Groundwater Model Development

Automated Calibration, PEST and Cloud Computation

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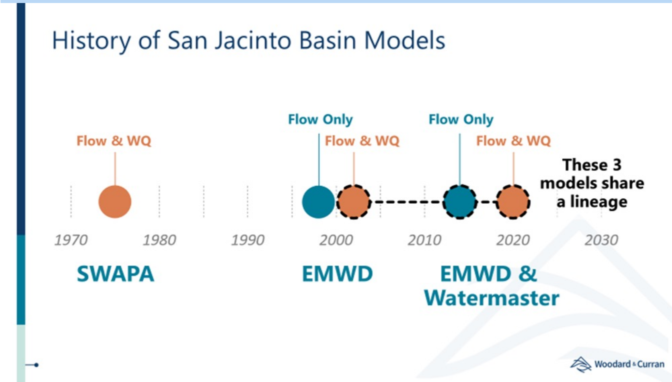
April 6, 2022

Model Calibration Context

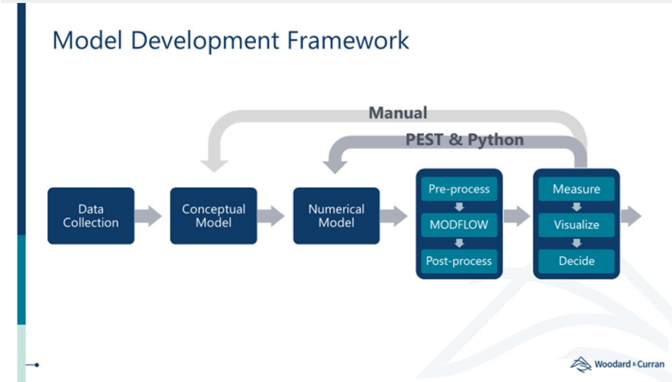
- EMWD has a long history of actively managing water resources in the basin using the latest calibrated integrated water resources model.
- Model calibration is periodically updated by EMWD as needed to accurately represent the basin conditions.
- The prior model (SJFM 2014) was utilized in a similar fashion by projects such as:
  - Perris North Program
  - The West San Jacinto GSP
- The Perris South Brackish Water Supply program utilized the most recent version of the San Jacinto Flow model, which was calibrated for the 1984-2018 period.

Overview

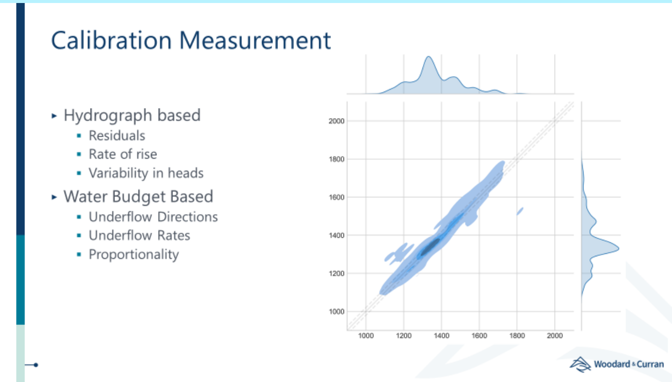
History



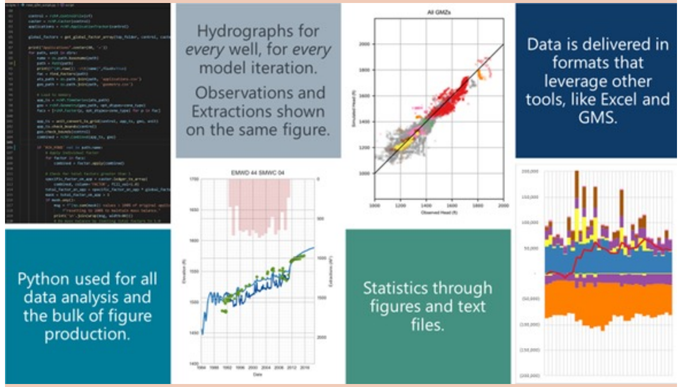
Framework



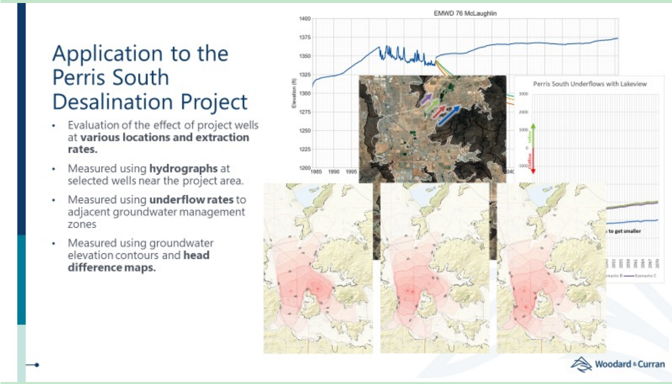
Measurement



Automation



Application



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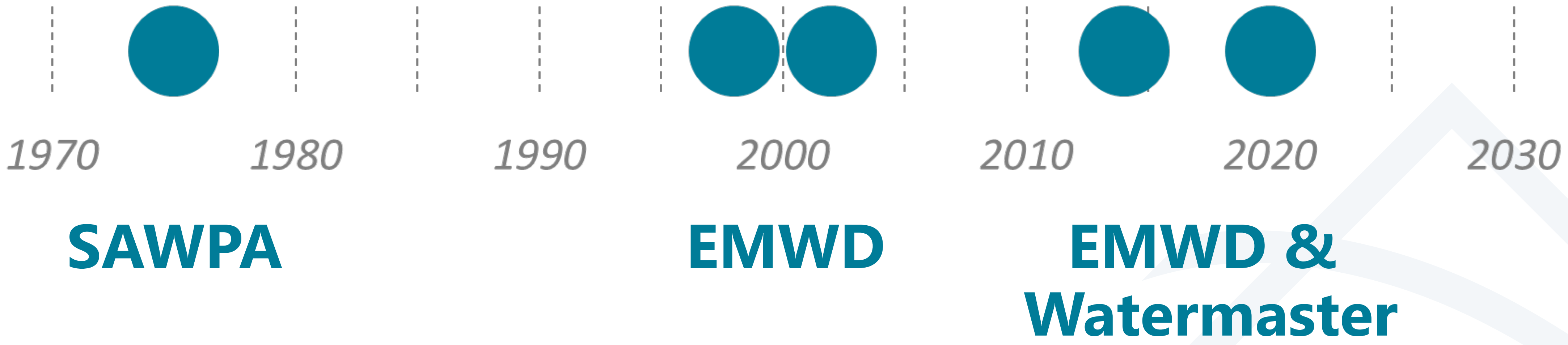
History of San Jacinto Basin Models

Each dot represents a model developed to cover the entire San Jacinto Basin



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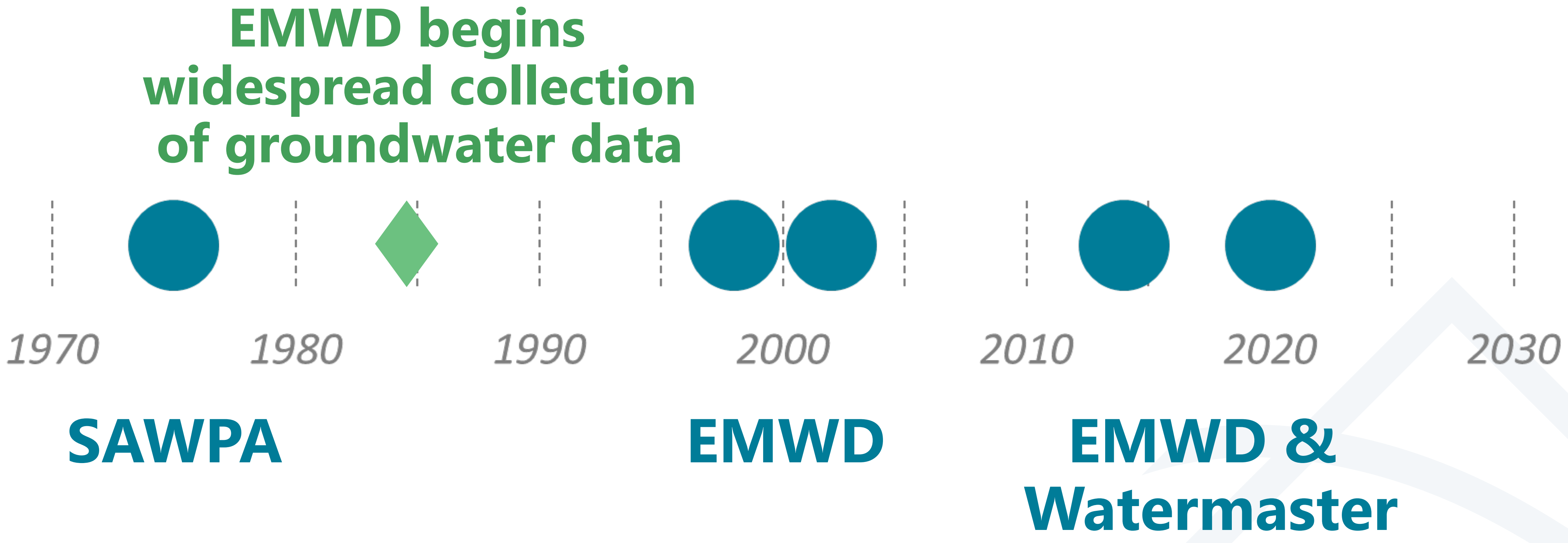

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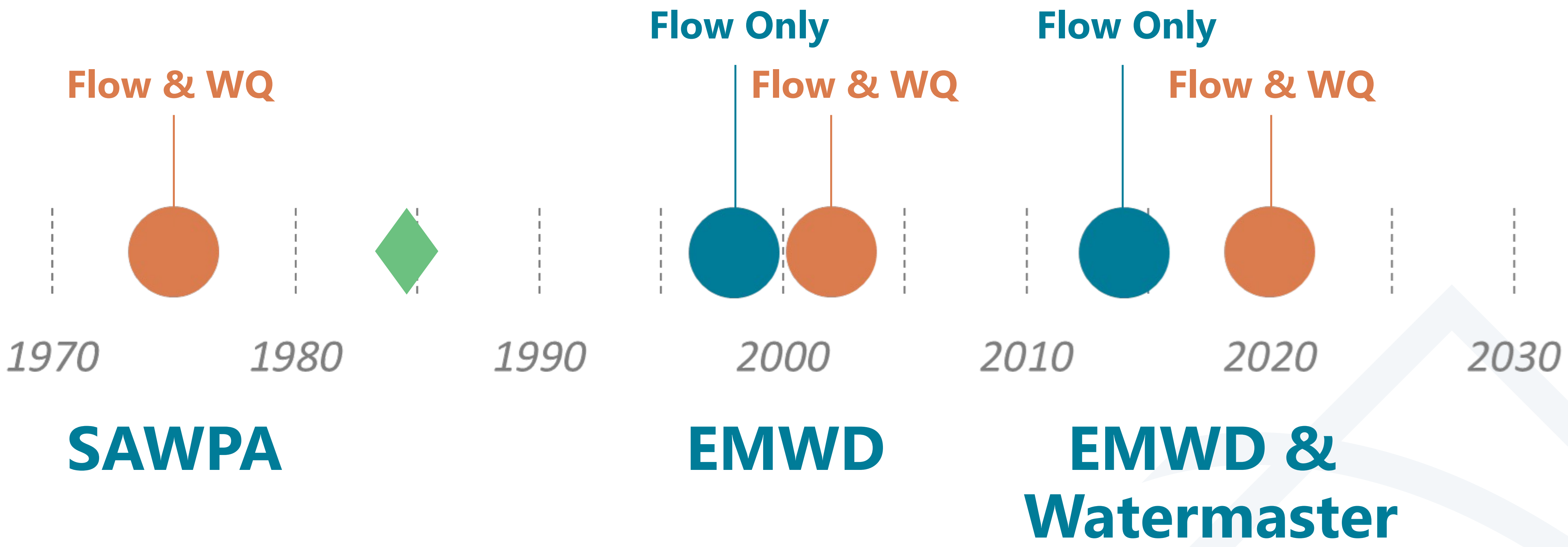

