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Structured Hazard Assessment Committee Process for Flooding (SHAC-F)

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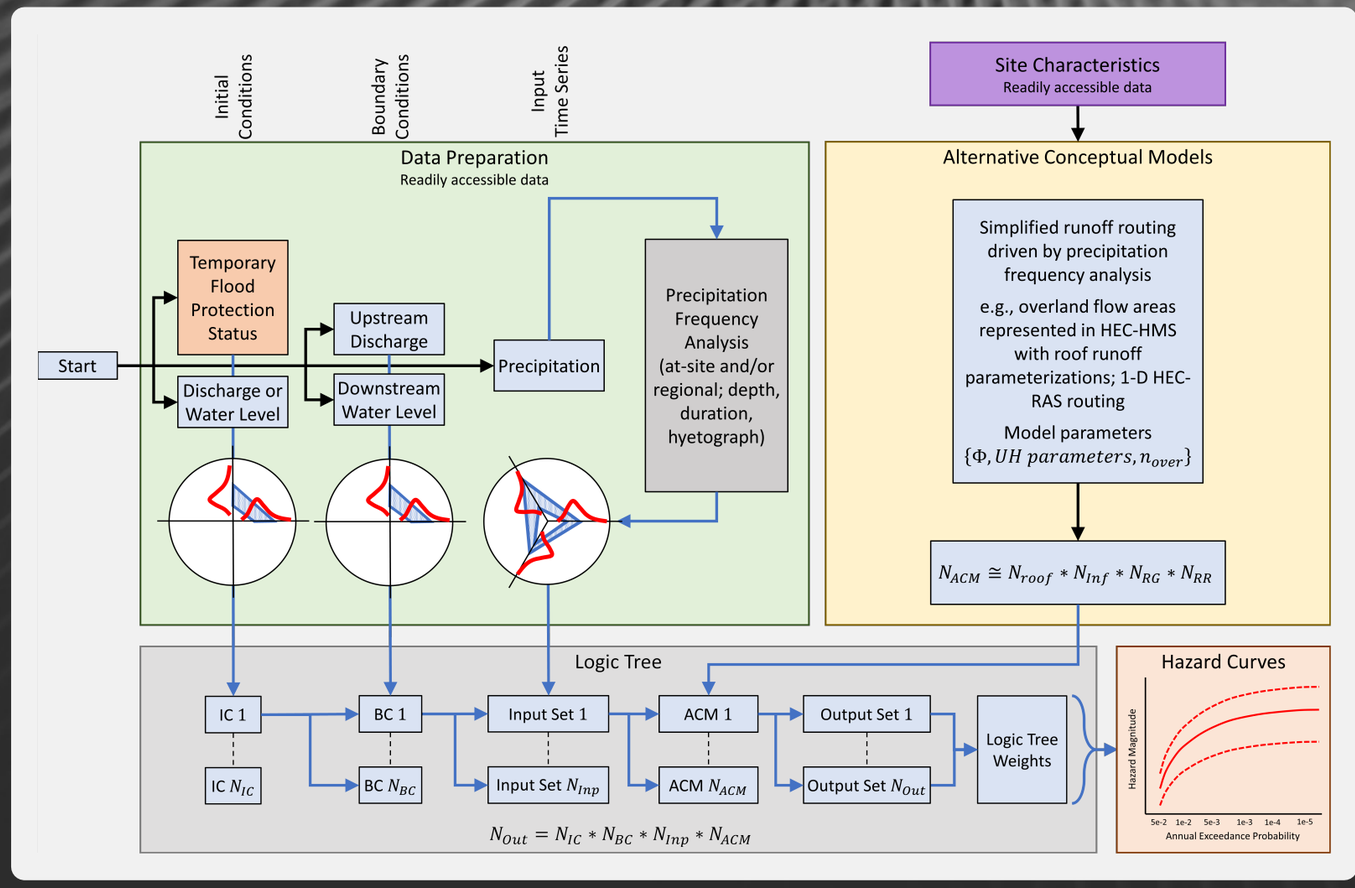
Rajiv Prasad,[1] Kevin Coppersmith,[2] and Philip Meyer[1]

[1]Pacific Northwest National Laboratory
[2]Coppersmith Consulting, Inc.



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Motivation

- Flood frequency analysis (FFA) is well established
  - Suitable for at-site estimation of distribution of flood discharge or flood volumes
  - Bulletin 17B, 17C; Asquith et al. 2017
- NRC flood reviews need estimation of dynamic flood parameters and associated effects at very low exceedance probabilities
  - Complete flood hydrographs – temporal flood characteristics
  - Hydrostatic and hydrodynamic loadings – spatial flood characteristics
  - Inundation map – spatial flood characteristics
  - Inundation duration – temporal and spatial flood characteristics
- FFA needs to be supplemented with conceptual flood models
  - Watershed models, site-scale models
  - Introduction of additional uncertainties – epistemic and aleatory
- A structured process to account for all uncertainties is needed
  - Structured Hazard Assessment Committee Process for Flooding (SHAC-F)

