A simplified classification and water-balance model of seasonal pools for the efficient characterization of hydroperiod: adaptive habitat management under changing climates in the Guadalupe-Coyote Valley, California

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Balance Hydrologics, Inc.®

Work completed in collaboration with:

Eric Donaldson, Balance Hydrologics

Stephanie Moreno, Guadalupe-Coyote Resource Conservation District

Funding sources:

- Santa Clara County Habitat Agency
- California Fish and Wildlife

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

Talk Outline:

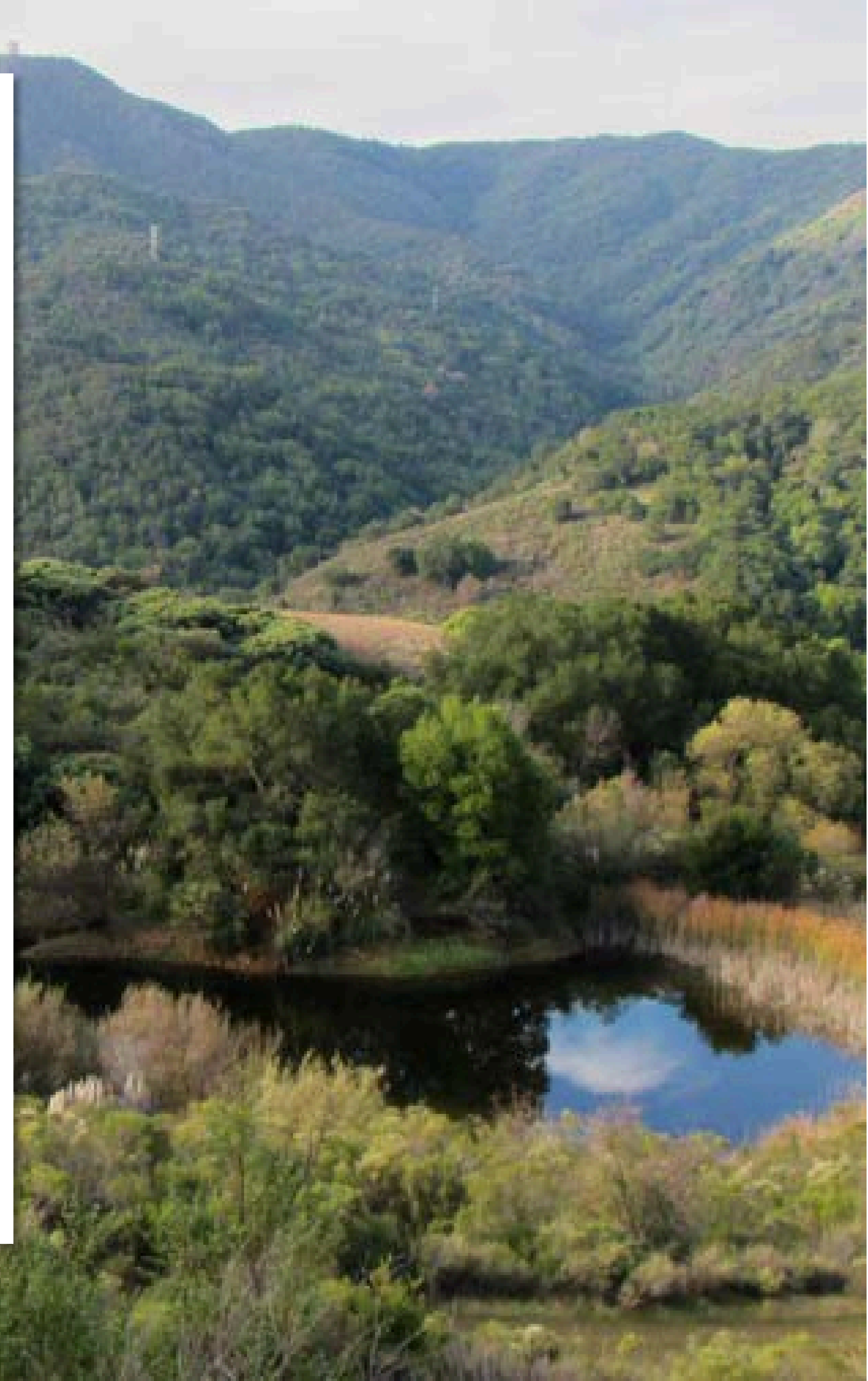
1. Classifying pools by their geomorphic development
2. Modeling the hydrologic processes, with hydroperiod as the first metric
3. Distinguish amongst pools using model parameters quickly and easily generated using Python and field data

Genetic classification

- Based on geology, soil types, pond geometry
- Useful tool for understanding first-order hydrologic processes

Initial version in:

Bauder, E. T., Bohonak, A. J., Hecht, B., Simovich, M. A., Shaw, D., Jenkins, D. G., and Rains, M., 2009, A Draft of Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Vernal Pool Depressional Wetlands in Southern California, 117p.