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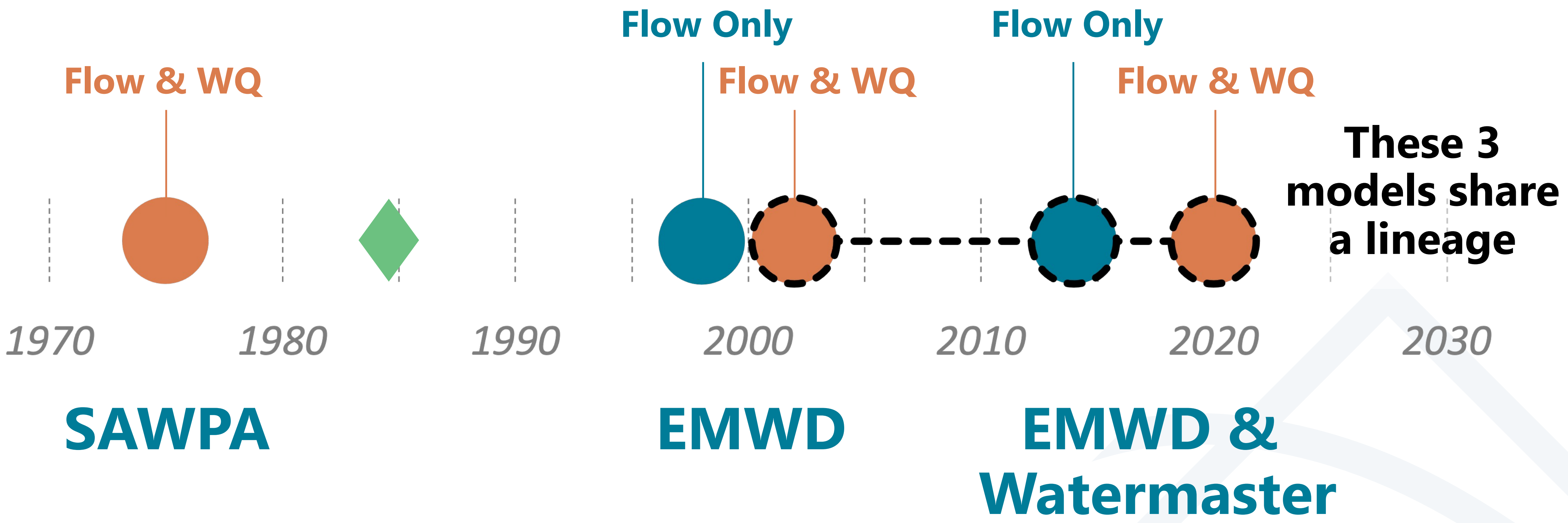
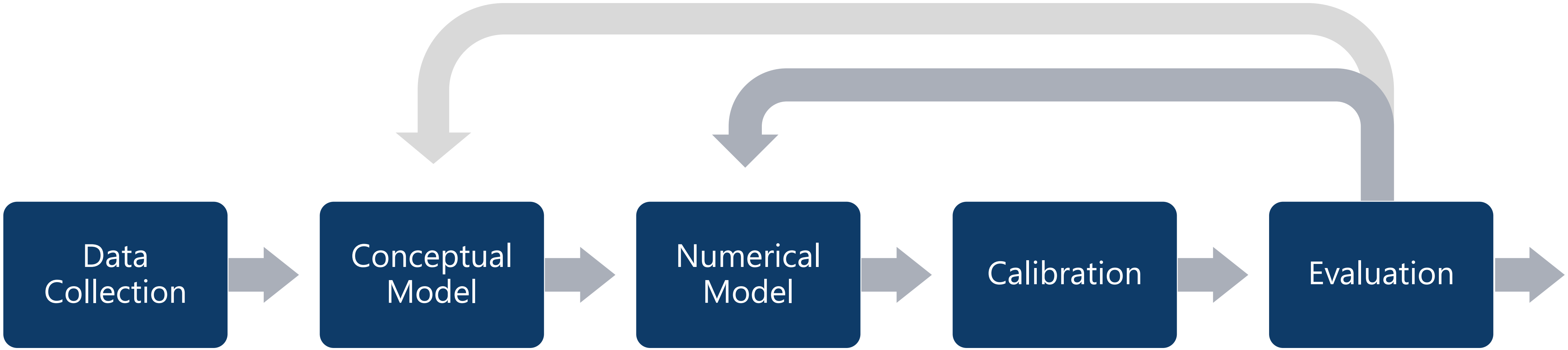


Model Development Framework



Based on ASTM D 5447-04, Fig 1

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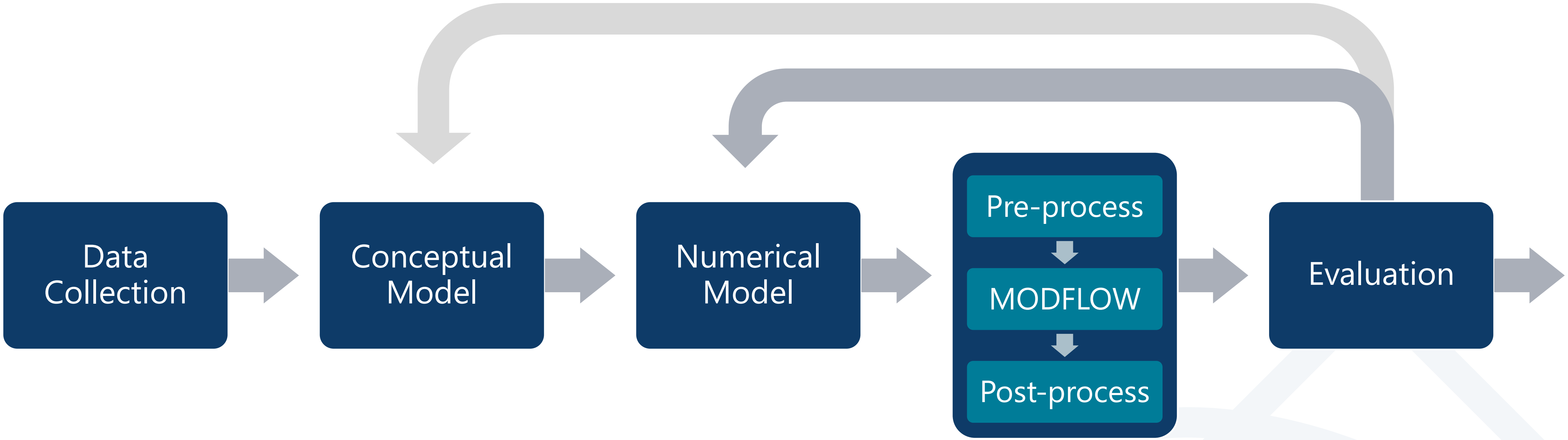

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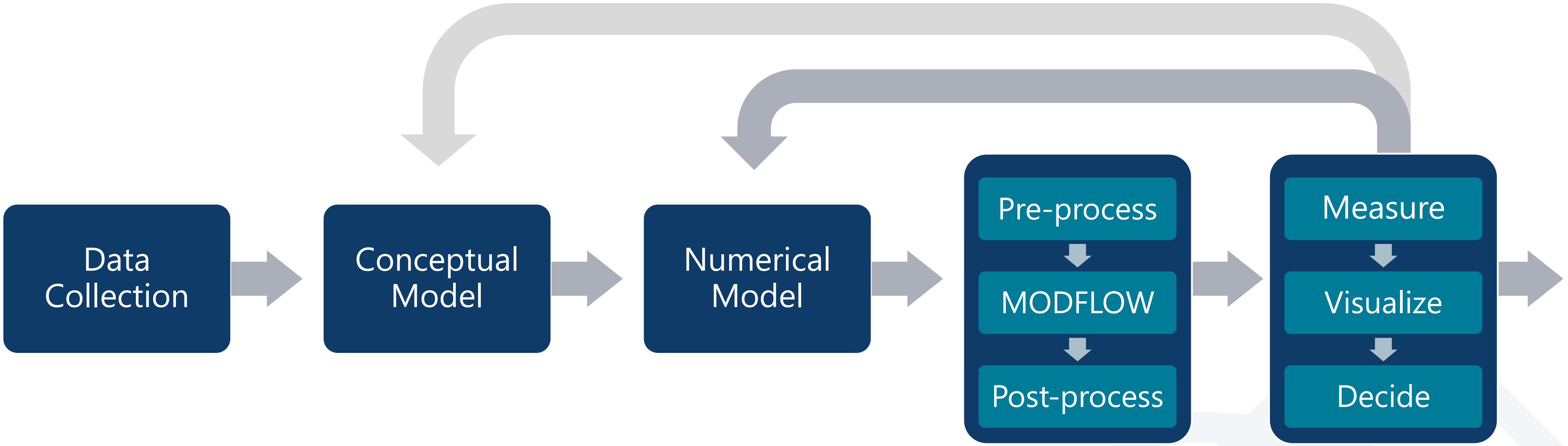

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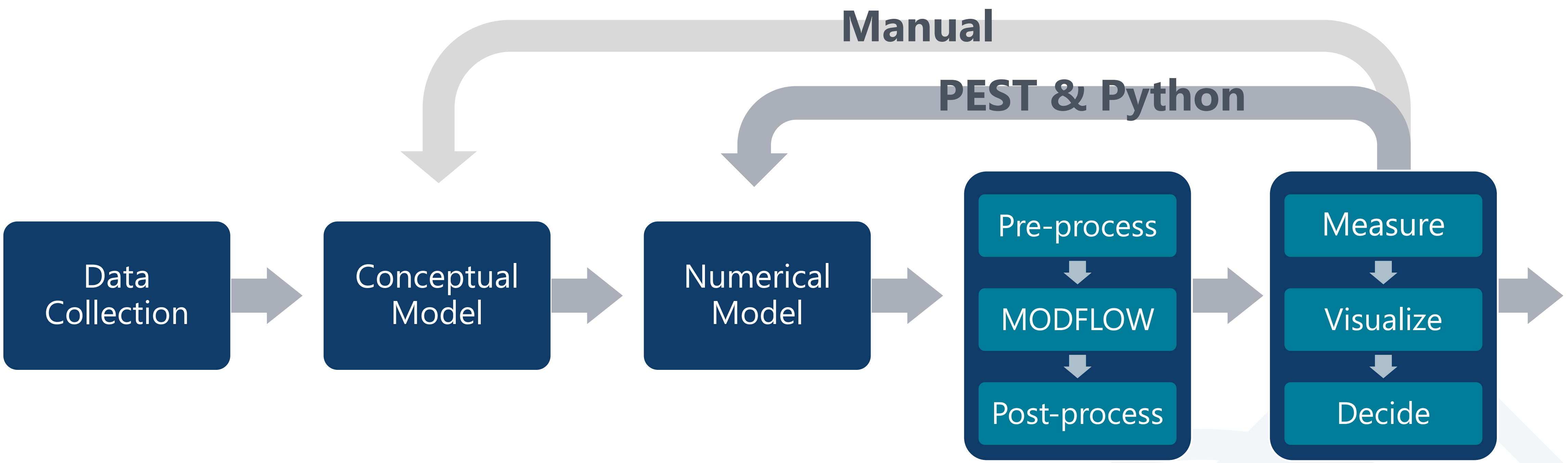

