SAND2007-3029C

Multi-Platform Decision Support System

Sandia National Laboratories
University of Texas – Austin

World Environmental & Water Resources Council
2007 Annual Conference
Tampa Bay, Fl

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Introduction

- Motivation
- Approach
  - Computer Aided Dispute Resolution DSS (CADRe DSS)
- Example
  - Barton Springs segment of the Edwards Aquifer, Austin, TX

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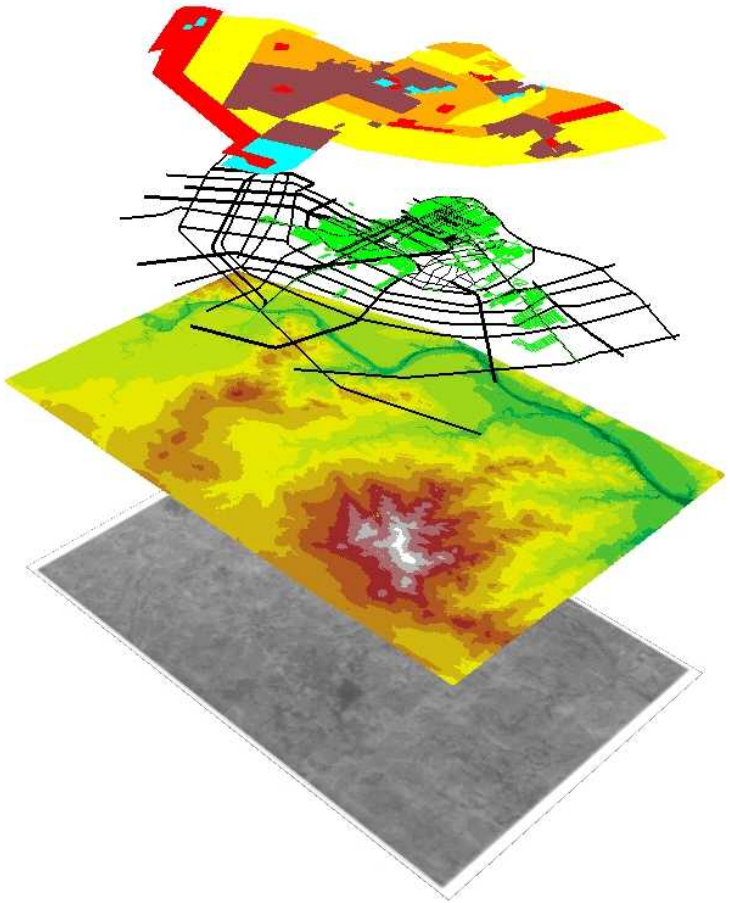
‘High-Level’ Motivation



- Incorporate scientific analysis into the decision making process
- Allow stakeholders to guide the scientific process
- Employ advanced policy and decision making techniques
- Maximize economic, environmental, and demographic sustainability

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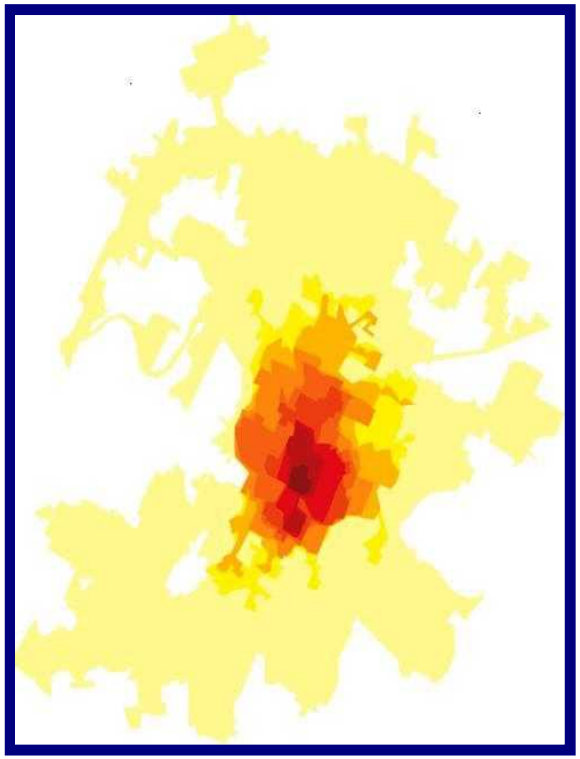
Barton Springs

- Assess impacts of development (e.g. impervious cover) on water quantity and quality issues
  - Spring flow
  - Drought triggers
  - Economic impacts
- Groundwater flow models
- Stakeholder involvement



Areal extent of Austin from 1885 to 1985

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‘Core’ Motivation

- Need to incorporate spatially detailed modeling capabilities
- Need to analyze systems level responses
- Need this as one tool that can be implemented by non-modelers

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Multiple Objectives, Multiple Stakeholders

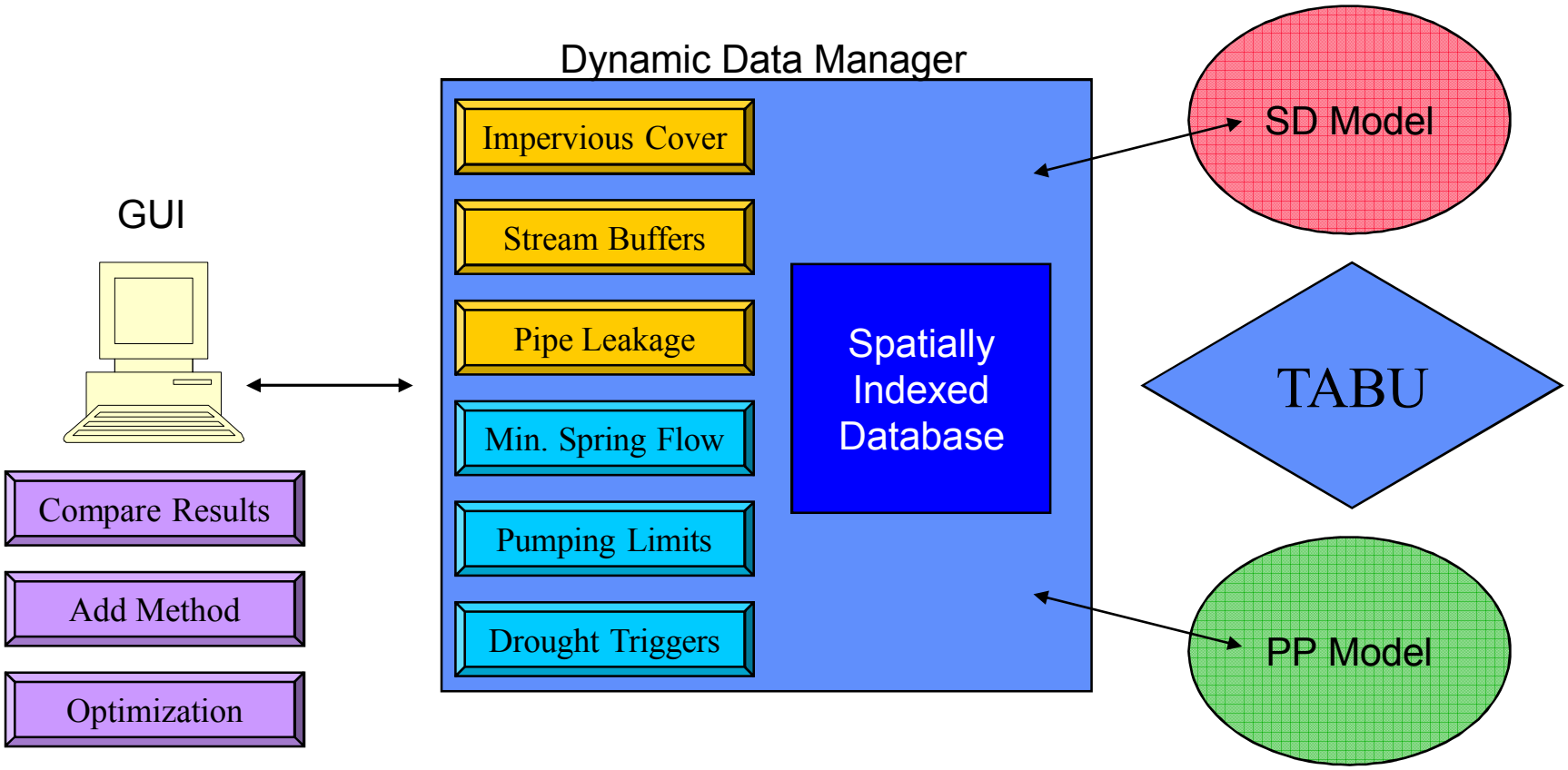
- Preserve flow in Barton Springs
- Maintain conditions suitable for Endangered Species
- Maximize pumping
- Maximize reliability
- Maximize economic benefit
- Minimize impact on daily life