Pedogenic

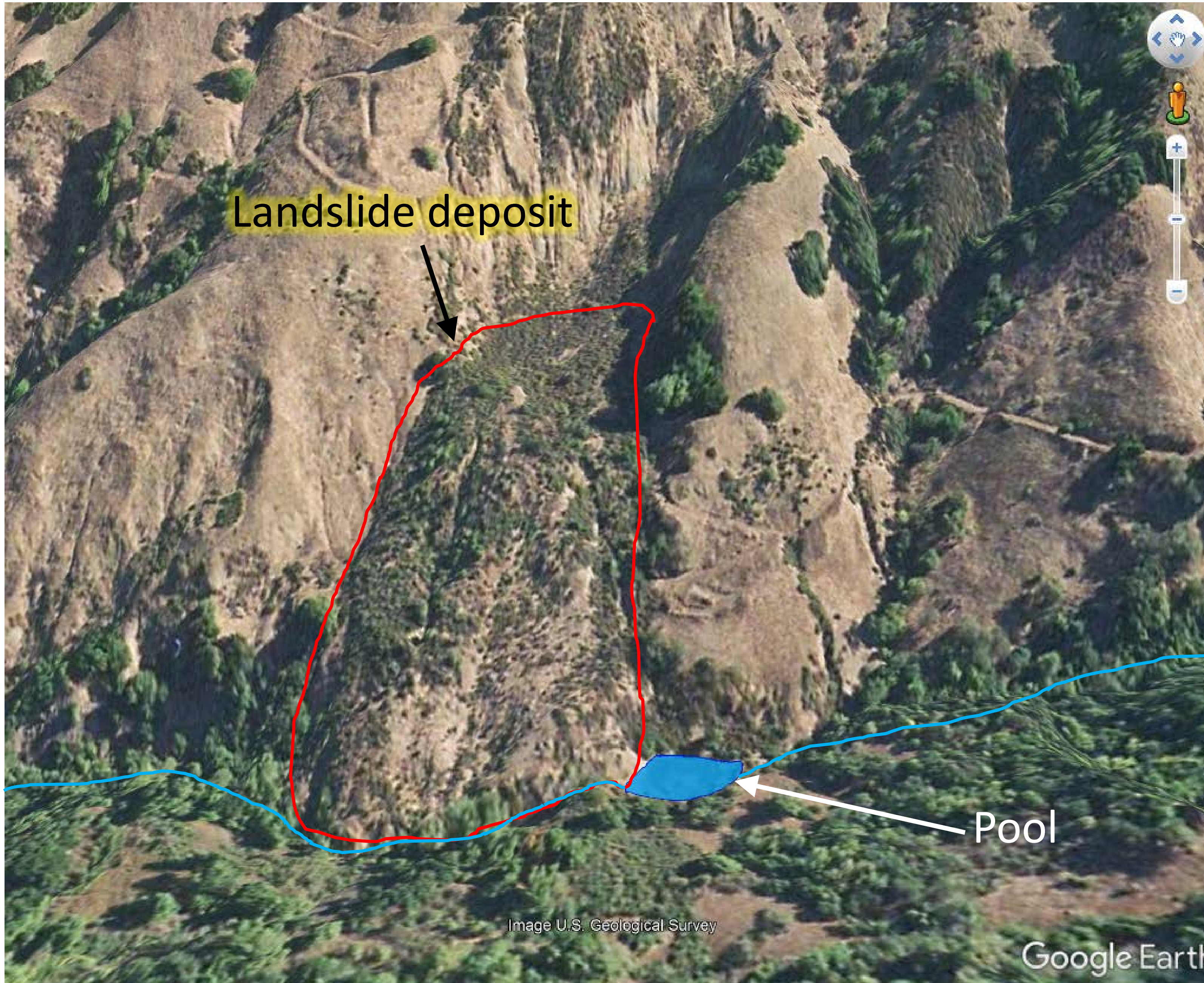
McCoy Basin, Fairfield, California – pedogenic pools, salts from bedrock in headwaters

Tectogenic

Landslide Head Scarp

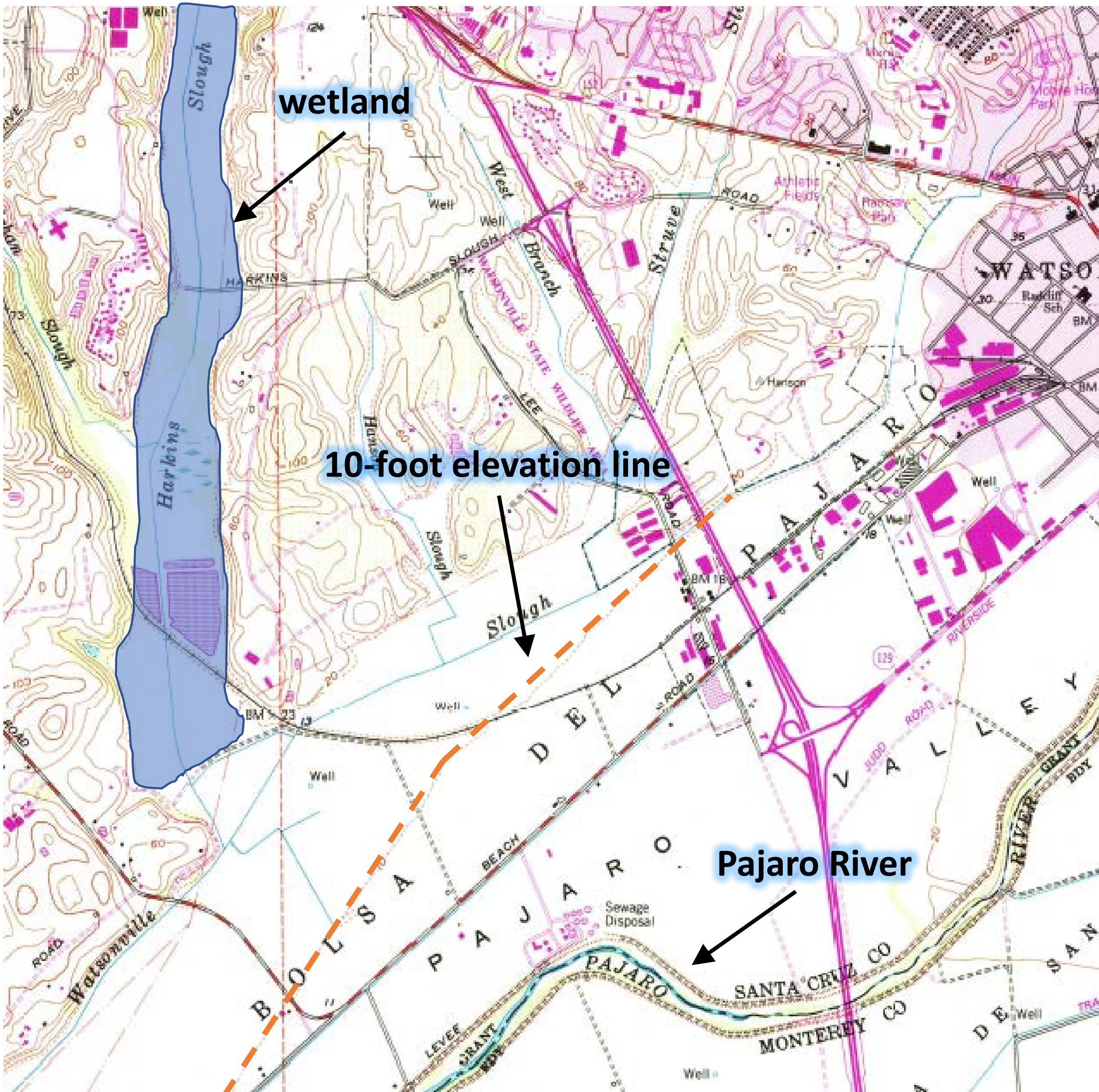
Coyote Harvey Bear Lake Ranch County Park, Santa Clara County, California

Landslide Dammed



Alamaden Quicksilver County Park, Santa Clara County, California

Alluvium Dammed



Watsonville West Quadrangle, 1954

Dune Dammed

Ellwood Beach, Goleta, California, video by hang glider Jim Becker, published March 9, 2014.