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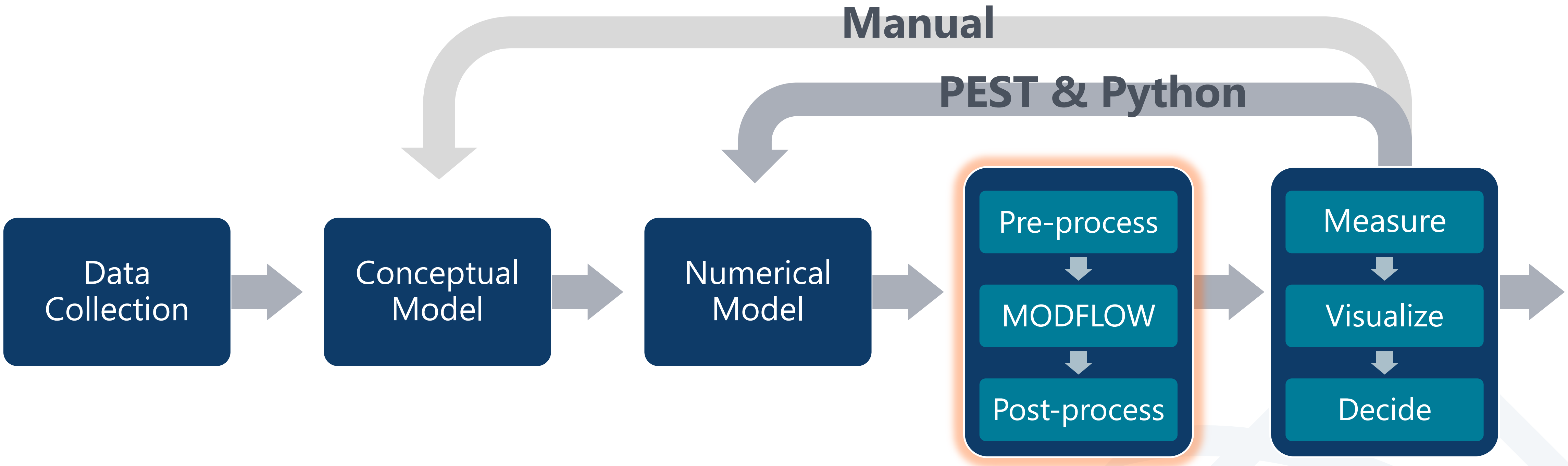

Calibration

Pre-process

- Areal Recharge
- Mountain Front Recharge

MODFLOW

- GMS-based
- Executable-based

Post-process

- Hydrographs
- Water Budgets
- Statistics

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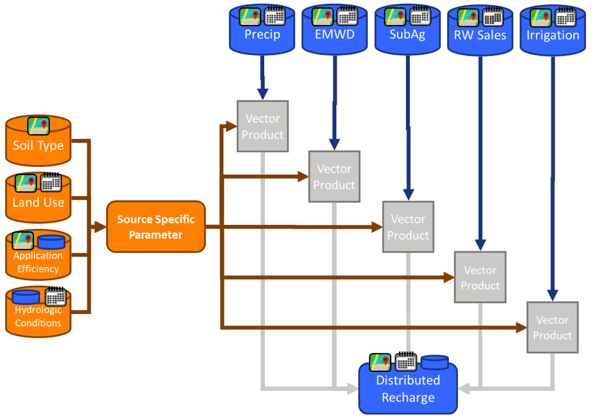

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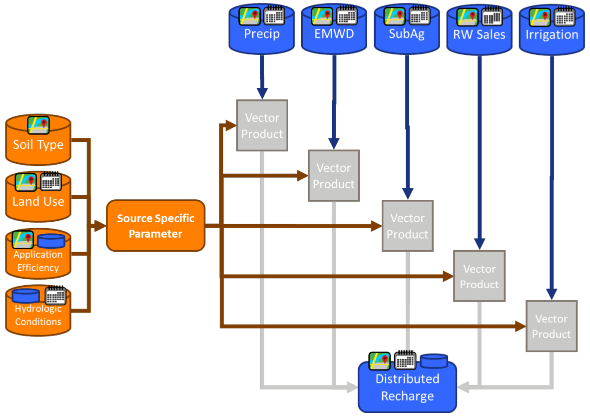

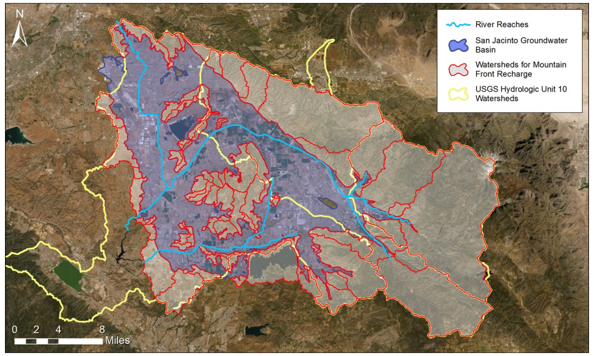

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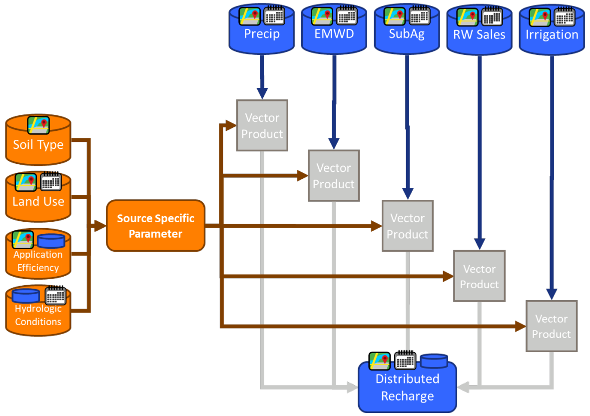

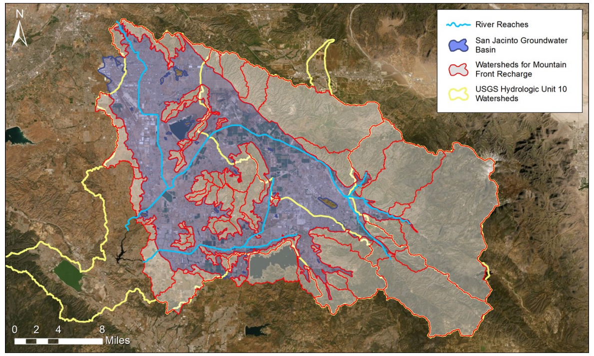

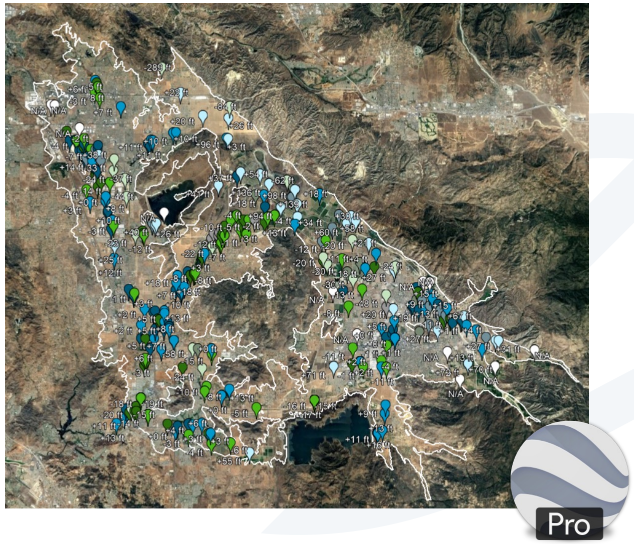

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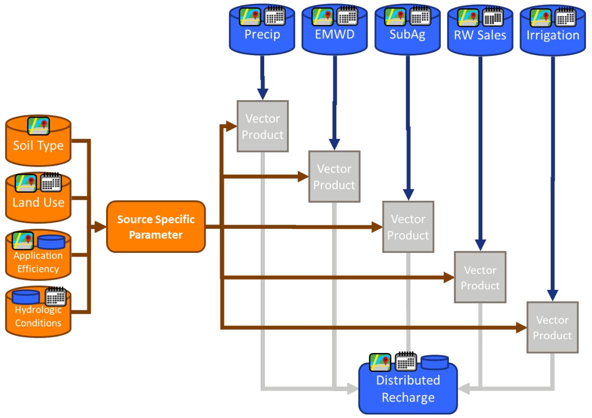

