HydroGeoSphere-Management (HGS-M) System

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Outline

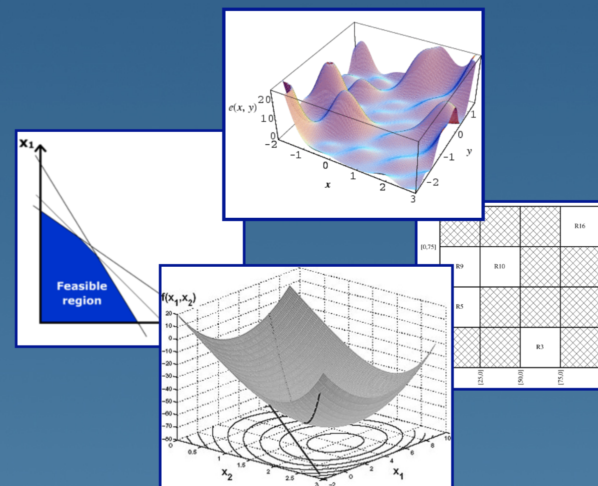
- Background
  - Project Objective
  - Broader Modeling Goals
  - General Design Considerations
  - Application Strategies
- Formulation
- Linkage methodologies
- HydroGeoSphere-Management System
- Next Steps

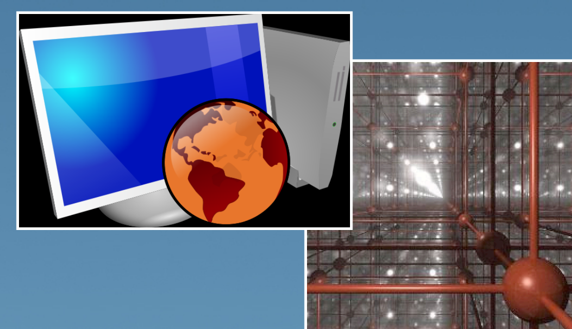
Project Objective

- To provide a tool that facilitates conjunctive and dynamic simulation of hydrologic processes and operation of multi-reservoir systems
  - Provide capability to assess issues in an integrated and optimal manner under changing climatic conditions with various water management scenarios

General Design Considerations

- Maintain an open architecture to facilitate future additions and upgrades
  - Linkage to various water-allocation (optimization) models/programs
  - Adaptability to future versions and new features in HydroGeoSphere and various water-allocation models/programs
  - Takes advantage of latest advances in computing resources (e.g. distributed computing environments)





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Outline

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  - System representation
  - Solution strategies
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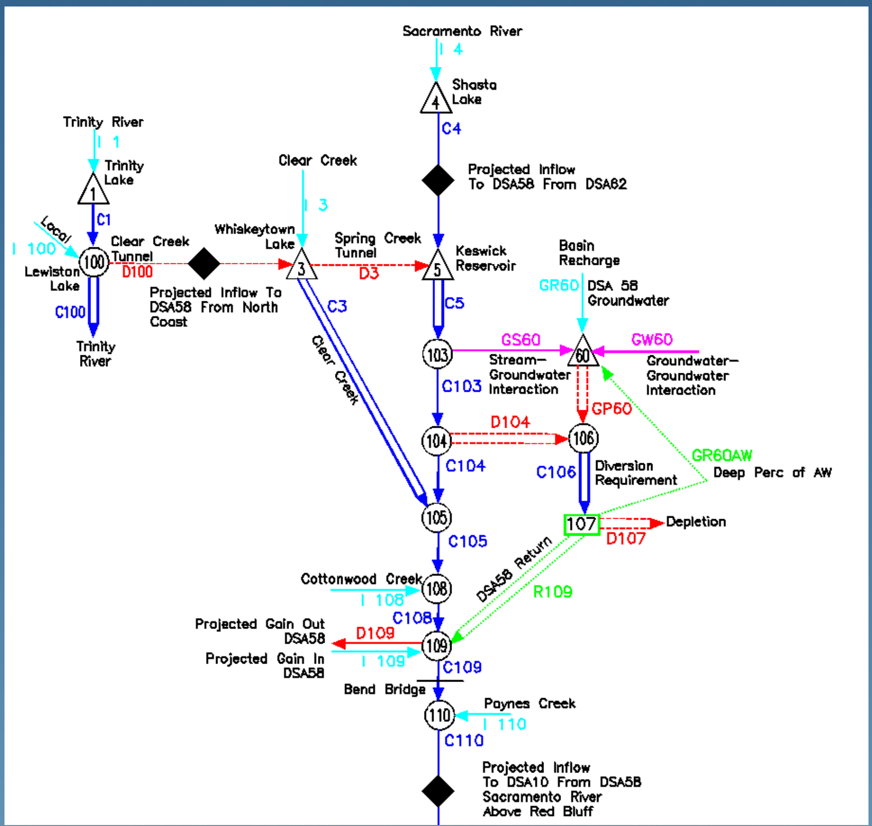
Considerations for Formulation