Approach

- **Link physical process models to system dynamics models**
  - **Common GUI**
  - **Common data store**
  - **Two-way communication**
  - **Decision Support**

CADRe DSS

Integrated Modular Simulation Framework



CADRe DSS

- Integrated ‘software wrapper’
  - Links spatially explicit, high-fidelity models to systems based analysis
  - Reduces redundancy and duplicate effort
  - Provides interface for rapid dispute resolution w/in a stakeholder process
  - Allows for multi-attribute optimization
  - Allows for ranking of scenarios based on user preferences

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CONTRIBUTING ZONE

Land Use Distribution	Barton	Bear	Little Bear	Onion	Slaughter	Williamson
Multi-Family	0.28 %	0.00 %	0.00 %	0.09 %	0.20 %	2.91 %
Single Family	1.80 %	0.93 %	0.15 %	0.28 %	3.33 %	14.06 %
Large Lot SF	12.46 %	22.40 %	1.76 %	6.53 %	24.98 %	14.98 %
Rural Lot SF	5.64 %	18.38 %	0.41 %	17.66 %	8.09 %	3.95 %
Farm Residence	3.30 %	21.62 %	11.21 %	34.13 %	1.59 %	0.00 %
Open Space	21.91 %	0.87 %	0.00 %	0.21 %	14.37 %	3.67 %
Commercial	0.55 %	0.60 %	0.00 %	1.08 %	2.13 %	4.09 %
Civic	0.47 %	2.00 %	0.00 %	0.16 %	0.39 %	2.45 %
Roads and Highways	3.10 %	3.28 %	0.68 %	1.77 %	6.32 %	11.20 %
Undeveloped	50.49 %	29.92 %	85.79 %	38.08 %	38.60 %	42.68 %
% Impervious Cover	3.69 %	4.19 %	0.55 %	2.22 %	7.62 %	15.01 %
Population	180,758	24,208	506	63,088	35,995	86,854
Sprawl	51.95	16.67	0.22	126.53	7.93	4.71
Land Value ($Billions)	$20.362	$2.750	$0.104	$5.681	$4.032	$8.594
TOTALS	POPULATION 1,072,560	VALUE ############	SPRAWL 245.38			

Recharge Graphs | Rech. Zone % Impervious | Rech. Zone Land Mix
Spring Flow Graphs | Cont. Zone % Impervious | Cont. Zone Land Mix
Map

CONTRIBUTING ZONE

PERCENT IMPERVIOUS	Barton	Bear	Little Bear	Onion	Slaughter	Williamson
Multi-Family	57.00 %	57.00 %	57.00 %	57.00 %	57.00 %	57.00 %
Single Family	22.00 %	22.00 %	22.00 %	22.00 %	22.00 %	22.00 %
Commercial	63.00 %	63.00 %	63.00 %	63.00 %	63.00 %	63.00 %
Civic	35.00 %	35.00 %	35.00 %	35.00 %	35.00 %	35.00 %
% Impervious Cover	3.69 %	4.19 %	0.55 %	2.22 %	7.62 %	15.01 %

Recharge Graphs | Rech. Zone % Impervious | Rech. Zone Land Mix

Spring Flow Graphs | Cont. Zone % Impervious | Cont. Zone Land Mix

Map

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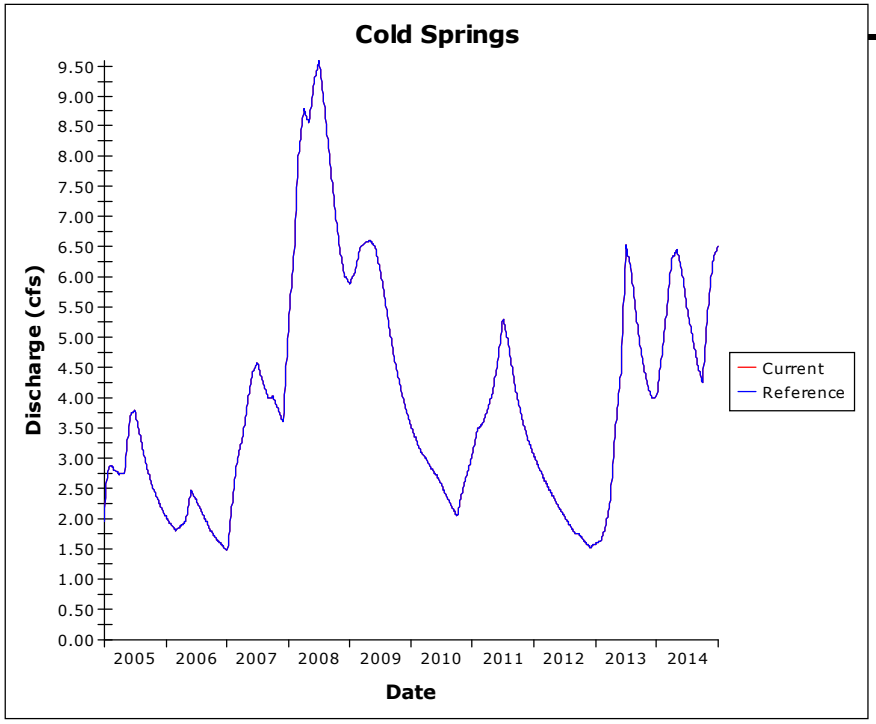

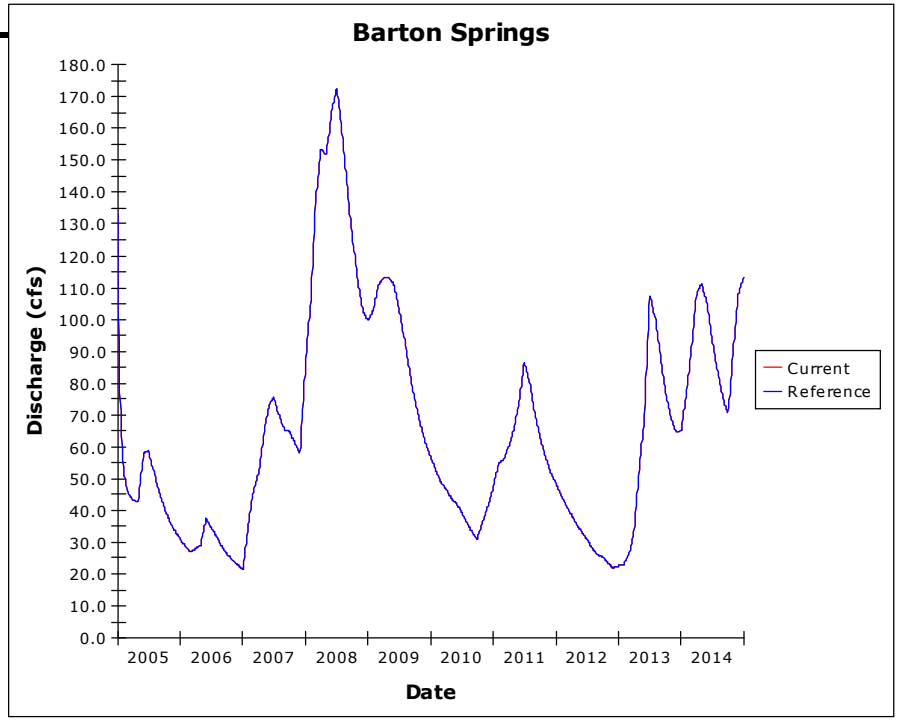

[Recharge Graphs]

[Rech. Zone % Impervious]

[Rech. Zone Land Mix]

[Spring Flow Graphs]

[Cont. Zone % Impervious]