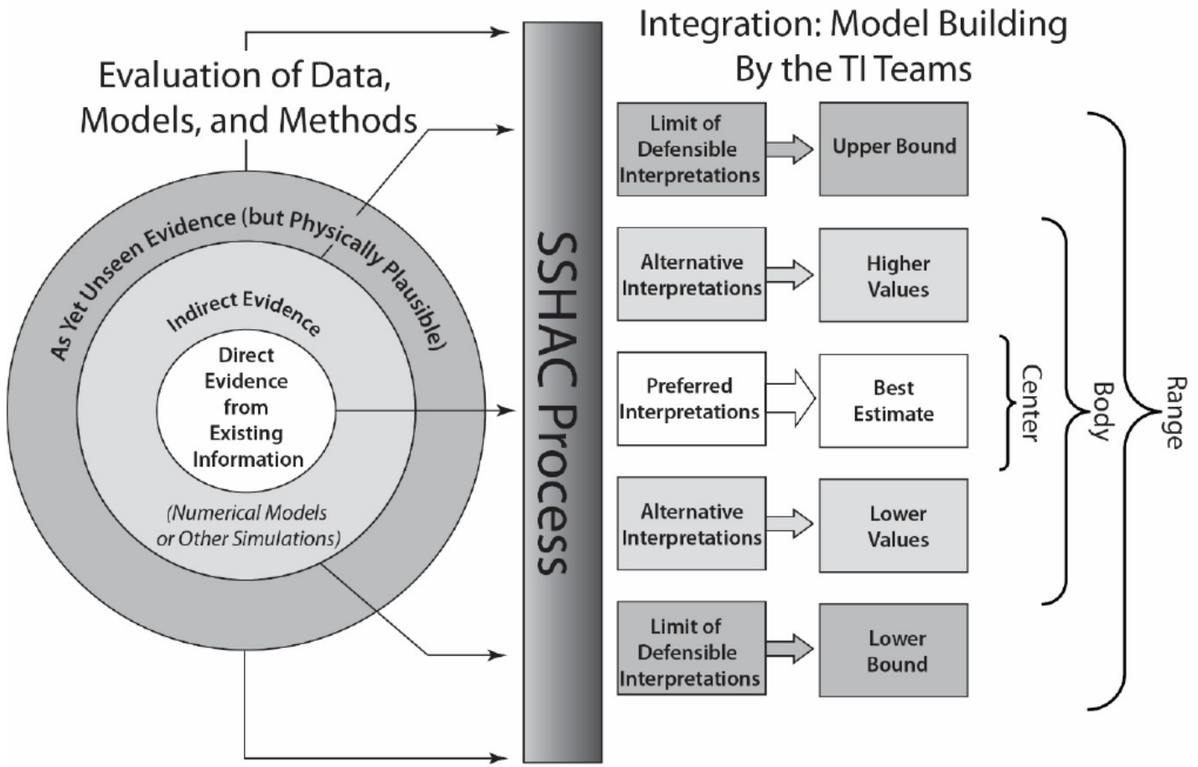
Lessons Learned from Virtual Study Approach to Development of SHAC-F

- Need to define the basic aleatory model for PFHA
  - FFA
    - Flood data → Fit selected statistical model → Create flood hazard curve
  - Simulation models
    - Input data, initial and boundary conditions → Drive selected conceptual model → Create flood hazard curve
- Need to explicitly incorporate epistemic uncertainties in PFHA

  - FFA
    - Flood data → Fit alternative statistical models → Create family of flood hazard curves
  - Simulation models
    - Input data, initial and boundary conditions → Drive selected alternative conceptual models → Create family of flood hazard curves
- Need to document all aspects of hazard assessment
  - Participatory peer review
- Need to define SHAC-F studies progressively – simplest to the most complex
  - Note – FFA is generally not possible for Local Intense Precipitation (LIP) PFHA

SHAC-F Goals

- The fundamental goal of a SHAC-F process is to properly carry out and completely document the activities of evaluation and integration, defined as:
  - Evaluation: The consideration of the complete set of data, models, and methods proposed by the larger technical community that are relevant to flood hazard analysis.
  - Integration: Representing the center, body, and range of technically defensible interpretations in light of the evaluation process (i.e., informed by the assessment of existing data, models, and methods).



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SHAC-F Features

- Five essential features provide regulatory confidence – that a hazard assessment has followed a sufficiently rigorous and transparent process that can be efficiently reviewed by the regulatory agency:
  1. **Clearly defined roles** for all participants, including the responsibilities and attributes associated with each role.
  2. **Objective evaluation** of all available data, models, and methods that could be relevant to the characterization of the hazard at the site. This will often include additional new data collected specifically for the hazard assessment. This process includes identifying the limits of the existing data, gaps in the existing data, and the resolution and uncertainties in the available data.
  3. **Integration** of the outcome of the evaluation process into models that reflect both the best estimate of each element of the hazard input with the current state of knowledge and the associated uncertainty. This distribution is referred to as the center, body, and range of technically defensible interpretations. This will generally involve the construction of hazard input models … that address both aleatory variability and epistemic uncertainties.
  4. **Documentation** of the study with sufficient detail to allow reproduction of the hazard analyses. The documentation must identify all the data, models, and methods considered in the evaluation, and justify in detail the technical interpretations that support the hazard input models.
  5. **Independent participatory peer review** is required to confirm that the evaluation considered relevant data, models, and methods, and that the evaluation was conducted objectively and without bias. The peer review is conducted following a “participatory” or continual process throughout the entire project.

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SHAC-F

- Three levels
- Levels address purposes of various NRC flood reviews
- Project teams and level of effort commensurate with complexity of reviews
- Data and methods commensurate with complexity of reviews
- Probabilistic flood assessment
- Incorporation of aleatory and epistemic uncertainties
- All three levels result in estimation of a family of flood hazard curves

