Phase 6 Climate Change Model Development

Gary Shenk and the CBPO modeling team

7/15/19

Presentation to CRWG

Watershed Model

increased precipitation volume =

increased precipitation intensity =

increase in temp and evapotranspiration =

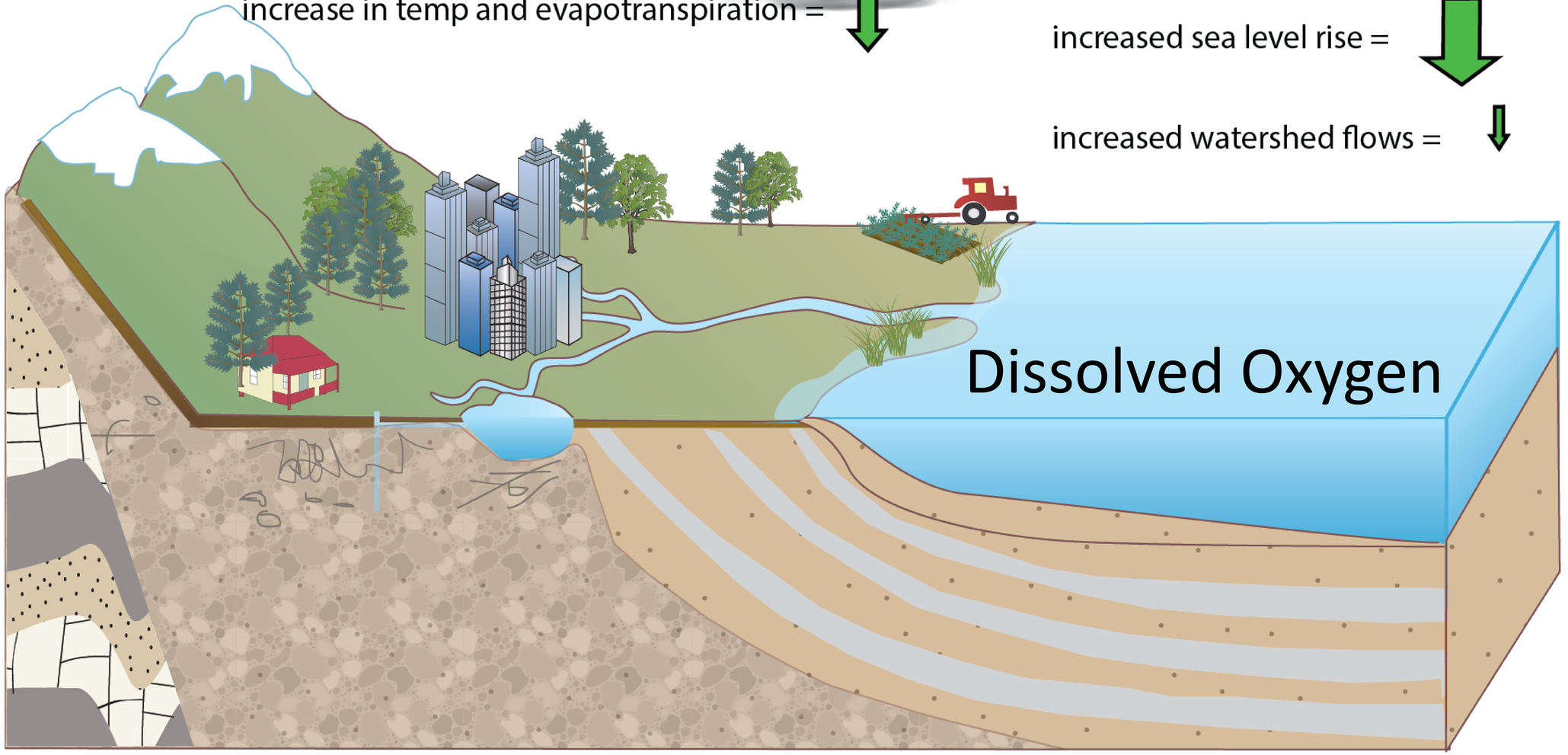
WQ Sediment Transport Model

increased watershed loads =

increased temperature =

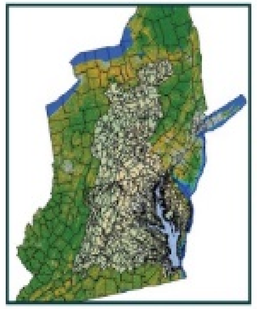
increased sea level rise =

increased watershed flows =

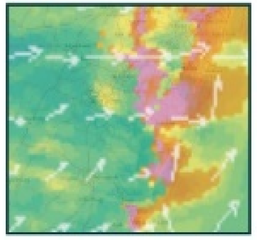


Data and Model Inputs

Pollution Control Data
Land Use Data
Point Sources Data
Septic Data
U.S. Census Data
Agricultural Data



Land Use Change Model



Airshed Model

Precipitation Data
Meteorological Data
Elevation Data
Soil Data

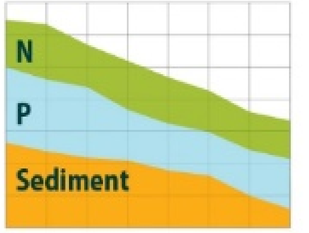
Phase 6 Watershed Model/CAST

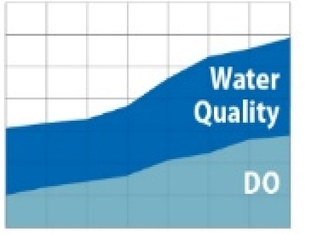
Estuary Model

Model Outputs

Prediction of Impacts

BMP Implementation Results





Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

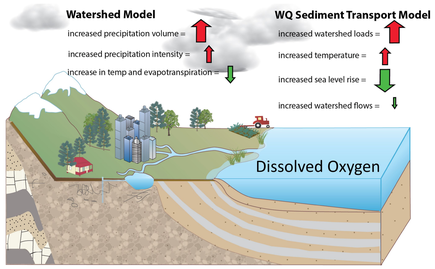
Complete

In Process

Not included
But important

Not included
minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Observed Precipitation Trends GB 2.1 **JUL**
Extrapolation GB2.1 **JUL**
Climate scenarios GB2.1 **JUL**
Down-scaling GB2.1 **JUL**
GCM Selection GB 2.1 **JUL**
RCP GB 2.1 **JUL**
GCMs GB 2.1 **JUL**

Climate

Support/Revise Flow--N relationship IB 4.4 **OCT**
APLE
Soil P history effect GS 4.5 **OCT**
Investigate Speciation changes 4.7.1 **OCT**
P sensitivity in developed IB 4.5 **Oct**
Process-based response of flow and sediment On land
Specified land nutrient response
Effect on land use GS 3.2 **JUL**
CMAQ Climate change effect LL/JB/BS 3.1 **OCT**
Carbon Dioxide effect **GB 4.1 JUL**
Nutrient Inputs
BMP effectiveness change GS 4.6 **OCT**
Effect on Ag GS 3.3 **JUL**
Land to water factor effect GS 4.7 **OCT**
BMPs
Land to Water
Stream to River factors effect GS 4.7 **OCT**
WWTP Effect GS 3.4.2 **JUL**
Streams
Septic Effect GS 3.4.2 **JUL**
Groundwater Travel Time effect GS 4.7 **JUL**
UNEC
Rivers
Reservoir Rules effects GS 4.7 **JUL**
Diversion Effect GS 3.4.2 **JUL**
CSO Effect IB 3.4.1 **JUL**

Watershed

Reasonable response to sea level rise? PS 5.3.1 **OCT**
Reasonable response to temperature? RT/IB 5.3.2 **OCT**
Wetlands losses and gains LL/CC 5.1.1 **OCT**
Examine wind effects RT 5.1.2 **JUL**
Estuarine Model WQSTM
Estuarine Inputs
Sea level Rise RT 5.1.3 **JUL**
Growth and respiration curve for phytoplankton RT 5.2 **JUL**
Ocean Temp & Salinity RT 5.1.4 **JUL**

Estuary

Effect on water quality standards
Management Effort Adjustment
STAC CC2.0 Framework recommendations

Management

CBP Climate Basics

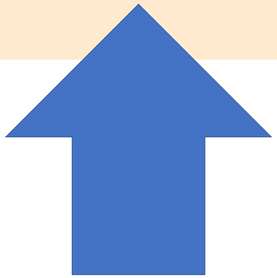
- Critical period for dissolved oxygen is 1993-1995
  - Selected as having a return period for wetness of 10 years
- Hydrologic averaging period is 1991-2000
  - Selected as an ‘average’ 10-year period
- Management questions
  - What would loads look like in a 1991-2000 that was translated through 30 years of climate change to 2025?
  - What would oxygen attainment look like during a 1993-1995 that was translated through 30 years of climate change to 2025?
  - What would loads have to be in 1991-2000 such that standards are attained with a 1993-1995 period translated to 2025?
- Take a first look at 2035, 2045, and 2055

CBP Climate Work Plan

Plan	Model	Review	Decide
2018	2019	2020	2021
STAC Workshop Climate Resiliency WG to investigate BMP response Jurisdictions provide narrative in WIP3s on climate strategies Modeling WG develop climate scenarios	Modeling WG, direct Modeling team to develop climate change assessment for TMDL with input from CRWG and WQGIT	Technical Review of Models	Climate change considerations will be implemented into the 2022-2023 milestones.