- What are the decisions that need to be made?
- What information is required to make these decisions?
- What are the objectives and constraints?
- Is the resulting problem linear or nonlinear?

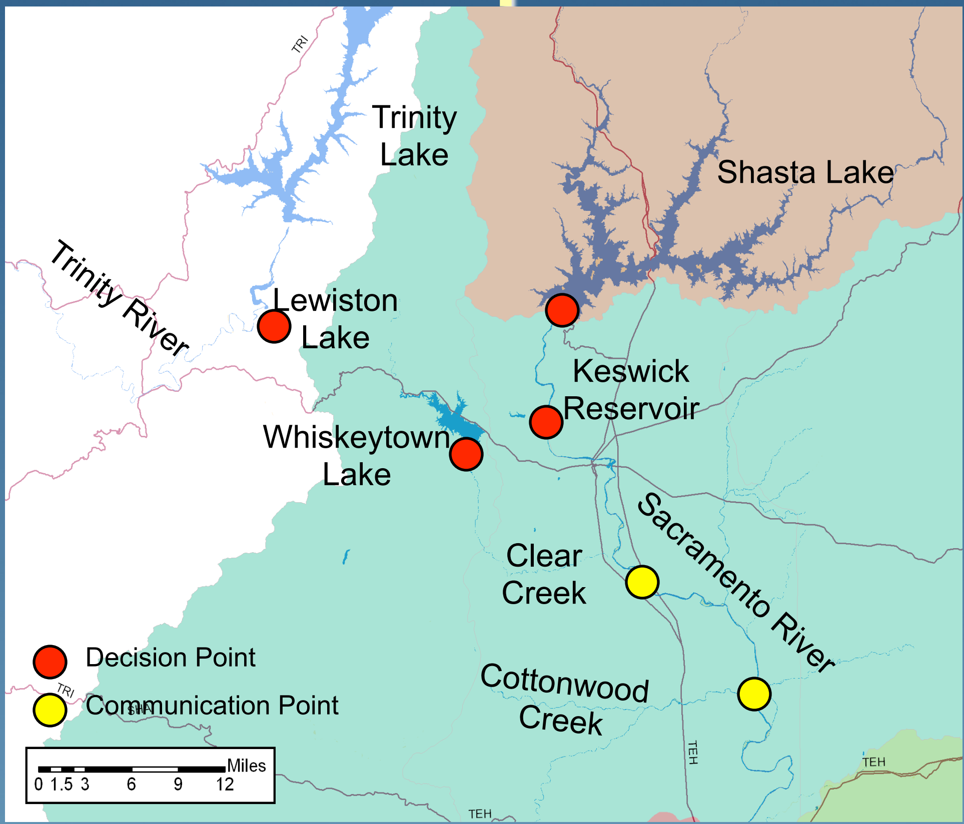
System Representation Options

Network-based



- CalSim-II configuration

Geospatial



- Geographical mapping

Solution Strategies

- Solution strategy governed predominantly by formulation

- Selected solution strategies:
  - Linear Programming Algorithms
  - Mixed Integer Programming Algorithms
  - Dynamic Programming Algorithms
  - Nonlinear Algorithms
    - Gradient-Based Methods
    - Heuristic Methods