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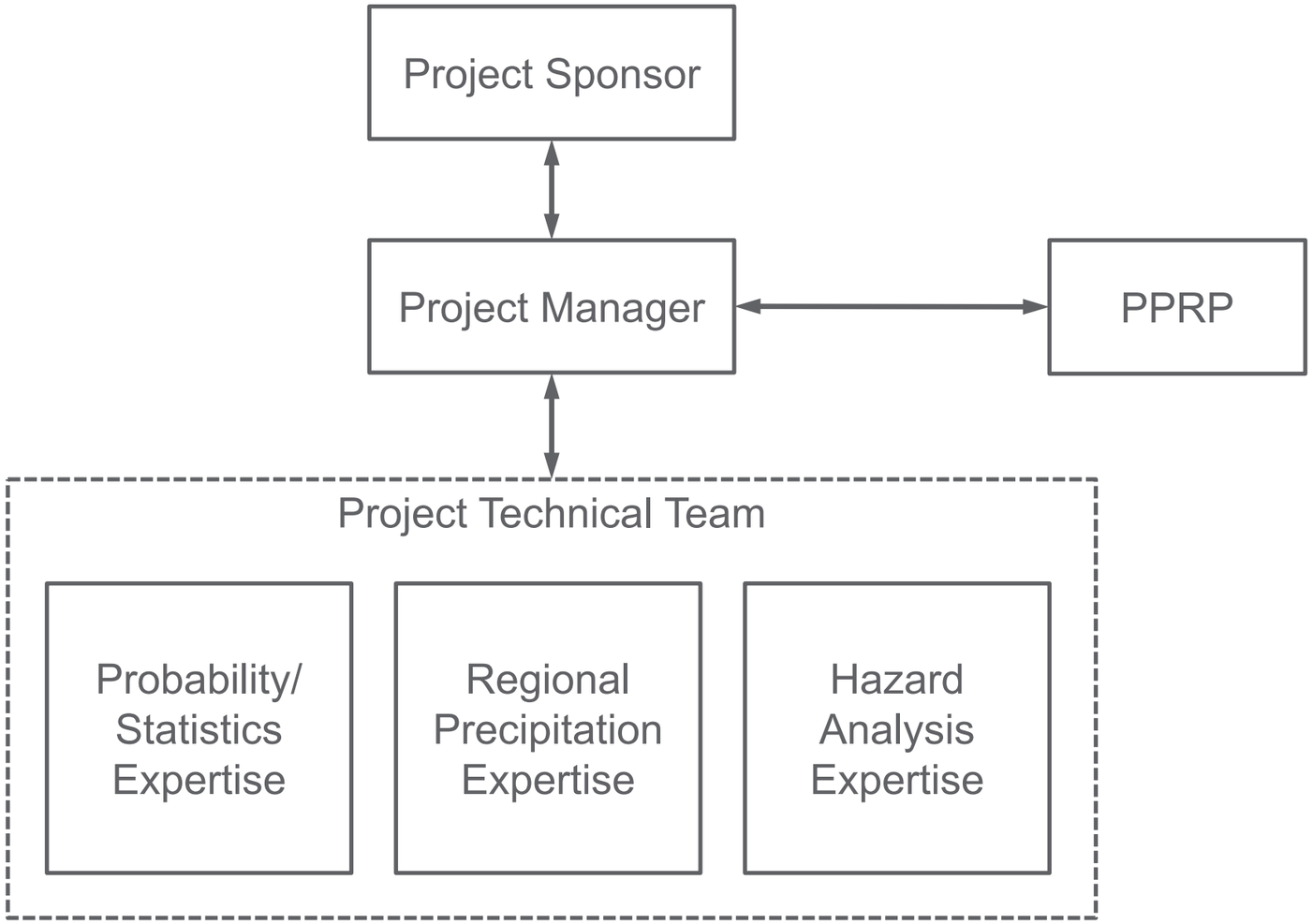
Level 1 SHAC-F Study

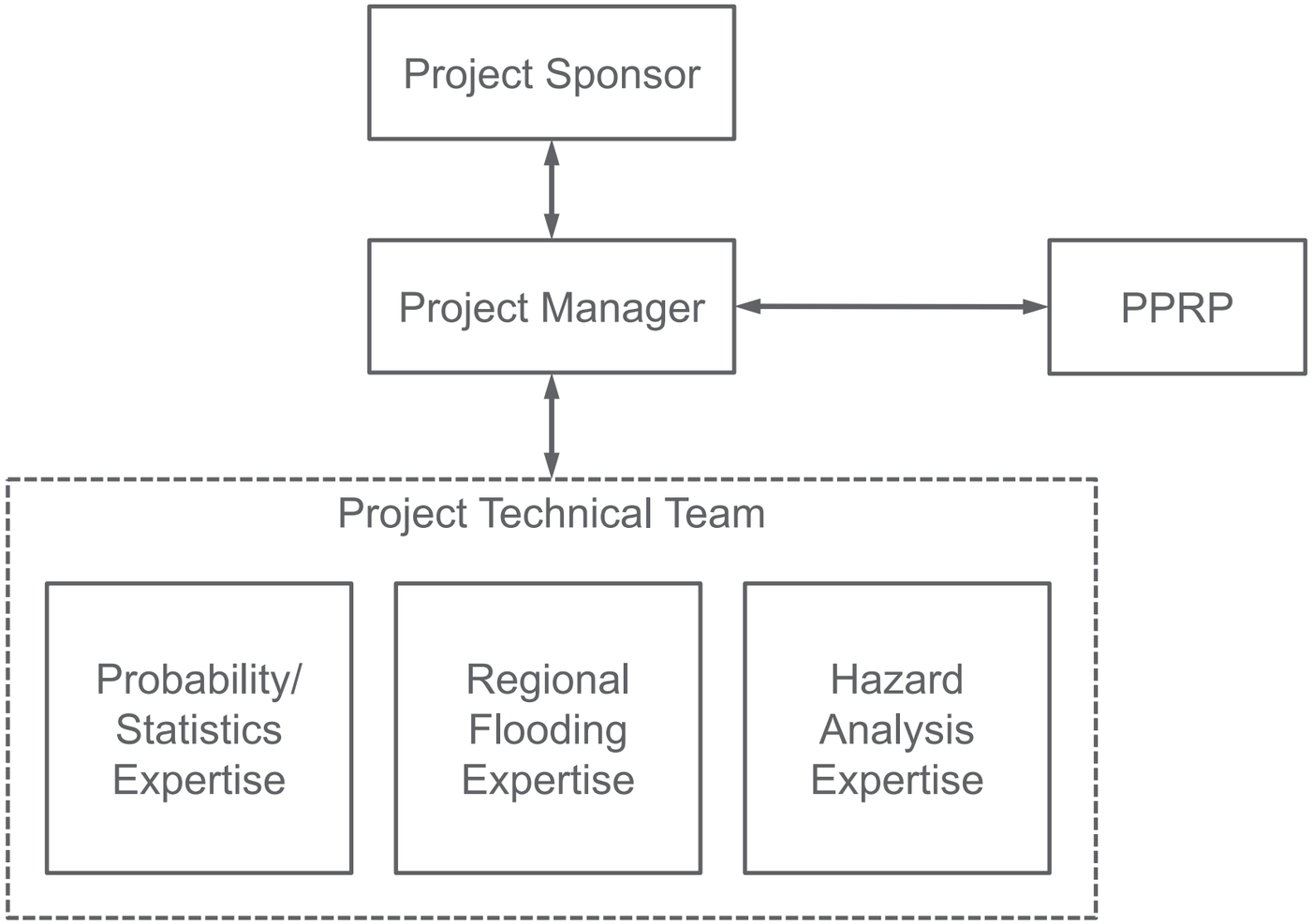
- Purpose: screening
  - Example: Significance Determination Process (SDP)
- Expected assessment results: family of flood hazard curves
  - Example: discharge and/or water surface elevation hazards plus associated effects for a LIP or riverine flood relevant to the system being analyzed in SDP
- Data
  - Readily-accessible data relevant to the chosen flood hazard assessment approach
  - Example: existing streamflow data, stage-discharge relationships
- Models and methods: ACM-L1
  - Statistical models—at-site and/or regional precipitation and/or flood-frequency analyses to drive simplified hydrologic/hydraulic process simulation models
  - Example: FFA (see Asquith et al. 2017) to drive at-site hydraulic stage estimation
- Sources of uncertainty
  - Aleatory: precipitation/streamflow; Epistemic: measurement, statistical models, parameters