CBP 2019 MWG Climate Work Plan

February	April	July	October	November
Climate Topics	Climate Topics	July 16-17 Technical Decisions on Climate Topics Draft documentation emailed 6/28	October 8-9 Technical Decisions on Climate Topics Draft documentation emailed 9/24	Delivery of model results based on October decisions



Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

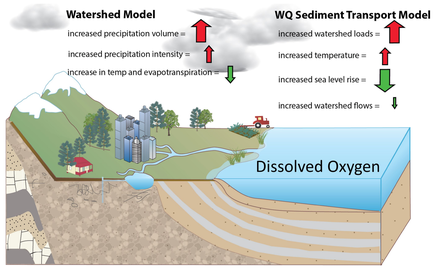
Complete

In Process

Not included
But important

Not included
minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Observed Precipitation Trends GB 2.1 **JUL**
Extrapolation GB2.1 **JUL**
Climate scenarios GB2.1 **JUL**
Down-scaling GB2.1 **JUL**
GCM Selection GB 2.1 **JUL**
RCP GB 2.1 **JUL**
GCMs GB 2.1 **JUL**

Climate

Support/Revise Flow--N relationship IB 4.4 **OCT**
APLE
Soil P history effect GS 4.5 **OCT**
Investigate Speciation changes 4.7.1 **OCT**
P sensitivity in developed IB 4.5 **Oct**
Process-based response of flow and sediment On land
Specified land nutrient response
Effect on land use GS 3.2 **JUL**
CMAQ Climate change effect LL/JB/BS 3.1 **OCT**
Carbon Dioxide effect **GB 4.1 JUL**
Nutrient Inputs
BMP effectiveness change GS 4.6 **OCT**
Effect on Ag GS 3.3 **JUL**
Land to water factor effect GS 4.7 **OCT**
BMPs
Land to Water
Stream to River factors effect GS 4.7 **OCT**
WWTP Effect GS 3.4.2 **JUL**
Streams
Septic Effect GS 3.4.2 **JUL**
Groundwater Travel Time effect GS 4.7 **JUL**
UNEC
Rivers
Reservoir Rules effects GS 4.7 **JUL**
Diversion Effect GS 3.4.2 **JUL**
CSO Effect IB 3.4.1 **JUL**

Watershed

Reasonable response to sea level rise? PS 5.3.1 **OCT**
Reasonable response to temperature? RT/IB 5.3.2 **OCT**
Wetlands losses and gains LL/CC 5.1.1 **OCT**
Examine wind effects RT 5.1.2 **JUL**
Estuarine Model WQSTM
Estuarine Inputs
Sea level Rise RT 5.1.3 **JUL**
Growth and respiration curve for phytoplankton RT 5.2 **JUL**
Ocean Temp & Salinity RT 5.1.4 **JUL**

Estuary

Effect on water quality standards
Management Effort Adjustment
STAC CC2.0 Framework recommendations

Management

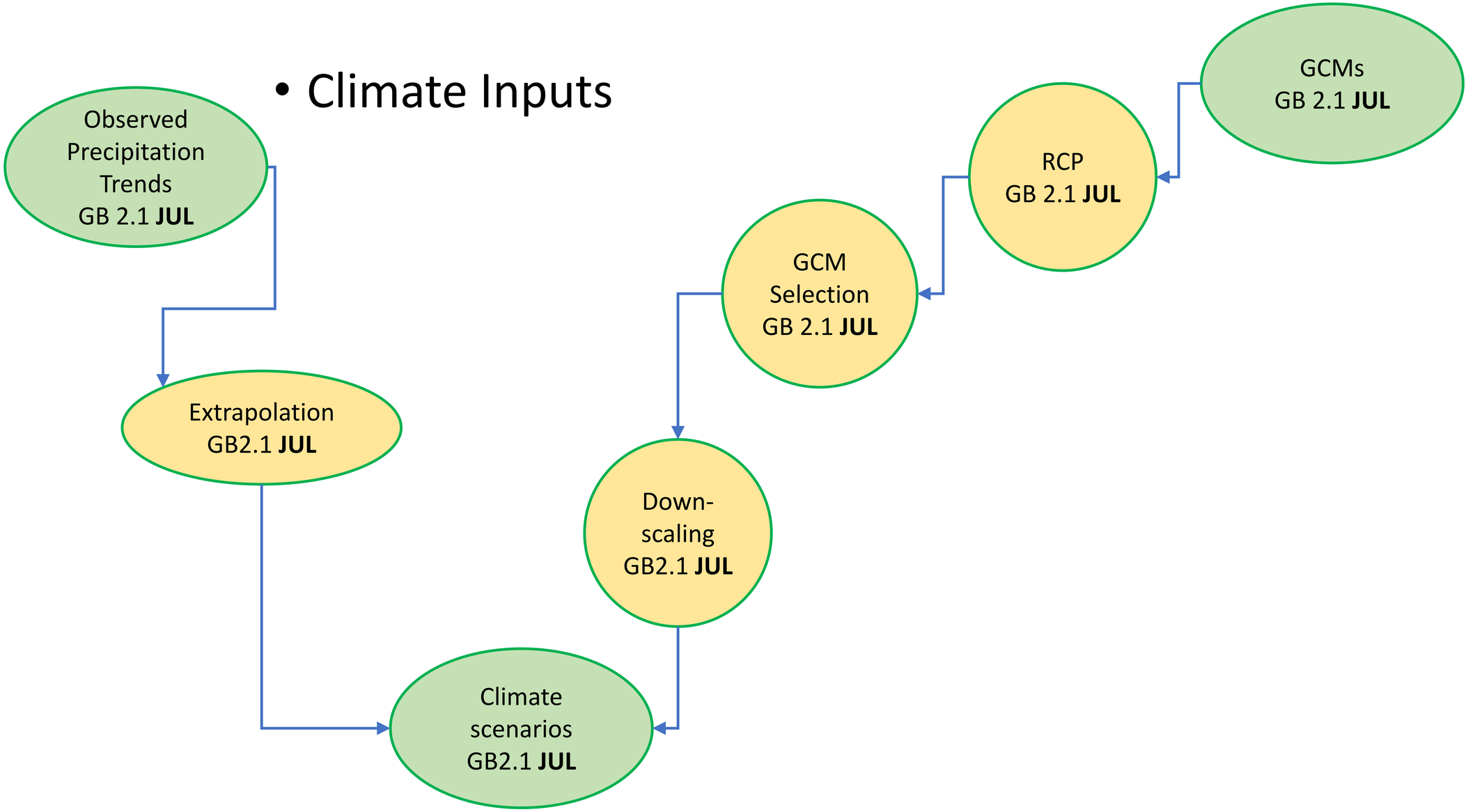
Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included But important
Not included minor

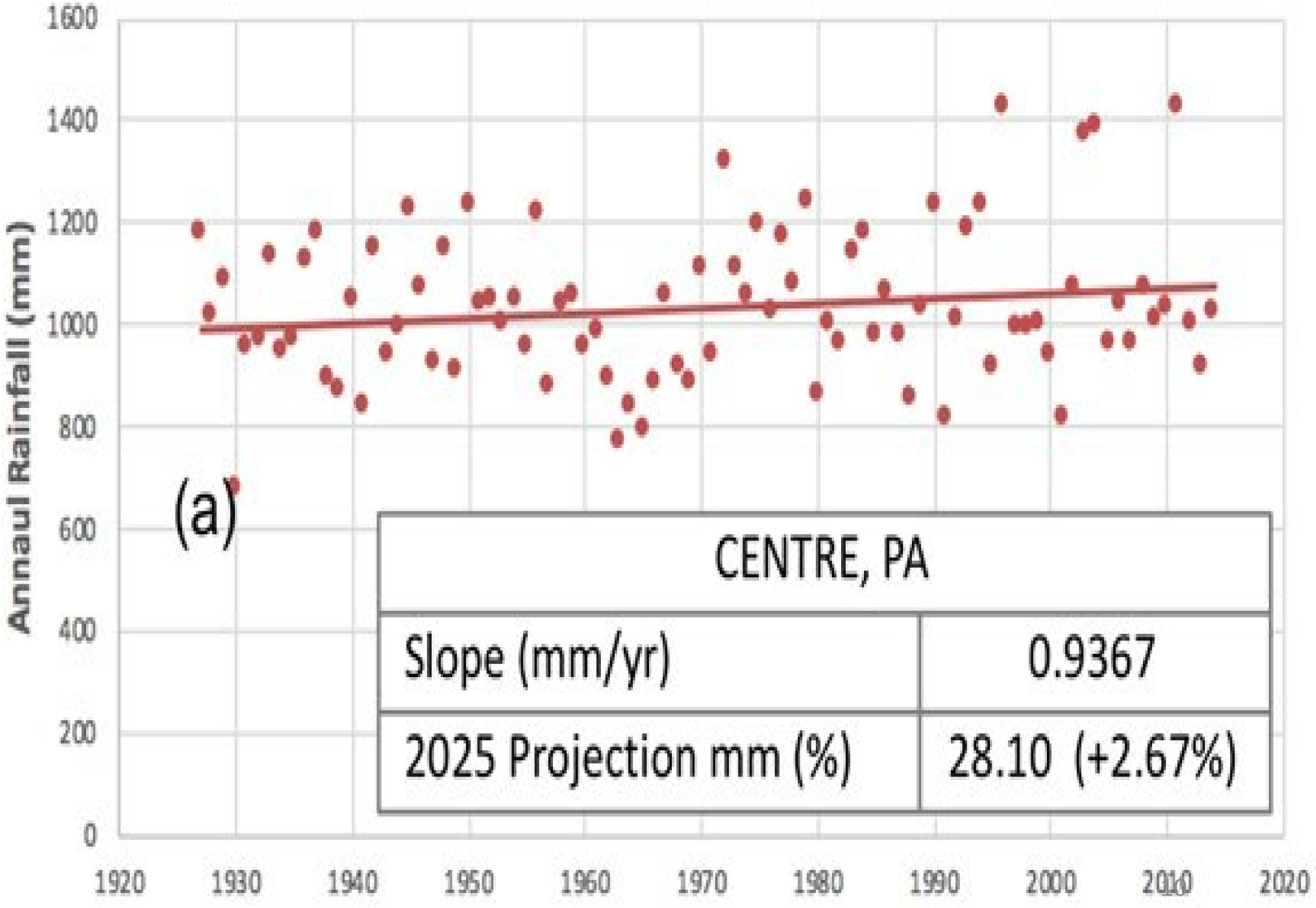
Initials indicate the responsible person
Numbers indicate the section of the documentation