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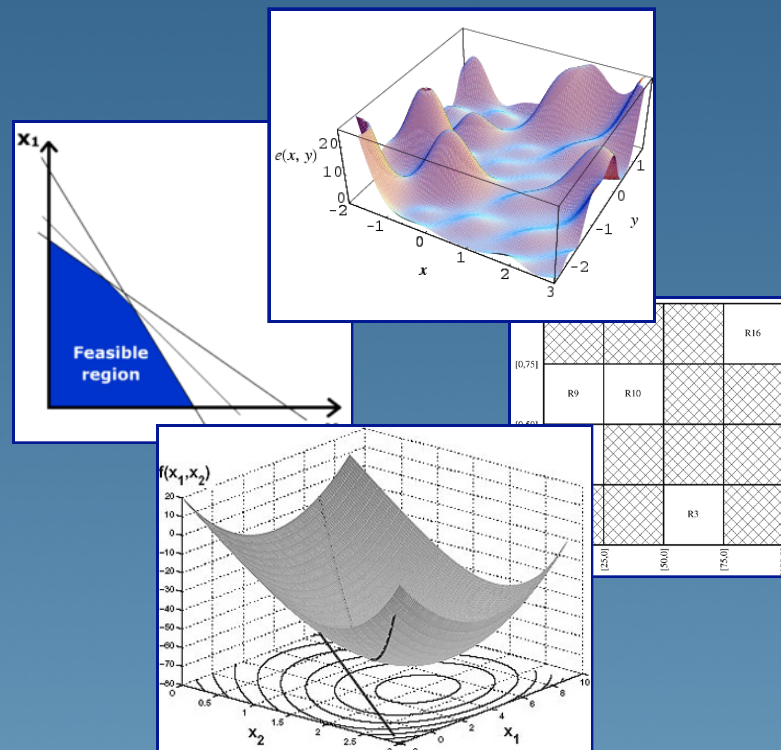

Translation / Linkage to Optimization Solver

- For linear problems, linear reponse theory is typically used
  - A collection of relationships between variables
    - Determined by examining responses to individual stresses
  - → *Decision Coefficient Matrix*
  - For nonlinear problems, can assume approximately linear for a short period of time

Outline

- Background
- Formulation
- Linkage methodologies
  - Key considerations
    - Integrated versus process-specific representation
    - Nonlinearities
    - Static versus dynamic
  - Existing linkage methodologies
- HydroGeoSphere-Management System
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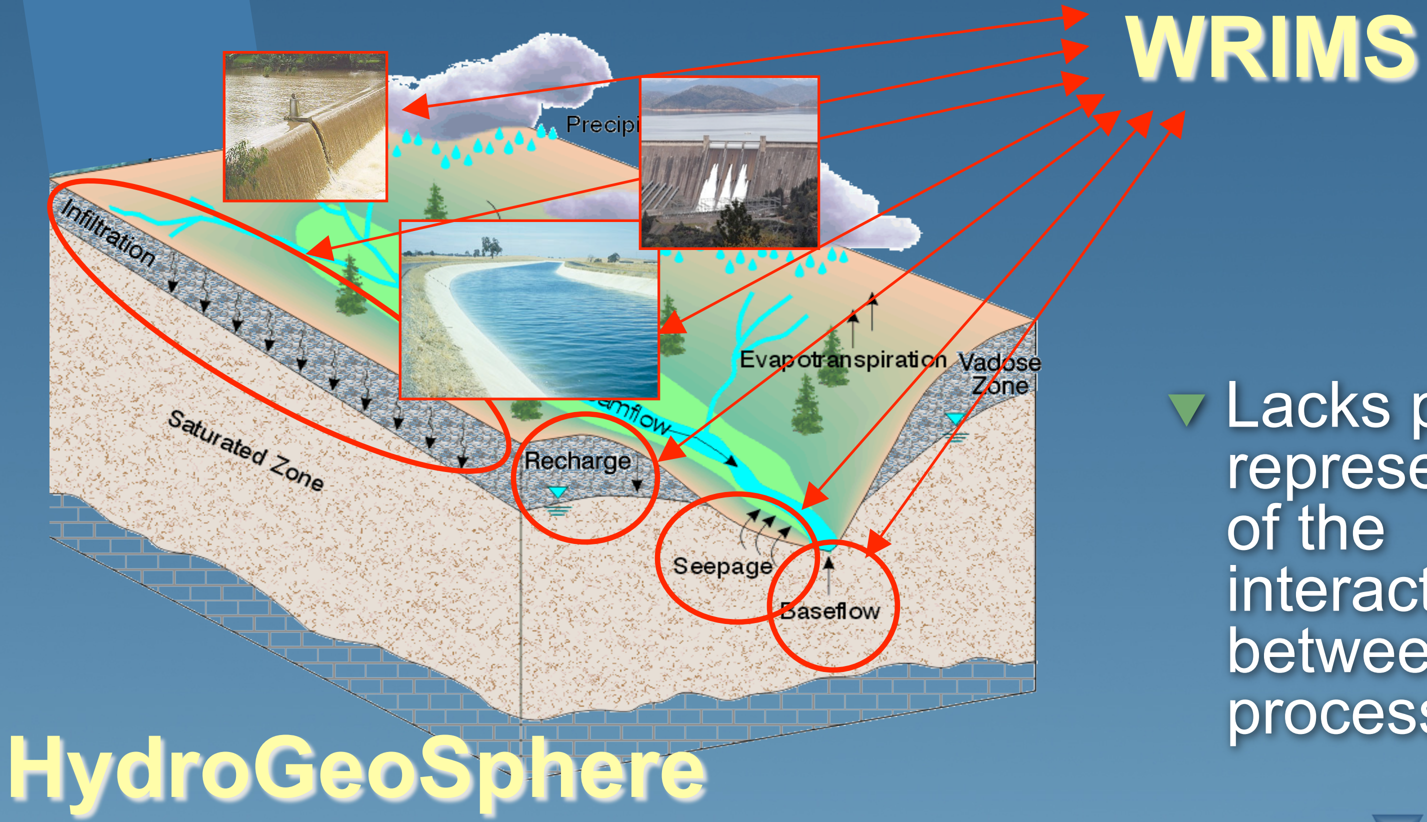
Representation of Hydrologic / Transport Systems

