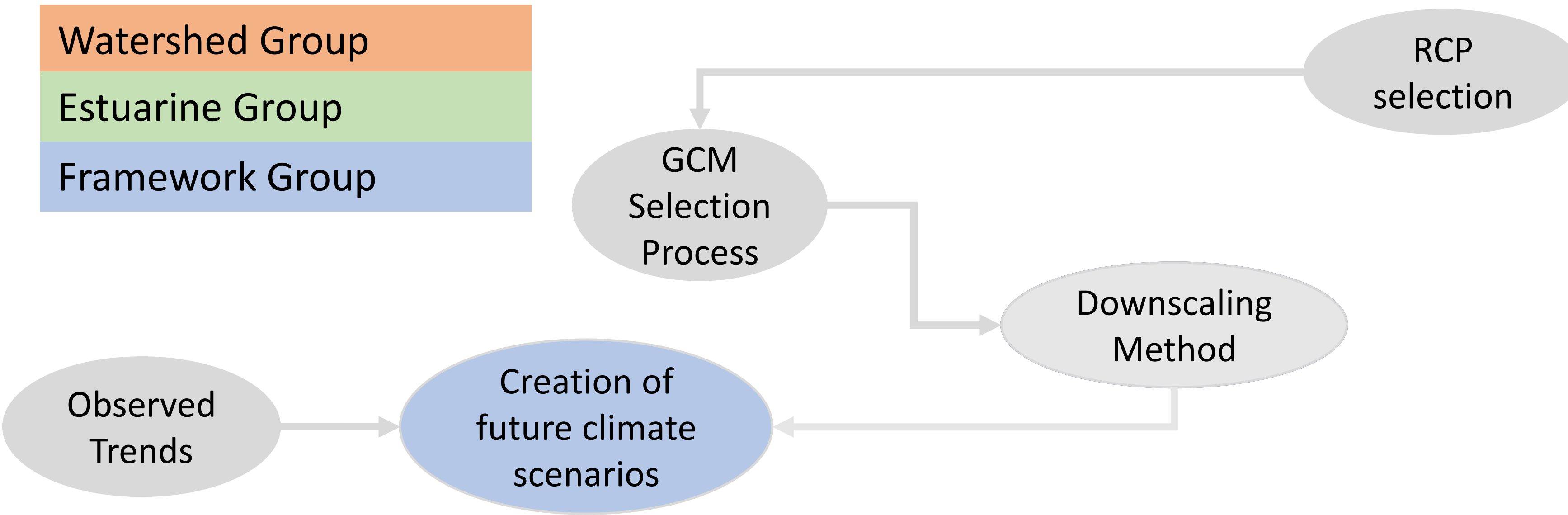
Literature exists to support the idea that all are reasonable approaches





Ensemble Method

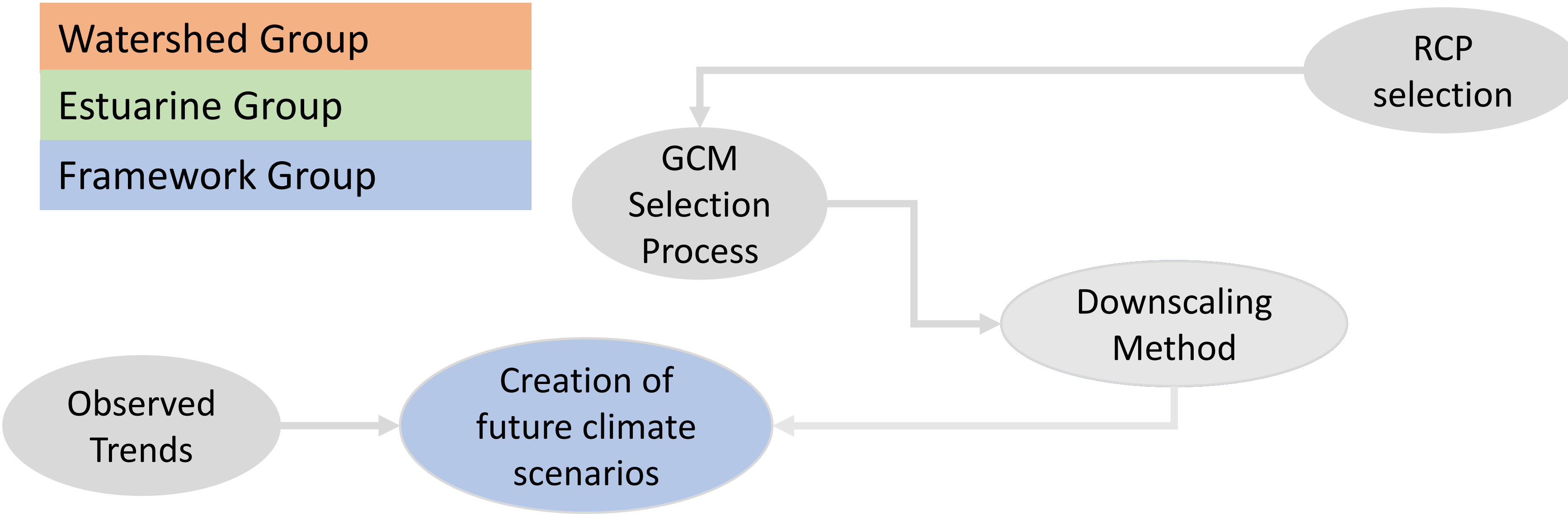
- Used the median temperature and precipitation change from the ensemble for each month for the primary run.
- Used the corners of the 90th percentile ‘box’ to investigate uncertainty



Literature shows that the increases in precipitation over the previous century have primarily occurred in the highest precipitation events.

Two methods of rainfall addition

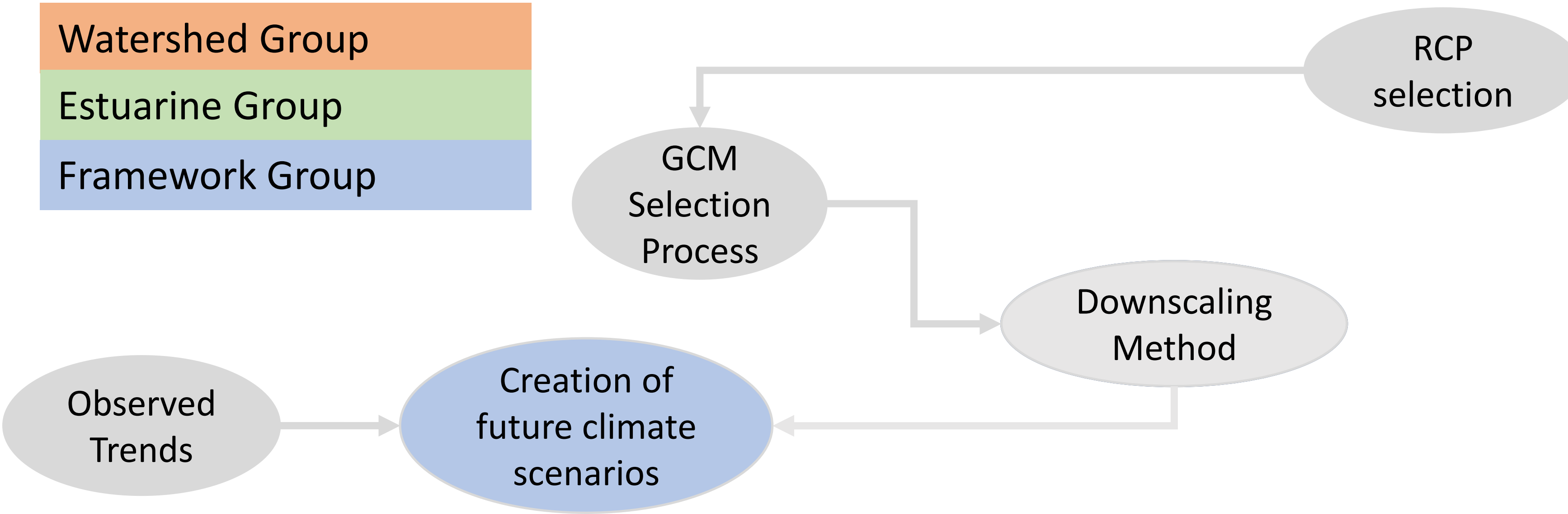
- Multiply all rainfall events by the same factor
- Multiply rainfall events within a decile by a factor such that the top decile increases a greater percentage as shown