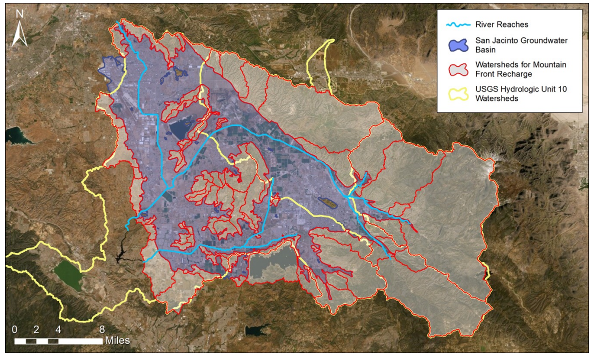

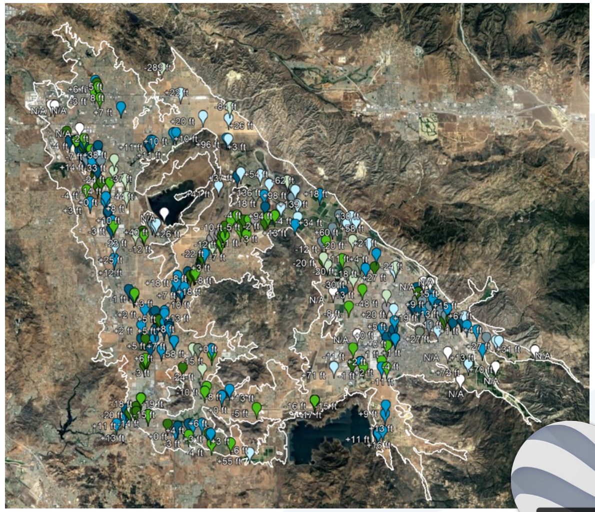

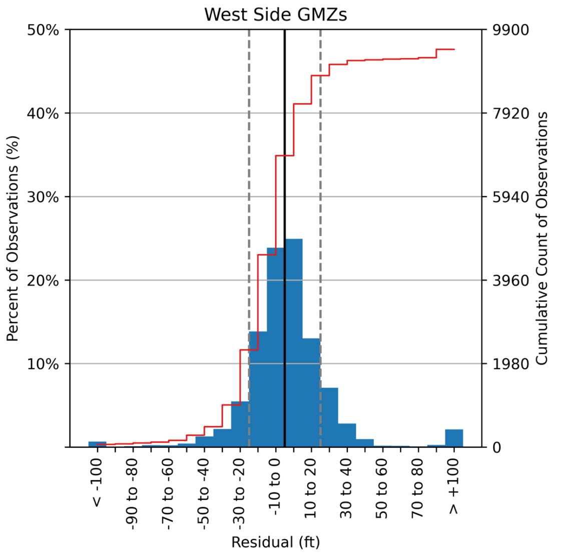

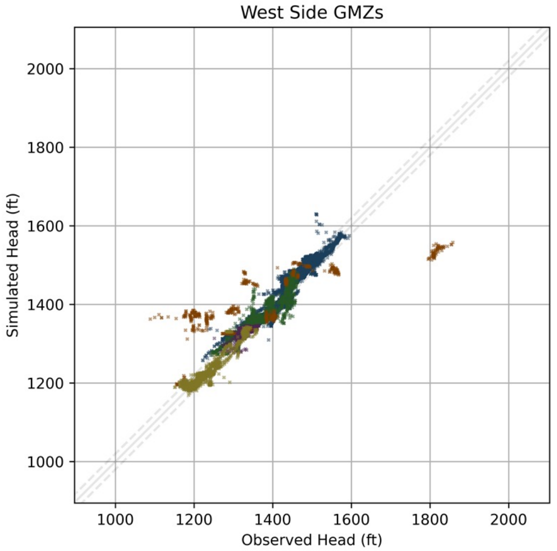

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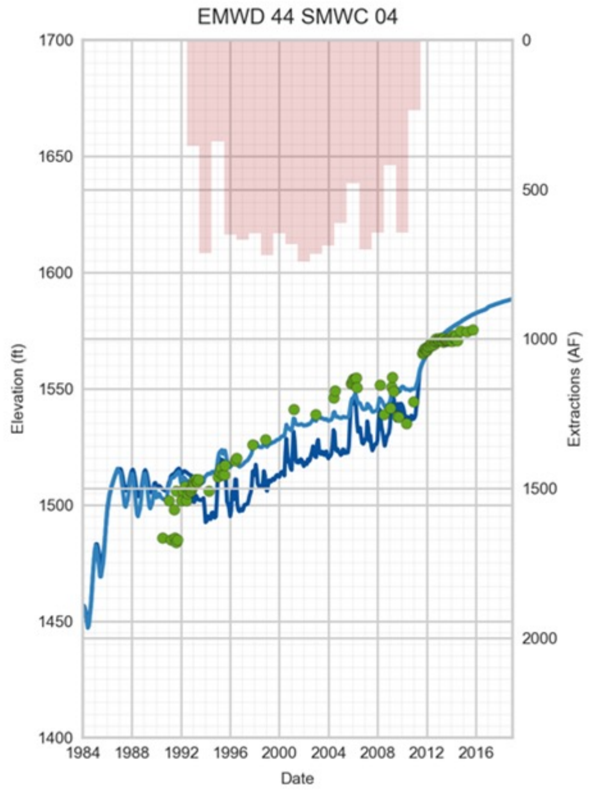
scripts > new_sjfm_script.py > script

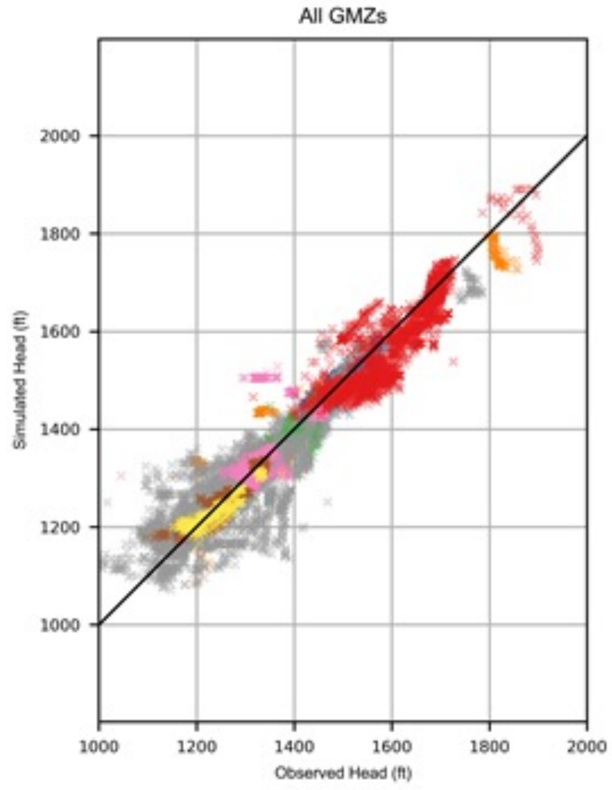
```
control = rchP.ControlFile(cf)
caster = rchP.Caster(control)
applications = rchP.ApplicationTracker(control)

global_factors = get_global_factor_array(top_folder, control, caste

print("Applications".center(80, '='))
for path, unit in dirs:
    name = os.path.basename(path)
    path = Path(path)
    print(f"{dt.now()} ->\t{name}",flush=True)
    fac = find_factors(path)
    ats_path = os.path.join(path, 'applications.csv')
    geo_path = os.path.join(path, 'geometry.csv')

    # Load to memory
    app_ts = rchP.TimeSeries(ats_path)
    geo = rchP.Geometry(geo_path, opt_dtypes=zone_type)
    facs = [rchP.Factor(p, opt_dtypes=zone_type) for p in fac]

    app_ts = unit_convert_to_grid(control, app_ts, geo, unit)
    app_ts.check_bounds(control)
    geo.check_bounds(control)
    combined = rchP.Combined(app_ts, geo)

    if 'RCH_POND' not in path.name:
        # Apply individual factor
        for factor in facs:
            combined = factor.apply(combined)

        # Check for total factors greater than 1
        specific_factor_on_app = caster.ledger_to_array(
            combined, column='FACTOR', fill_val=1.0)
        total_factor_on_app = specific_factor_on_app * global_facto
        mask = total_factor_on_app > 1
        if mask.any():
            msg = f"{np.sum(mask)} values > 100% of original applic
                f"resetting to 100% to maintain mass balance."
            print('\n'.join(wrap(msg, width=80)))
            # Do mass balance by limiting total factors to 1.0
```

Python used for all data analysis and the bulk of figure production.

Hydrographs for *every* well, for *every* model iteration.

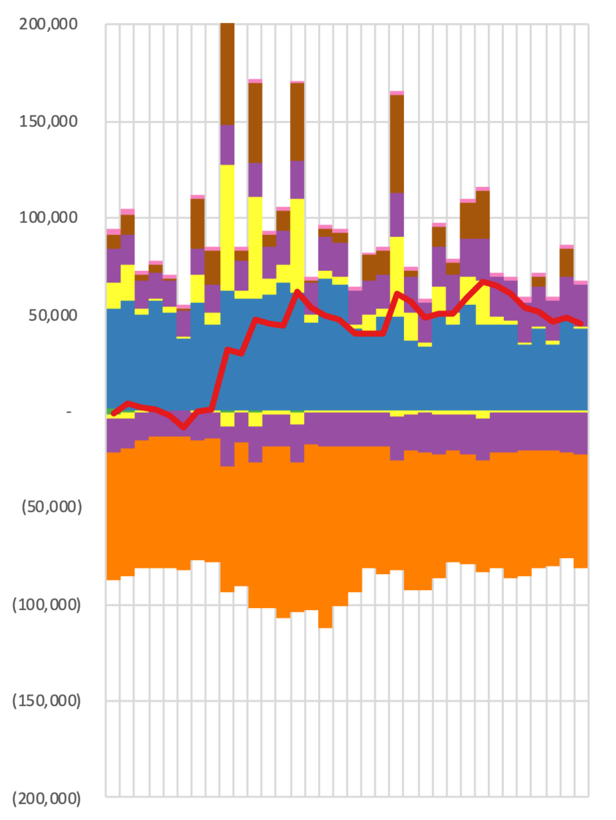
Observations and Extractions shown on the same figure.



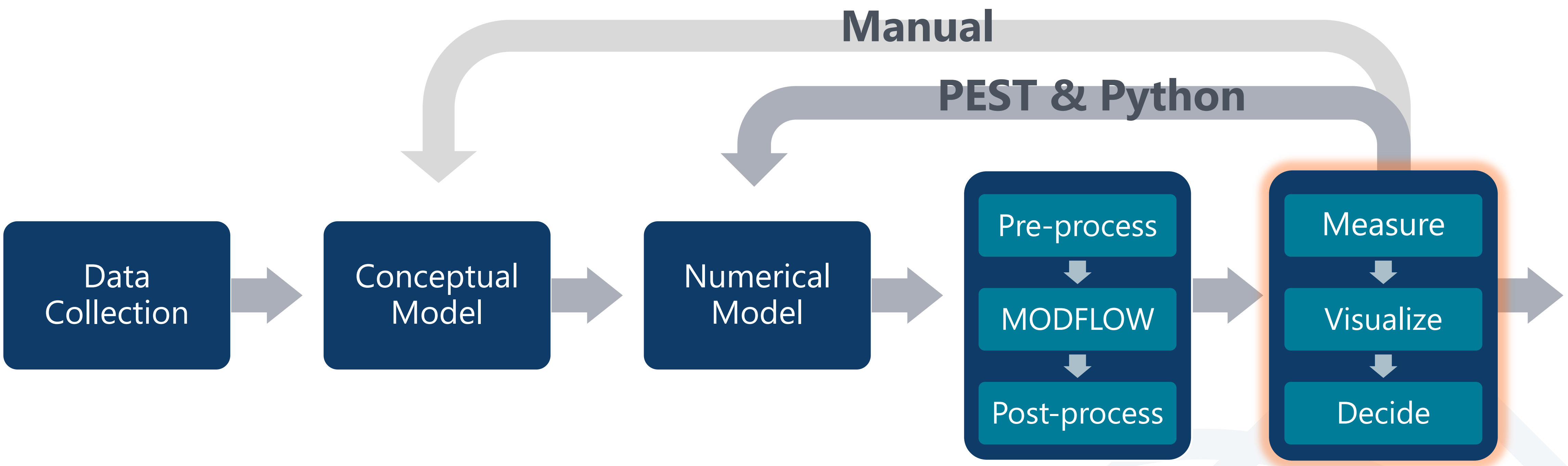


Statistics through figures (for manual evaluation) and text files (automatic evaluation).

Data is delivered in formats that leverage other tools, like Excel and GMS.