Level 1 SHAC-F Study – LIP Project Team Structure



PPRP: Participatory Peer Review Panel

Level 1 SHAC-F Study – Riverine Project Structure



PPRP: Participatory Peer Review Panel

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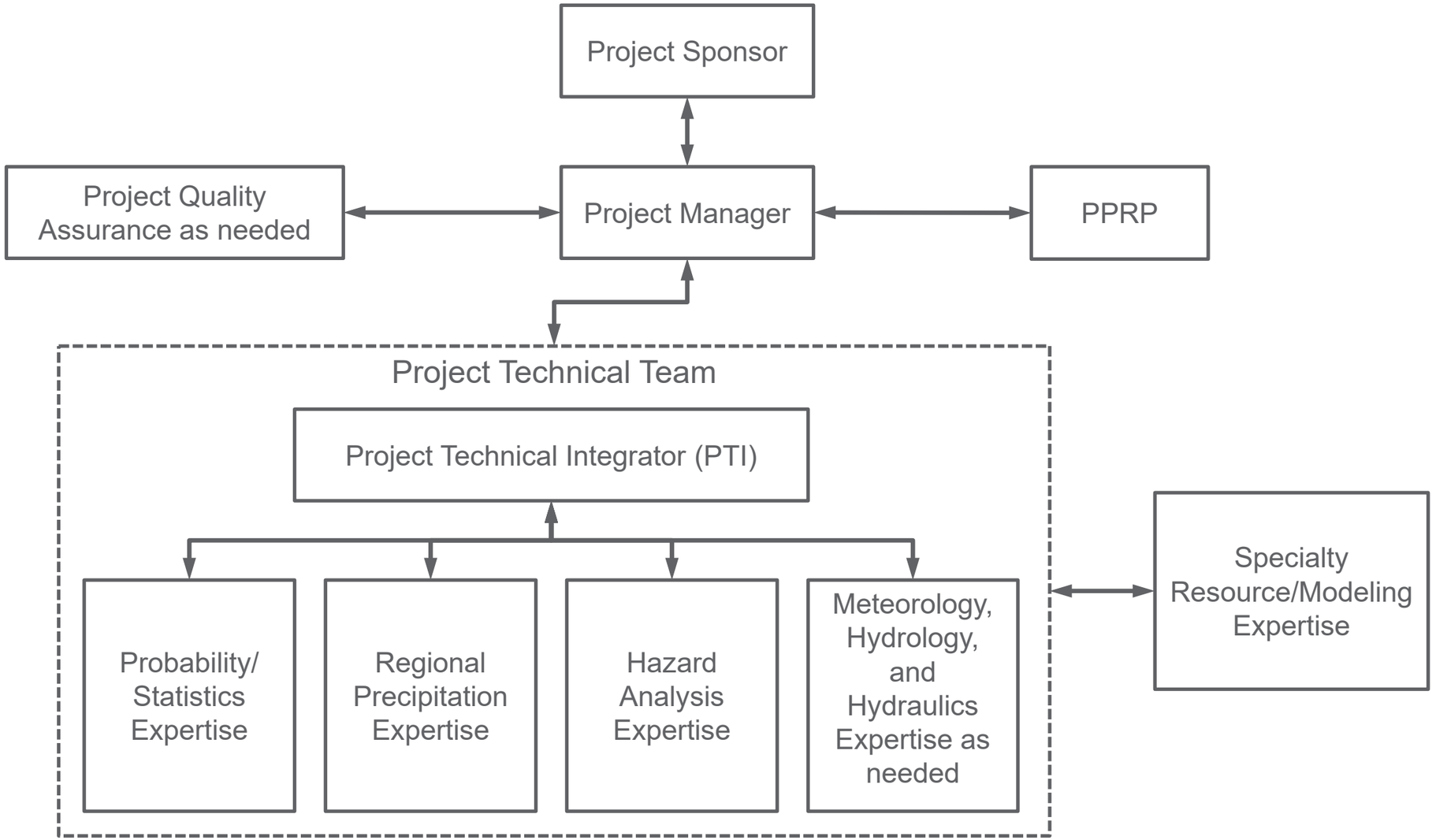
Level 2 SHAC-F Study

- Purpose: updating existing analyses or refining screening analyses
  - Example: support corrective actions, update an existing Level 3 assessment, support License Amendment Requests, refine a Level 1 assessment
- Expected assessment results: family of flood hazard curves
  - Example: family of hazard curves plus associated effects for multiple systems/locations of interest for corrective actions or permitting/licensing
- Data
  - More extensive effort to assemble existing data, contact resource experts
  - Example: historical, non-public, reanalysis, available paleoflood, and synthetic data
- Models and methods: ACM-L2
  - Statistical models, process-simulation models with spatial variations, consider nonstationarities
  - Example: frequency analysis incorporating additional data (see Asquith et al. 2017) to drive a watershed model
- Sources of uncertainty
  - Aleatory: streamflow, precipitation, initial conditions; Epistemic: discharge/precipitation/initial conditions measurement, alternative statistical/conceptual models, statistical/watershed model parameters