[Cont. Zone Land Mix]

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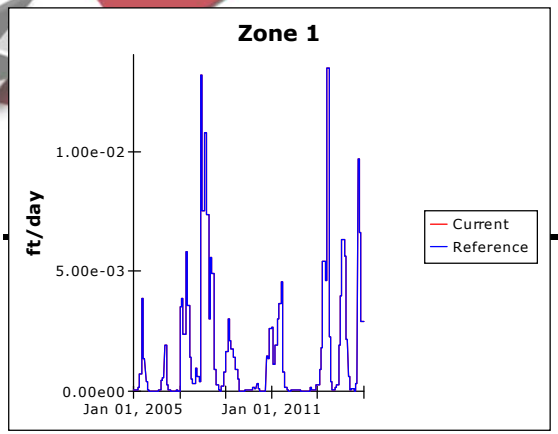

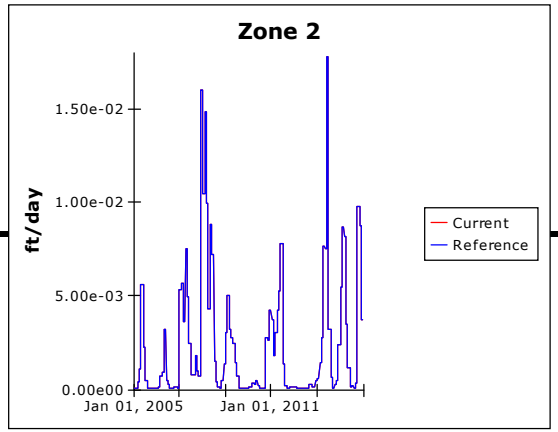

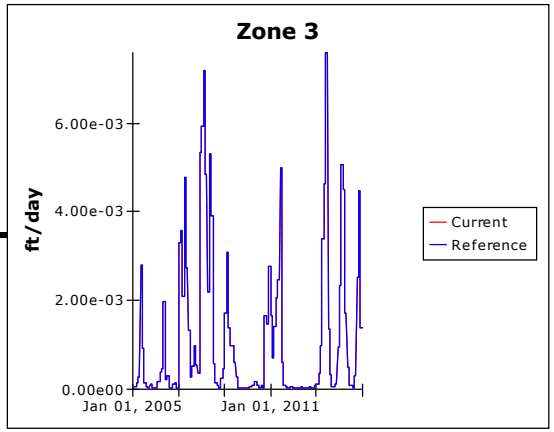

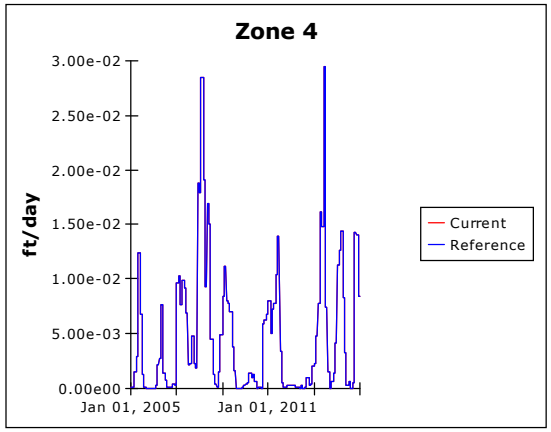

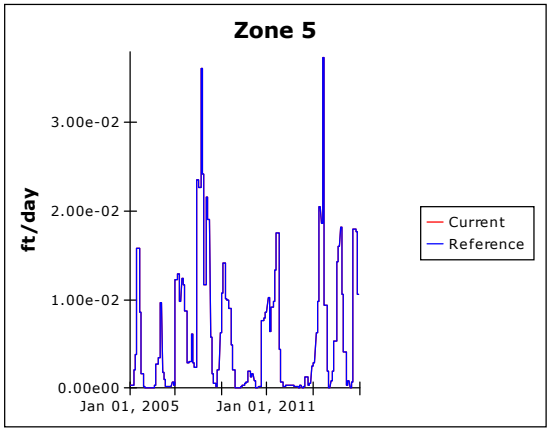

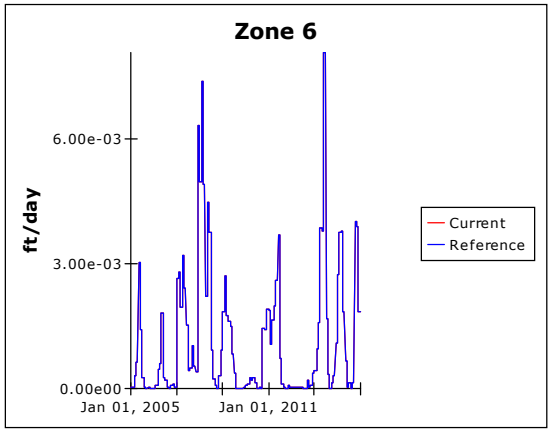

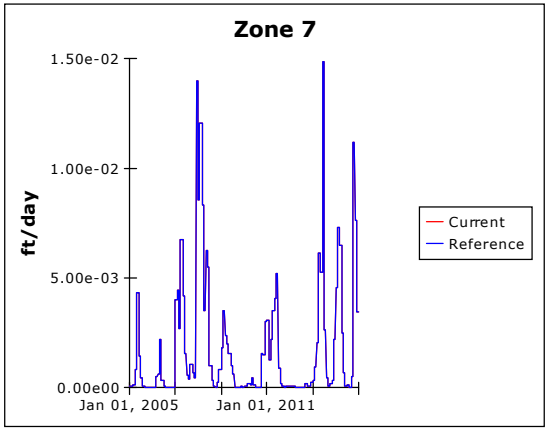

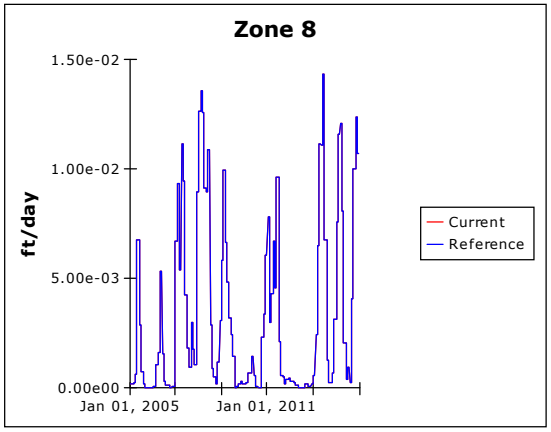

[Spring Flow Graphs]

[Rech. Zone % Impervious]

[Cont. Zone % Impervious]

[Rech. Zone Land Mix]

[Cont. Zone Land Mix]

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Recharge Graphs Rech. Zone % Impervious Rech. Zone Land Mix