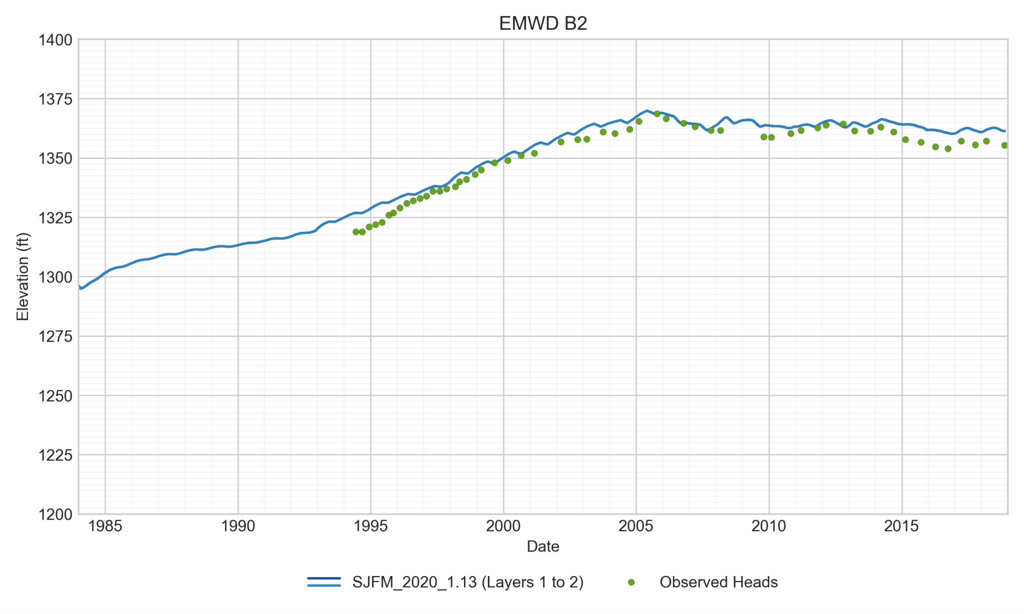


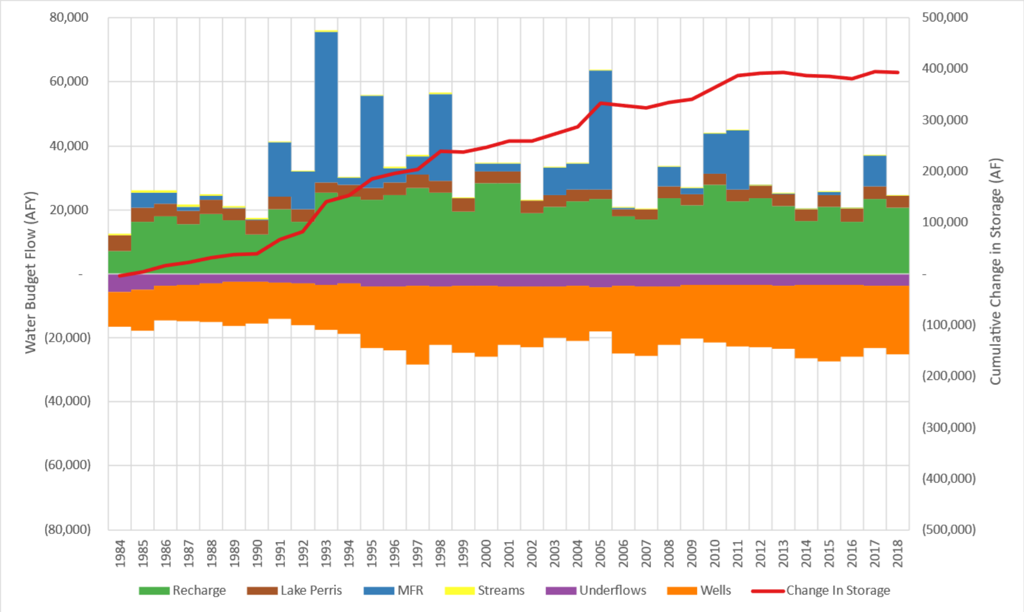
Model Development Framework



Measurement & Visualization

- Observed vs Simulated Groundwater Elevations
  - Comparative Hydrographs
  - Model Residuals
  - Trend analysis
- Basin Wide & Zonal Water Budgets
  - Flow directions
  - Relative Flow Magnitudes





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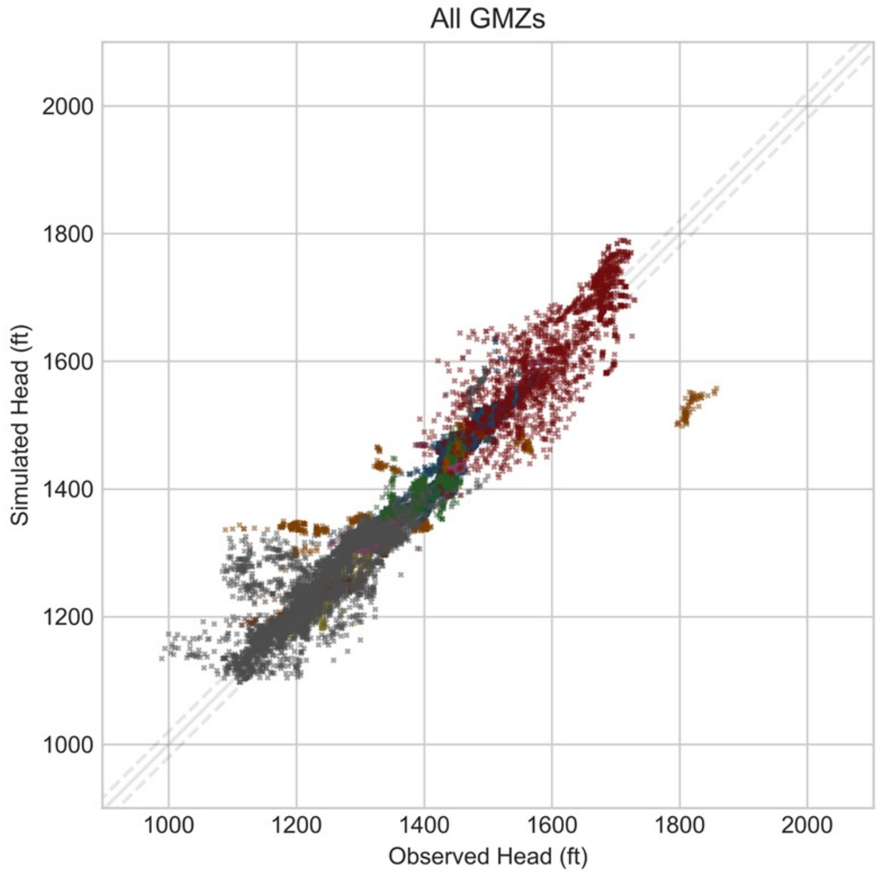
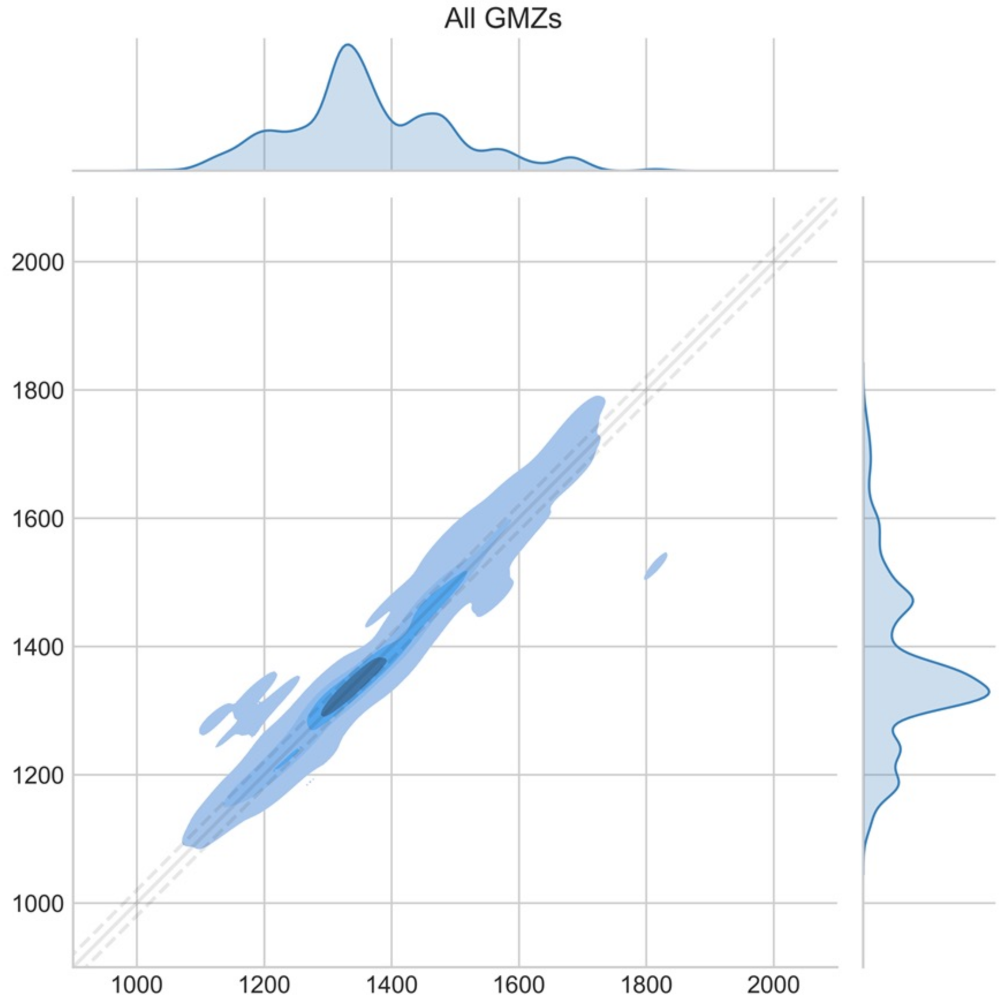