Bedrock (Tenaja)

Tenaja Falls Trail, Santa Ana Mountains, California

Anthropogenic Pools

Instream Modified

Mining or Quarry Depressions

Model decisions are informed by pond classification based on geomorphic origin

Classification	Relative Age
Pedogenic	100,000 – 1,000,000
Tectogenic	100,000 – 1,000,000
Landslide Head Scarp	100 – 10,000
Volcanigenic	10,000,000 – 100,000,000
Alluvium Dammed	100 – 100,000
Dune Dammed	100 – 10,000
Landslide Dammed	100 – 10,000
Bedrock (Tenaja) **Bedrock (Karst)**	100,000 – 1,000,000 100 – 10,000
Regional Subsidence	n/a
Mining or Quarry Depressions	100 – 10,000
Instream Modification	100

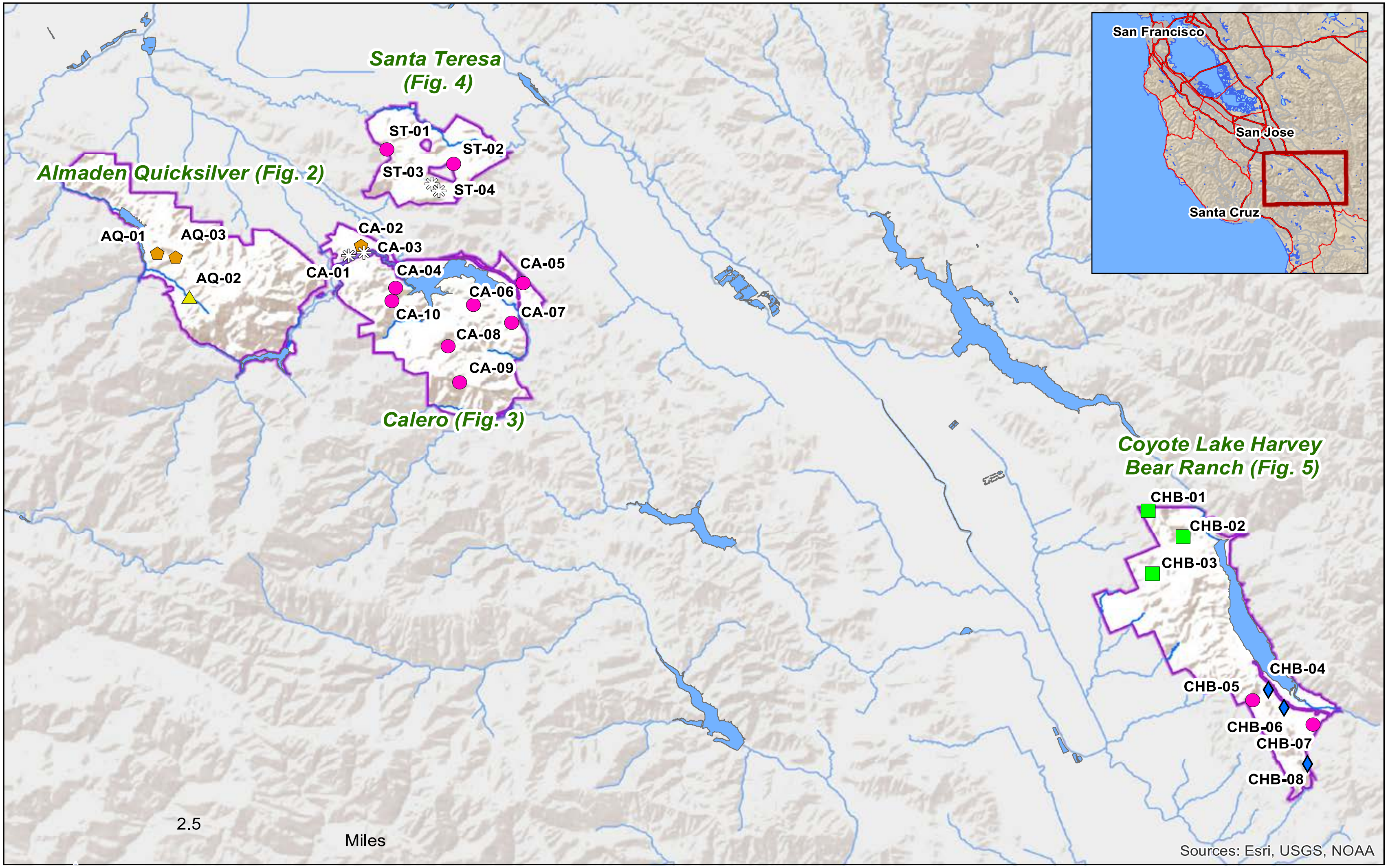


Figure 1. Pond Locations, Central Santa Clara County, California

Source: Santa Clara County Parks

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Goal:

Understand hydroperiod trends in pools with respect to habitat optimization for target species

(California red-legged frog, western pond turtle, native California tiger salamander)

Open Questions:

1. How can we optimize hydroperiod for target species?
2. How will climate change affect hydroperiod?

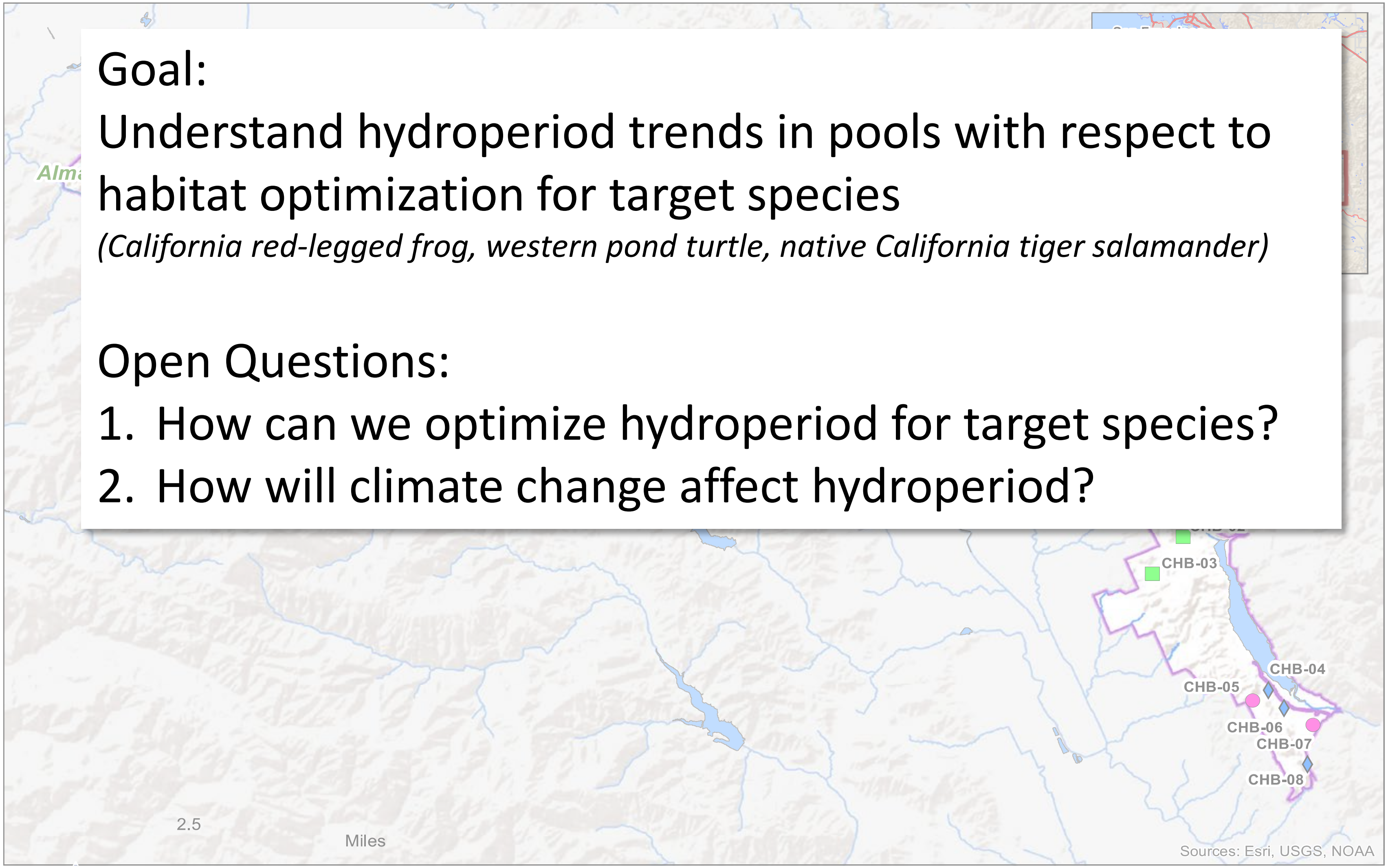

Figure 1. Pond Locations, Central Santa Clara County, California

Source: Santa Clara County Parks

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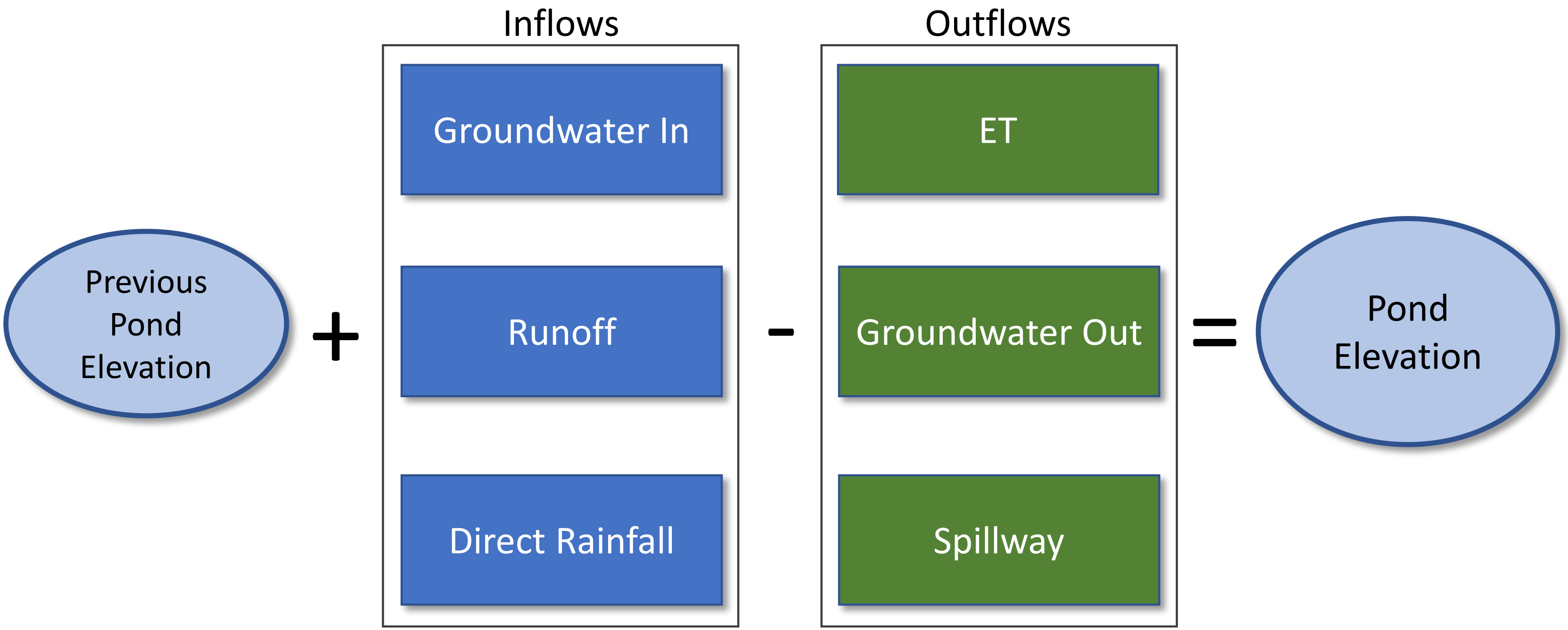
Water Balance Model