- Process-specific representation of physical processes



- Lacks physical representation of the interactions between processes

Representation of Hydrologic / Transport Systems

- Integrated representation of all physical processes

WRIMS

HydroGeoSphere

Treatment of Nonlinearities

- "Base-case" conditions will change over time in transient problems

→ ***Dynamic Decision Coefficient Matrix (DDCM)***

  - Coefficients in decision coefficient matrix updated at every decision time period

Static Versus Dynamic

- Statistical versus physically-based representation of hydrologic / transport systems

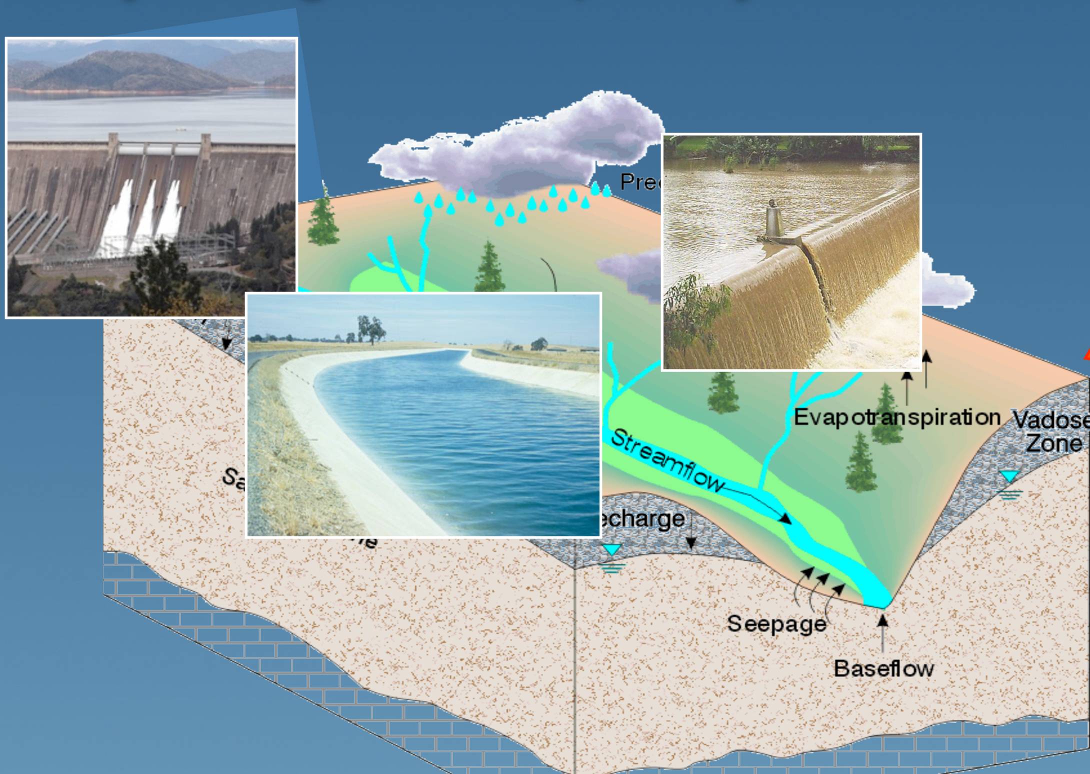
STATIC

WRIMS

HydroGeoSphere

Static Versus Dynamic

- Statistical versus physically-based representation of hydrologic / transport systems