Level 2 SHAC-F Study – LIP Project Team



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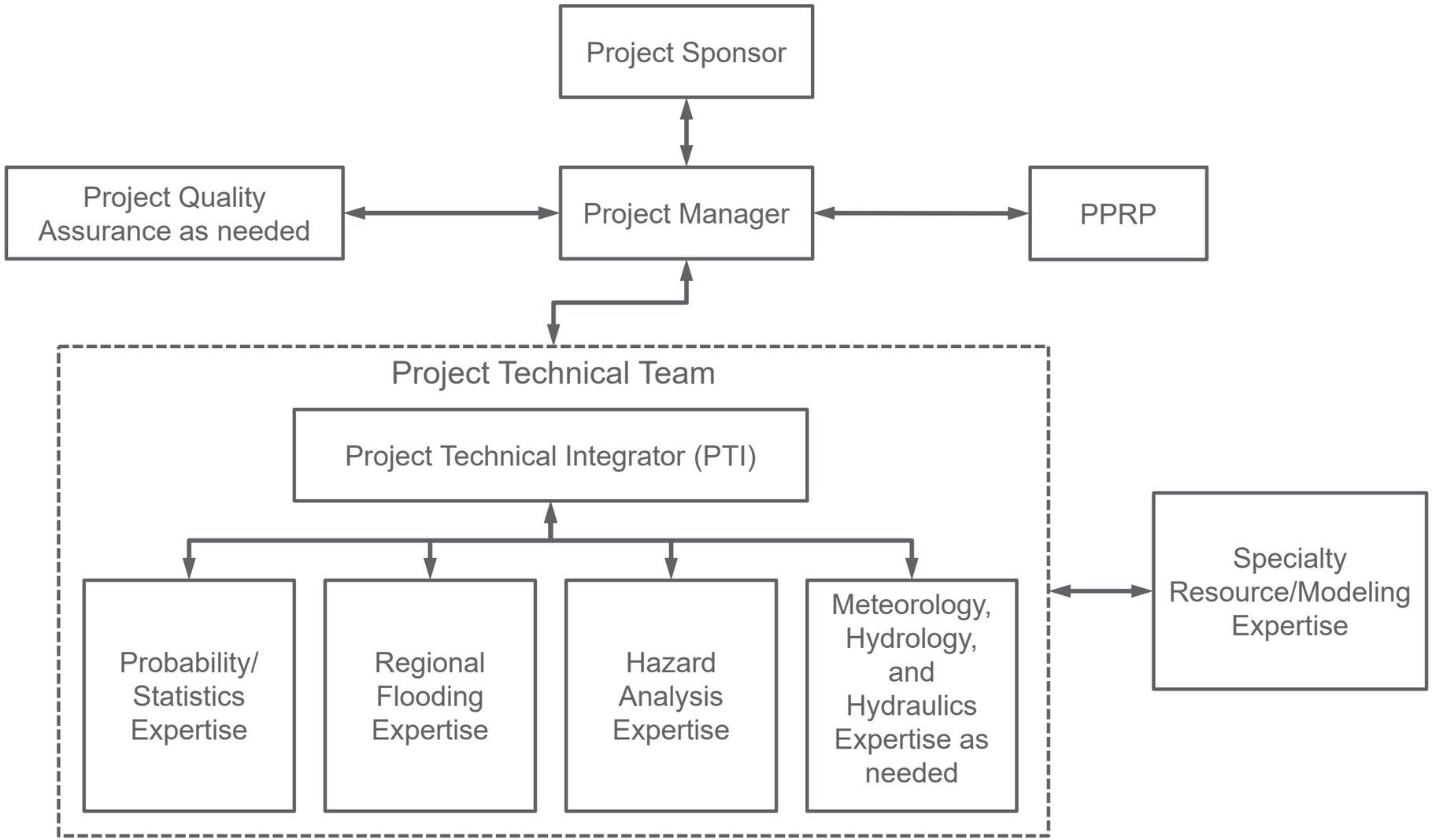
Level 2 SHAC-F Study – Riverine Project Team