- Climate Inputs



2025 Precipitation – Using observed trends

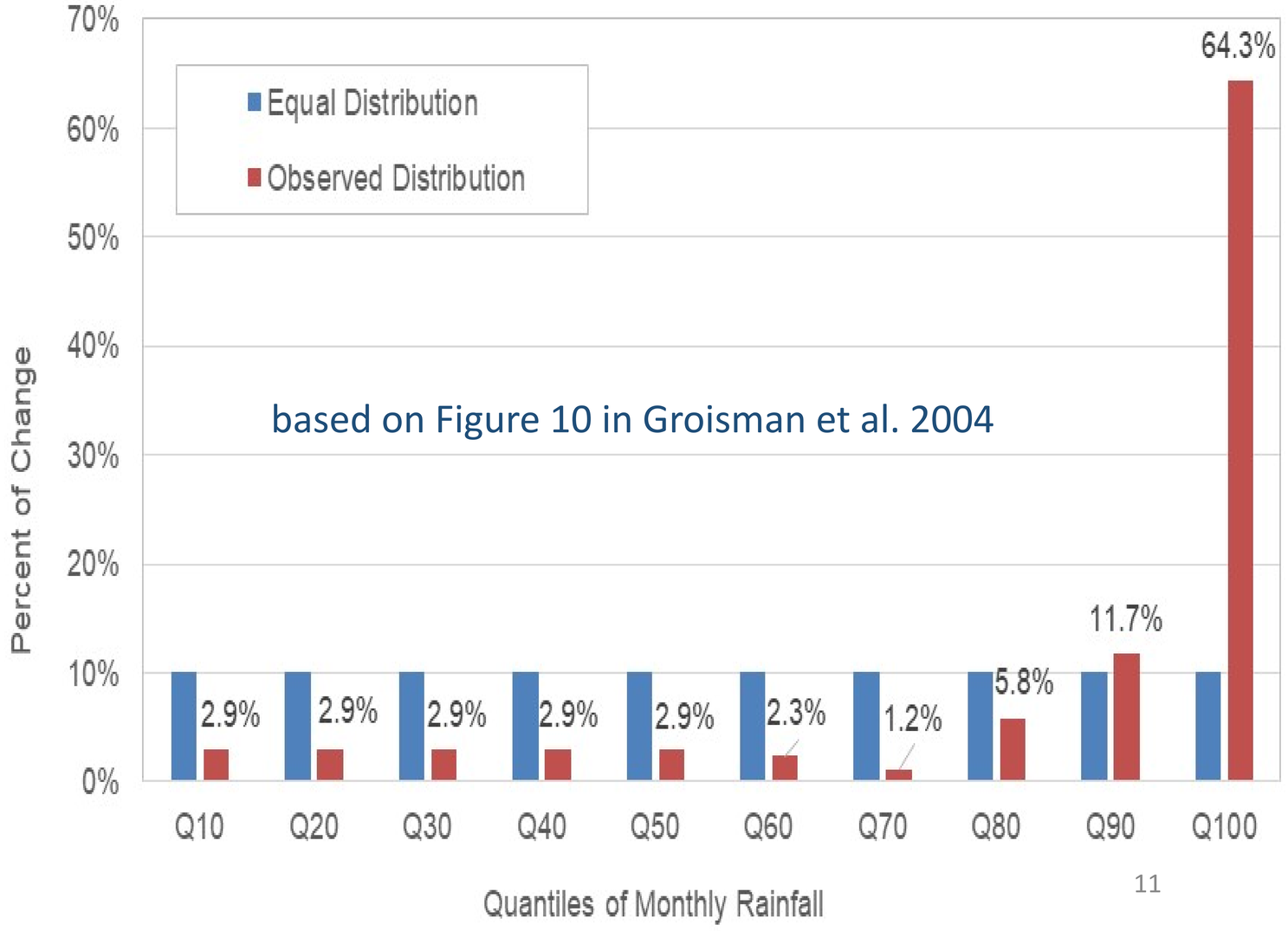
- regression of annual rainfall
- Applied as a percentage change to each month of rainfall



STAC 2016 CC workshop recommendations

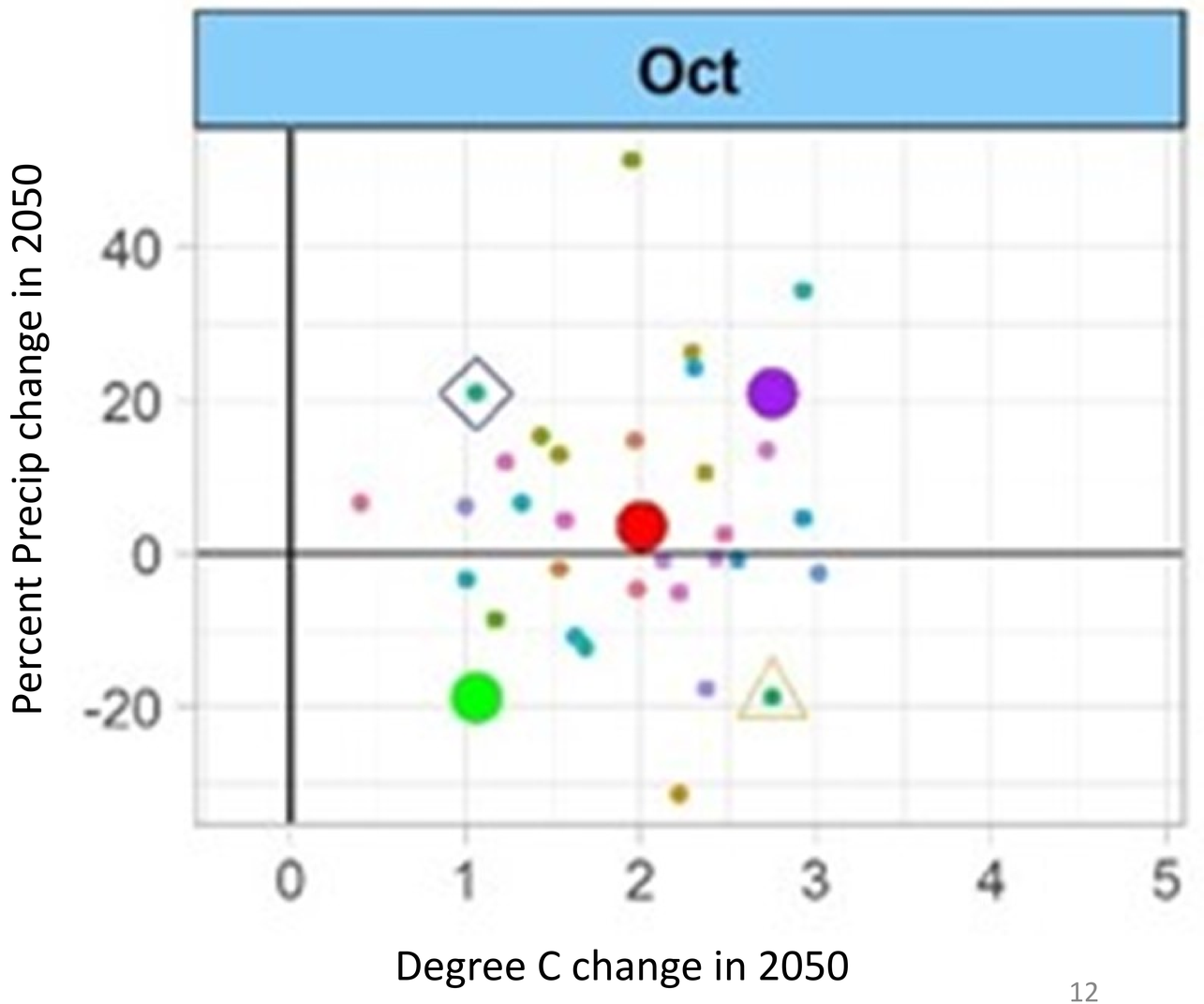
2025 Precipitation – Using observed trends

- Precip changes applied to the highest rainfall



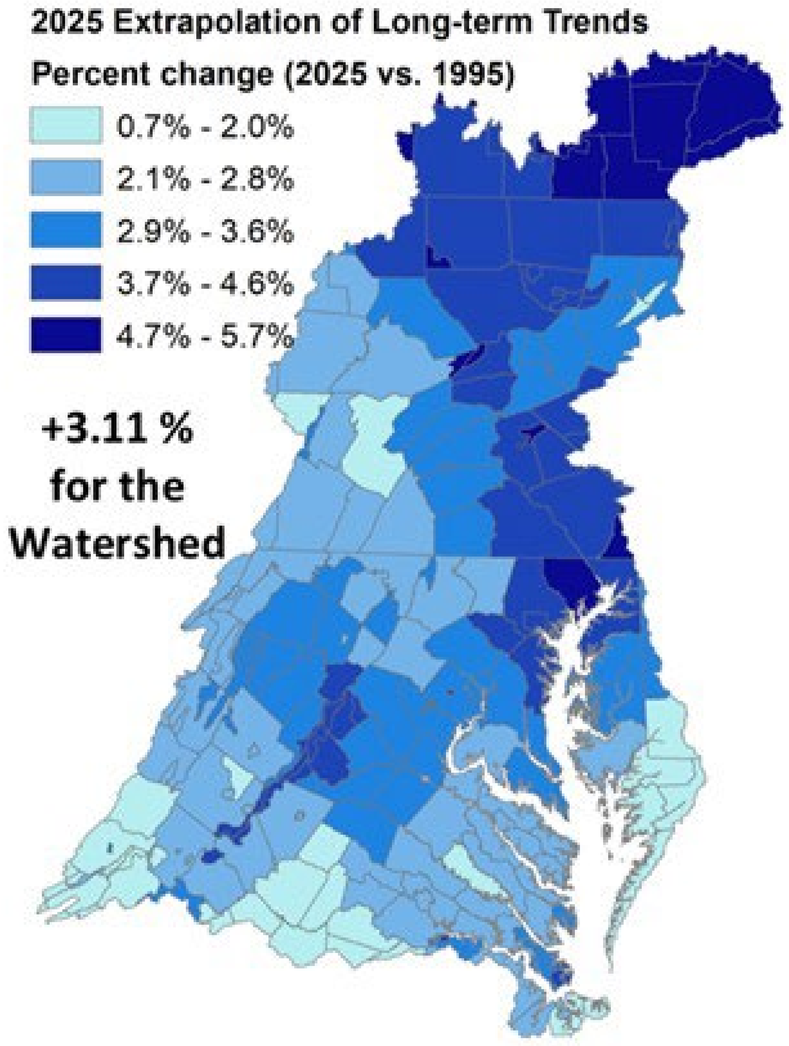
2025 Temperature and 2050 precip & Temperature – GCM ensemble

- Select median monthly change
- 10th and 90th for uncertainty
- Temperature applied as constant degree addition