WRIMS

HydroGeoSphere

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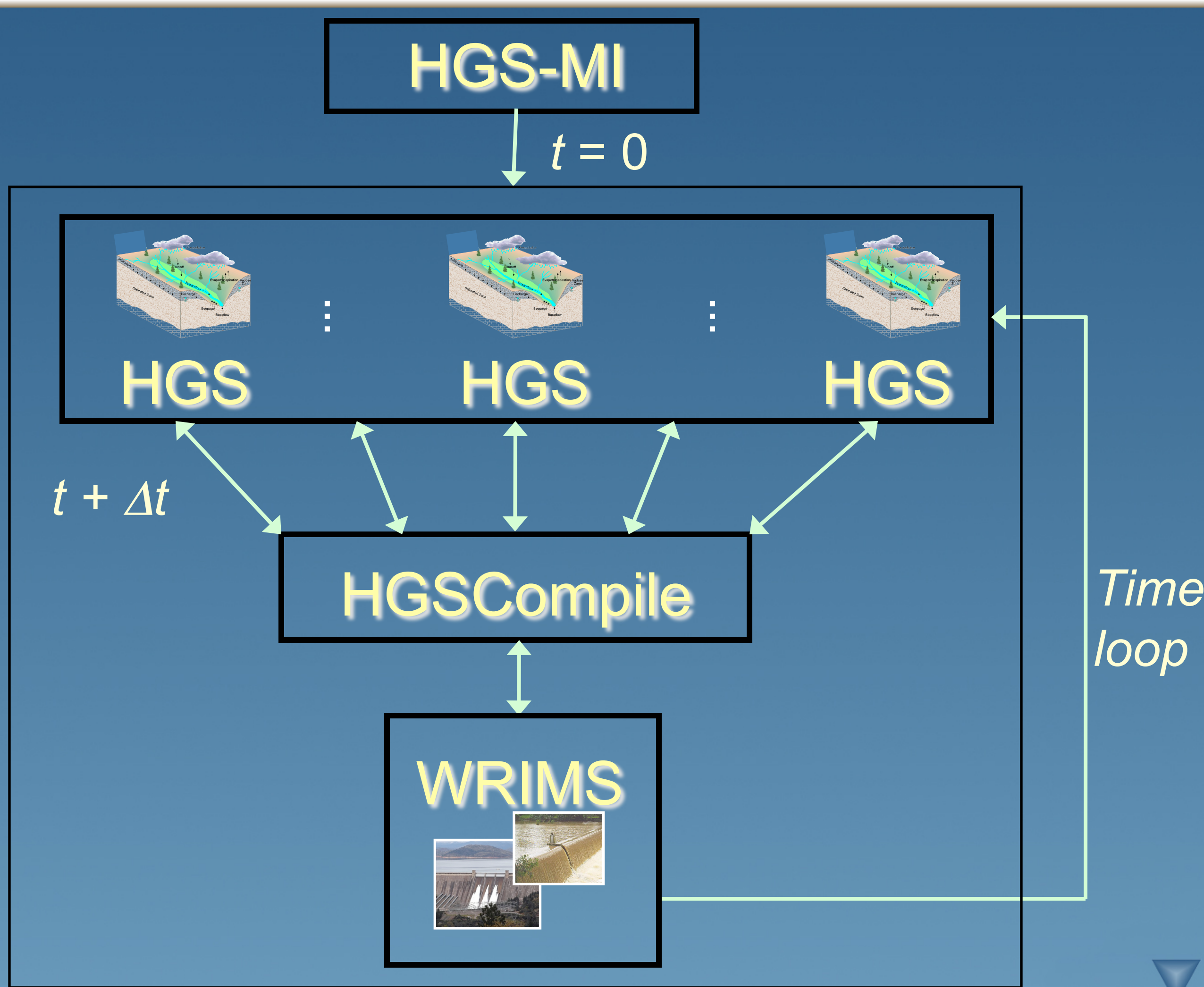
HydroGeoSphere-Management System