Scatter Plot



Kernel Density Estimate Plot

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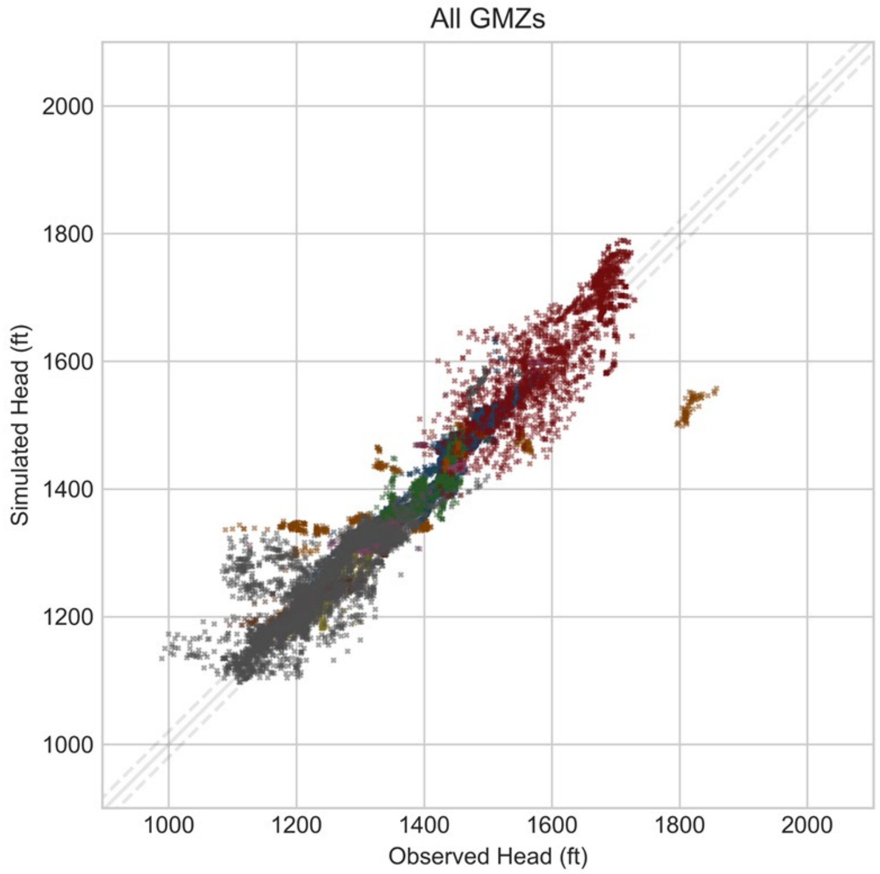
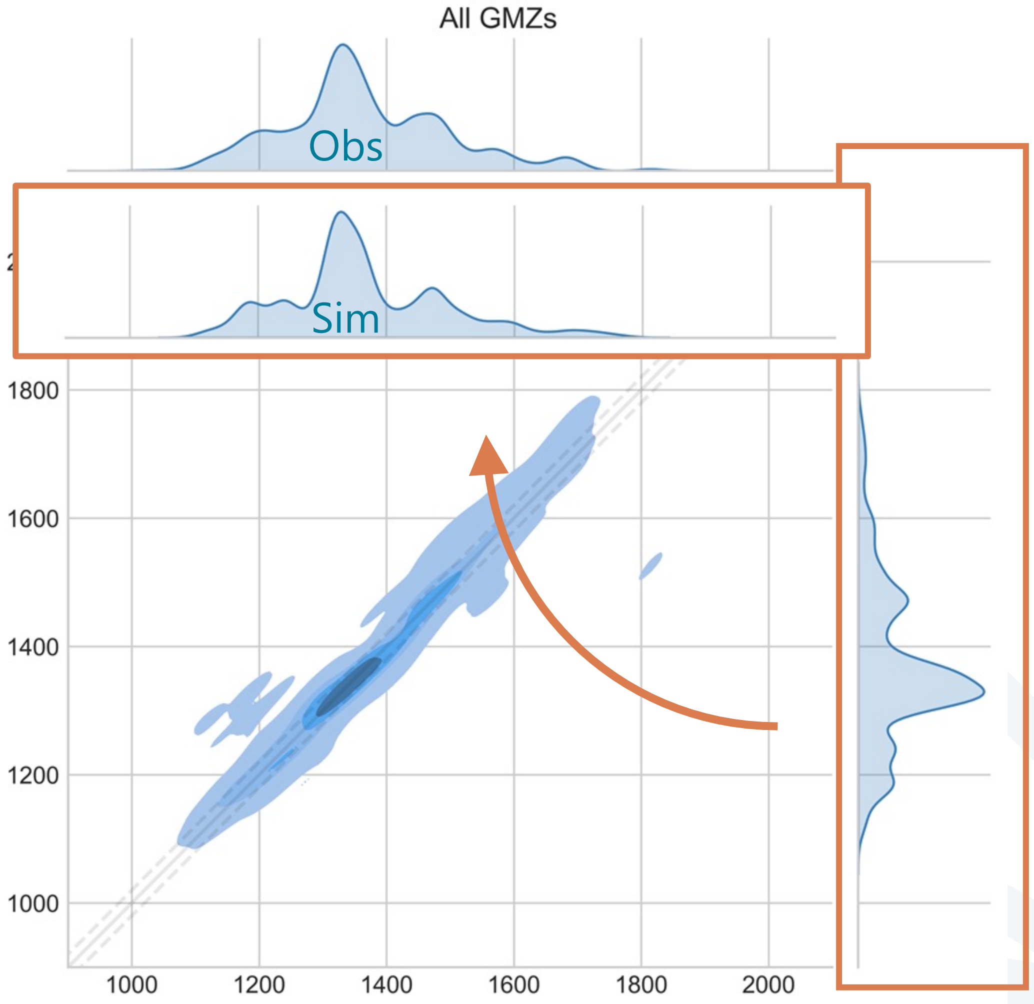
Measurement & Visualization





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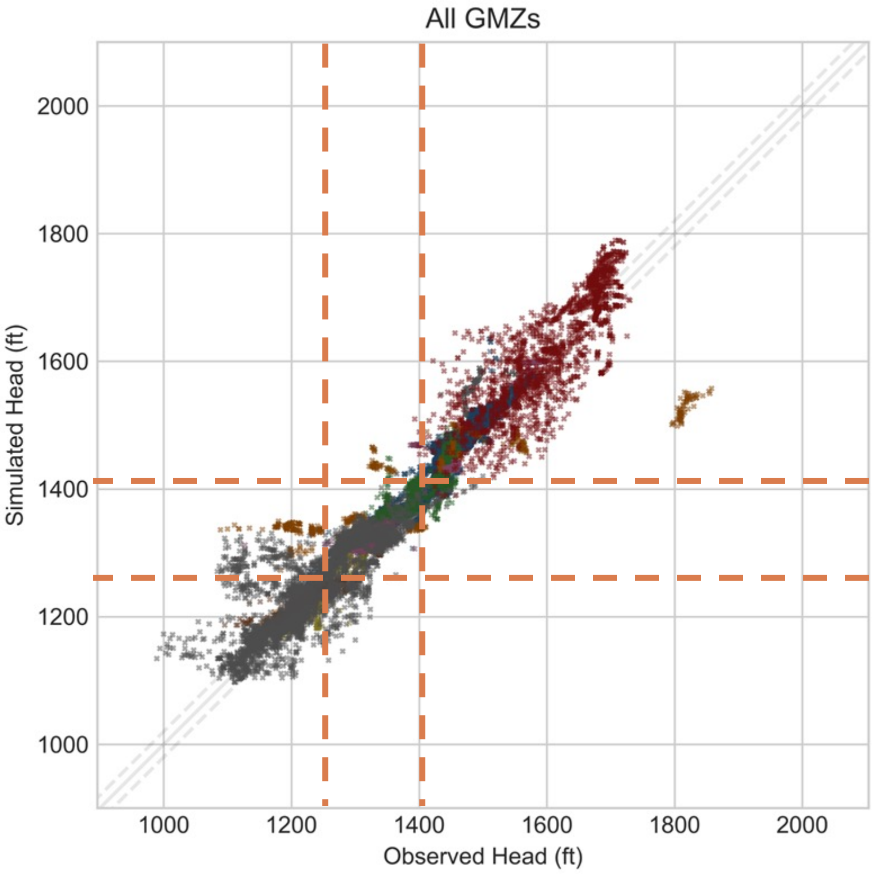

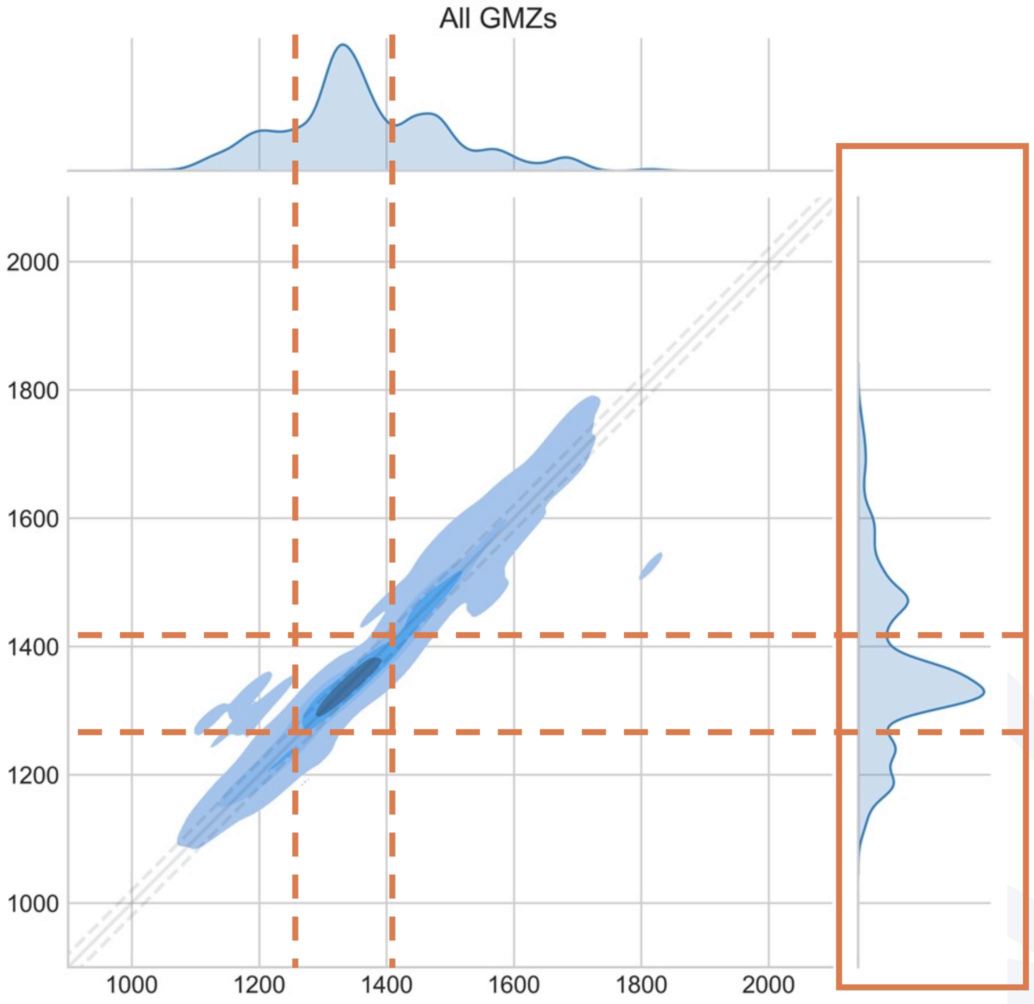

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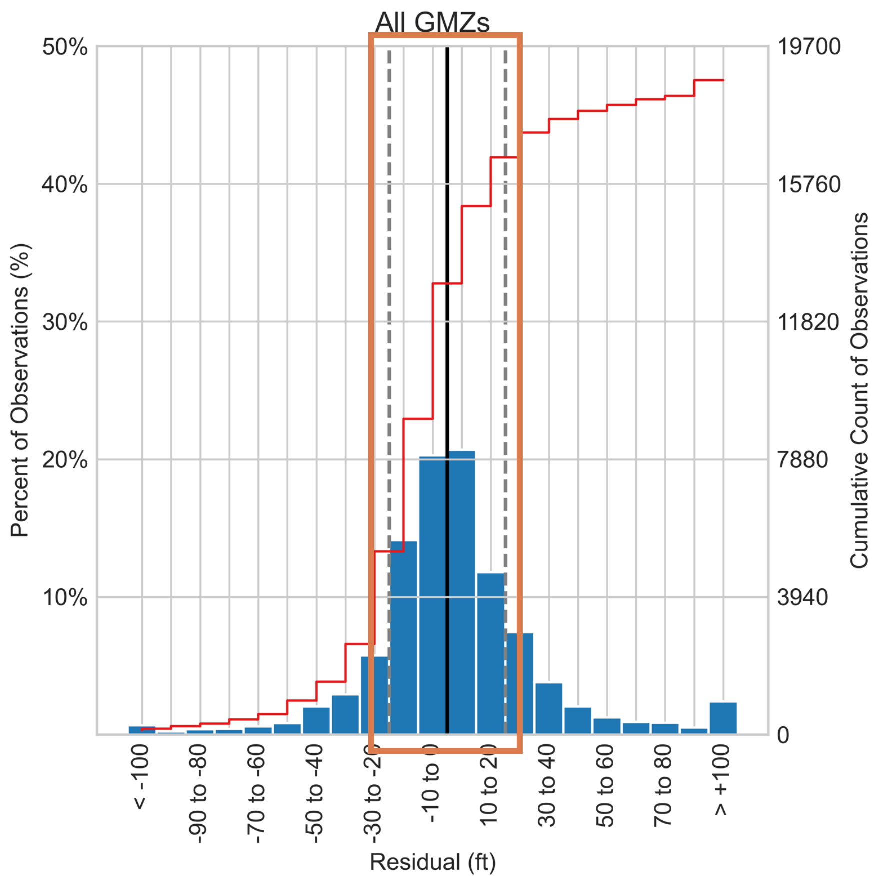