Spring Flow Graphs Cont. Zone % Impervious Cont. Zone Land Mix

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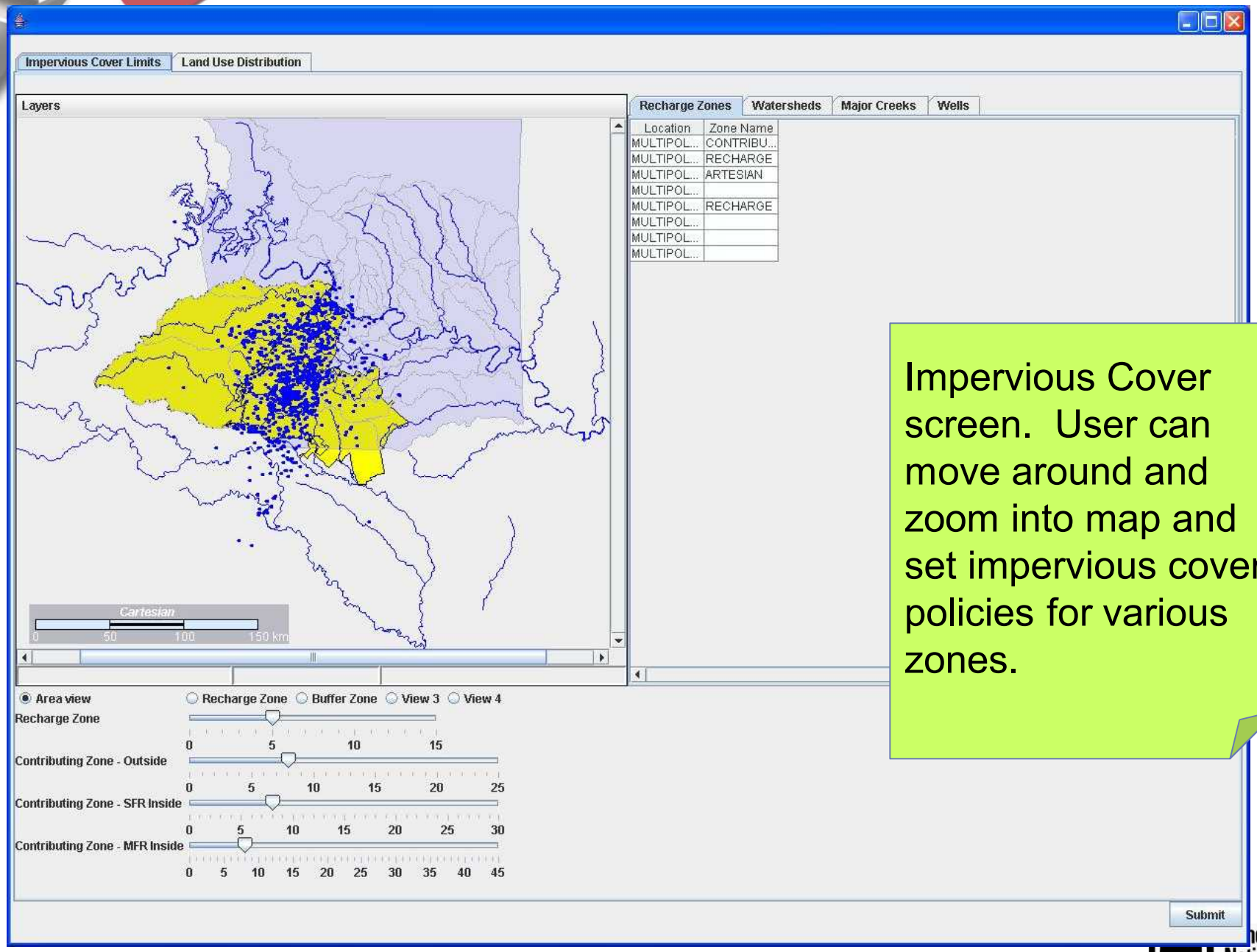
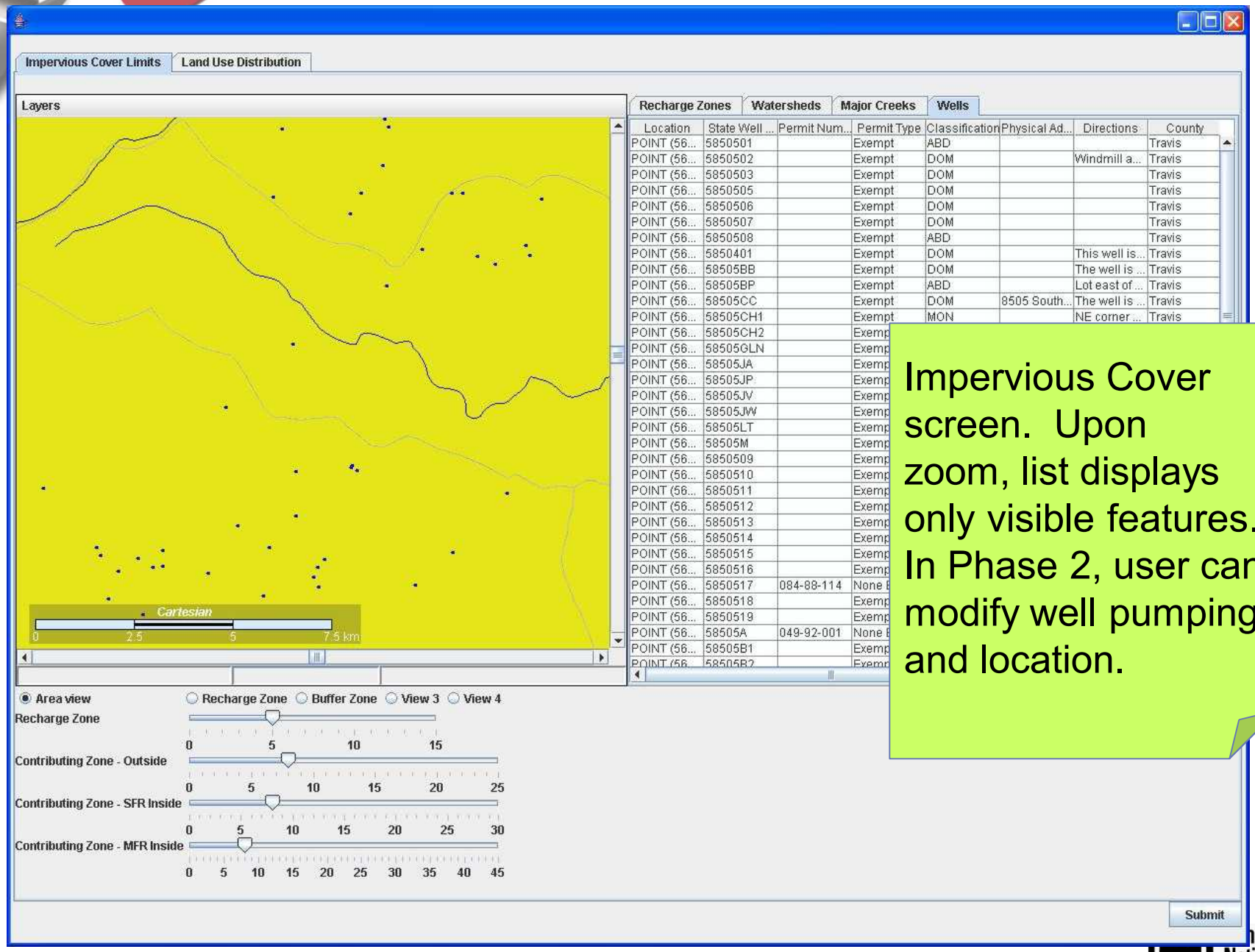
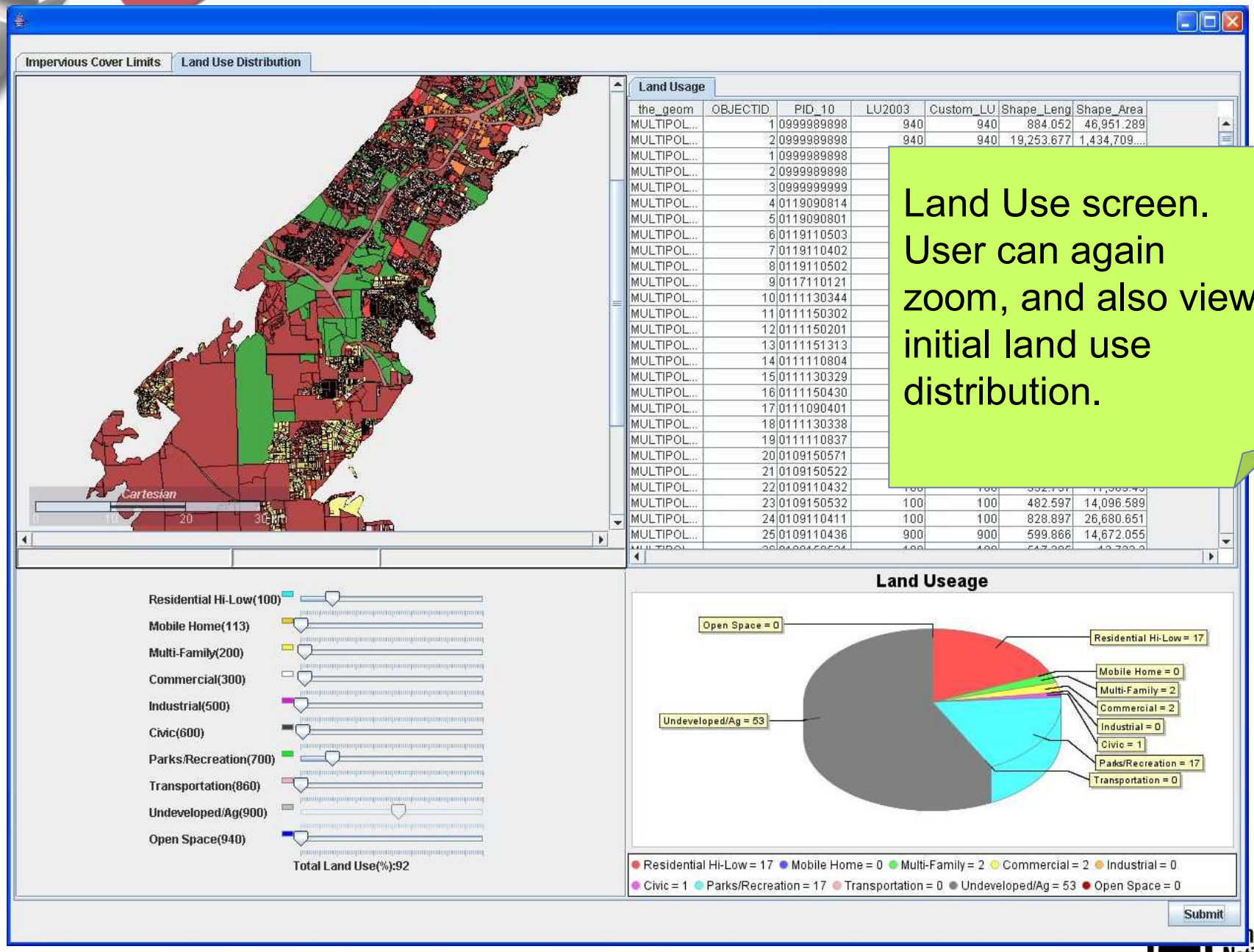