CO_2

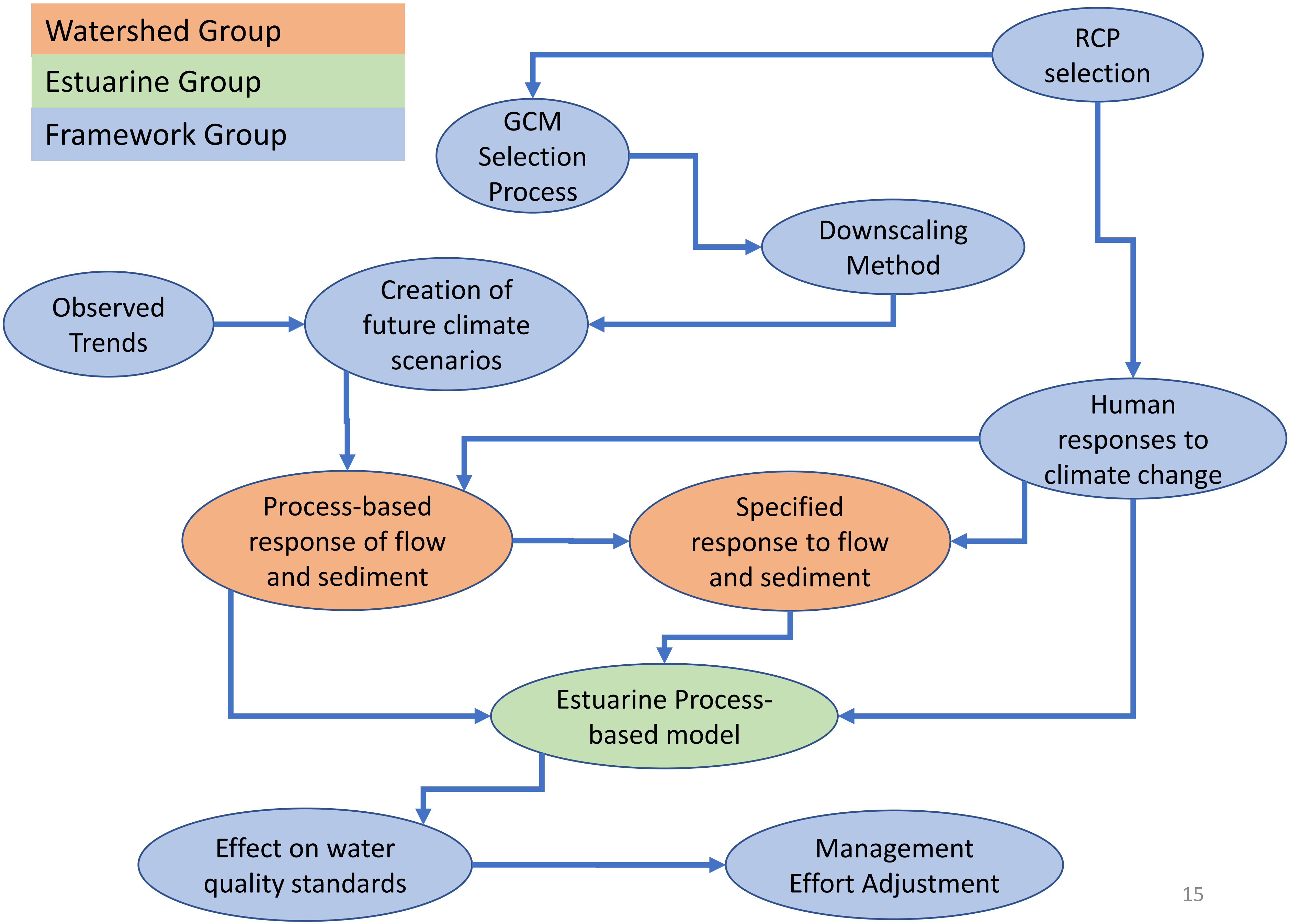
- IPCC 5 Working Group 1

	RCP 2.6	RCP 4.5	RCP 8.5
1995	363	363	363
2025	421	423	432
2050	443	487	541



PET

- Use Hargreaves-Samani to calculate change in PET
- Function of temperature and extraterrestrial radiation
- Apply the change in PET to the Base PET used in the Phase 6 model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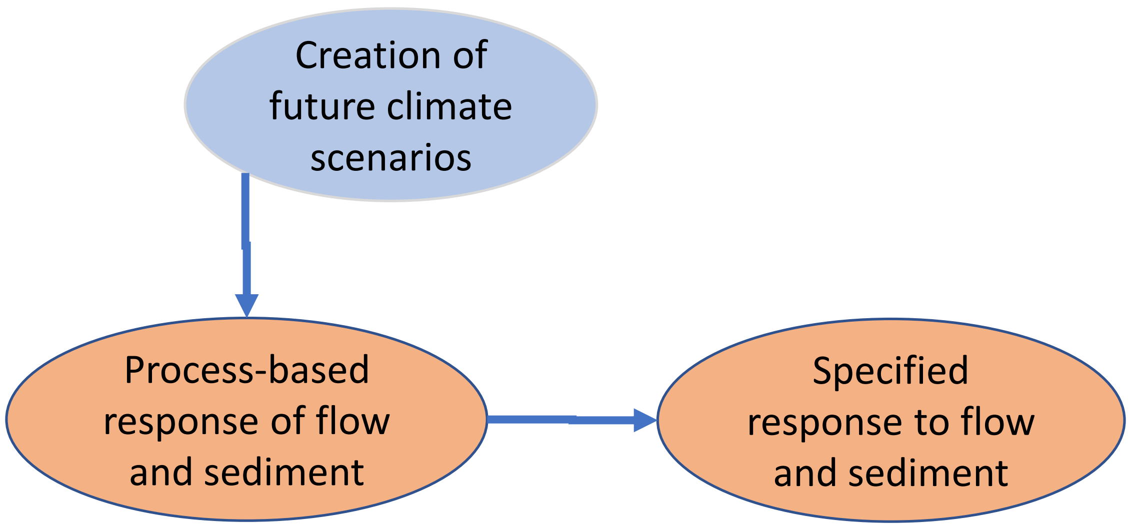

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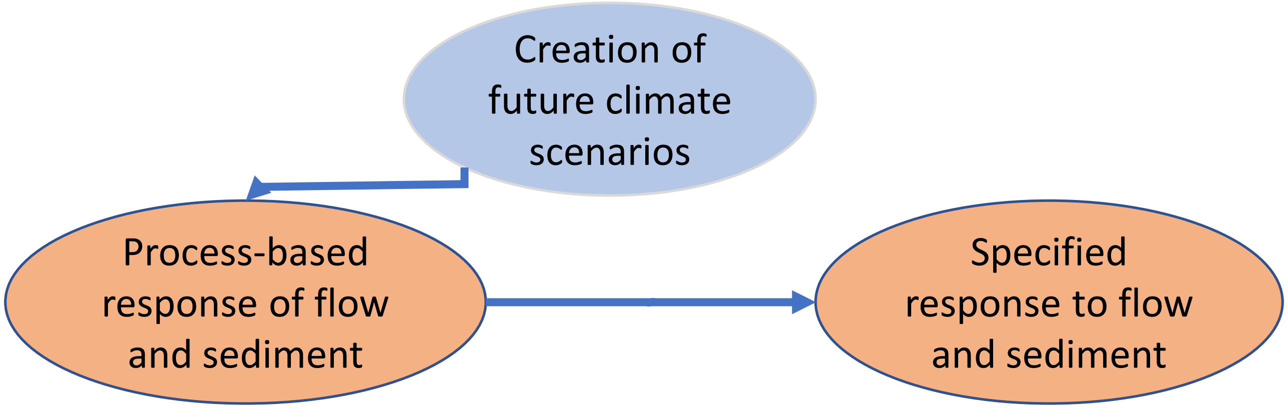

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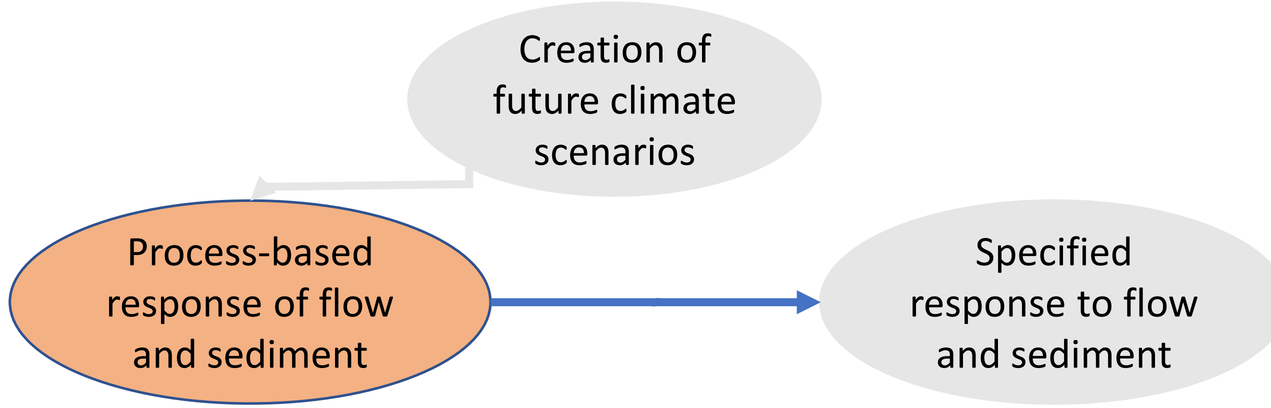
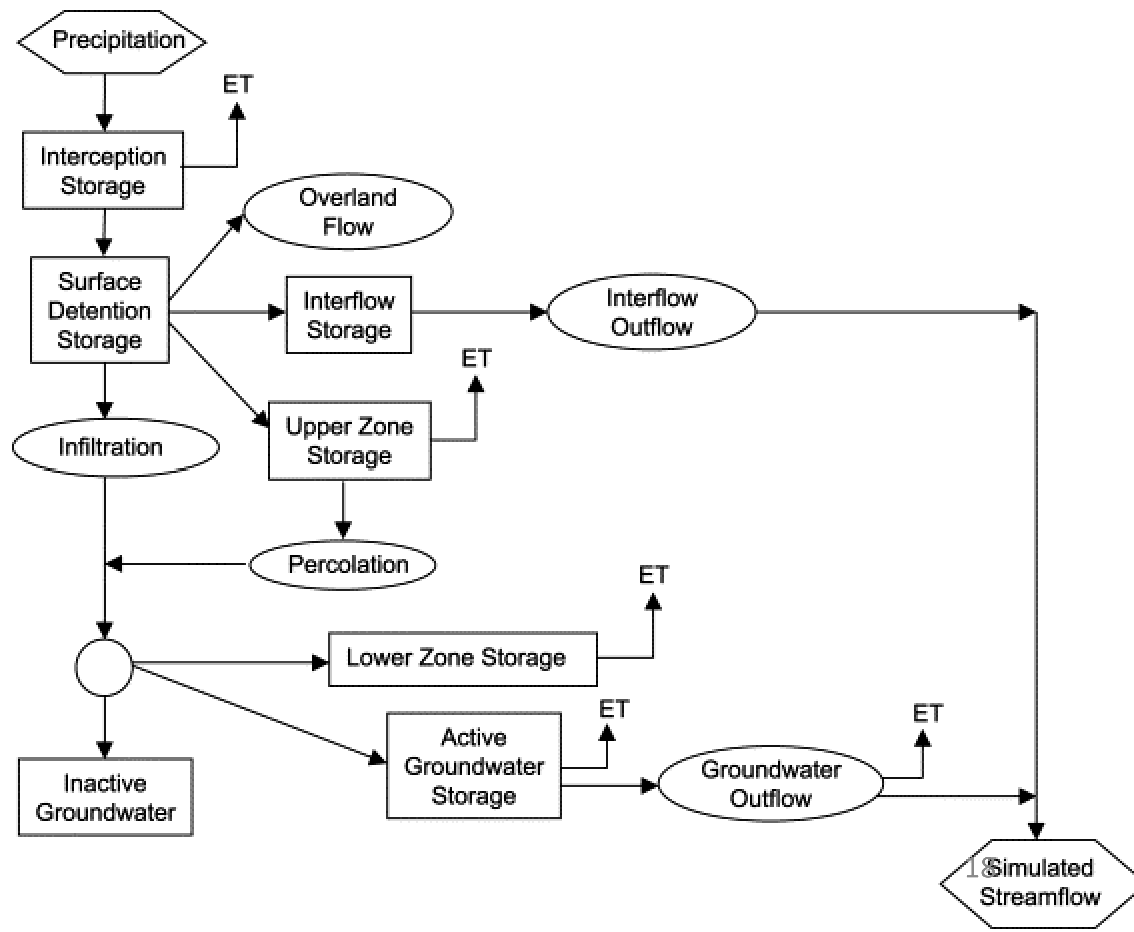


- HSPF simulation of hydrology is sensitive to:
- Precipitation
- PET
- CO_2
- Temperature (snowfall and snowmelt)