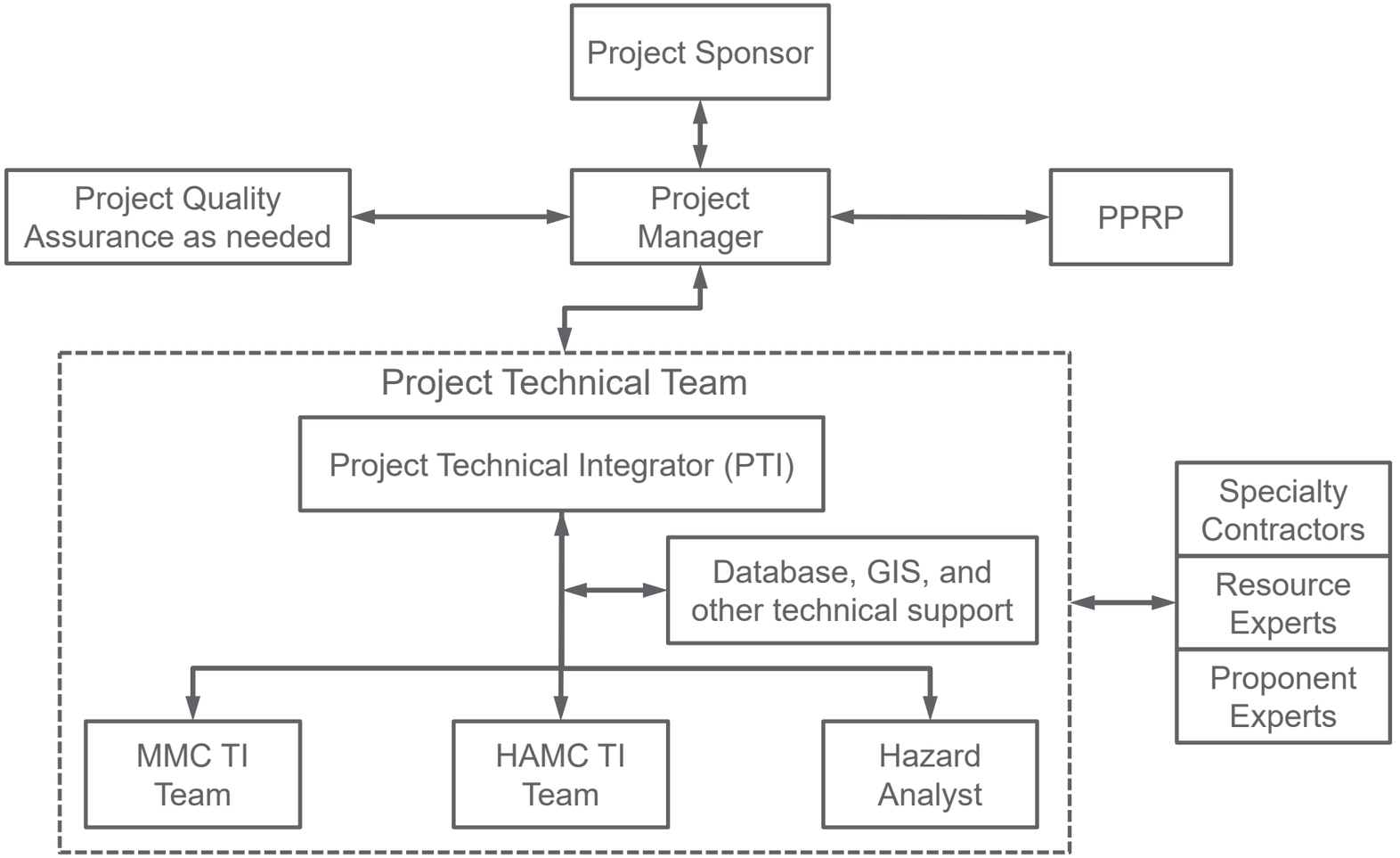


PPRP: Participatory Peer Review Panel

Level 3 SHAC-F Study

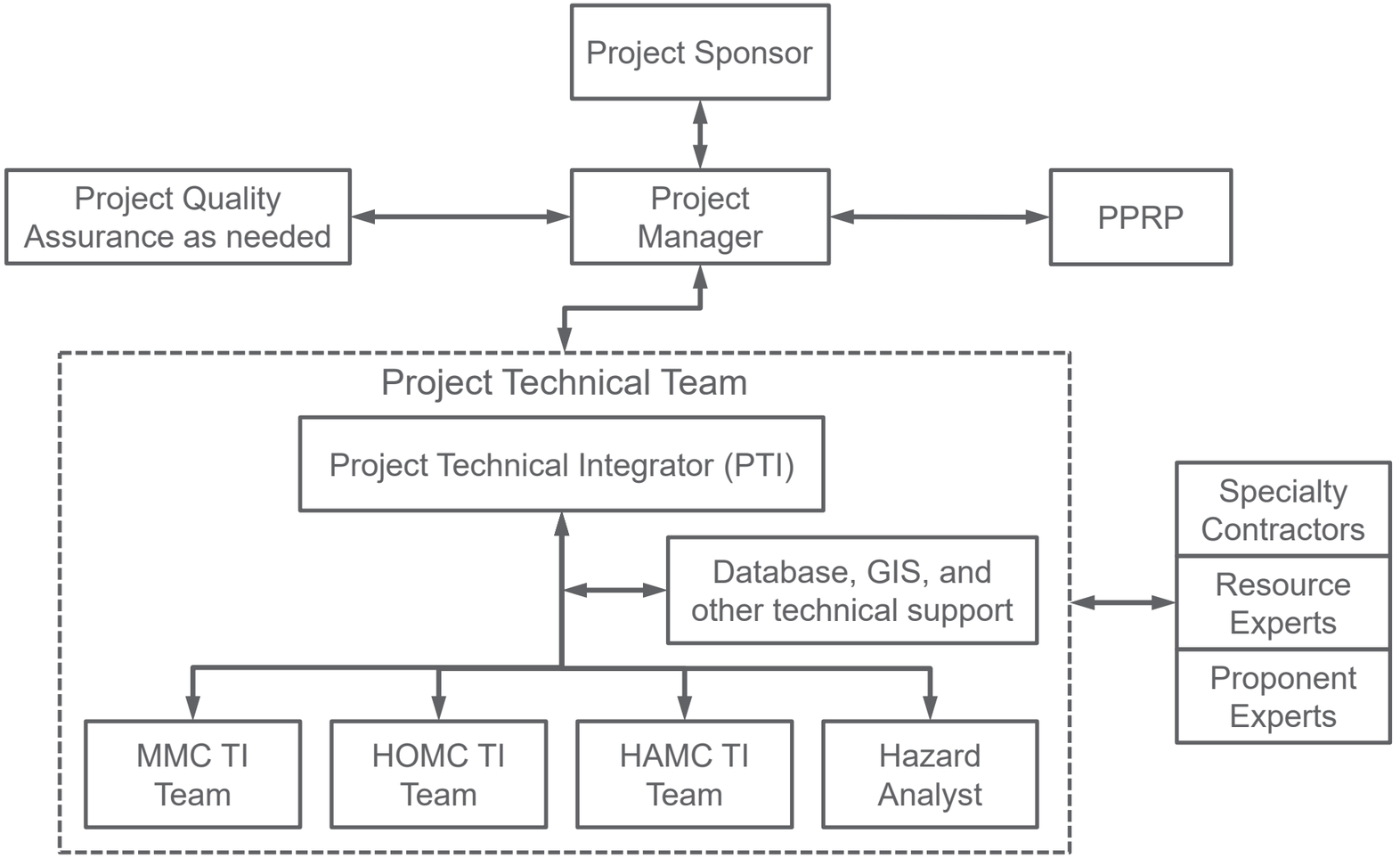
- Purpose: supporting design and/or providing inputs to a PRA
  - Example: support Combined License Application, support License Amendment Requests
- Expected assessment results: family of flood hazard curves
  - Example: family of hazard curves plus associated effects for site-wide hazards
- Data
  - Consider collecting new data
  - Example: paleoflood data, LiDAR surveys, remote sensing LULC data, bathymetric surveys
- Models and methods: ACM-L3
  - Statistical and process-simulation models with spatiotemporal resolution to support PRA; consider nonstationarities
  - Example: FFA incorporating paleoflood data, site-specific watershed models driven with frequency inputs
- Sources of uncertainty
  - Aleatory: streamflow, precipitation, initial, and boundary conditions; Epistemic: discharge/precipitation/initial/boundary conditions measurement, alternative statistical models, statistical/watershed model parameters, alternative process representations in watershed models