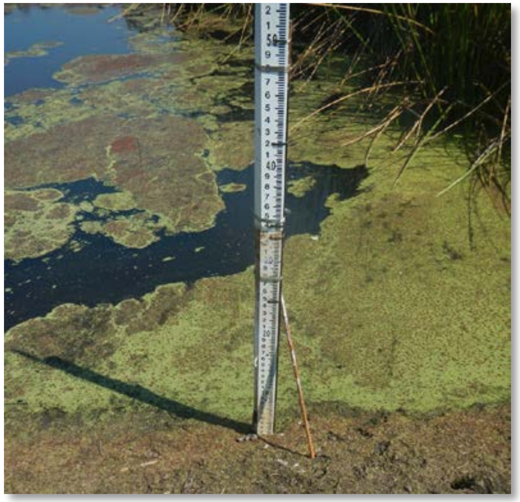


Model Inputs

Input	Source
Historical mean monthly air temp	PRISM[1]
Historical total monthly precip	PRISM[1]
Projected air temp and precip	Downscaled GCMs sourced from SIMClim[2]
Stage-storage/spillway elevation	Surveyed, Balance Hydrologics staff
Soil water capacity	SSURGO
Watershed area	Computed, DEM/Lidar dataset

[1]*PRISM data sourced from www.prism.oregonstate.edu*
[2]*More info available at www.climsystems.com/simclim*

Model Calibration



Short-term monitoring or observations supplemented with google earth imagery data

If LiDAR and good aerial coverage, possible to build hydroperiod model without field visit

Step 1: Calculate Known Quantities

Runoff

ET

Direct Rainfall

Spillway

Step 2: Calibrate Inferred Quantities

Groundwater In

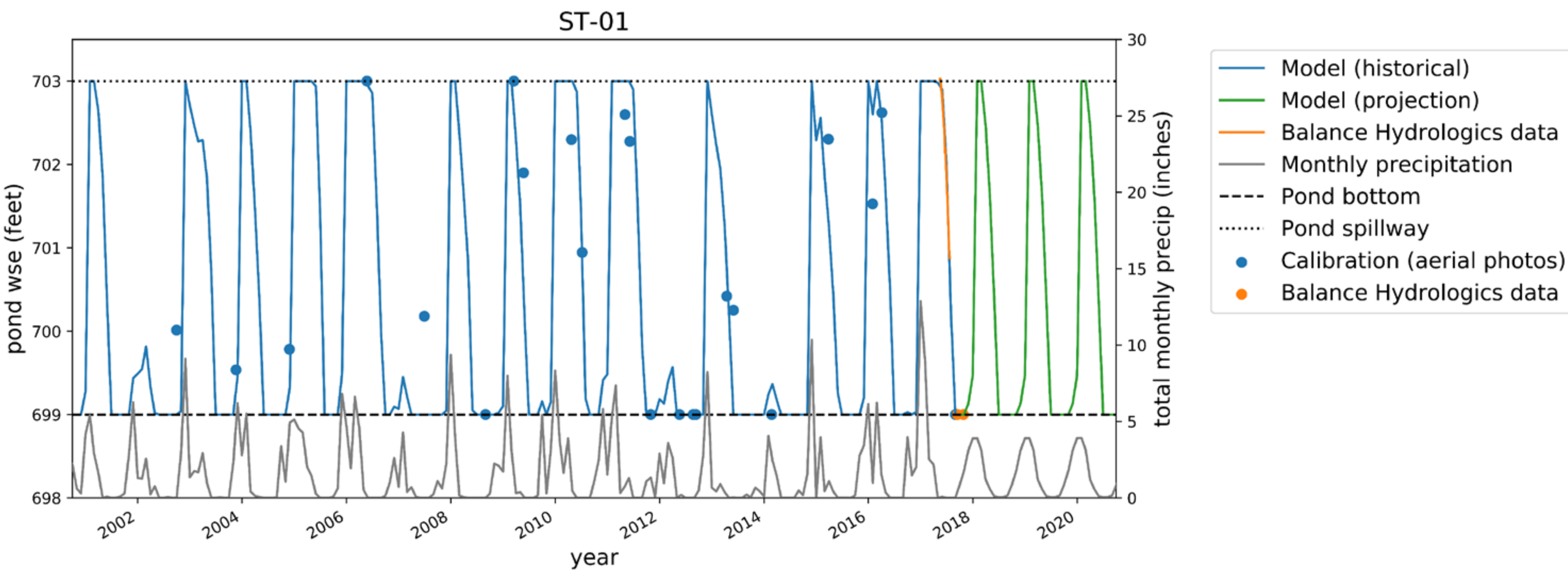
- Local Soil Moisture Groundwater = F(precip)
- Bedrock Fracture Groundwater = F(total winter precip), lagged, threshold
- Fault-sourced Groundwater = F(total winter precip), lagged

Groundwater Out

- Percolation Groundwater = F(pond volume), i.e. pond head
- Soil Moisture Wicking Groundwater = F(ET)