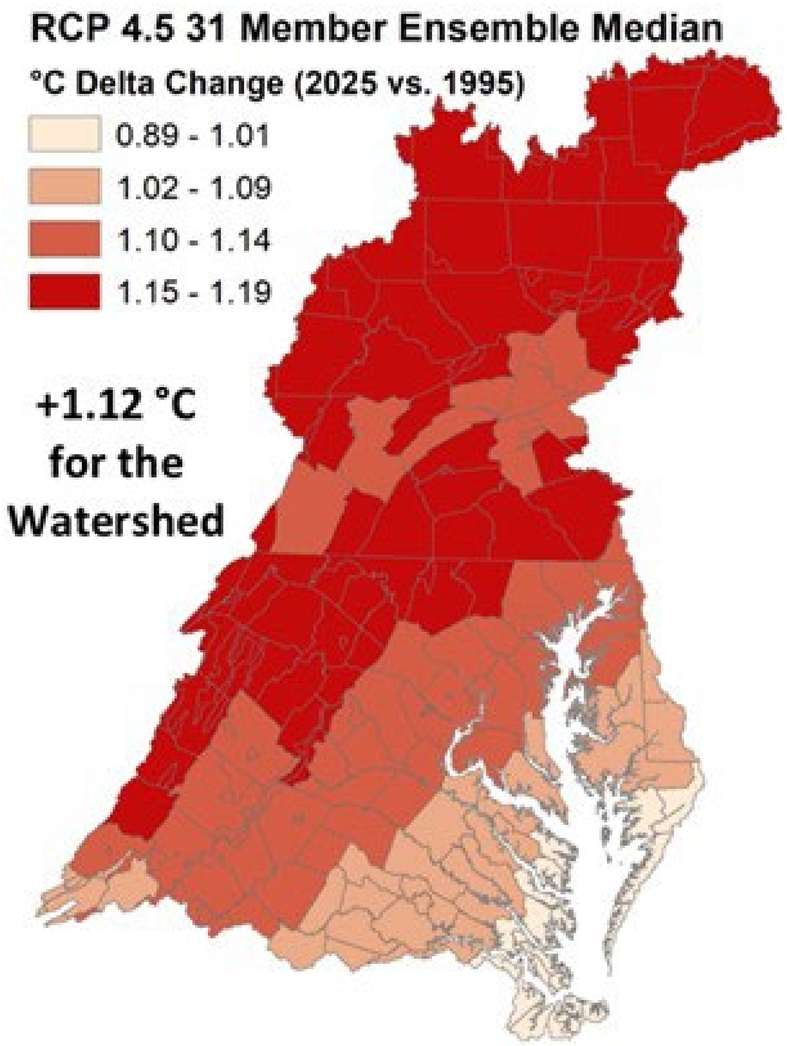


2025 Climate vs 1995 Climate

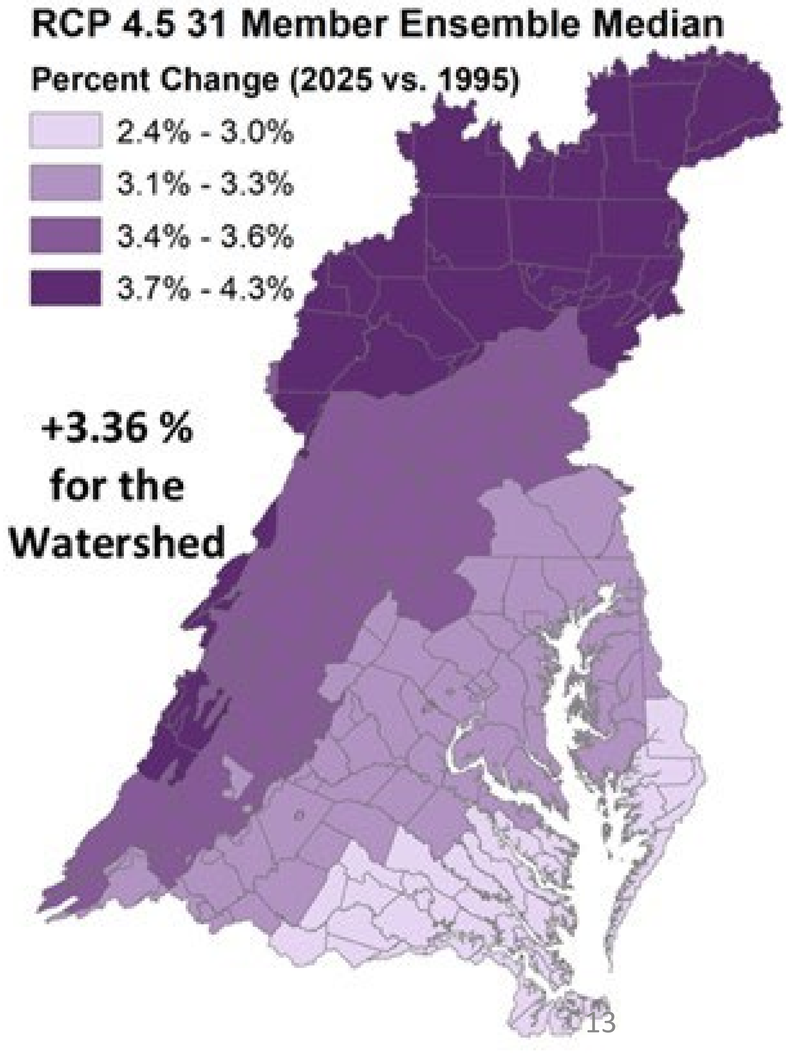
Precipitation



Temperature



PET

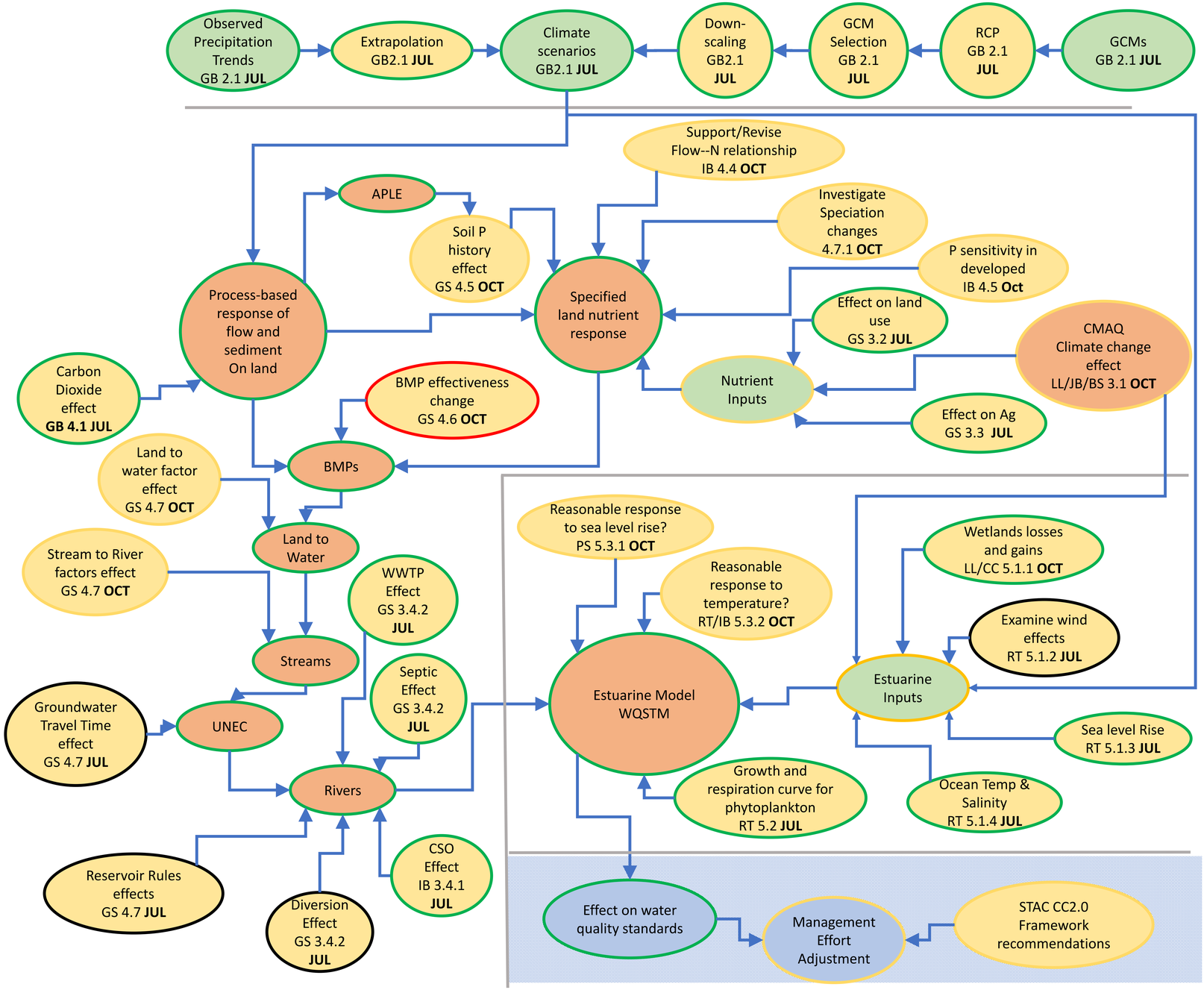


Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included But important
Not included minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Climate