- HGS-M: HydroGeoSphere-Management (HydroGeoSphere-M or HGS-M) system
  - Linkage between HGS and the Water Resources Integrated Modeling System (WRIMS) (and other water allocation models)
  - Components:
    - HGS-MI (HydroGeoSphere-Management Interface)
    - HGS
    - HGSCompile
    - WRIMS (and other water allocation models)

Proposed HGS-M Schematic



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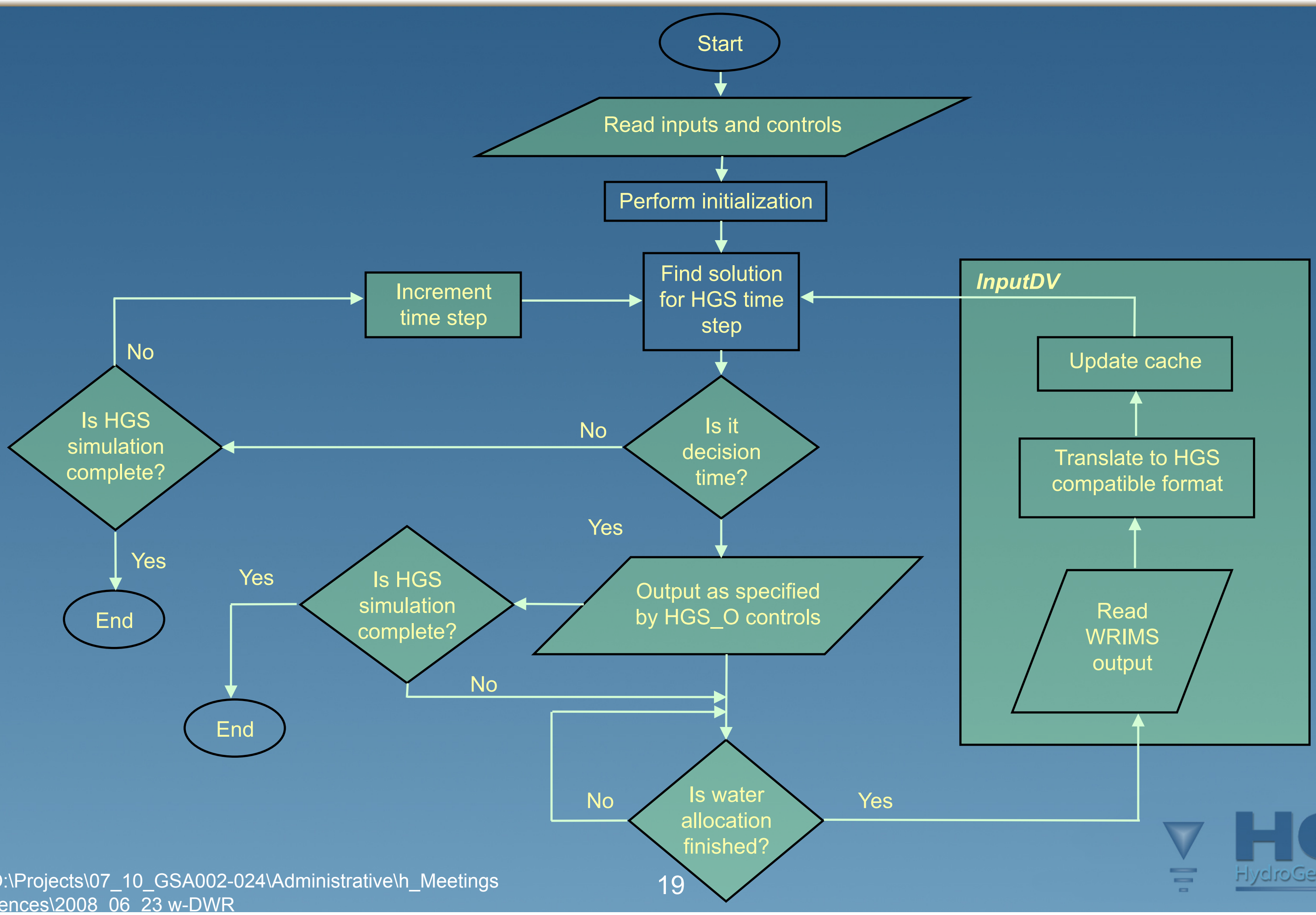
Proposed HGS Schematic