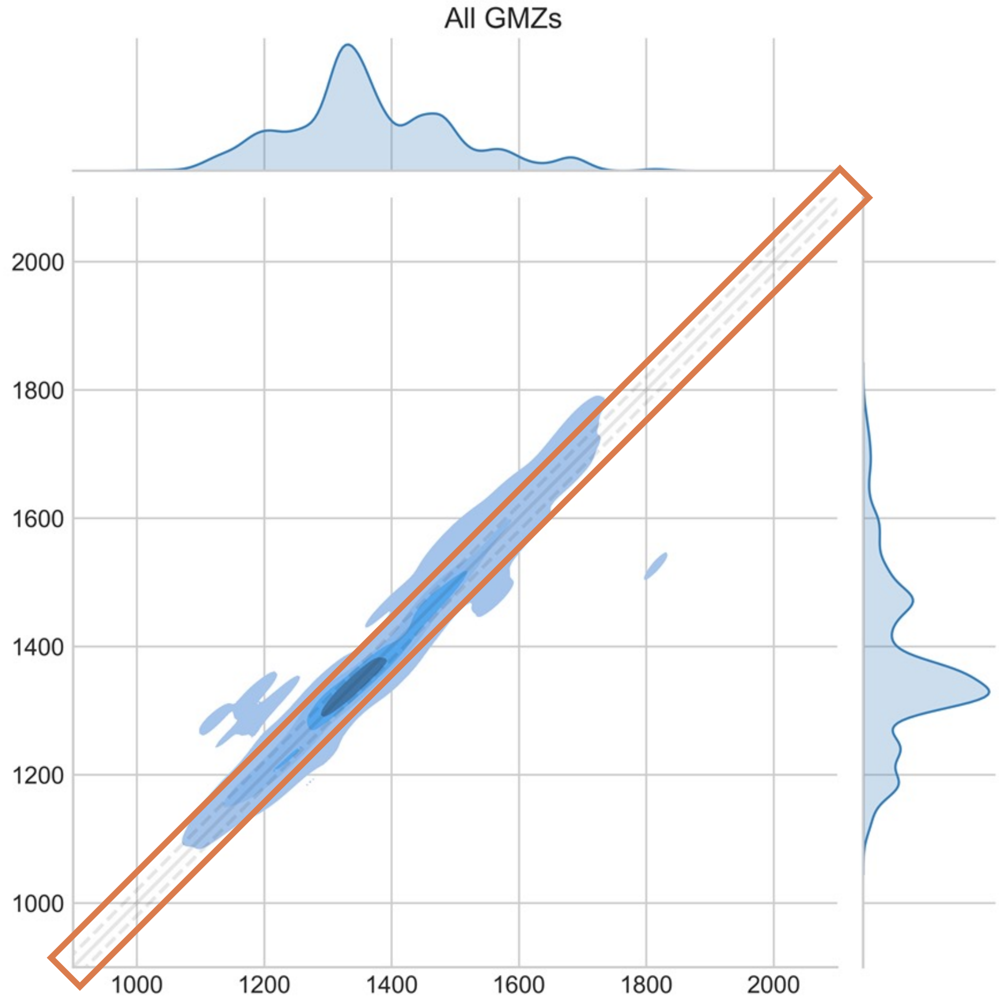

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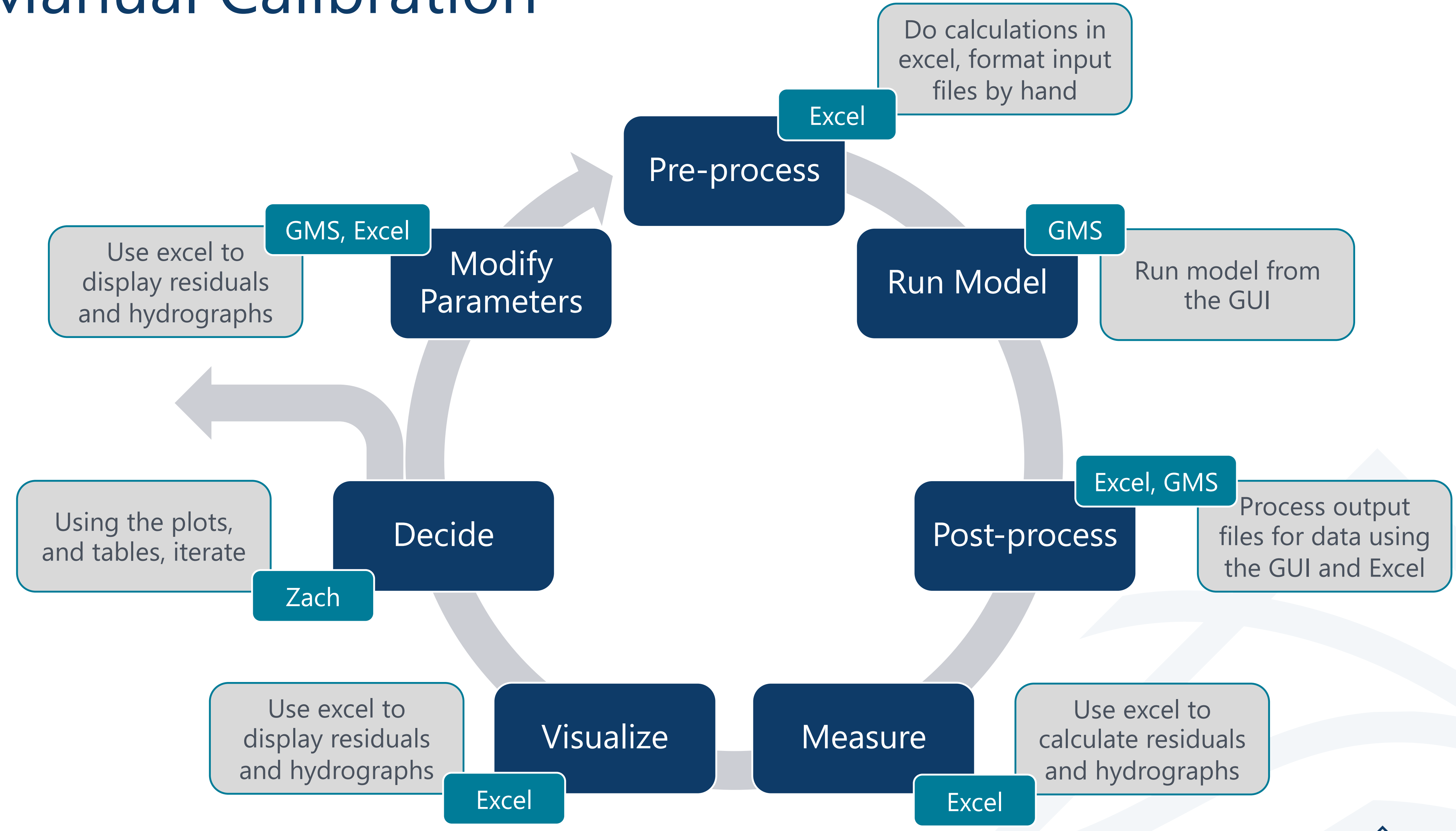
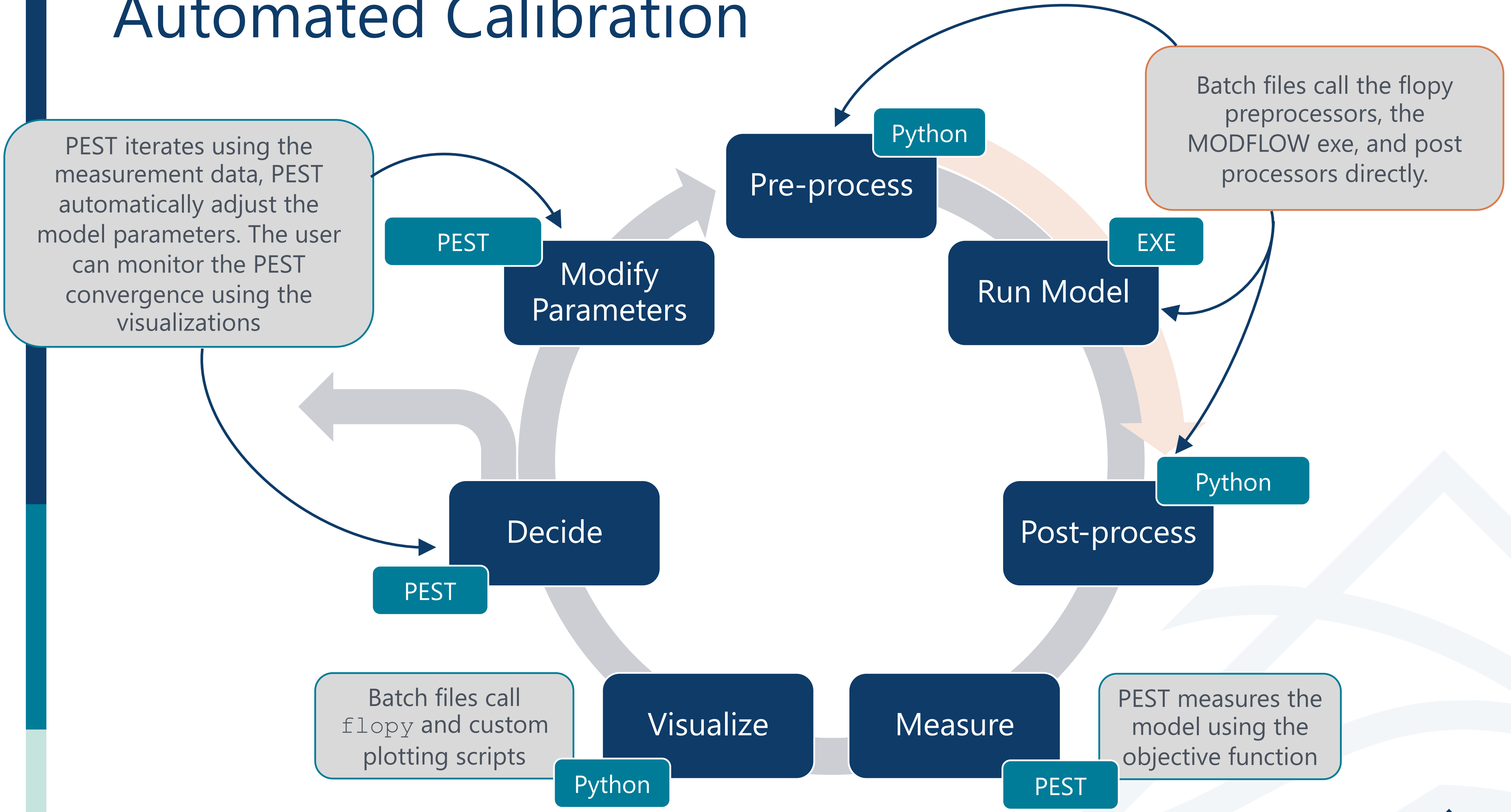
Manual Calibration