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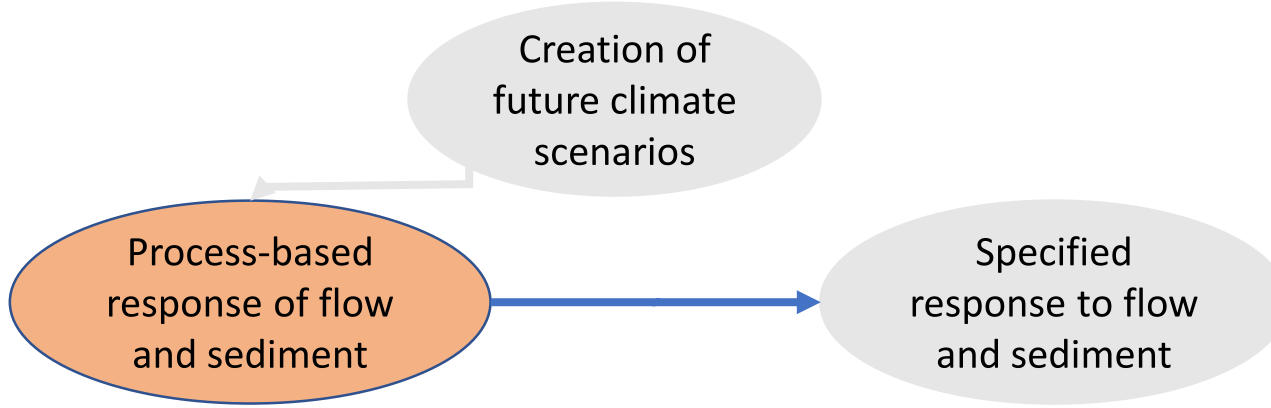
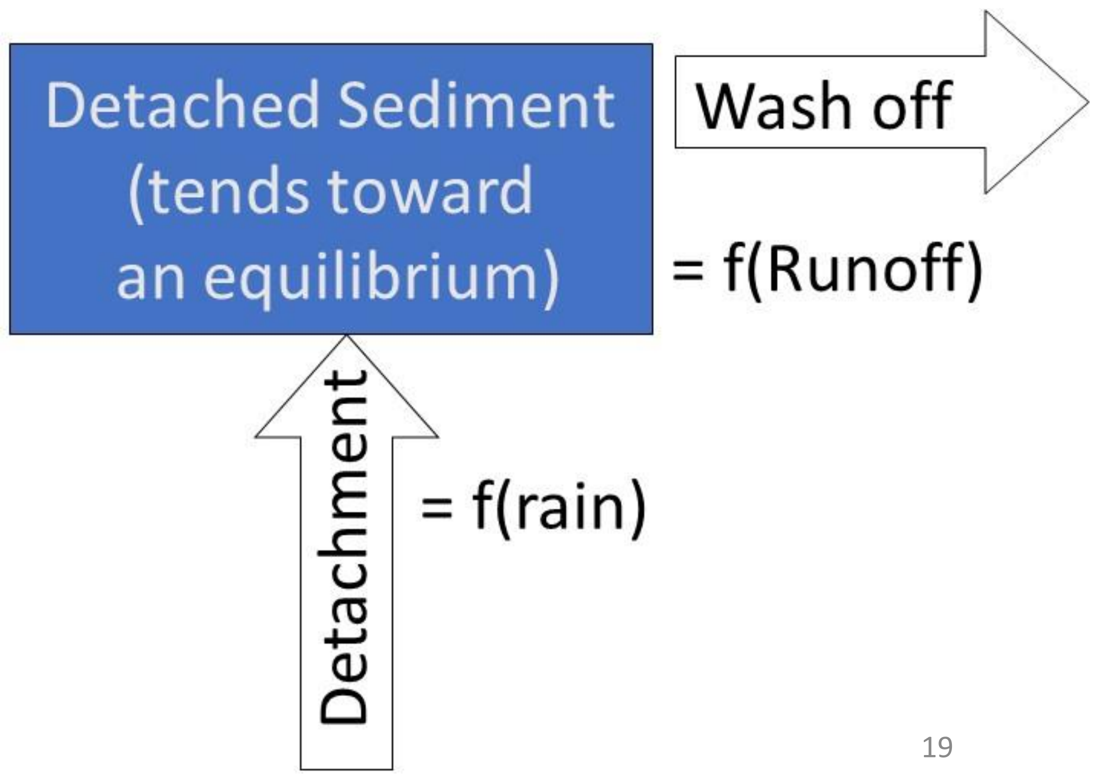


- HSPF simulation of sediment is sensitive to:
- Precipitation
- Runoff
  - PET, temperature, CO_2, precip



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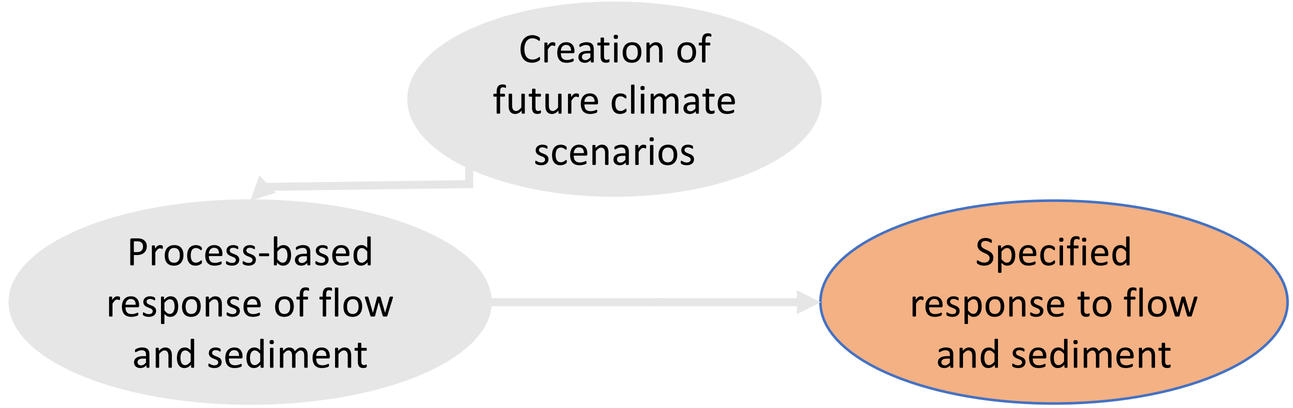
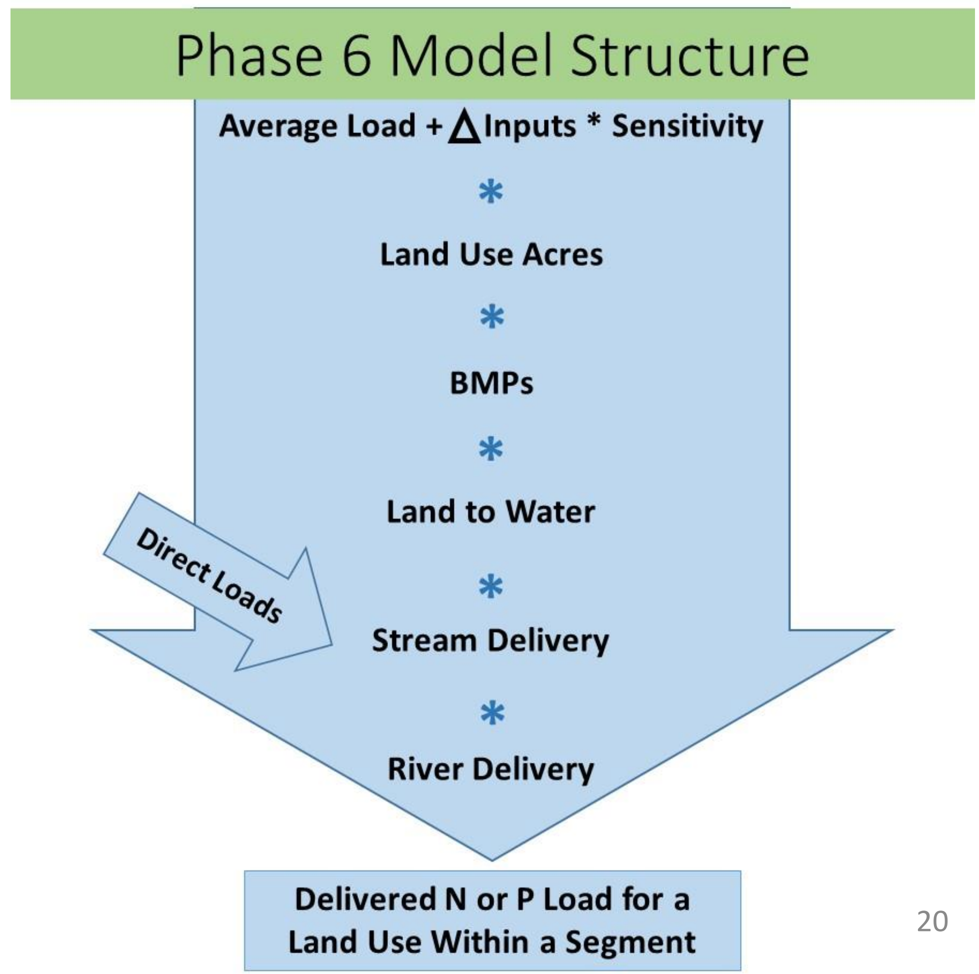


- Phase 6 model is time-averaged for N and P from the land
- Sensitivity to climate must be specified



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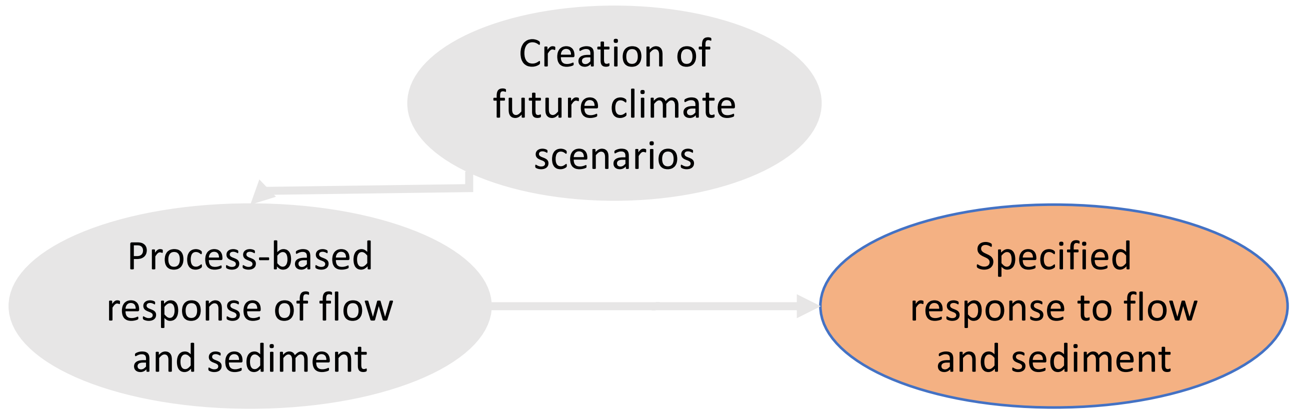
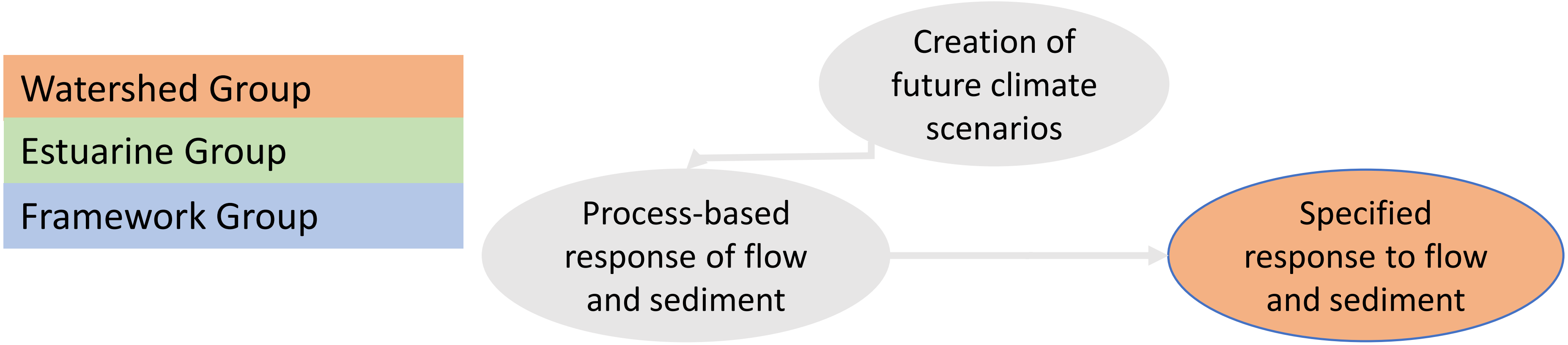