Watershed

Estuary

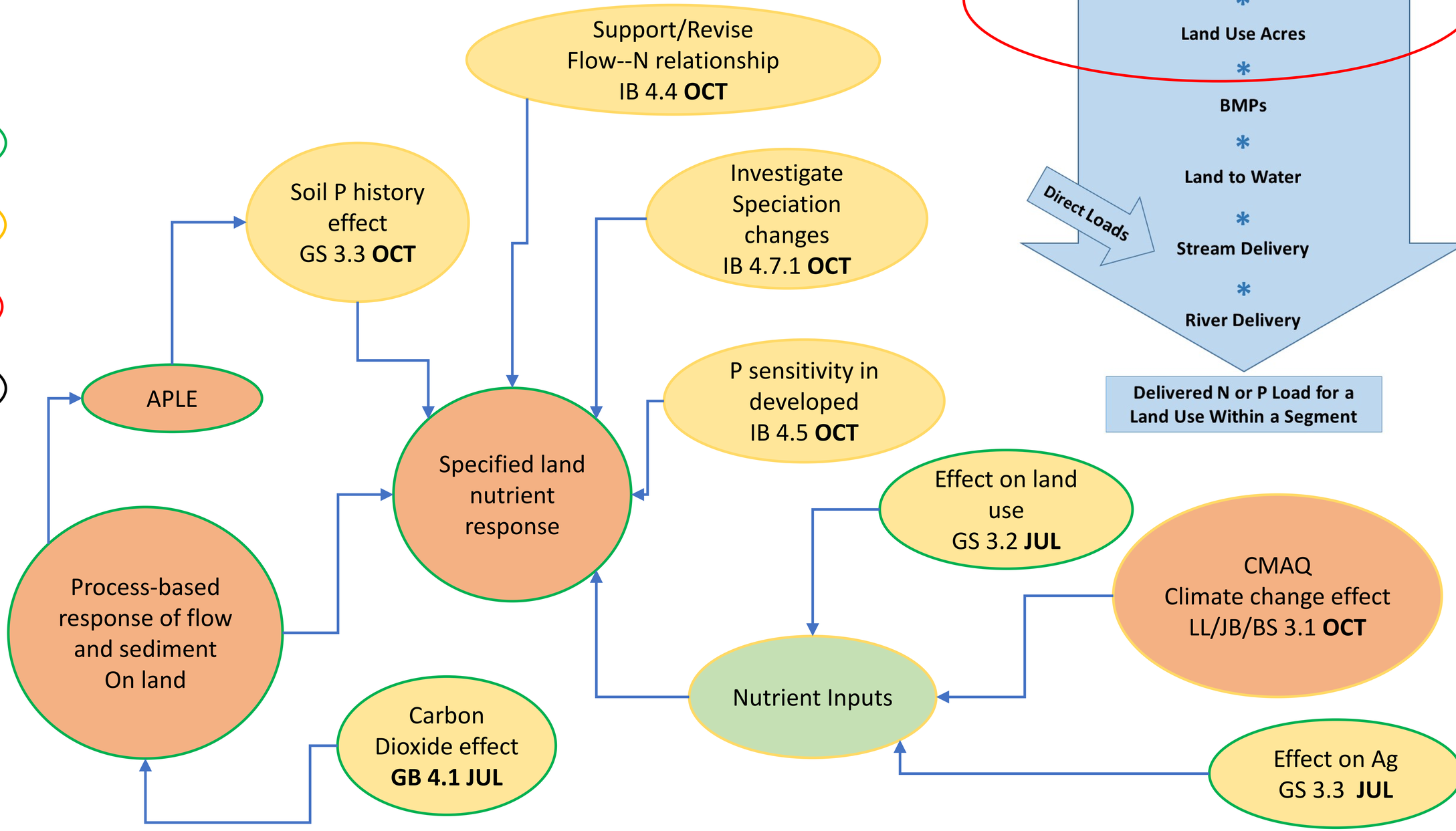
Management

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included But important
Not included minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Phase 6 Model Structure

Average Load + Δ Inputs * Sensitivity

*

Land Use Acres

*

BMPs

*

Land to Water

*

Direct Loads

Stream Delivery

*

River Delivery

Delivered N or P Load for a Land Use Within a Segment

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

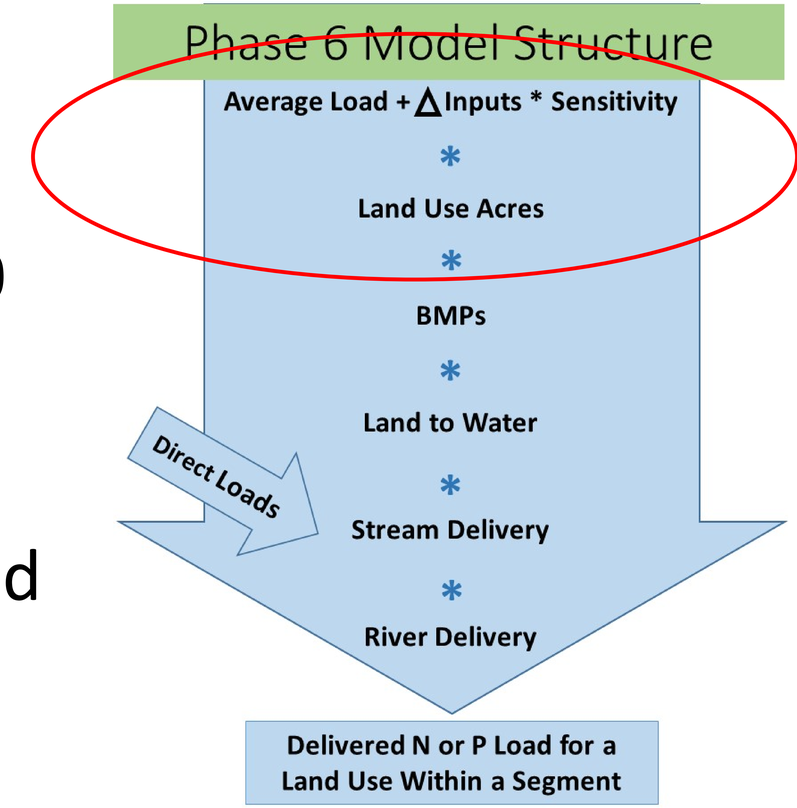
Complete

In Process

Not included
But important

Not included
minor

- Land use is already estimated through 2050
- Agriculture is estimated through 2022
  - Climate effects not broken out
- CMAQ atmospheric deposition suggests load proportional to rainfall
- CO2 effect on plant hydrology



Initials indicate the responsible person
Numbers indicate the section of the documentation

Effect on land use
GS 3.2 **JUL**

CMAQ
Climate change effect
LL/JB/BS 3.1 **OCT**

Carbon Dioxide effect
GB 4.1 JUL

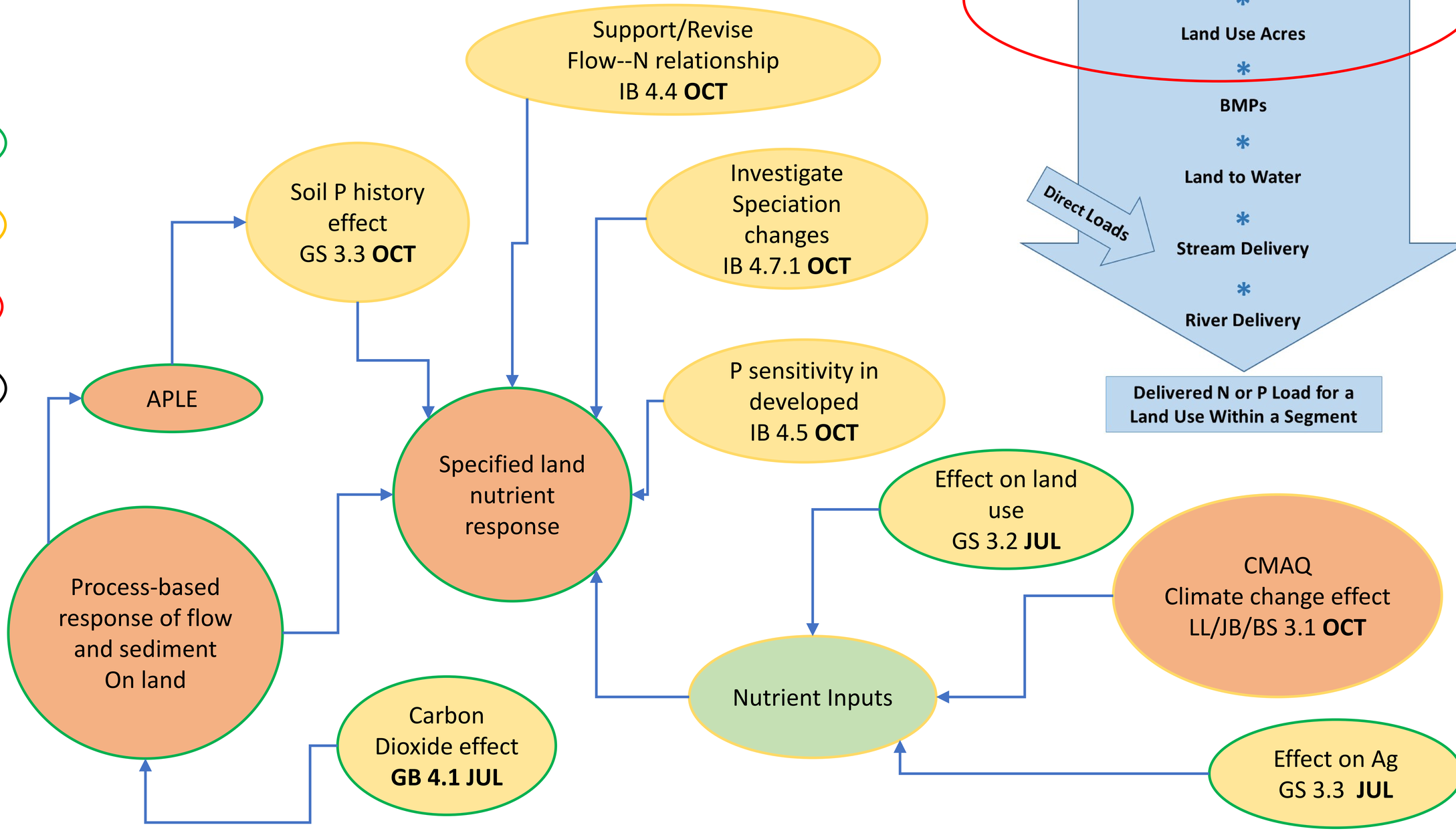
Effect on Ag
GS 3.3 **JUL**

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included But important
Not included minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Phase 6 Model Structure

Average Load + Δ Inputs * Sensitivity

*

Land Use Acres

*

BMPs

*

Land to Water

*

Direct Loads

Stream Delivery

*

River Delivery

Delivered N or P Load for a Land Use Within a Segment

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

- Literature Reviews for climate effects
  - Nitrogen change proportional to flow change
  - Literature review for P sensitivity in developed
  - Investigate speciation changes relative to flow and temperature