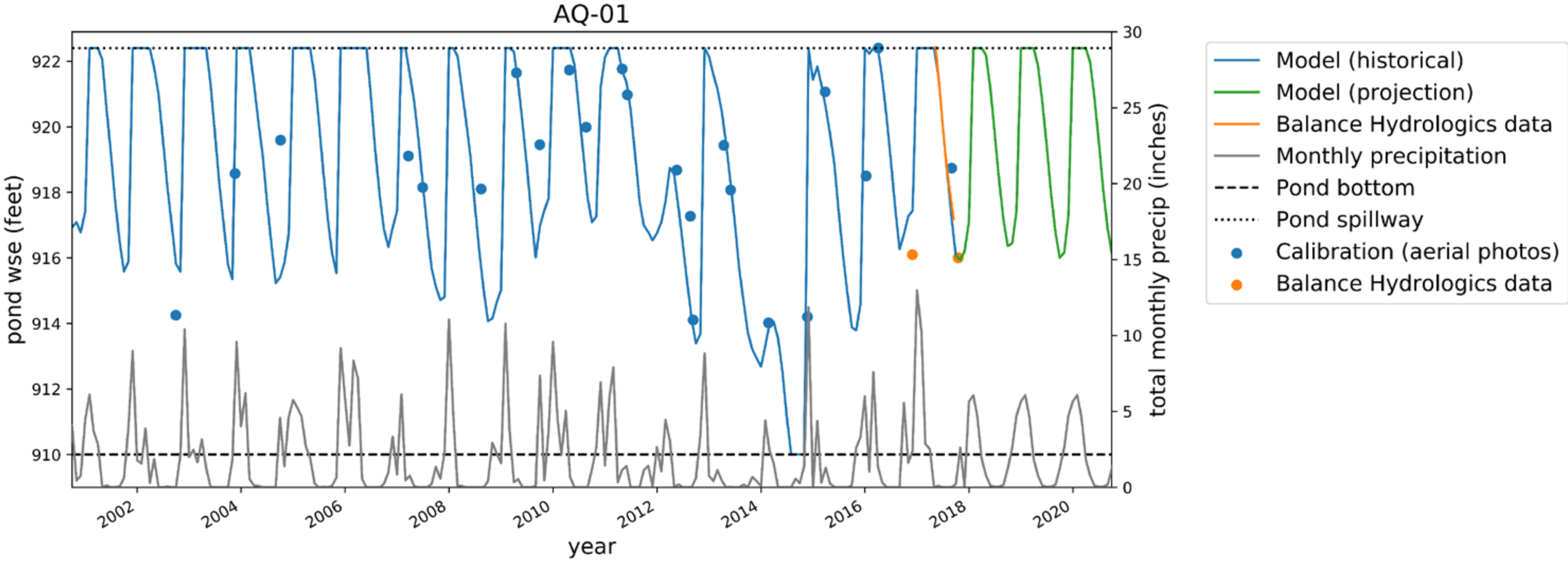
ST-01

- Instream modified pool
- Hydroperiod Dec – Jun, 7 months
- Some groundwater input in wet years
- Leaky pond/berm



AQ-01

- Mining or Quarry Depression
- Hydroperiod: year-round
- Some groundwater input in wet years
- Moderately leaky pond/berm



Model Results Summary

Leaky ponds:

- Instream modified ponds, berm construction
- Landslide head scarp pools
- Tectogenic pools
- Landslide dammed

Groundwater-dominant fluxes:

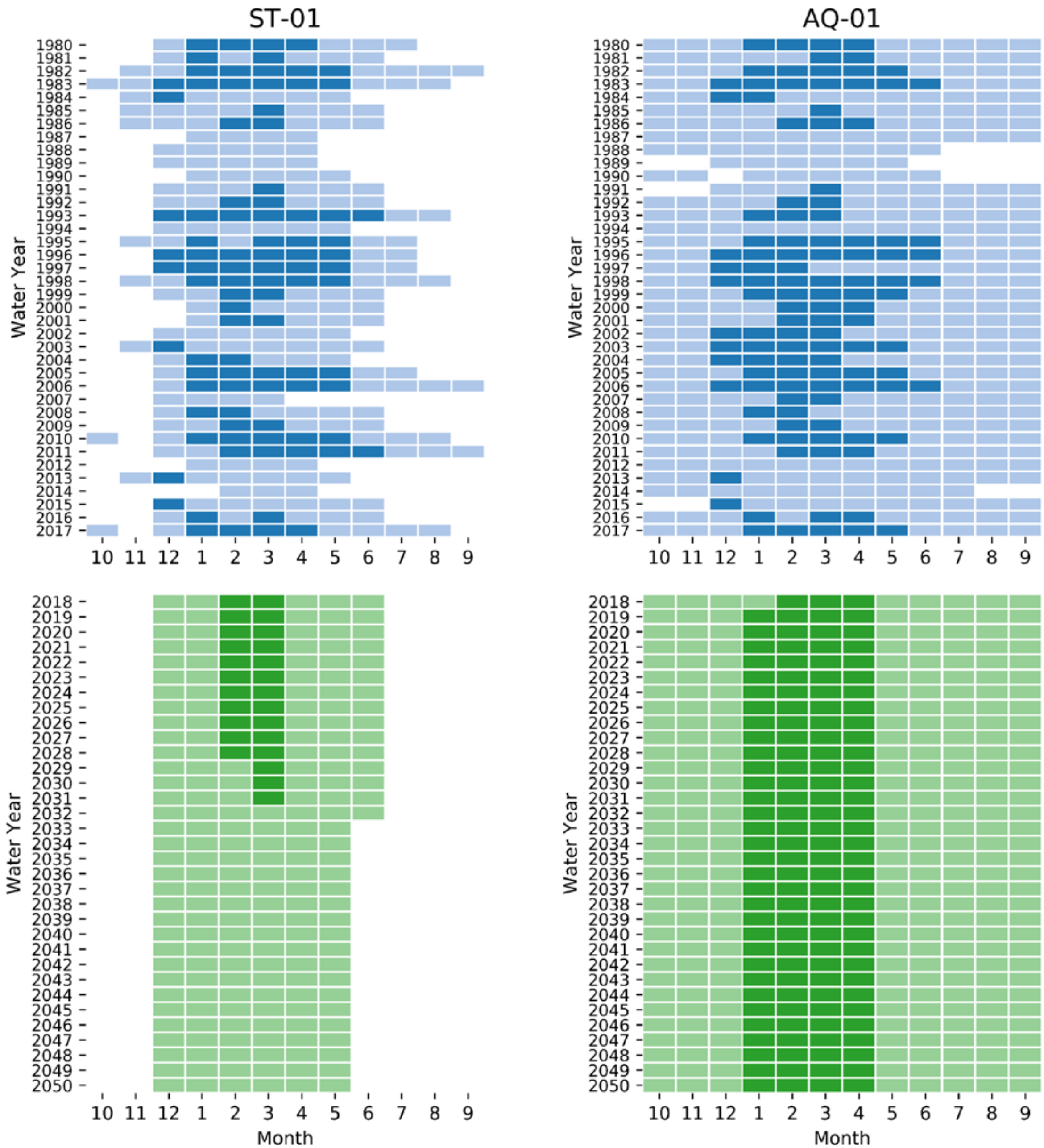
- Tectogenic pools
- Landslide head scarp pools, when co-located with faults

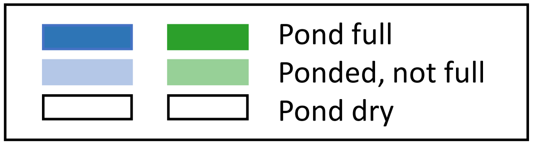
Runoff-ET dominated fluxes:

- Instream modified pools
- Mining or quarry depression pools
- Landslide dammed

What does hydroperiod look like?