- Nitrogen Sensitivities
- Agriculture
  - Fertilizer
  - Manure
  - Atmospheric Deposition
  - Fixation
  - Crop Cover
  - Uptake

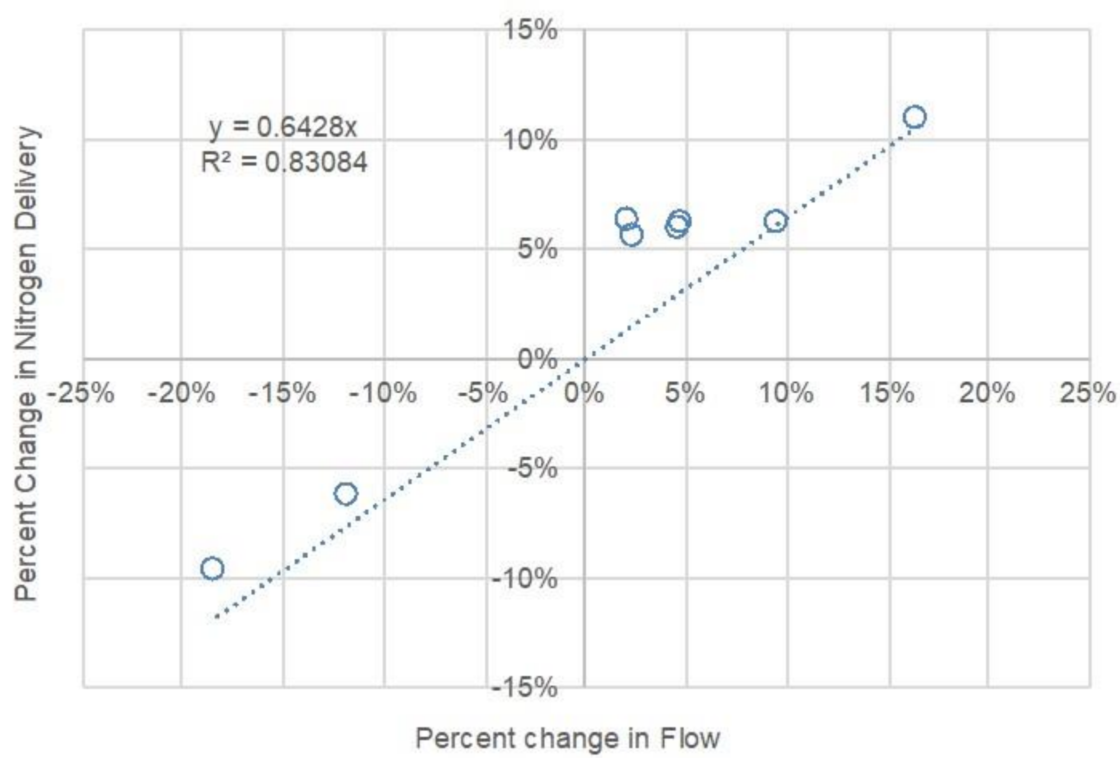
- Nitrogen Sensitivities
- Developed
  - Fertilizer
  - Atmospheric Deposition
  - Crop Cover
  - Uptake
- Natural
  - Atmospheric Deposition

- Delivery
  - Available water capacity
  - Groundwater recharge
  - Piedmont carbonate



- Nitrogen assumption:
  - No changes to the concentrations
  - proportional change in load to a change in flow.

- Phase 5.3.2
  - Nitrogen change = 64% of flow change



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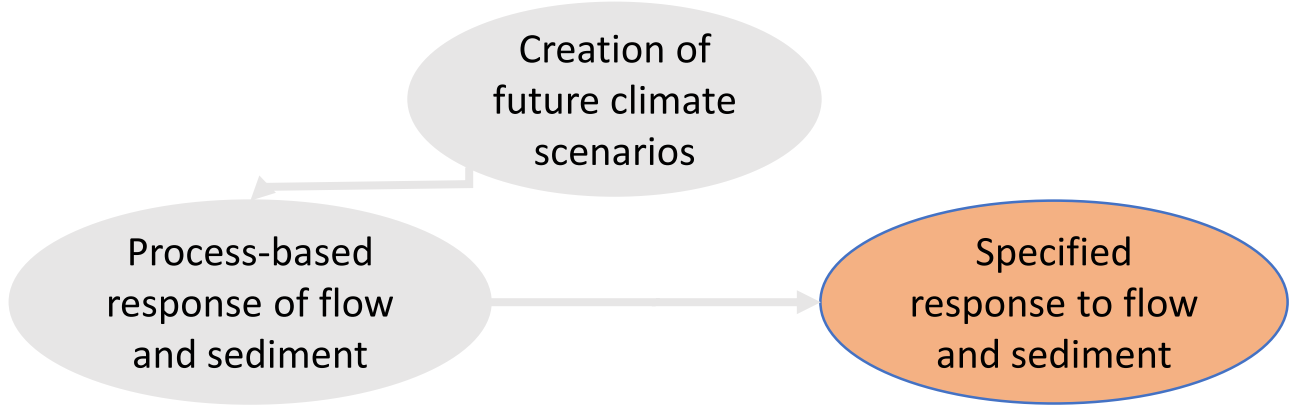
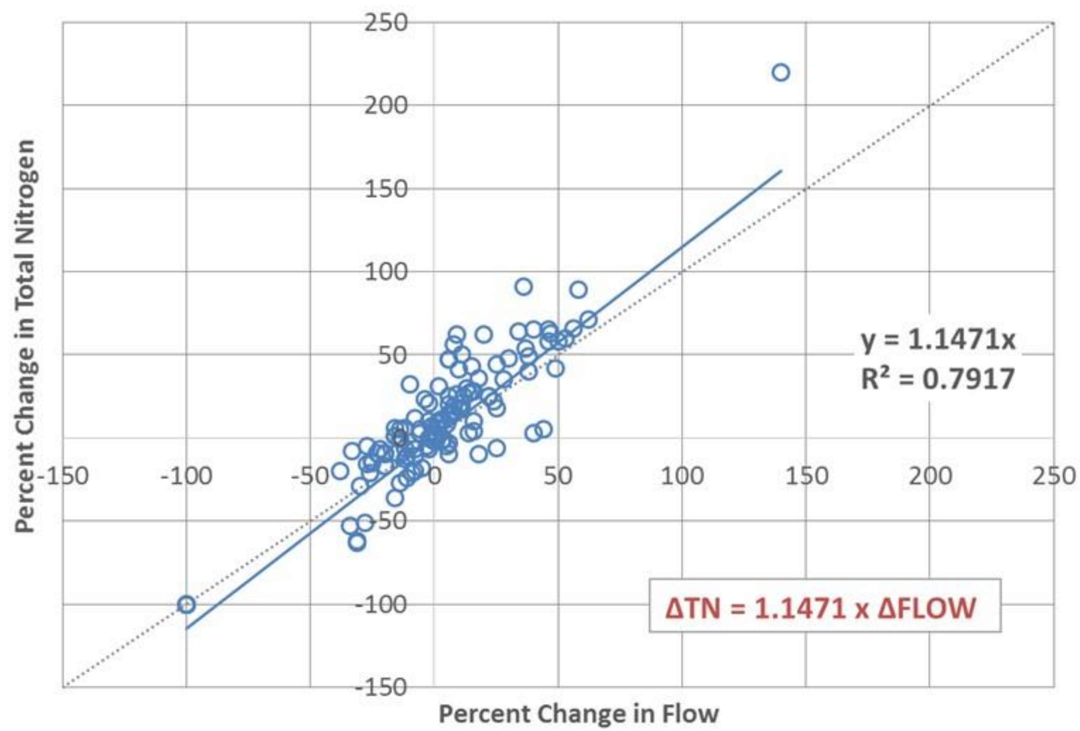


- Nitrogen assumption:
  - No changes to the concentrations
  - proportional change in load to a change in flow.

- ‘20 watersheds’ study
  - Nitrogen change = 115% of flow change



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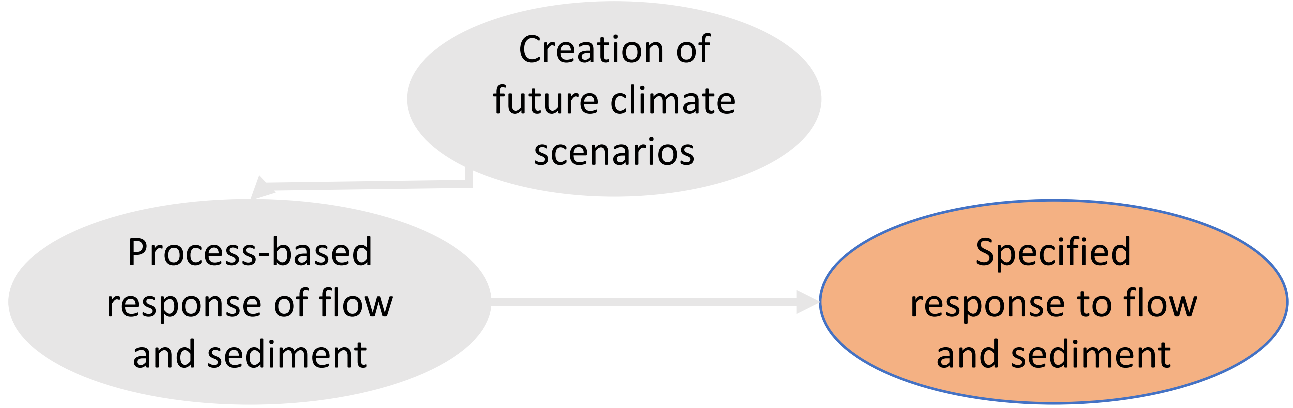
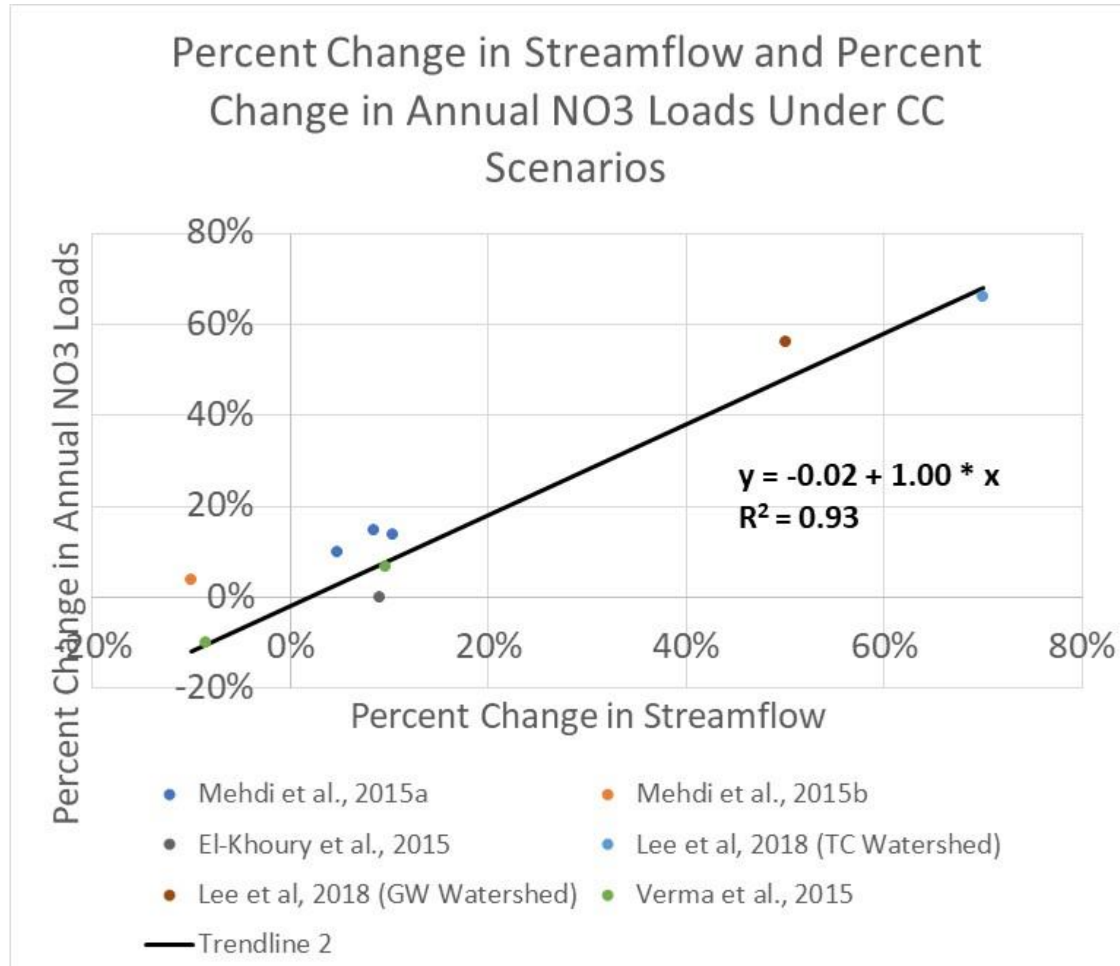