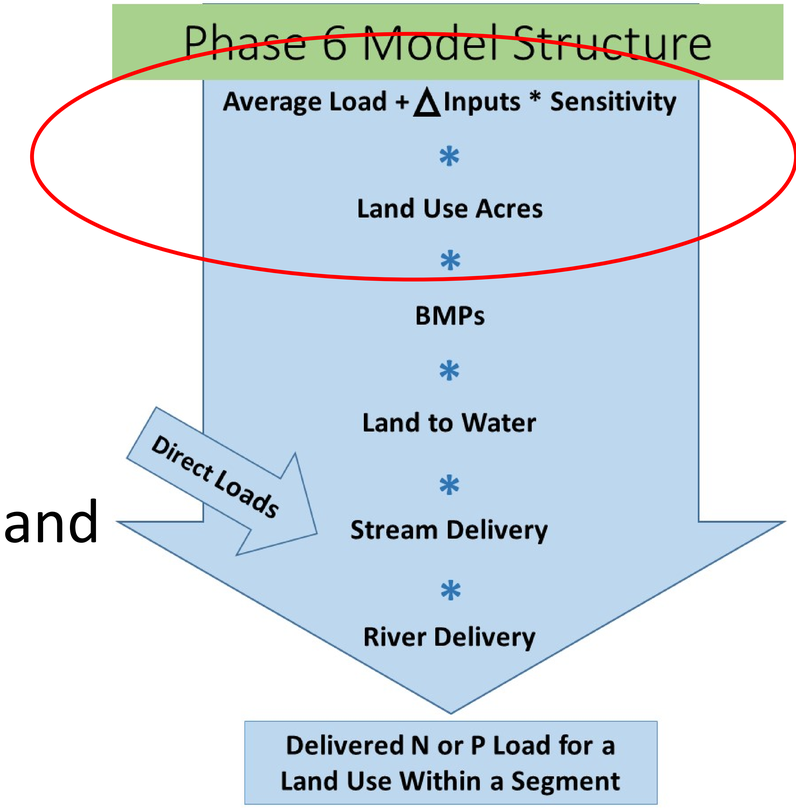
Complete

In Process

Not included
But important

Not included
minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Support/Revise
Flow--N relationship
IB 4.4 **OCT**

Investigate
Speciation
changes
IB 4.7.1 **OCT**

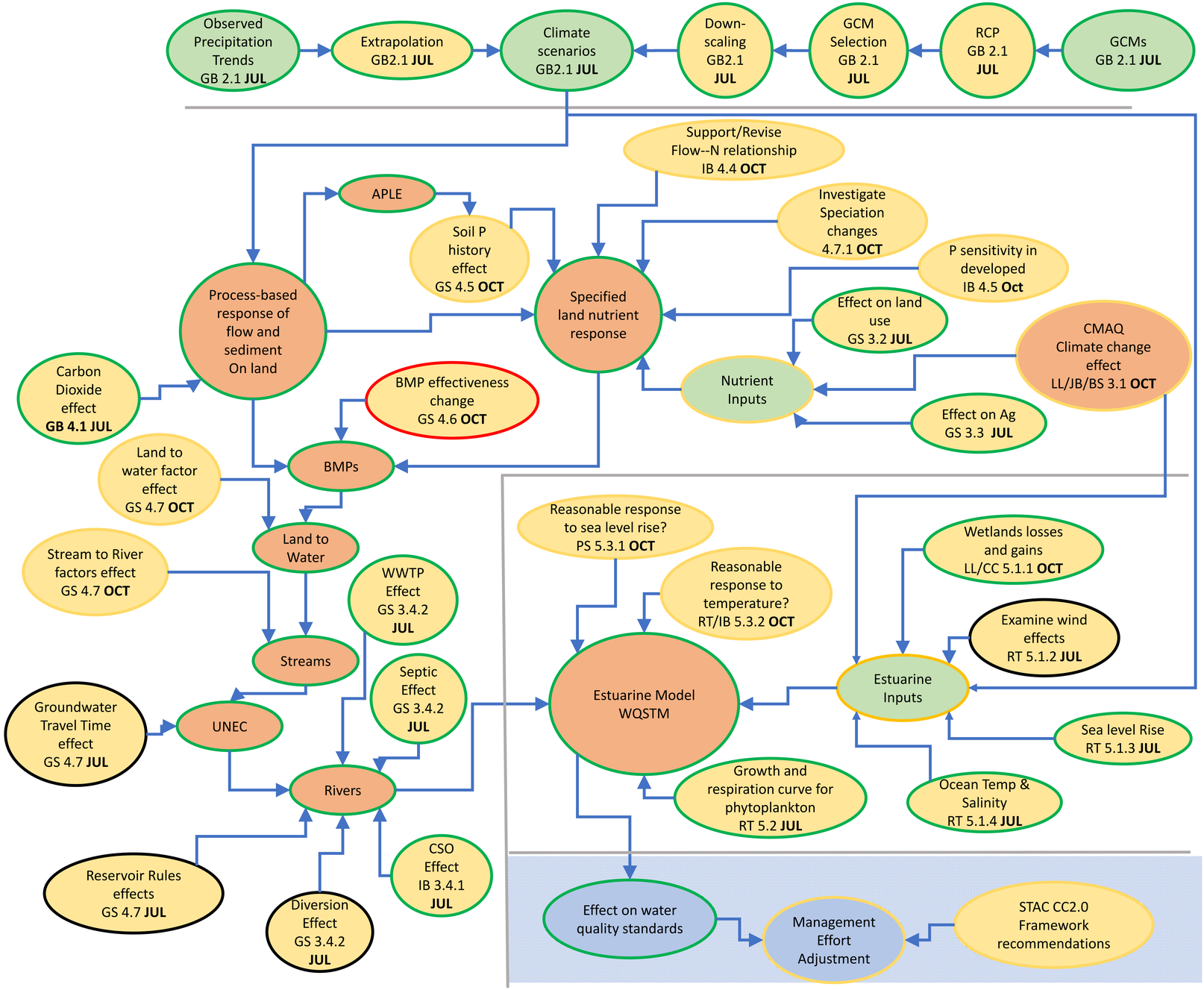
P sensitivity in
developed
IB 4.5 **OCT**

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included But important
Not included minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Climate

Watershed

Estuary

Management

Climate Change Processes and Dependencies

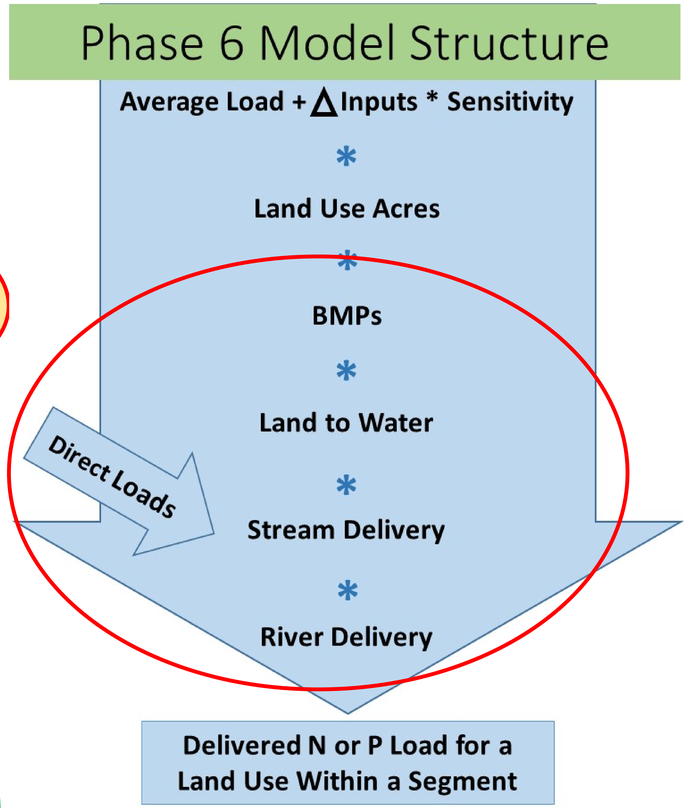
Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included But important
Not included minor

Initials indicate the responsible person
Numbers indicate the section of the documentation

BMPs
Land to water factor effect GS 4.7 **OCT**
BMP effectiveness change GS 4.6 **OCT**
Land to Water
Stream to River factors effect GS 4.7 **OCT**
Streams
Groundwater Travel Time effect GS 4.7 **JUL**
UNEC
WWTP Effect GS 3.4.2 **JUL**
Rivers
Reservoir Rules effects GS 4.7 **JUL**
Diversion Effect GS 3.4.2 **JUL**
CSO Effect IB 3.4.1 **JUL**

Phase 6 Model Structure



Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

- WWTPs, septic systems, diversions all have data associated with them projected through 2025
- CSOs are modeled. The model has been updated for climate change