Level 3 SHAC-F Study – LIP Project Team



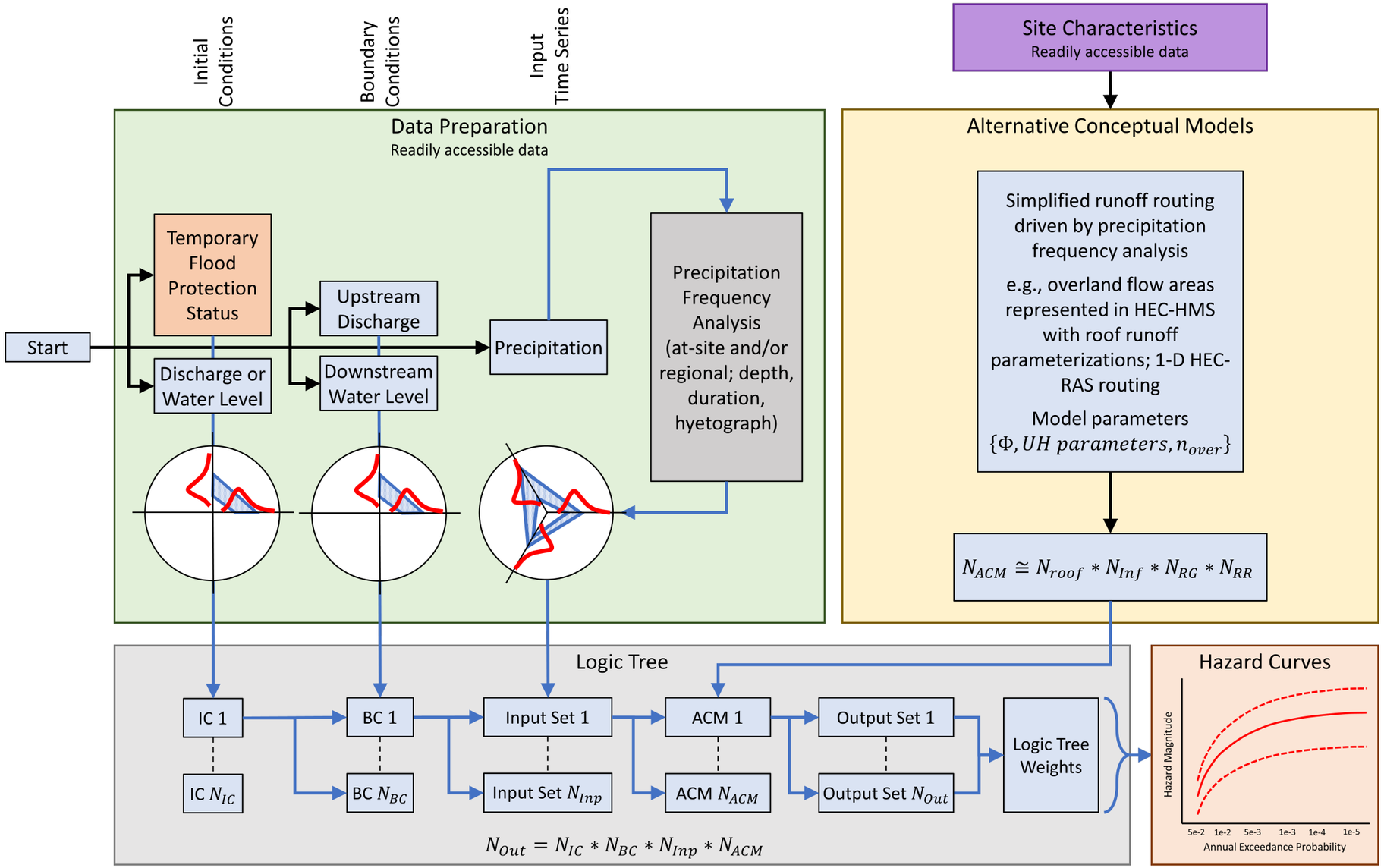
PPRP: Participatory Peer Review Panel; MMC: Meteorological Model Characterization; HAMC: Hydraulic Model Characterization