- Nitrogen assumption:
  - No changes to the concentrations
  - proportional change in load to a change in flow.
- CBPO literature review
  - Nitrate change = 100% of flow change



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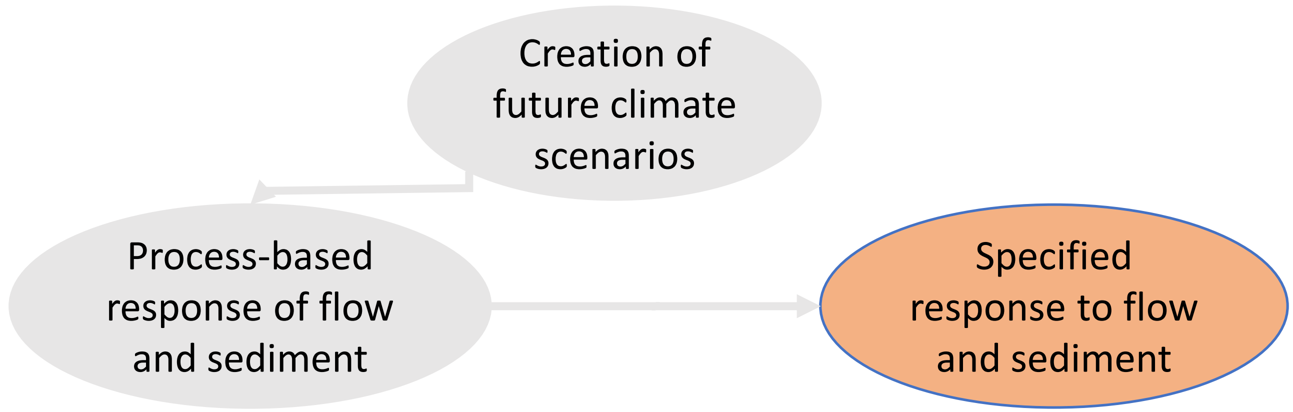

- Phosphorus Sensitivities
- Agriculture
  - Soil P
  - Applied Water Extractable P
  - Stormflow
  - Sediment Washoff
- Developed
  - Fertilizer
- Natural
  - Stormflow
  - Sediment Washoff
- Delivery
  - Well-drained soils

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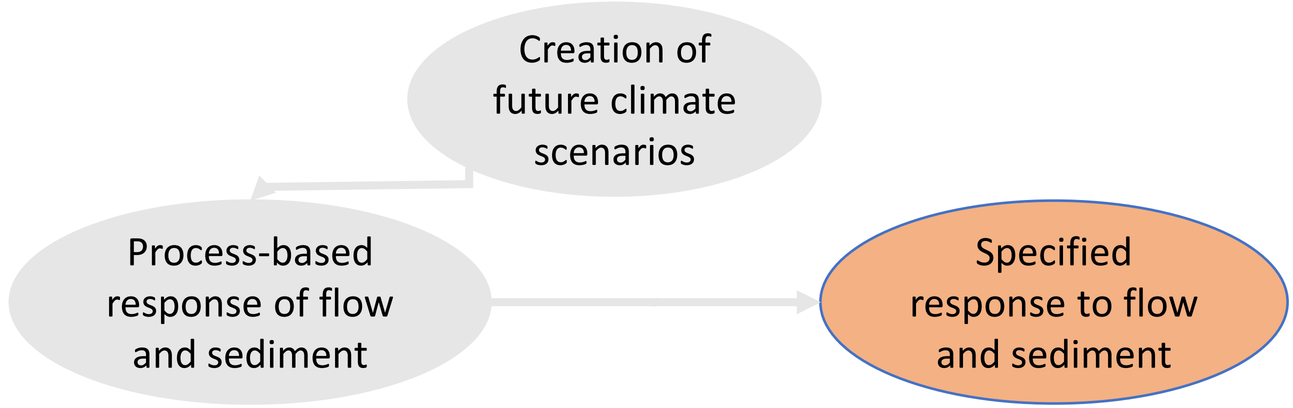
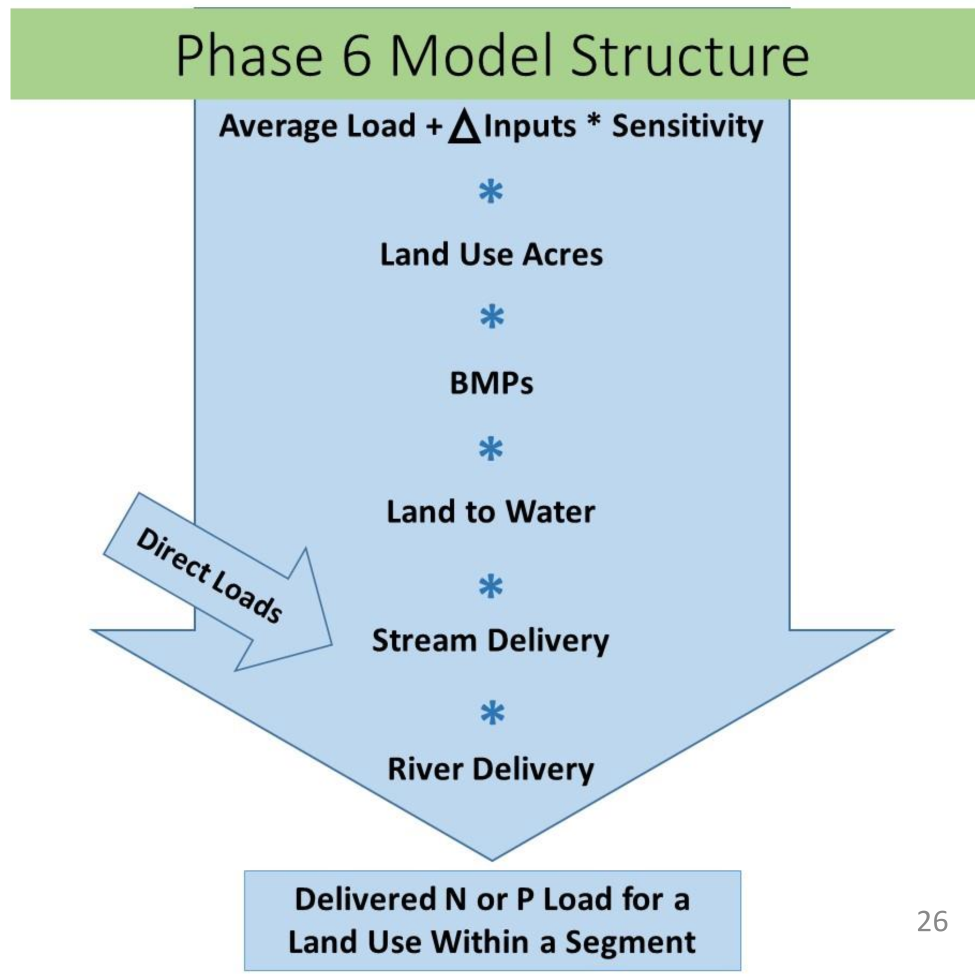
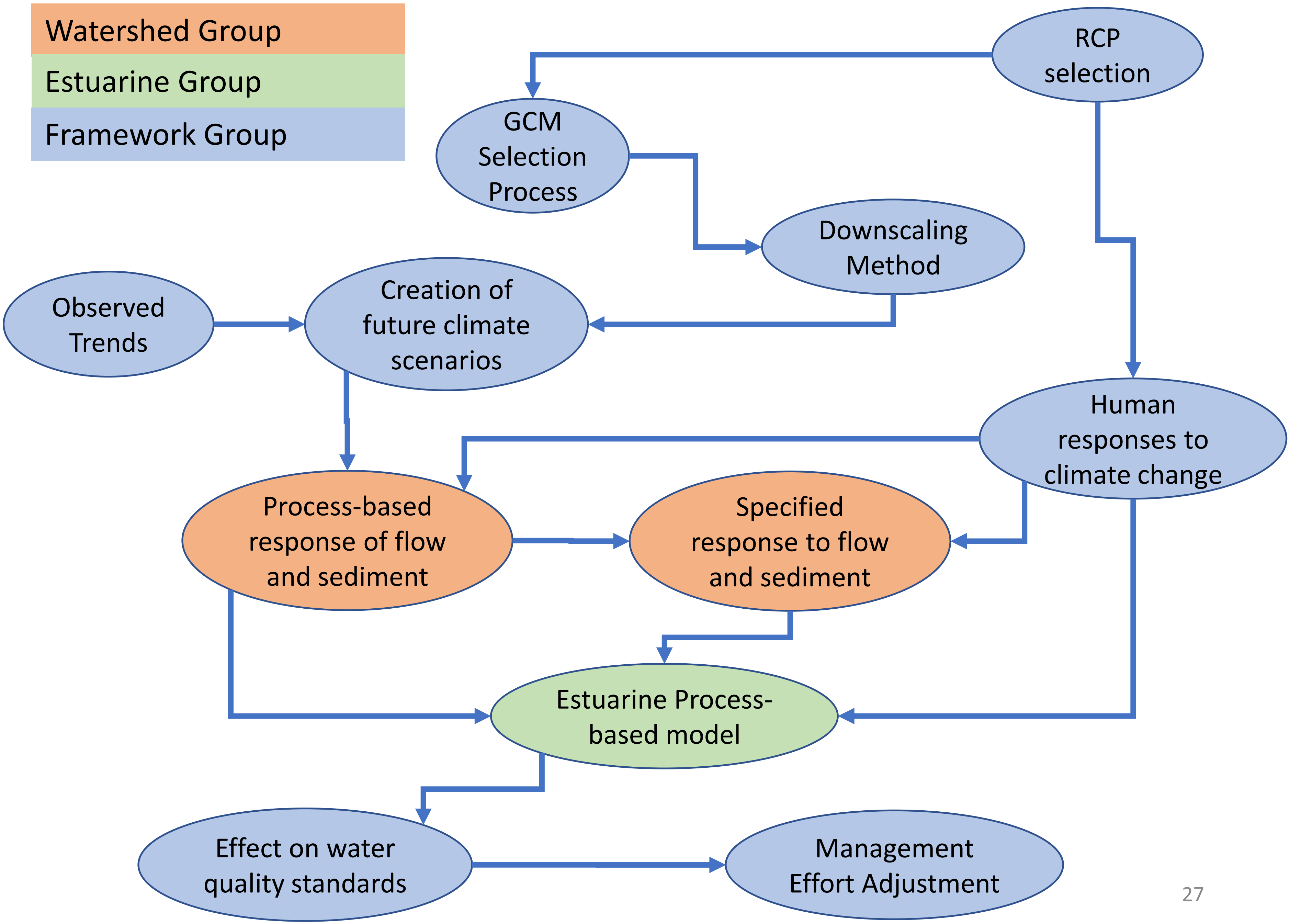