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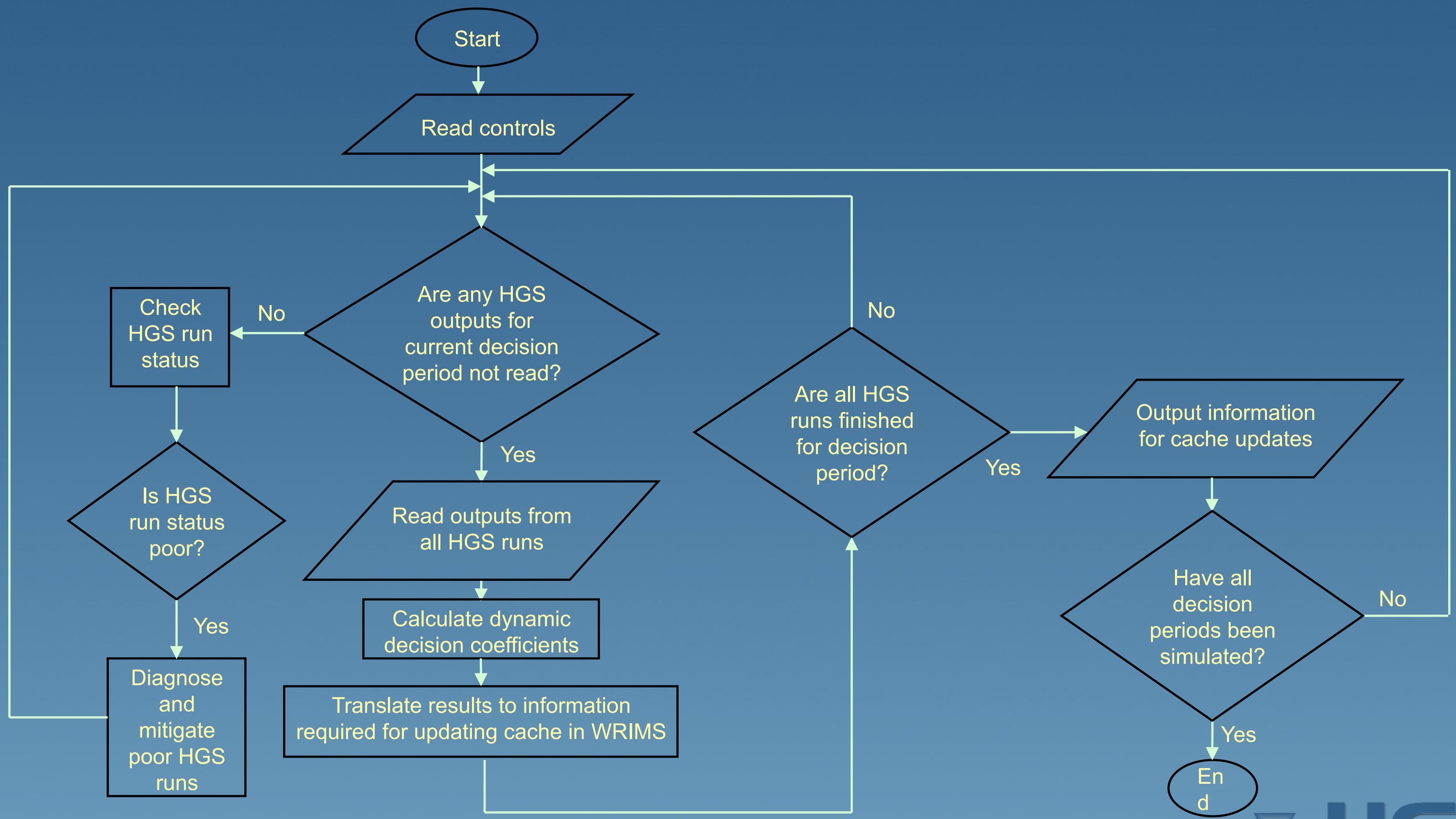
Proposed HGSCompile Schematic