Impervious Cover screen. User can move around and zoom into map and set impervious cover policies for various zones.

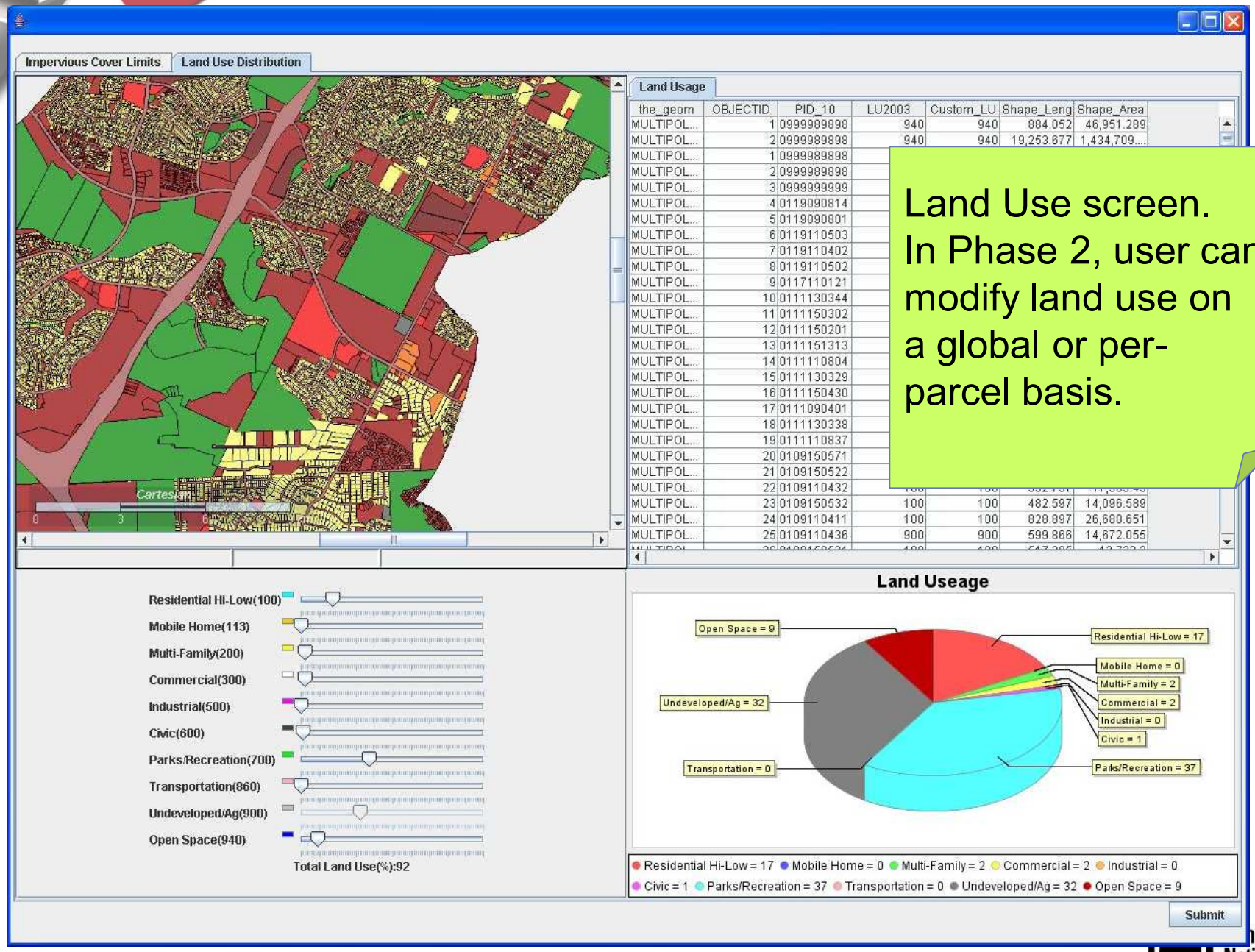


Impervious Cover screen. Upon zoom, list displays only visible features. In Phase 2, user can modify well pumping and location.