- River Delivery is simulated by HSPF
- Scour and deposition of sediment nutrients simulated in rivers greater than 100 cfs

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Human responses to climate change

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Human responses to climate change

- Sensitivities are built in, but need to know how they change in response to human actions

- Nitrogen Sensitivities
- Agriculture
  - Fertilizer
  - Manure
  - Atmospheric Deposition
  - Fixation
  - Crop Cover
  - Uptake

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- Developed
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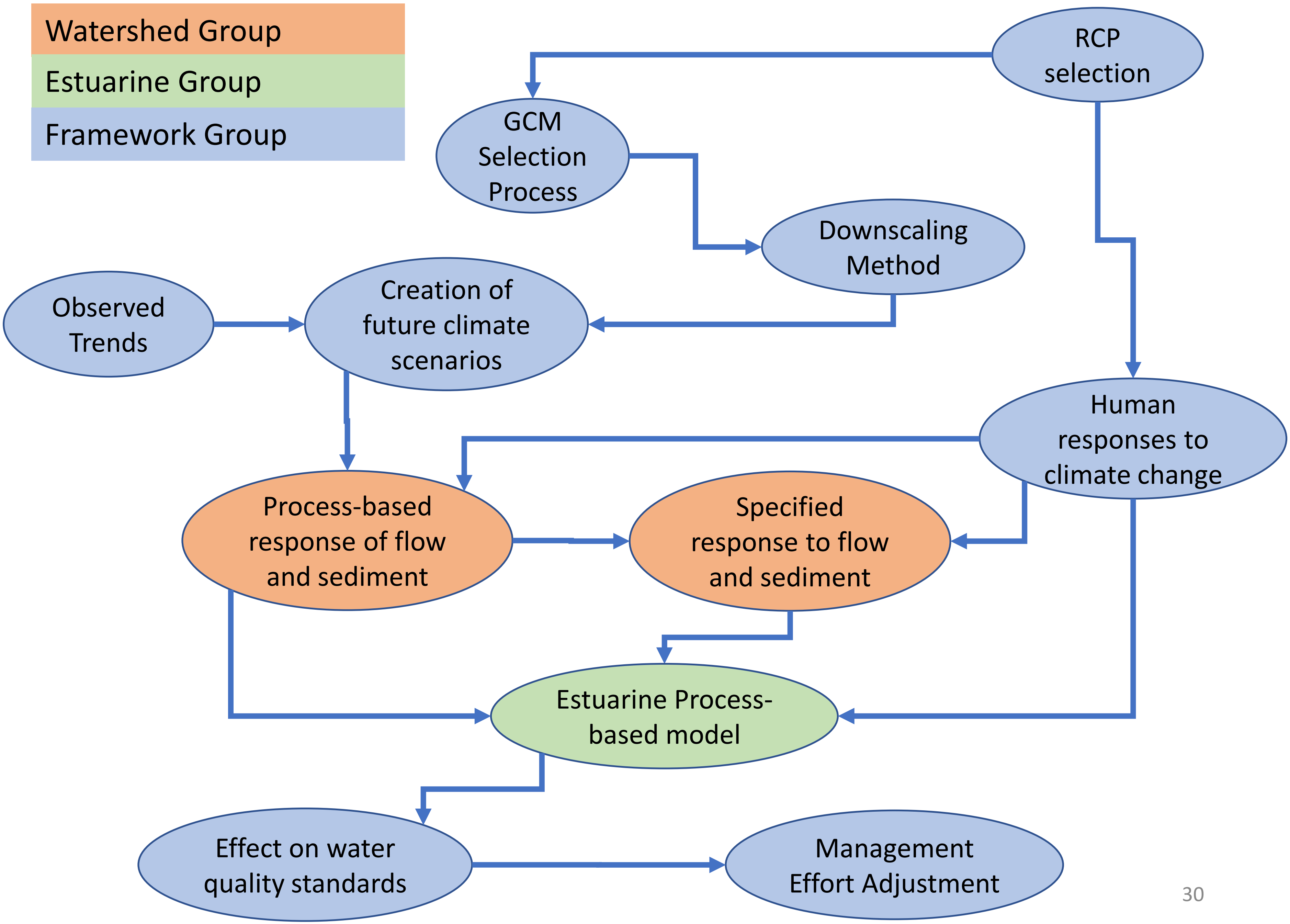
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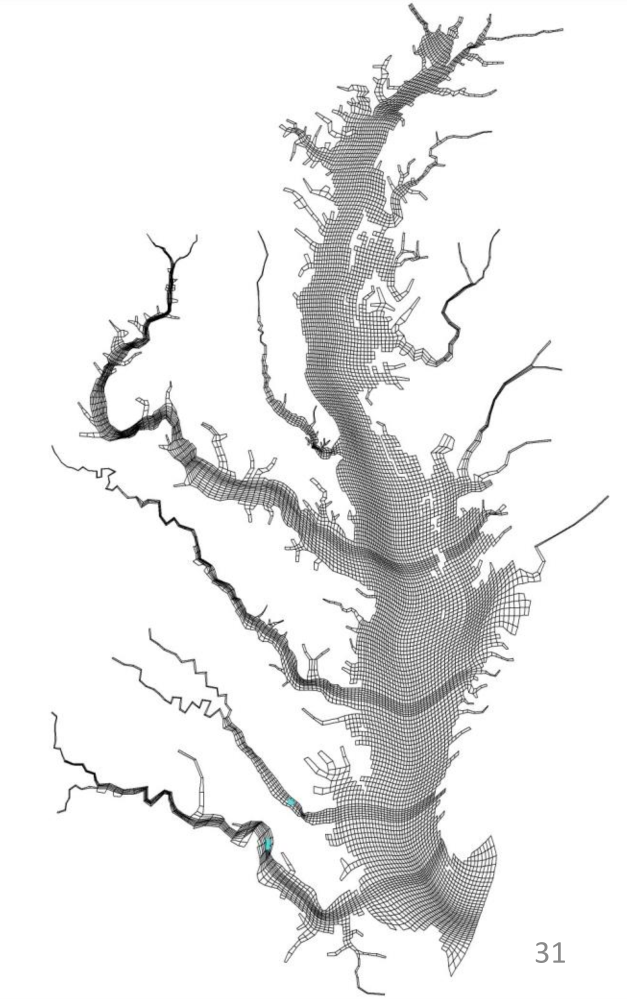
Estuarine Process-based model

- CH3D hydrodynamic
- CE-QUAL-ICM WQ
  - Sediment biogeochemistry
  - Sediment Transport
  - Living Resources
    - SAV
    - Oysters
    - Menhaden



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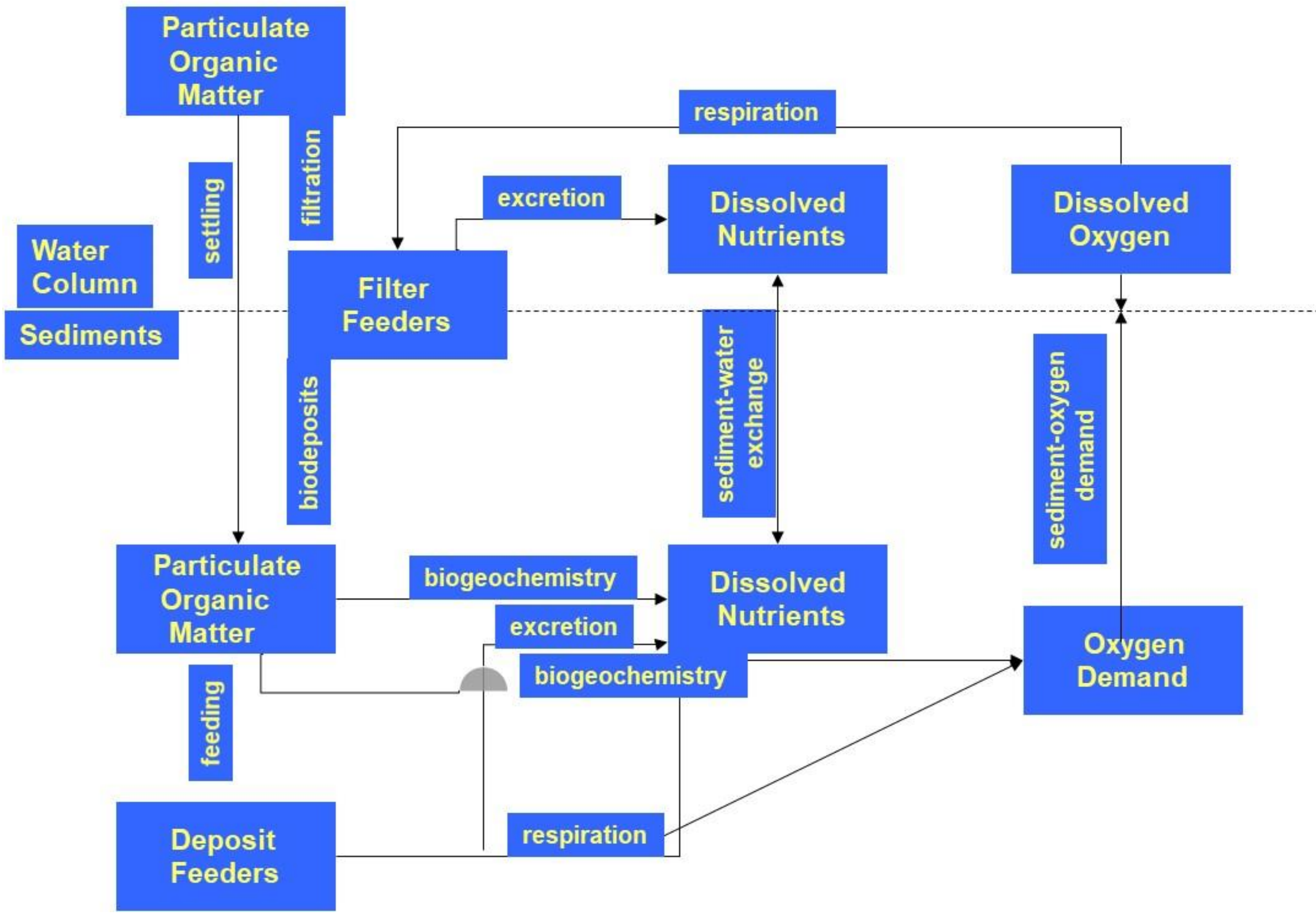