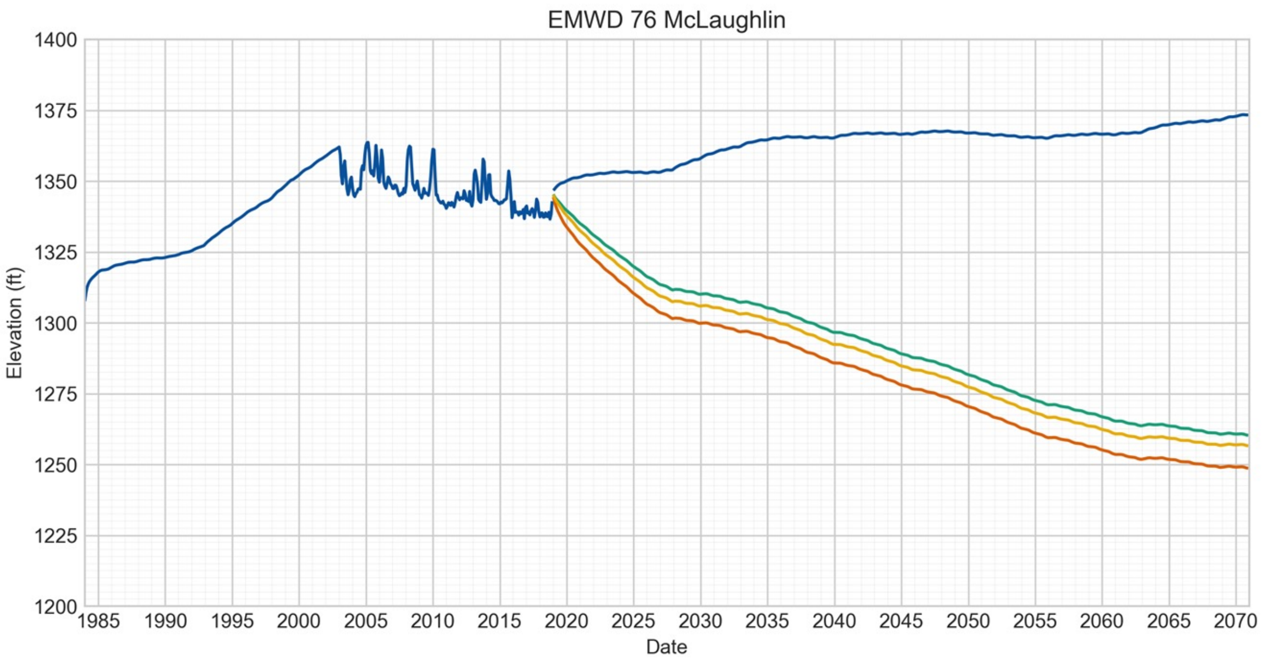


Automated Calibration



Application to the Perris South Desalination Project

- Evaluation of the effect of project wells at **various locations and extraction rates.**
- Measured using **hydrographs** at selected wells near the project area.
- Measured using **underflow rates** to adjacent groundwater management zones
- Measured using groundwater elevation contours and **head difference maps.**



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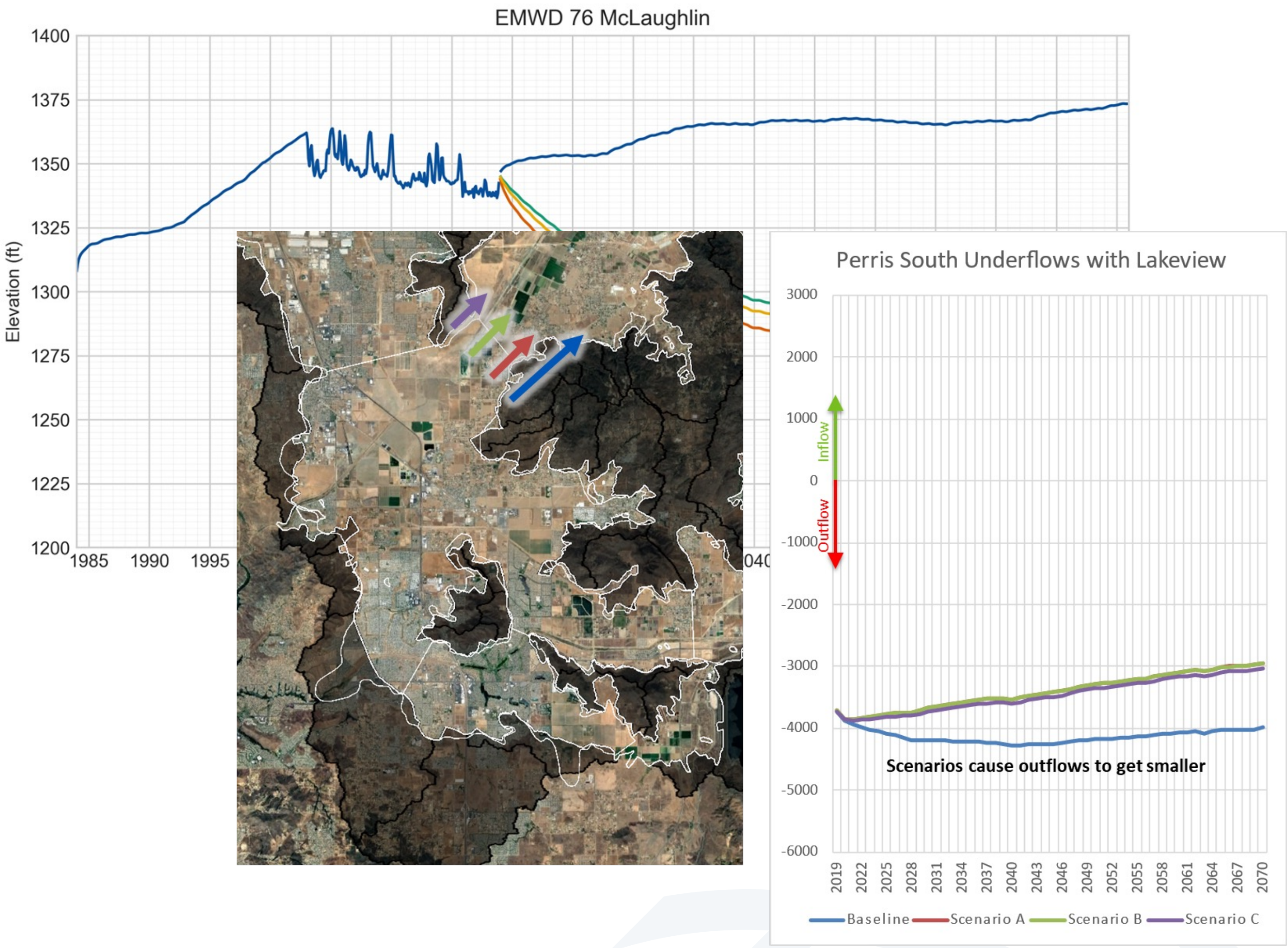

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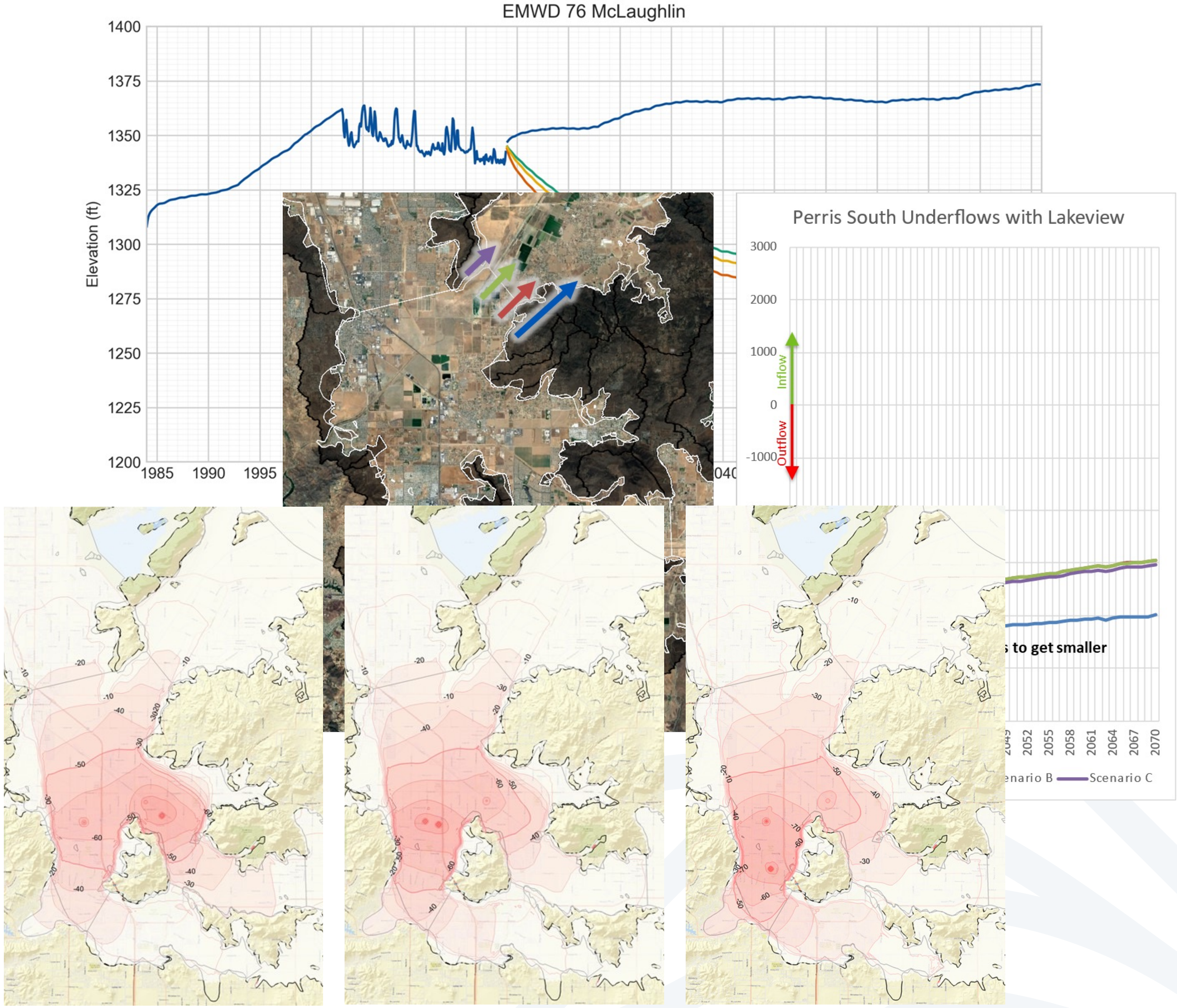

Any Questions?

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