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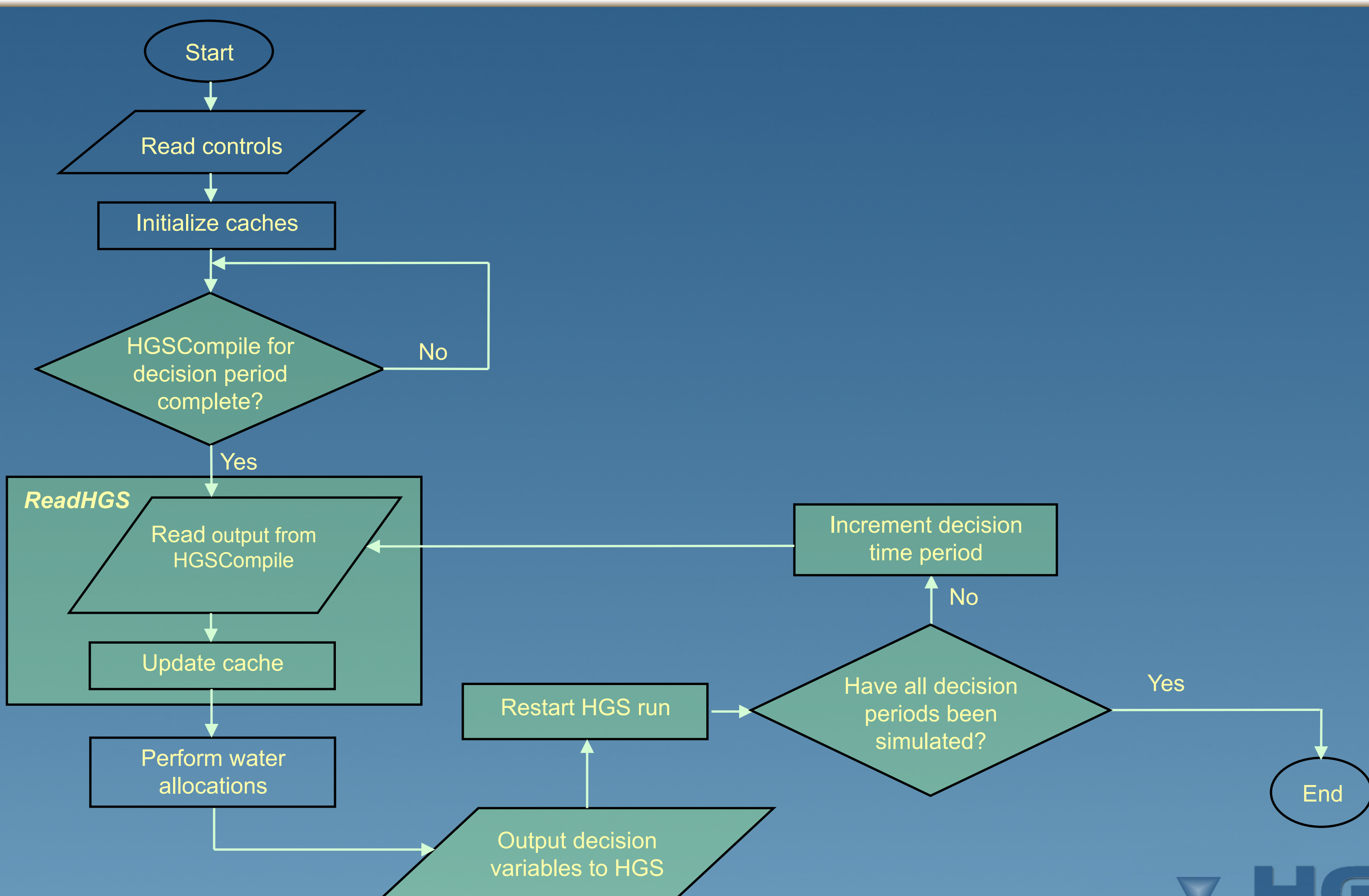
Proposed WRIMS Schematic



Next Steps

- Code Modifications
  - Based on:
    - Schematic of HGS-M
    - Schematic of HGS-M components
    - Mathematical programming formulation
  - Considerations:
    - Interface design
    - Programming platform
- Verification and Validation
  - Data
  - Scenarios

References

1. DWR/BOR, 2001. A Memorandum Report on the Application of CALSIM II Model At 2020 Level-of-Development
2. Draper et al., 2004. CalSim: Generalized Model for Reservoir System Analysis. *Journal of Water Resources Planning and Management*. Vol. 130, No. 6, 480-489.
3. Labadie, J., 2004. Optimal Operation of Multireservoir Systems: State-of-the-Art Review. *Journal of Water Resources Planning and Management.* Vol. 130, No. 2, 93-111.
4. 2000. CALSIM Water Resources Simulation Model Manual – Draft Documentation
5. Federal Remediation Technologies Roundtable – Remediation Optimization http://www.frtr.gov/optimization/simulation/transport/codesmethod.htm
6. Ilich, N., 2008. Shortcomings of linear programming in optimizing river basin allocation