Level 3 SHAC-F Study – Riverine Project Team

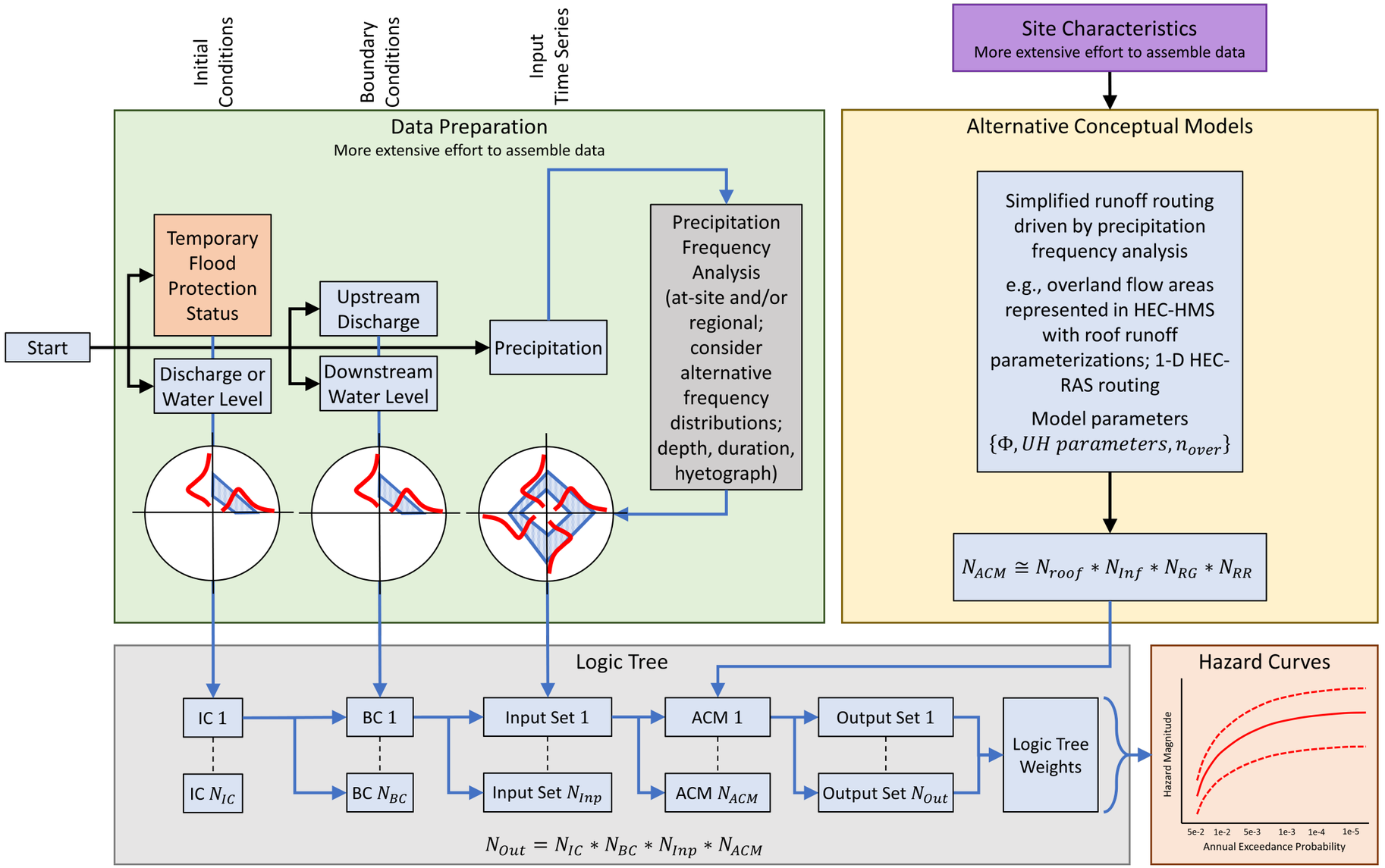


PPRP: Participatory Peer Review Panel; MMC: Meteorological Model Characterization; HOMC: Hydrologic Model Characterization; HAMC: Hydraulic Model Characterization

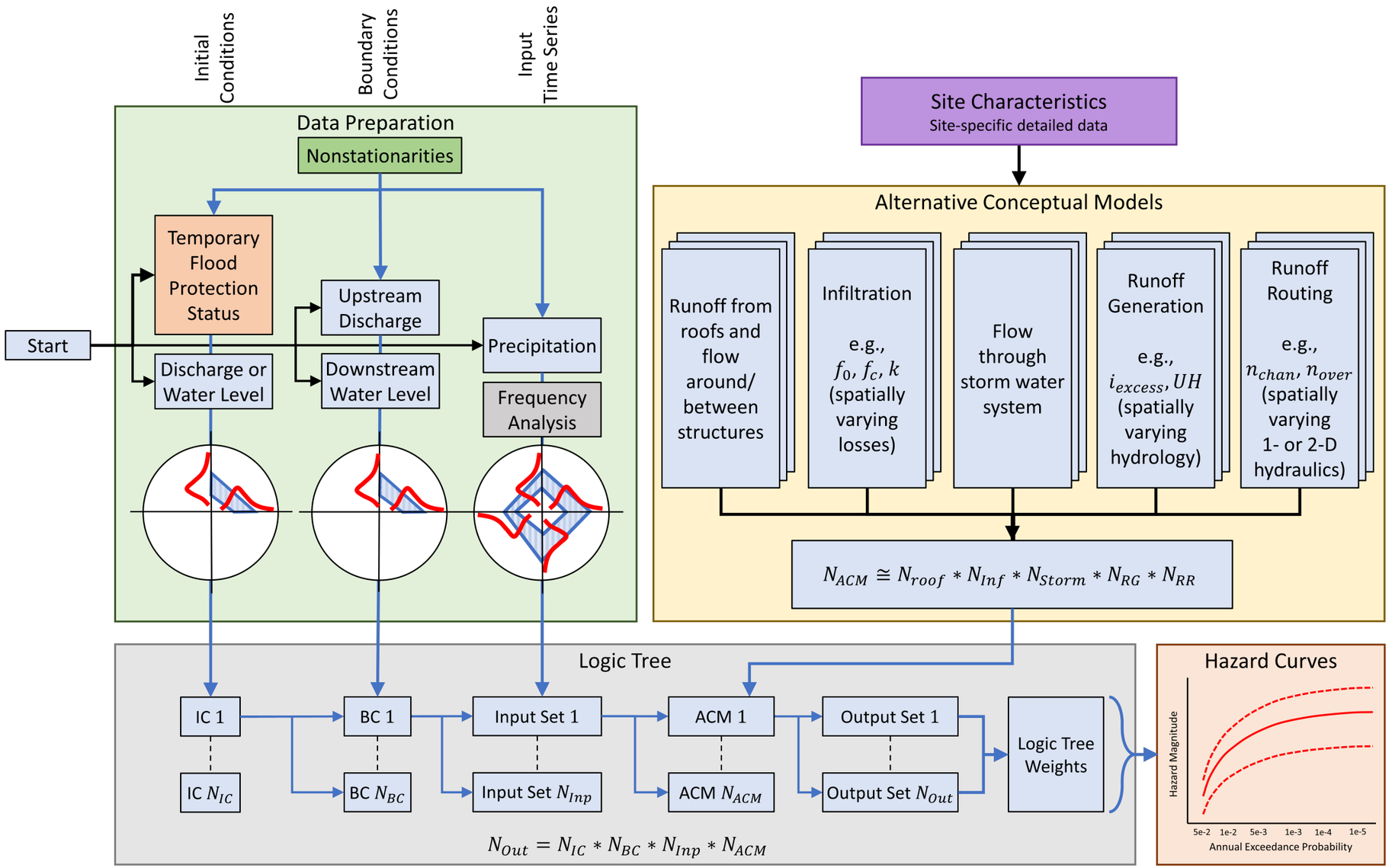
SHAC-F Level 1 for LIP PFHA



SHAC-F Level 2 for LIP PFHA



SHAC-F Level 3 for LIP PFHA



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Conclusions

- SHAC-F is tailored after the Senior Seismic Hazard Assessment Committee (SSHAC) process
  - Three levels address purposes of various NRC flood reviews
  - Project teams and levels of effort commensurate with complexity of reviews
- SHAC-F does not require specific models or methods to be used
- SHAC-F does require probabilistic flood assessment with incorporation of aleatory and epistemic uncertainties in estimation of a family of flood hazard curves
- SHAC-F does require documentation with sufficient detail to allow review, reproduction, and update to a PFHA

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Thank you