Watershed Group

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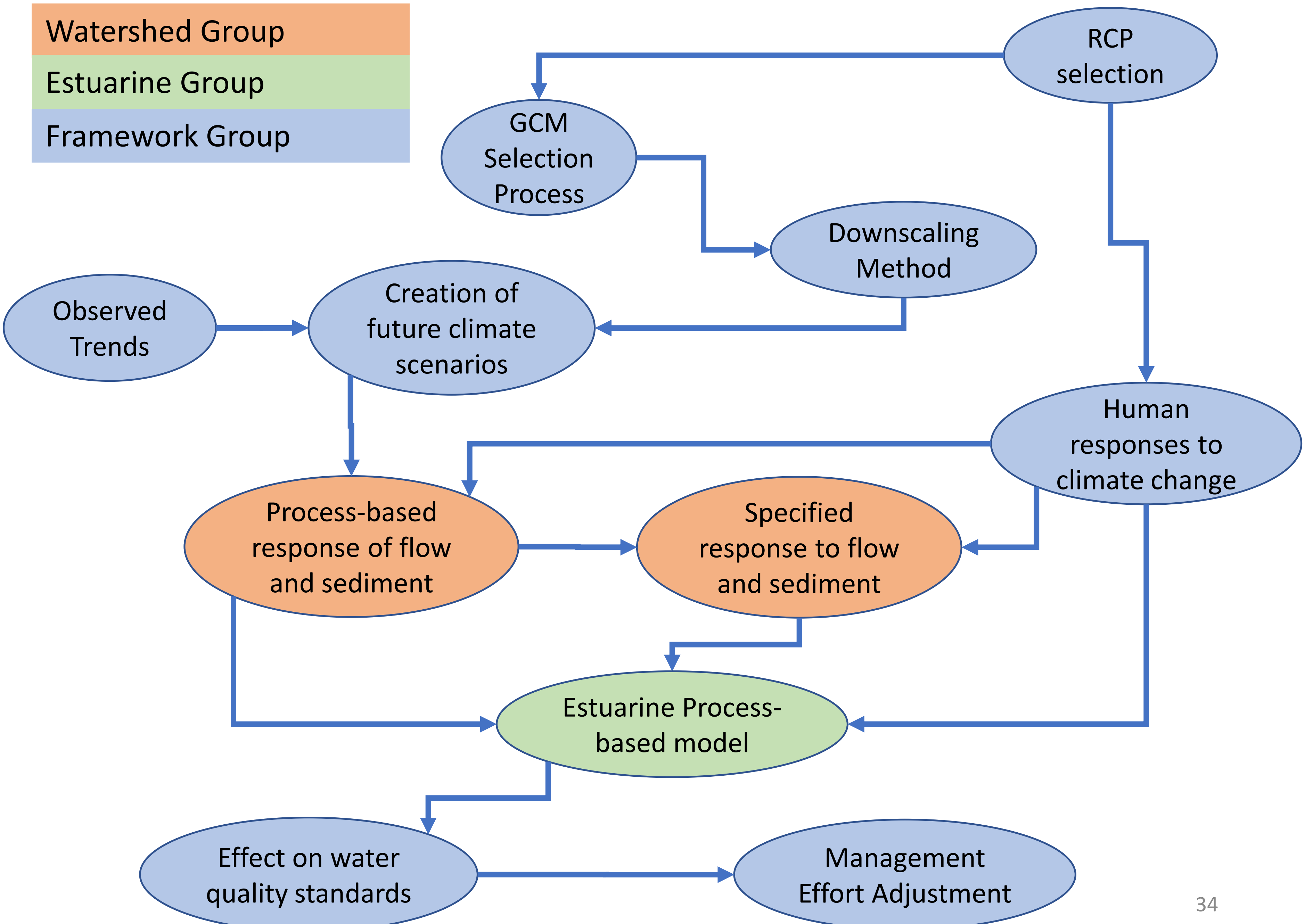
Estuarine Process-based model

- Considerations
  - Sea level Rise
  - Surface Temperature
  - Ocean Boundary Condition
  - Flow, Nutrients, Sediment, Heat from the watershed



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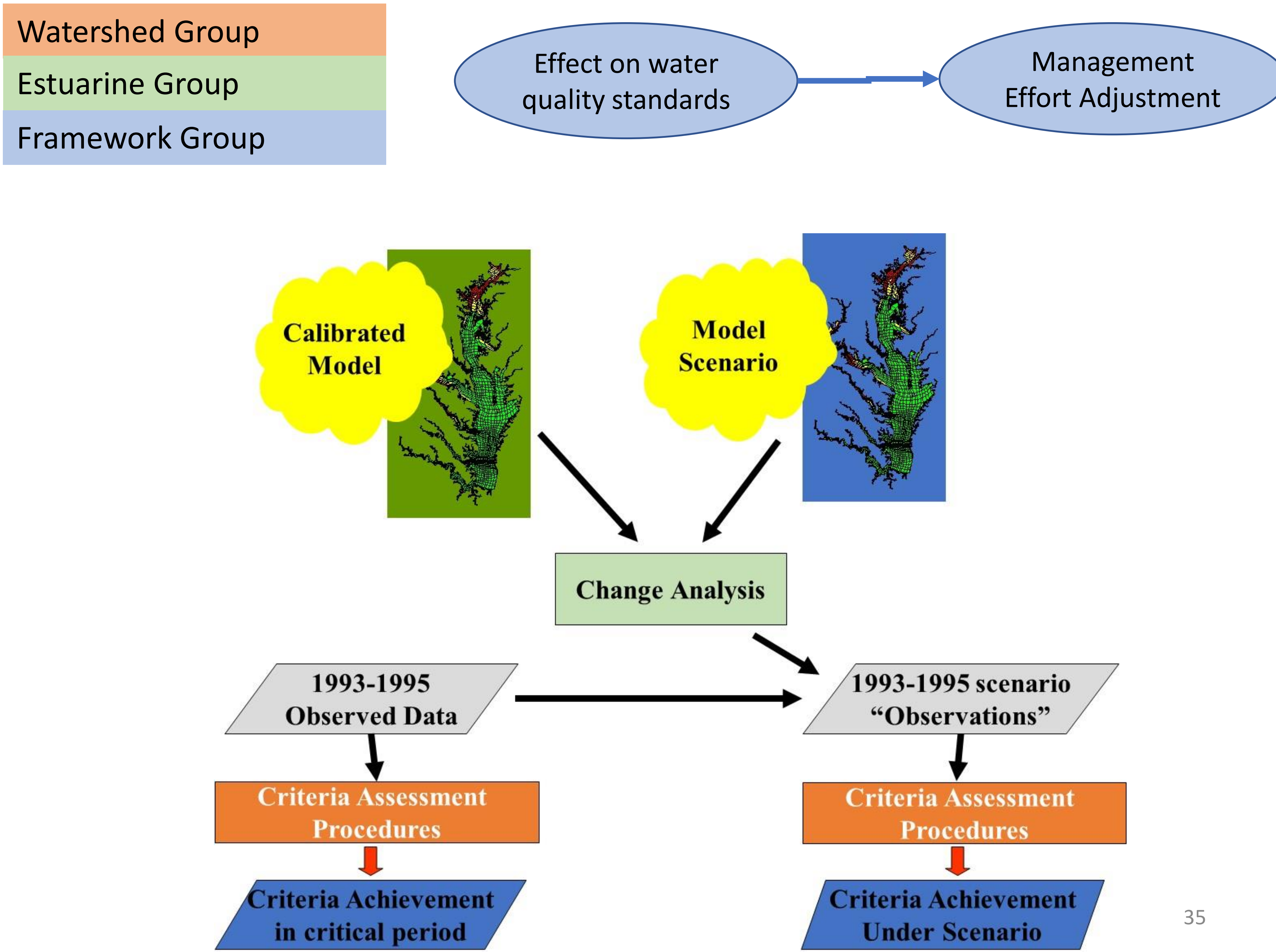
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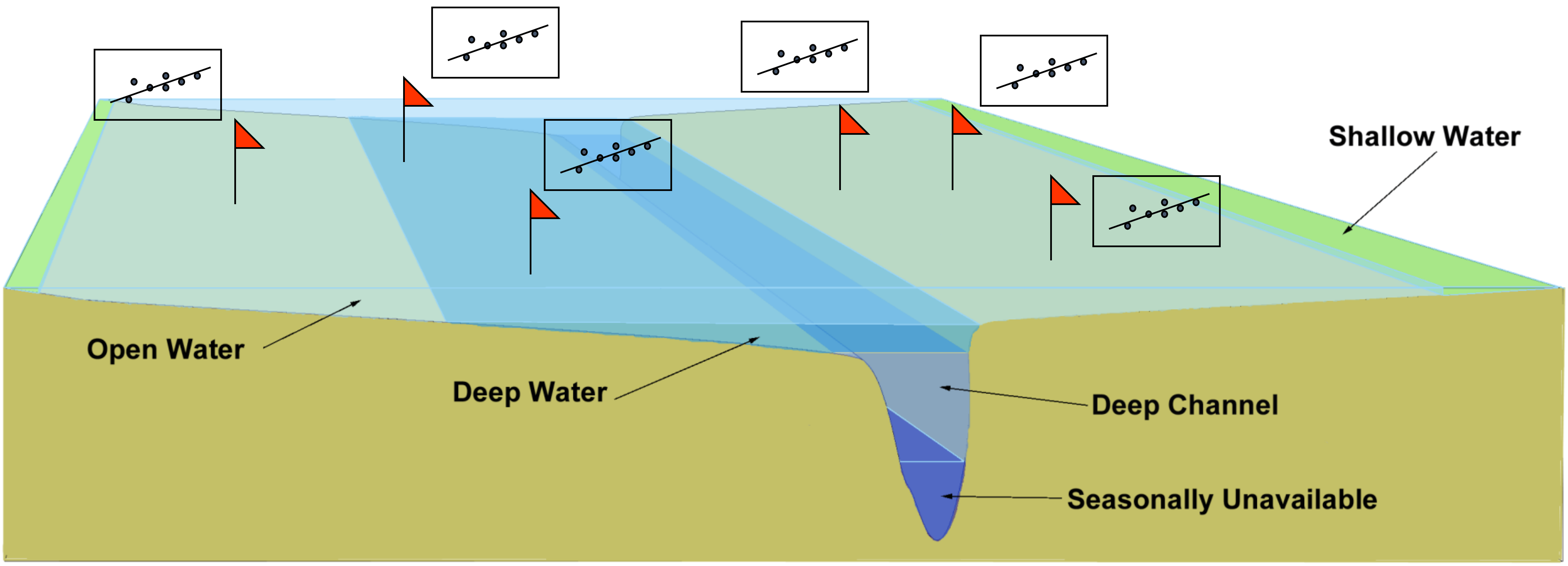
Calibrated Model
Model Scenario
Change Analysis
1993-1995 Observed Data
1993-1995 scenario "Observations"
Criteria Assessment Procedures
Criteria Assessment Procedures
Criteria Achievement in critical period
Criteria Achievement Under Scenario