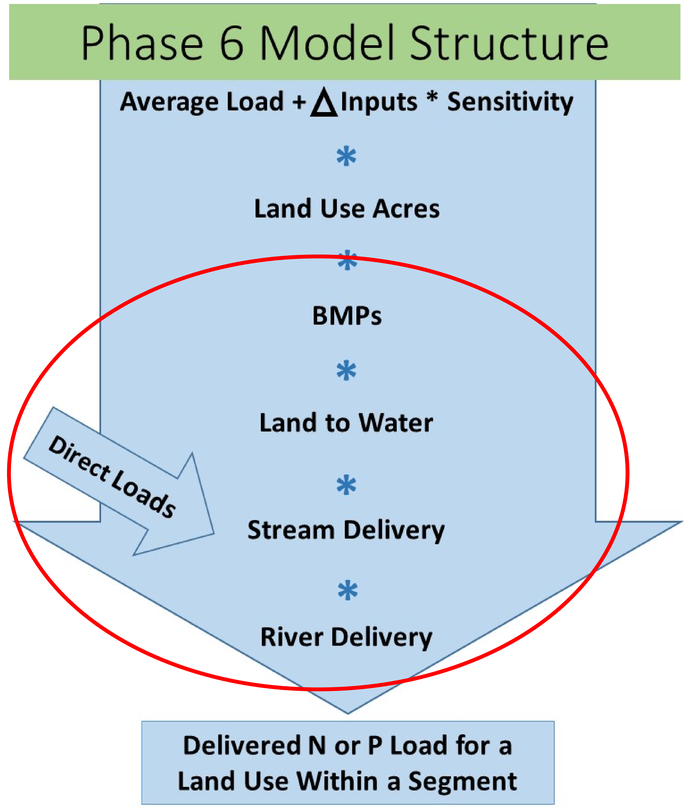
Complete

In Process

Not included
But important

Not included
minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



WWTP
Effect
GS 3.4.2
JUL

Diversion
Effect
GS 3.4.2 **JUL**

CSO
Effect
IB 3.4.1 **JUL**

Climate Change Processes and Dependencies

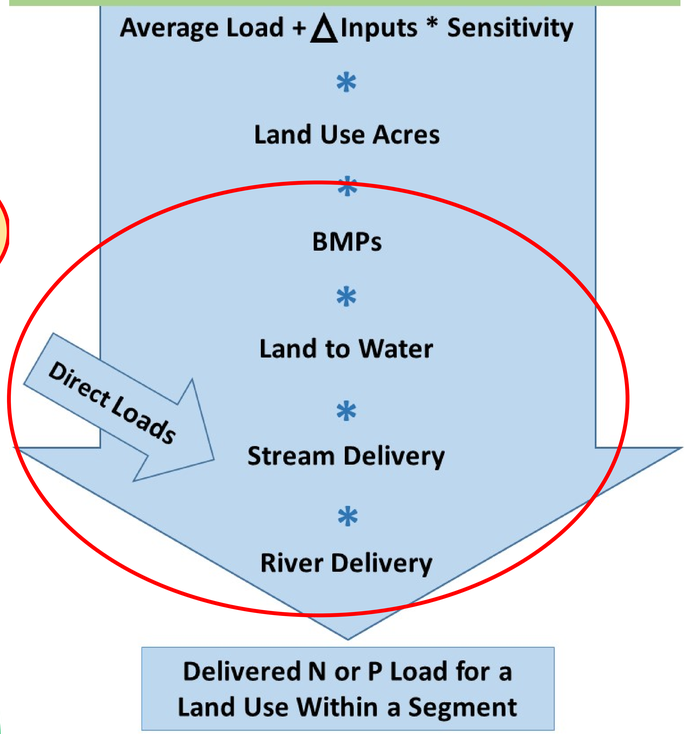
Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included But important
Not included minor

Initials indicate the responsible person
Numbers indicate the section of the documentation

BMPs
Land to water factor effect GS 4.7 **OCT**
BMP effectiveness change GS 4.6 **OCT**
Land to Water
Stream to River factors effect GS 4.7 **OCT**
Streams
Groundwater Travel Time effect GS 4.7 **JUL**
UNEC
WWTP Effect GS 3.4.2 **JUL**
Rivers
Reservoir Rules effects GS 4.7 **JUL**
Diversion Effect GS 3.4.2 **JUL**
CSO Effect IB 3.4.1 **JUL**

Phase 6 Model Structure



Delivered N or P Load for a Land Use Within a Segment

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

- BMP effectiveness
  - CBP understands that effectiveness changes with climate and that it is important
  - No way to address it at this time

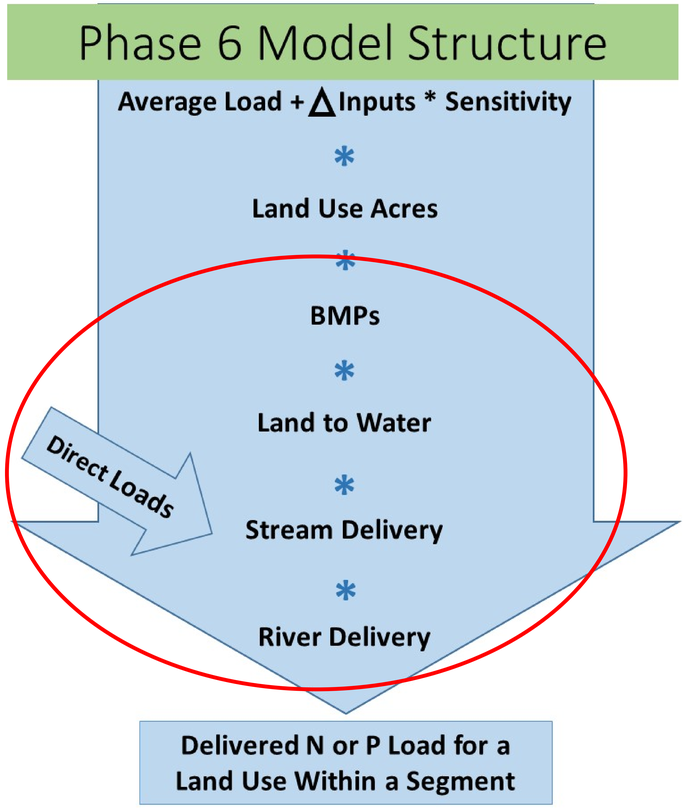
Complete

In Process

Not included
But important

Not included
minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



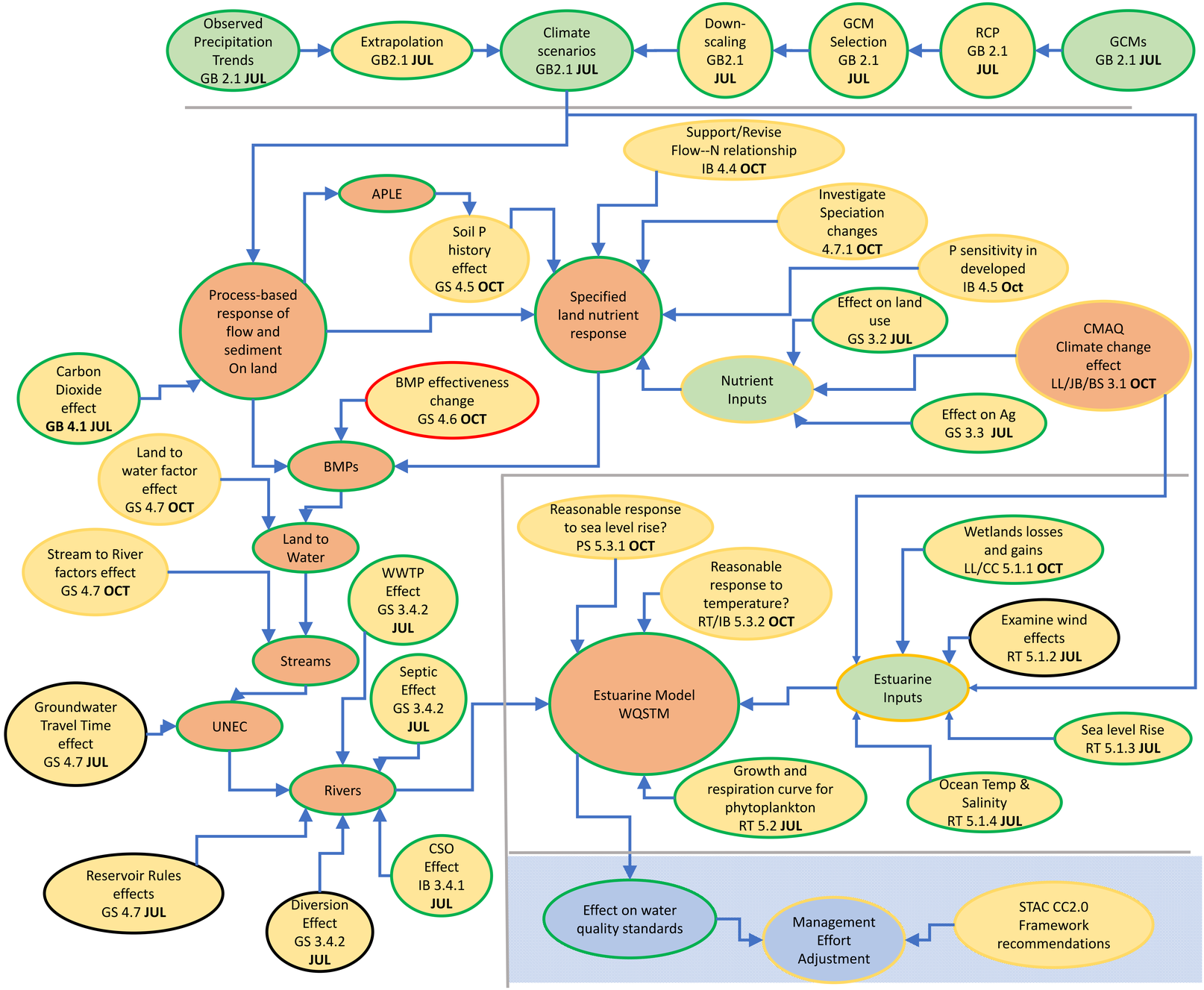
BMP effectiveness
change
GS 4.6 **OCT**

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included But important
Not included minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Climate