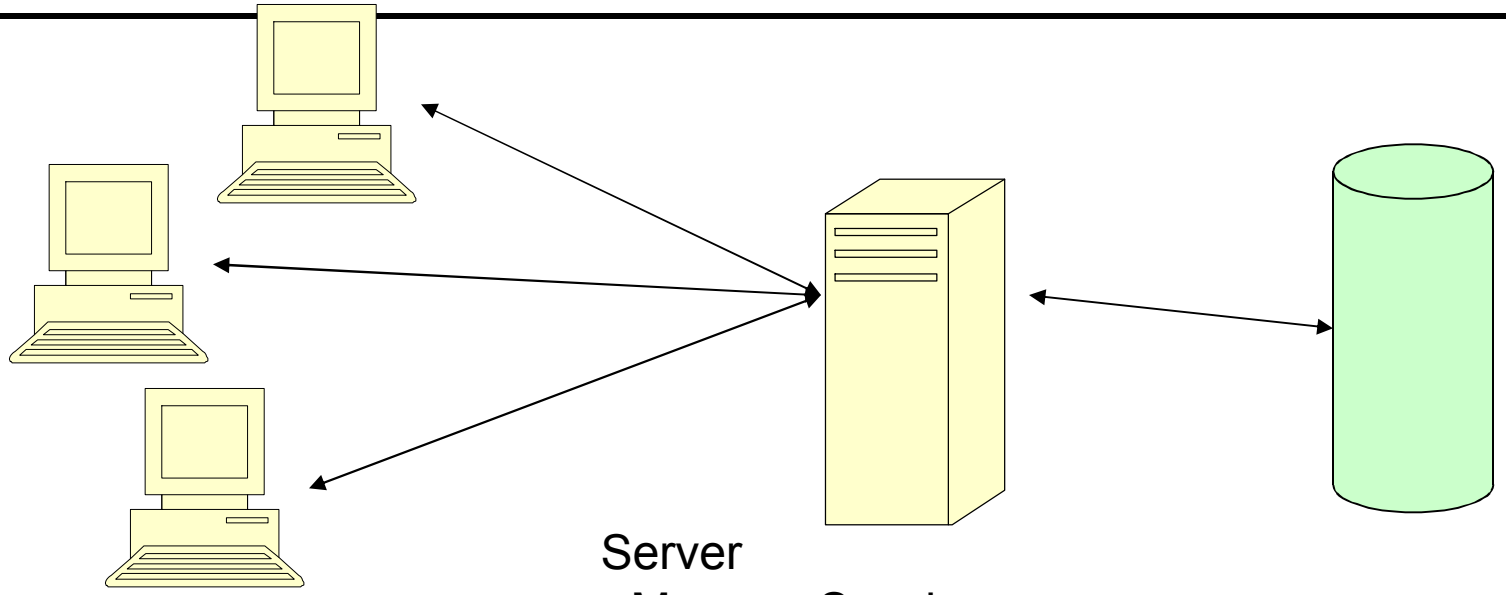


the_geom	OBJECTID	PID_10	LU2003	Custom_LU	Shape_Leng	Shape_Area
MULTIPOL...	1	0999989898	940	940	884.052	46,951.289
MULTIPOL...	2	0999989898	940	940	19,253.677	1,434,709....
MULTIPOL...	1	0999989898				
MULTIPOL...	2	0999989898				
MULTIPOL...	3	0999999999				
MULTIPOL...	4	0119090814				
MULTIPOL...	5	0119090801				
MULTIPOL...	6	0119110503				
MULTIPOL...	7	0119110402				
MULTIPOL...	8	0119110502				
MULTIPOL...	9	0117110121				
MULTIPOL...	10	0111130344				
MULTIPOL...	11	0111150302				
MULTIPOL...	12	0111150201				
MULTIPOL...	13	0111151313				
MULTIPOL...	14	0111110804				
MULTIPOL...	15	0111130329				
MULTIPOL...	16	0111150430				
MULTIPOL...	17	0111090401				
MULTIPOL...	18	0111130338				
MULTIPOL...	19	0111110837				
MULTIPOL...	20	0109150571				
MULTIPOL...	21	0109150522				
MULTIPOL...	22	0109110432				
MULTIPOL...	23	0109150532	100	100	482.597	14,096.589
MULTIPOL...	24	0109110411	100	100	828.897	26,680.651
MULTIPOL...	25	0109110436	900	900	599.866	14,672.055

Land Use screen. User can again zoom, and also view initial land use distribution.



Tier Functions

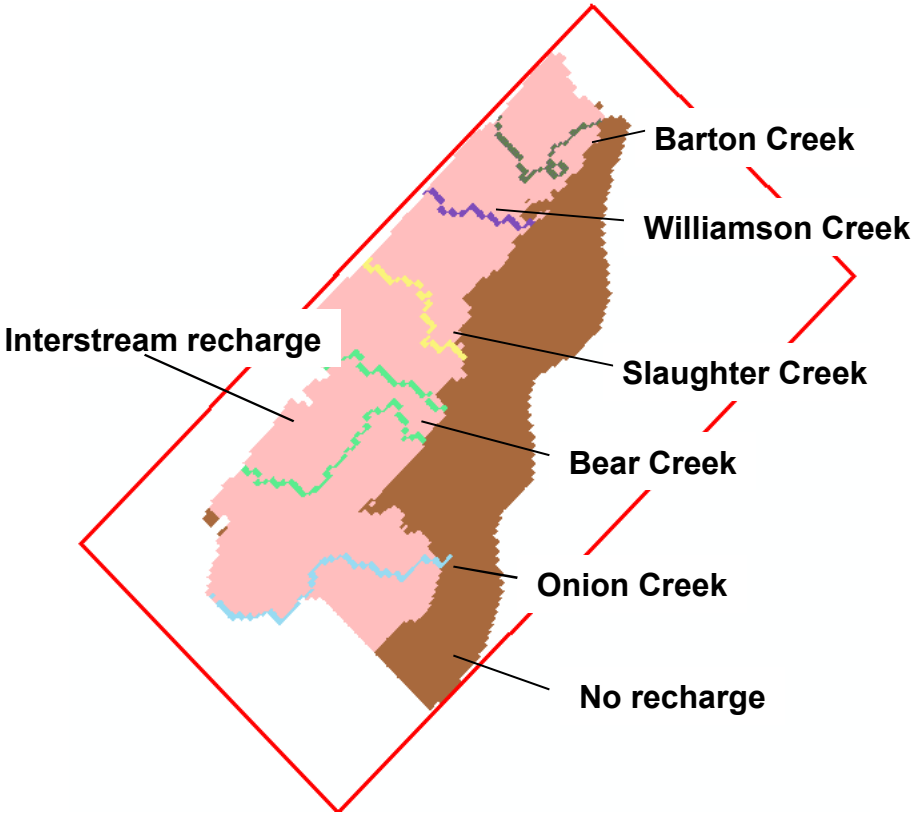


Clients
- Administration
- Import Cases
- Display Case Info
- Choose Policies
- Submit for Model Run
- Evaluate/Compare Results
- Export Reports

Server
- Manage Sessions
- Run Models
- Run Optimizer

Database
- Store/Retrieve Permanent Data

Example: Barton Springs Groundwater Availability Model (GAM)



- 120 x 120 cells
- 1000 m x 500 m cell size
- Steady State and Transient Versions
- Recharge, well pumping, drains (Barton and Cold Springs)

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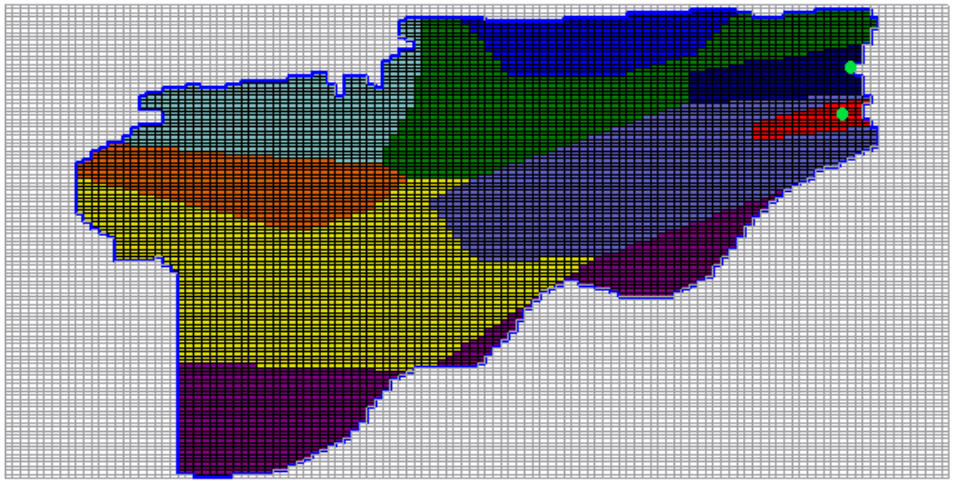
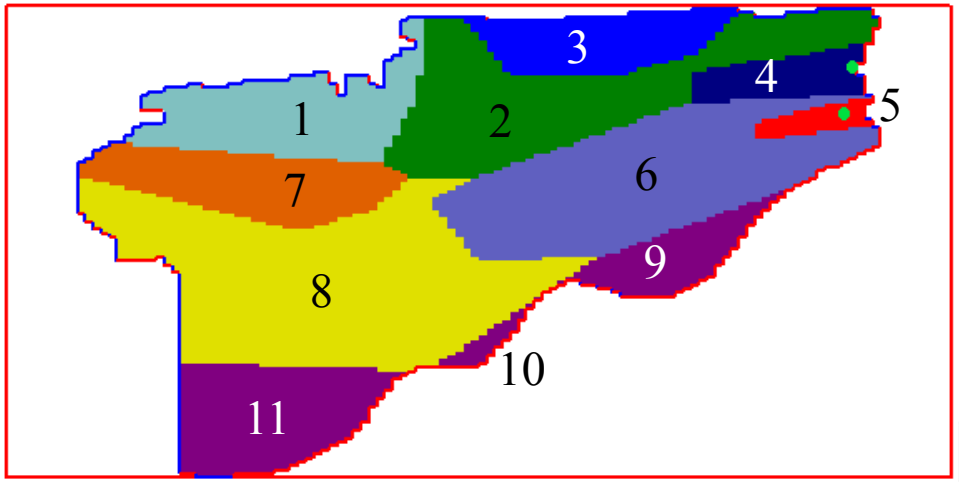
Change of Resolution