One regression for each point and each month

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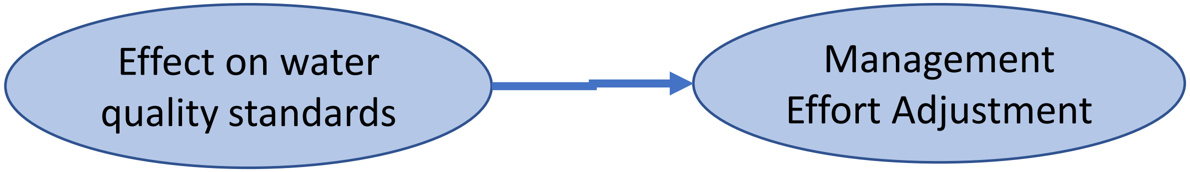

Calculate Climate Effect

December 2017 results

CB Seg	Designated Use	Designated Use Total Volume	Red Percent WIP + Conow	Red Volume WIP + Conow	Red Percent WIP + Conow + CC	Red Volume WIP + Conow + CC
CB3MH	DW	864	0.05%	0	0.05%	0
CB4MH	DW	2854	5.52%	158	6.50%	186
MD5MH	DW	2097	1.09%	23	1.51%	32
VA5MH	DW	1605	0.00%	0	0.00%	0
POMMH	DW	1839	0.00%	0	0.00%	0
CB3MH	DC	390	0.00%	0	0.00%	0
CB4MH	DC	2126	8.04%	171	10.09%	215
MD5MH	DC	2875	0.00%	0	0.00%	0
VA5MH	DC	1848	0.00%	0	0.00%	0
				352		432
					CC Difference	**80**

Volume Weighted means a ‘red area’ increase of 80 million cubic meters

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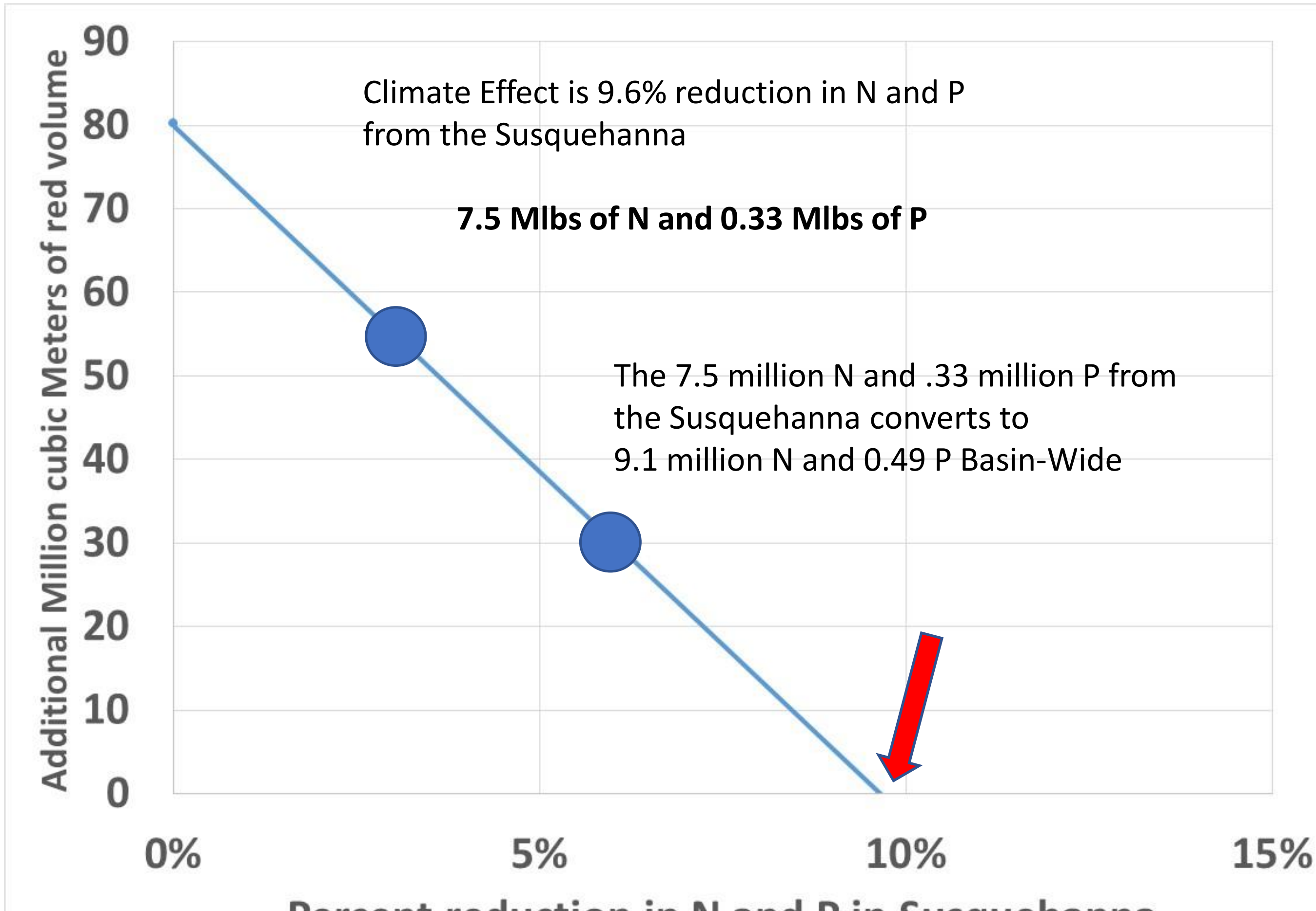
December 2017 results

Ran Scenarios with 3% and 6% reduction in Susquehanna N and P



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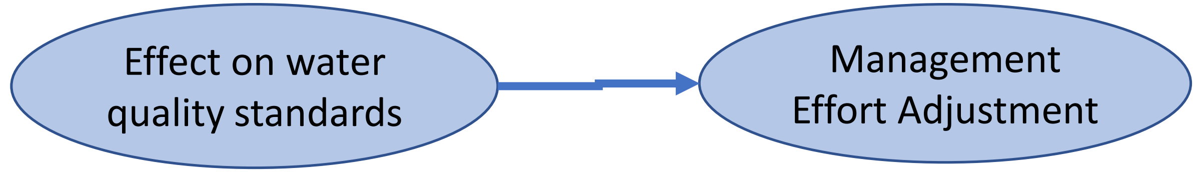
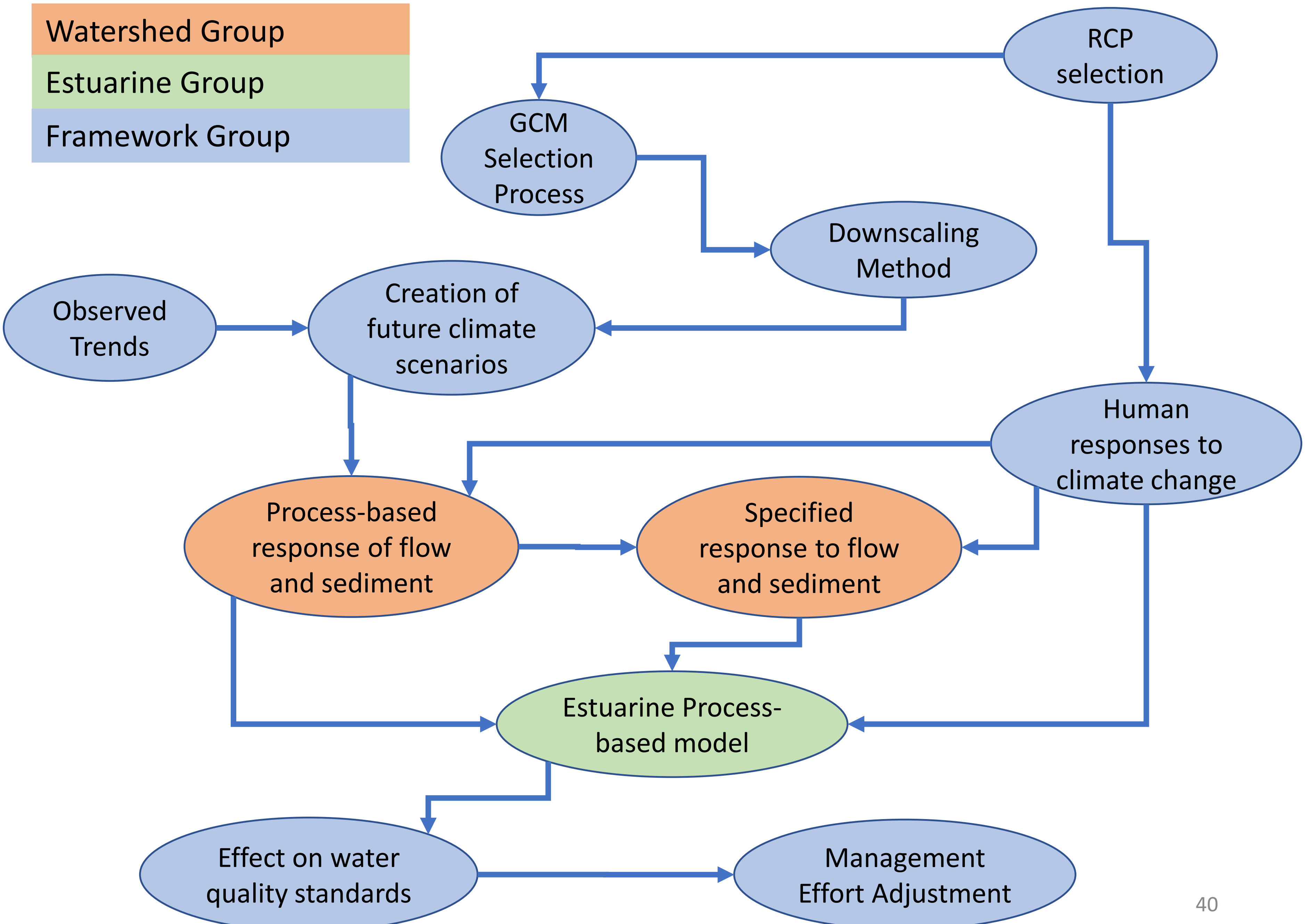


December 2017 results

Climate Change Loads: Nitrogen

Jurisdiction	1985 Baseline	2013 Progress	Climate Change	Growth in Load to 2025	Conowingo Load Responsibility	2013 Progress +	Phase III Planning Target
NY	18.71	15.44	0.400			15.84	10.62
PA	122.41	99.28	4.135			103.41	72.99
MD	83.56	55.89	2.194			58.09	45.39
WV	8.73	8.06	0.236			8.30	6.36
DC	6.48	1.75	0.006			1.76	2.25
DE	6.97	6.59	0.397			6.98	4.66
VA	84.29	61.53	1.722			63.25	56.37
BasinWide	331.15	248.54	9.09			257.63	198.64

*Units: millions of pounds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