Simulated Historical Ponding, 1980 – 2018, Projections 2018 - 2030





How will hydroperiod be affected by climate change?

In the Bay Area:

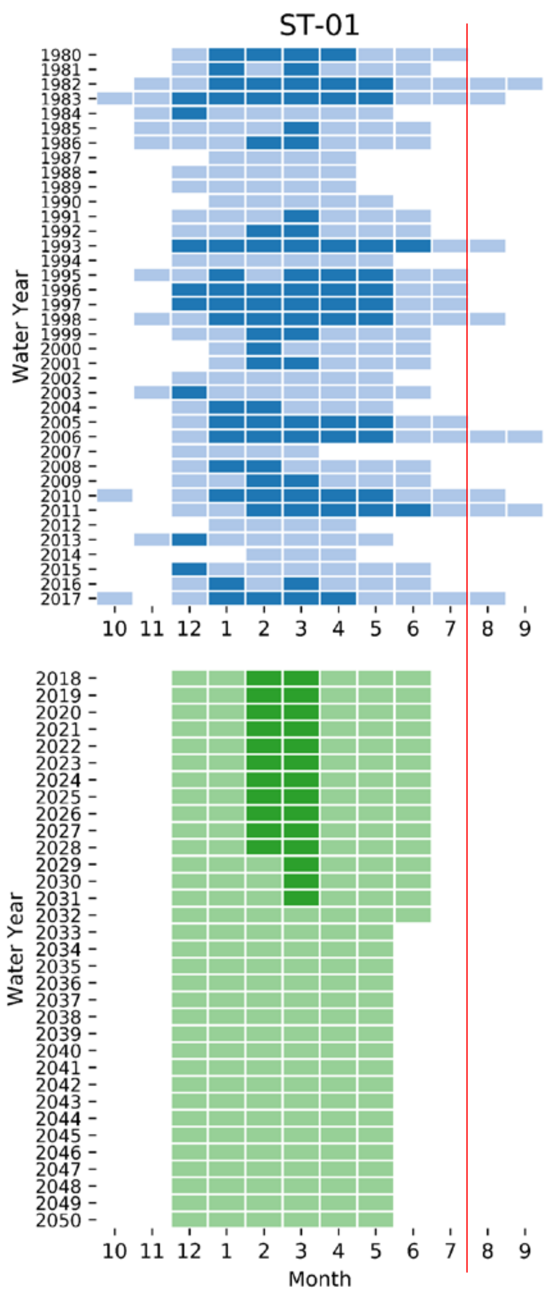
- rainfall projected to concentrate in winter months
- temperatures projected to increase by <1°C

How can hydroperiod be managed?

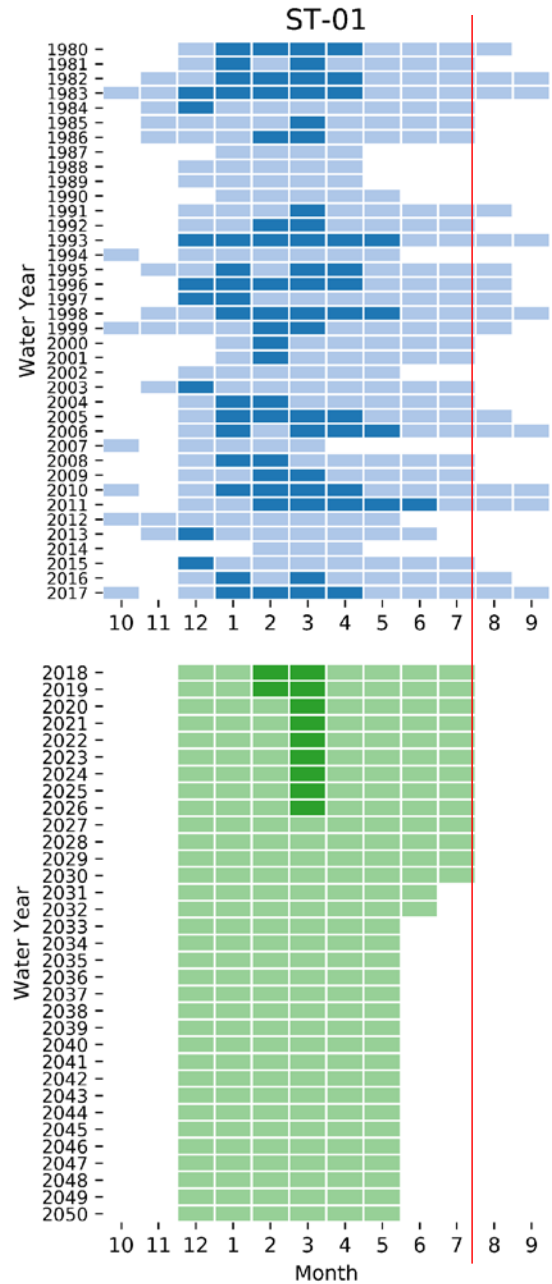
Ex: target hydroperiod for CRLF extends to Aug/Sep