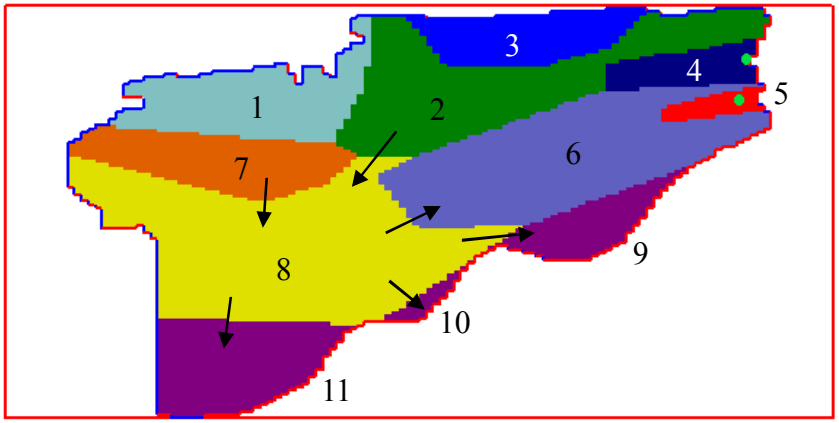
Convert PP model to coarse-resolution SD model through zonation

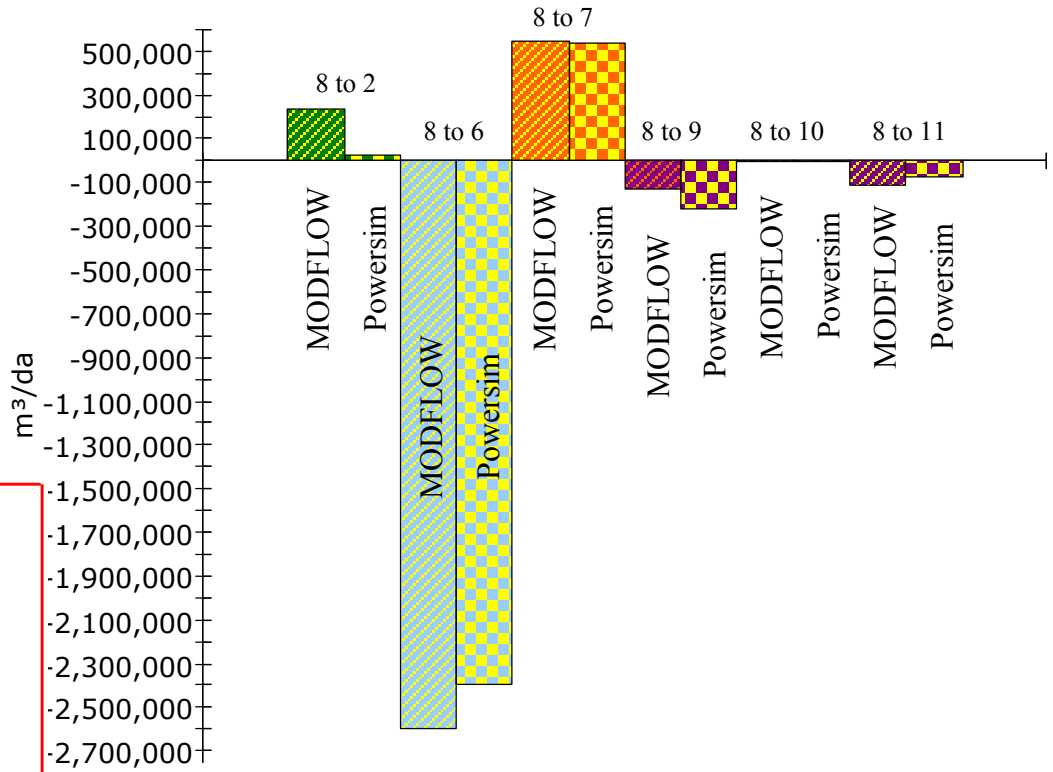
Effective parameters are extracted from the MODFLOW model. Powersim model is calibrated using a TABU search.



Calibration

- **Flow b/t Zones**
- Average Heads
- Spring Flow





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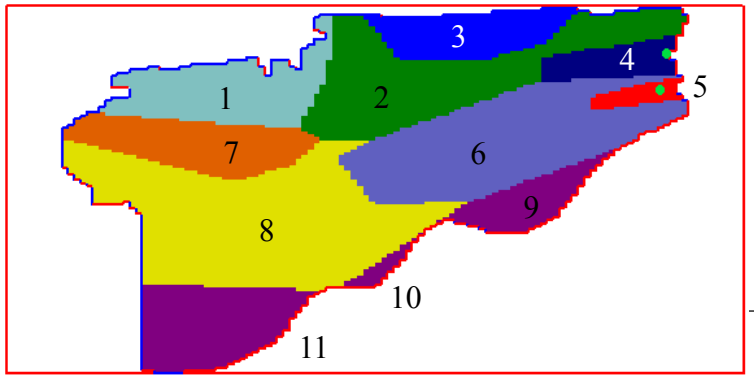
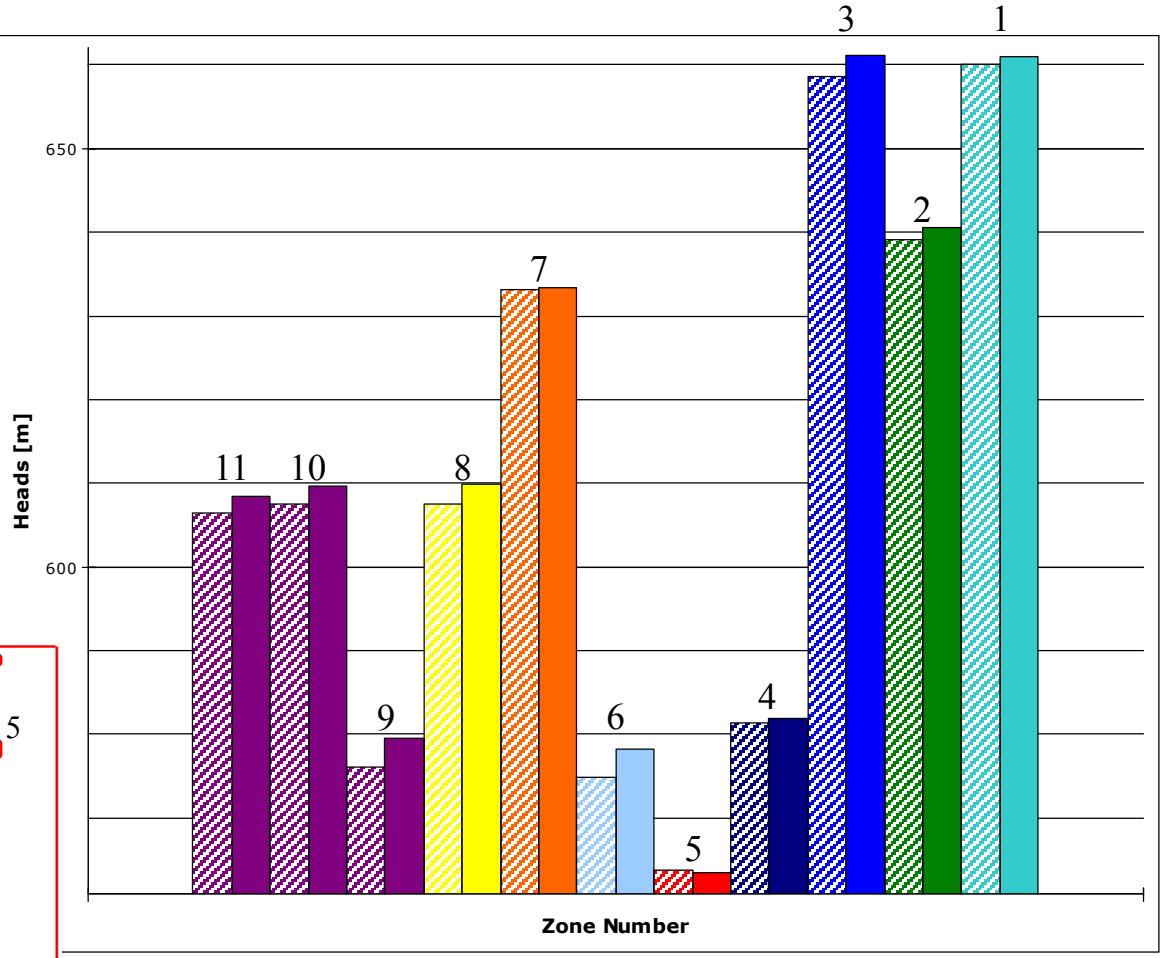
Calibration