Watershed

Estuary

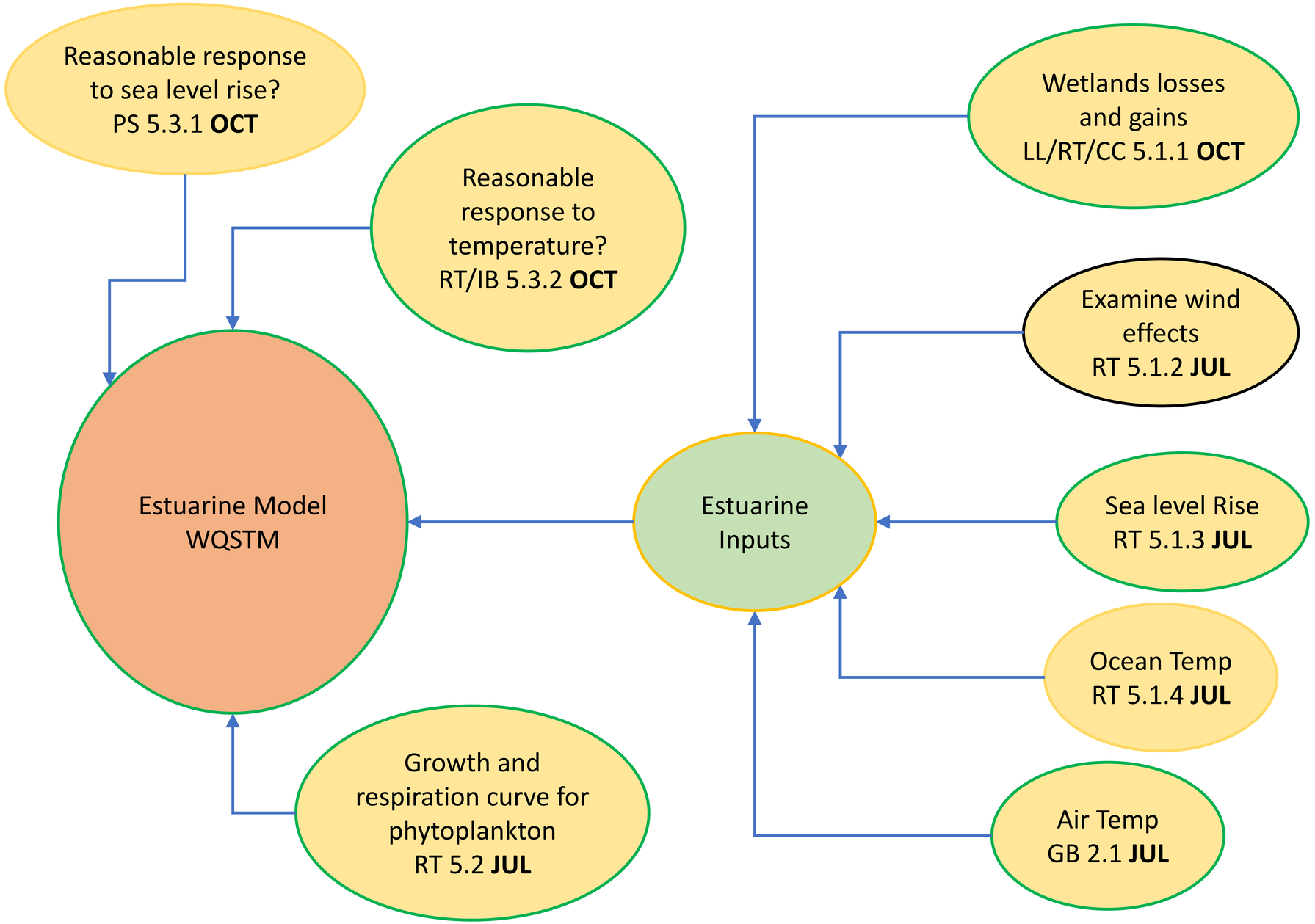
Management

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included
But important
Not included
minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete

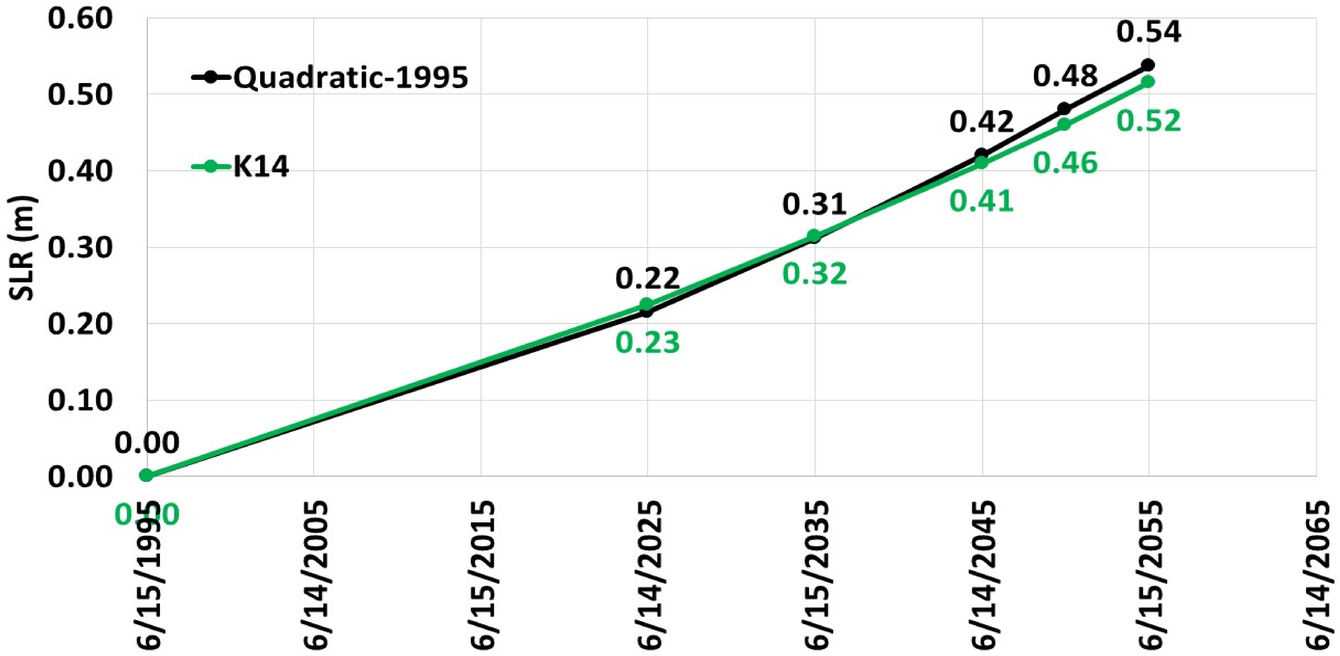
In Process

Not included
But important

Not included
minor

Initials indicate the responsible person
Numbers indicate the section of the documentation

- Growth and respiration curves changed
- Wind effects ignored
- Ocean boundary temperature and salinity set through literature review
- Sea level rise quantified as per recommendation of CRWG



Growth and respiration curve for phytoplankton
RT 5.2 **JUL**

Examine wind effects
RT 5.1.2 **JUL**

Ocean Temp
RT 5.1.4 **JUL**

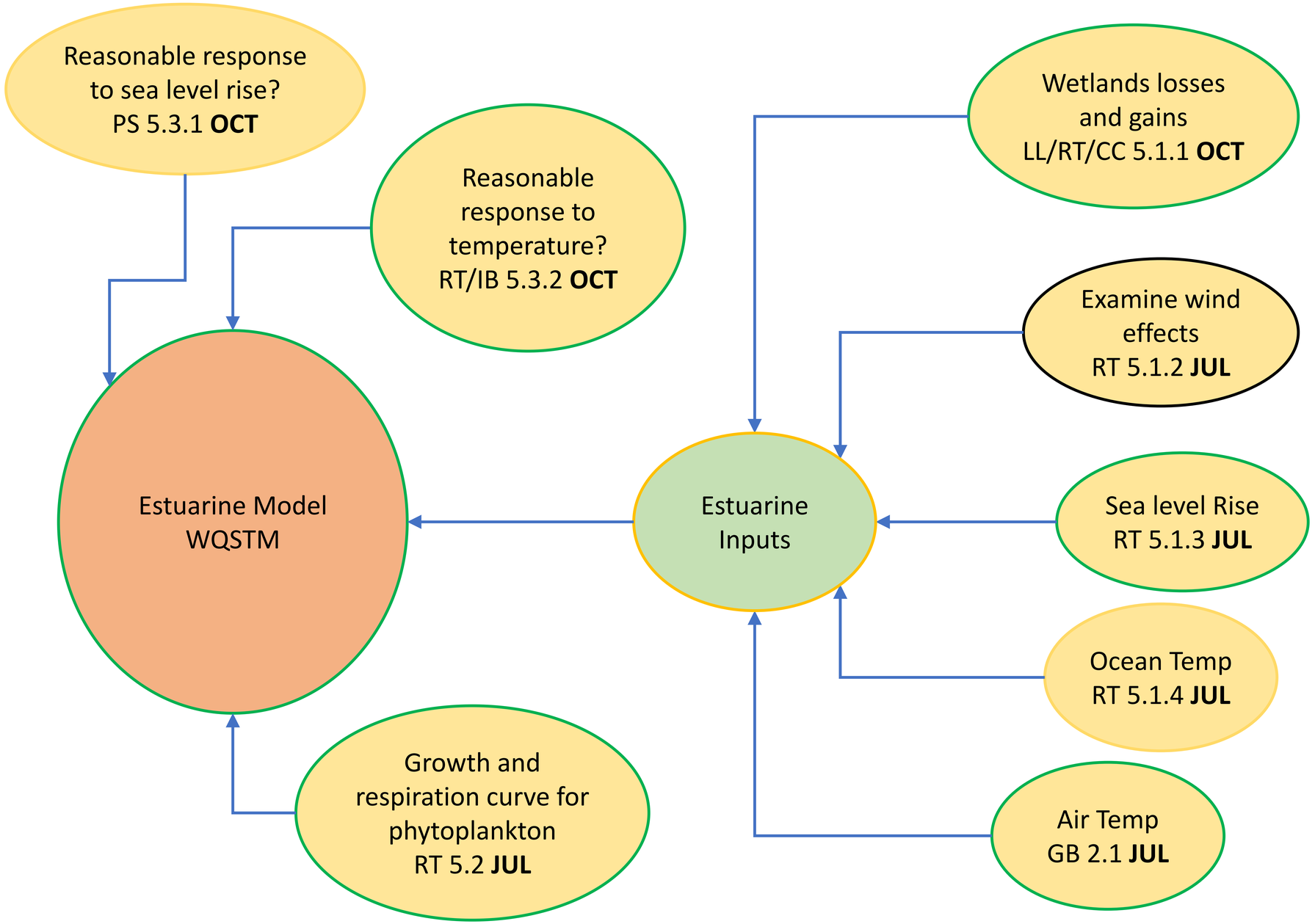
Sea level Rise
RT 5.1.3 **JUL**

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete
In Process
Not included
But important
Not included
minor

Initials indicate the responsible person
Numbers indicate the section of the documentation



Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

- Validation of WQSTM response to CC

Complete

In Process

Not included
But important

Not included
minor

- Sea Level Rise
  - Pierre St Laurent's work in CHAMP
  - Comparing and understanding WQSTM and two versions of ROMS

Reasonable response to sea level rise?
PS 5.3.1 **OCT**

Initials indicate the responsible person
Numbers indicate the section of the documentation

- Temperature
  - Questions raised in the MWG about temperature propagation in the WQSTM
  - Addressed through CHAMP and comparison with observation

Reasonable response to temperature?
RT/IB 5.3.2 **OCT**

Climate Change Processes and Dependencies

Model
Data Set
Endpoint
Project/Decision

Complete

- Approval process
- Topics split into July and October quarterly meetings
- November delivery for final model results
- July topics
  - Documentation for July topics sent out to MWG, CRWG, and interested parties June 28th
  - Ask for approval from MWG tomorrow