- Flow b/t Zones
- **Average Heads**
- Spring Flow





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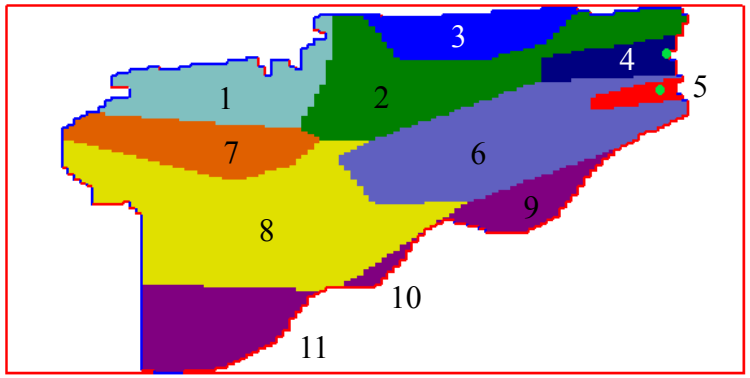
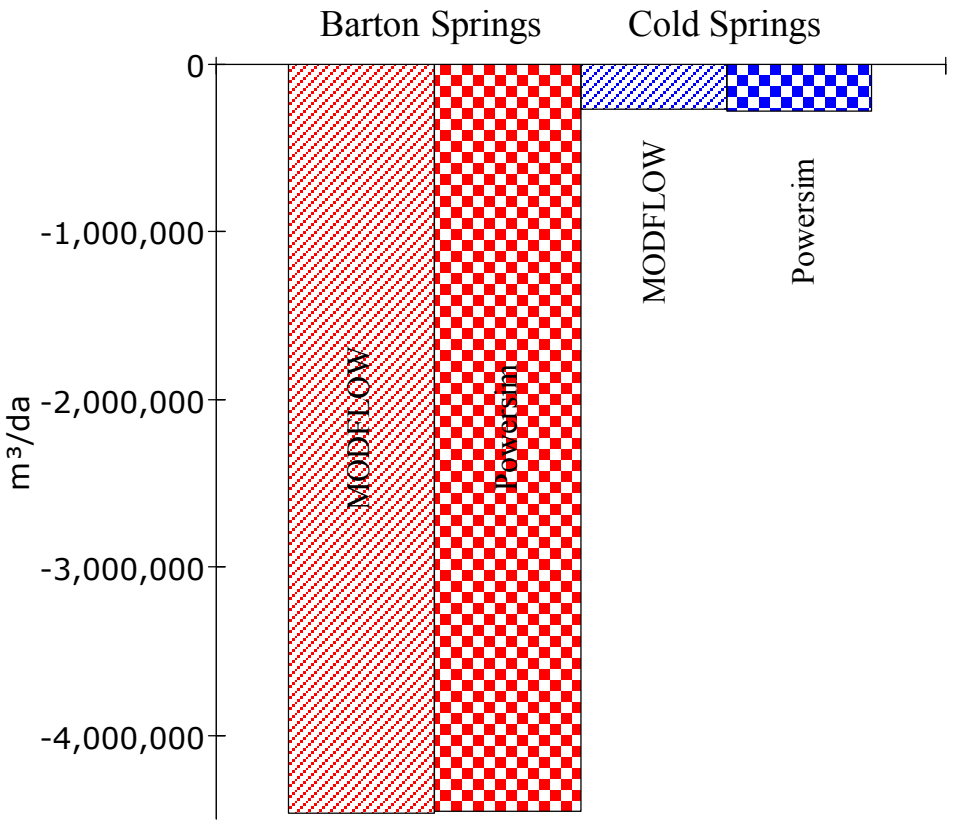
Calibration

- Flow b/t Zones
- Average Heads
- **Spring Flow**





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Impervious Cover Limits | Land Use Distribution

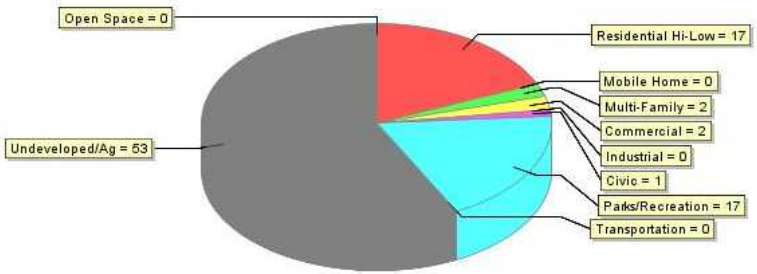
Land Usage

the_geom	OBJECTID	PID_10	LU2003	Custom_LU	Shape_Leng	Shape_Area
MULTIPOL...	1	0999989898	940	940	884.052	46,951.289
MULTIPOL...	2	0999989898	940	940	19,253.677	1,434,709....
MULTIPOL...	1	0999989898	940	940	884.052	46,951.289
MULTIPOL...	2	0999989898	940	940	19,253.677	1,434,709....
MULTIPOL...	3	0999999999	860	800	546,104.487	21,529,323...
MULTIPOL...	4	0119090814	900	900	839.975	40,052.812
MULTIPOL...	5	0119090801	900	900	335.828	6,371.413
MULTIPOL...	6	0119110503	100	100	886.103	28,980.092
MULTIPOL...	7	0119110402	150	100	500.884	14,889.552
MULTIPOL...	8	0119110502	100	100	976.071	41,926.087
MULTIPOL...	9	0117110121	900	900	4,577.491	664,608.703
MULTIPOL...	10	0111130344	100	100	853.695	44,084.791
MULTIPOL...	11	0111150302	100	100	523.147	15,005.568
MULTIPOL...	12	0111150201	100	100	912.245	43,236.44
MULTIPOL...	13	0111151313	100	100	849.018	45,086.915
MULTIPOL...	14	0111110804	100	100	1,580.797	102,197.337
MULTIPOL...	15	0111130329	100	100	688.654	30,026.894
MULTIPOL...	16	0111150430	150	100	758.092	29,889.17
MULTIPOL...	17	0111090401	100	100	551.635	19,668.823
MULTIPOL...	18	0111130338	900	900	776.359	21,323.662
MULTIPOL...	19	0111110837	100	100	599.227	22,331.422
MULTIPOL...	20	0109150571	710	700	3,107.535	151,060.555
MULTIPOL...	21	0109150522	100	100	570.837	17,271.609
MULTIPOL...	22	0109110432	100	100	532.757	17,589.45
MULTIPOL...	23	0109150532	100	100	482.597	14,096.589
MULTIPOL...	24	0109110411	100	100	828.897	26,680.651
MULTIPOL...	25	0109110436	900	900	599.866	14,672.055

Residential Hi-Low(100)
Mobile Home(113)
Multi-Family(200)
Commercial(300)
Industrial(500)
Civic(600)
Parks/Recreation(700)
Transportation(860)
Undeveloped/Ag(900)
Open Space(940)

Total Land Use(%):92

Land Useage



Residential Hi-Low = 17 Mobile Home = 0 Multi-Family = 2 Commercial = 2 Industrial = 0
Civic = 1 Parks/Recreation = 17 Transportation = 0 Undeveloped/Ag = 53 Open Space = 0

Submit

Benefits and Summary

- SD model executes much faster than the PP model
  - Scenario testing
  - Stakeholder education
- Allows for connecting important physical processes to other systems
- Provides a single user interface that works with both models
- Provides on-the-fly calibration between each model
- Modular approach allows for application to different types of problems

Acknowledgements

- Sandia National Laboratories
  - Thomas S. Lowry
  - Vincent C. Tidwell
  - Suzanne Pierce
- University of Texas
  - John M. Sharp
  - Marcel Dulay
  - David Eaton
  - Michael Ciarleglio
  - Aliza Gold
  - Roy Jenevein
  - A host of others…..
- William Cain

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Thank You

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