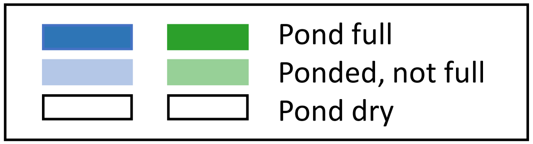
Bullfrog prefer year-round

Modeled Actual

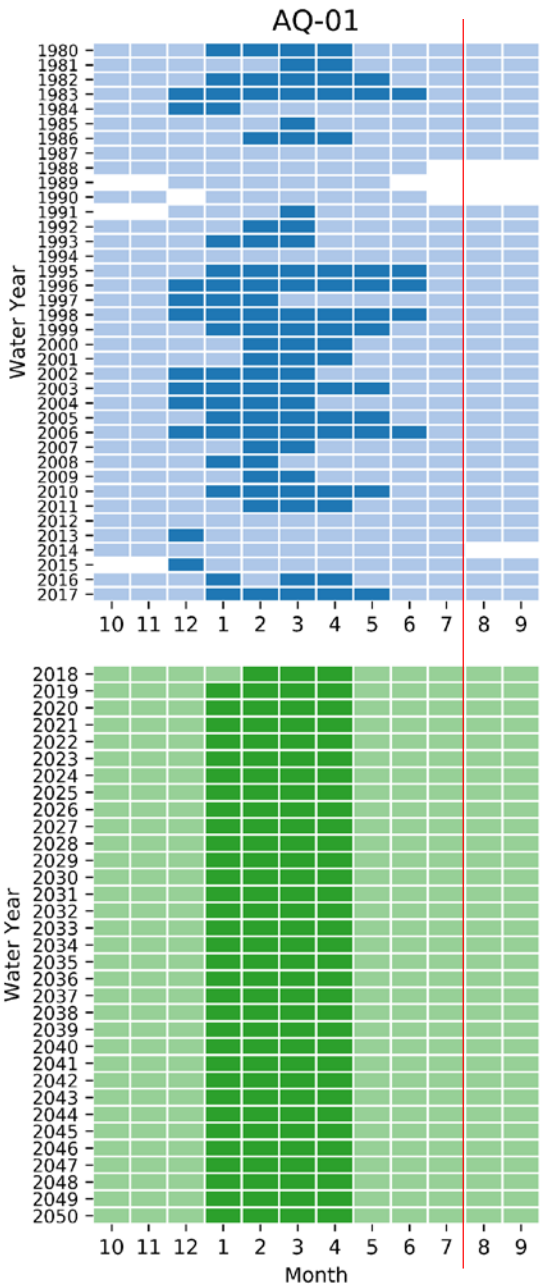


Raise spillway 3 feet

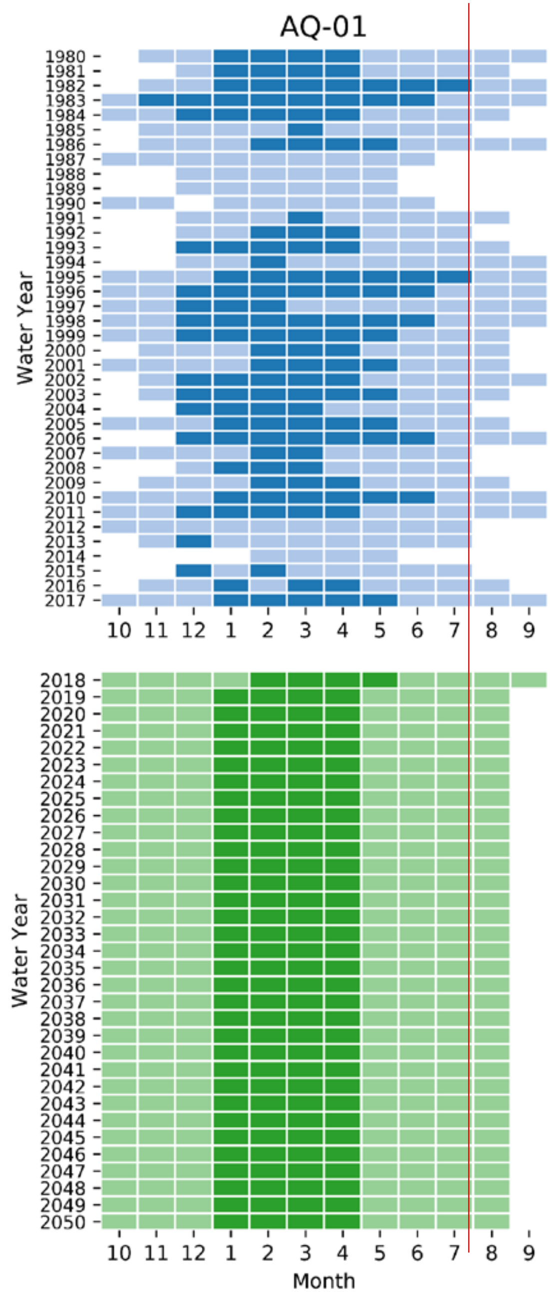


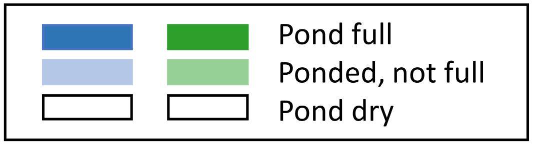


Modeled Actual



Lower spillway 7.5 feet





Key Take-Home Points:

1. Genetic classification
   – Groundwater inputs from faults? Leaky pond?
2. Hydroperiod model
   – Cost-effective, open-source way to estimate month-scale hydroperiod
3. Habitat Management
   – Use hydroperiod model to simulate enhancements: spillway elevation, pond geometry, clay lining
4. Climate Change Resilience
   – Impose temperature and precipitation record to understand cycles of extreme wet and dry periods

Other applications*:

1. Multiple desiccation events in a year
2. Temperature
3. Turbidity
4. Salinity

**if calibration data available*

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Model decisions are informed by pond classification based on geomorphic origin

Classification	Primary Infows	Primary Outflows	Relative Age
Pedogenic	Surface runoff	ET	100,000 – 1,000,000
Tectogenic	Fracture/fault groundwater	ET, bedrock fractures	100,000 – 1,000,000
Landslide Head Scarp	Groundwater seeps	Leaky – loosely packed landslide sediments	100 – 10,000
Volcanigenic	Surface runoff	ET, leaky bedrock cracks	10,000,000 – 100,000,000
Alluvium Dammed	Surface runoff	Leaky when alluvial highly permeable	100 – 100,000
Dune Dammed	Varies	Leaky - dune sediments highly permeable	100 – 10,000
Landslide Dammed	Surface runoff	Leaky berms, losses through landslide deposits	100 – 10,000
Bedrock (Tenaja) **Bedrock (Karst)**	Surface runoff	ET, surface outflow	100,000 – 1,000,000 100 – 10,000
Regional Subsidence	Surface runoff	ET, surface outflow	n/a
Mining or Quarry Depressions	Surface runoff, likely no groundwater	ET	100 – 10,000
Instream Modification	Surface runoff	Leaky berms, ET, lateral infiltration	100

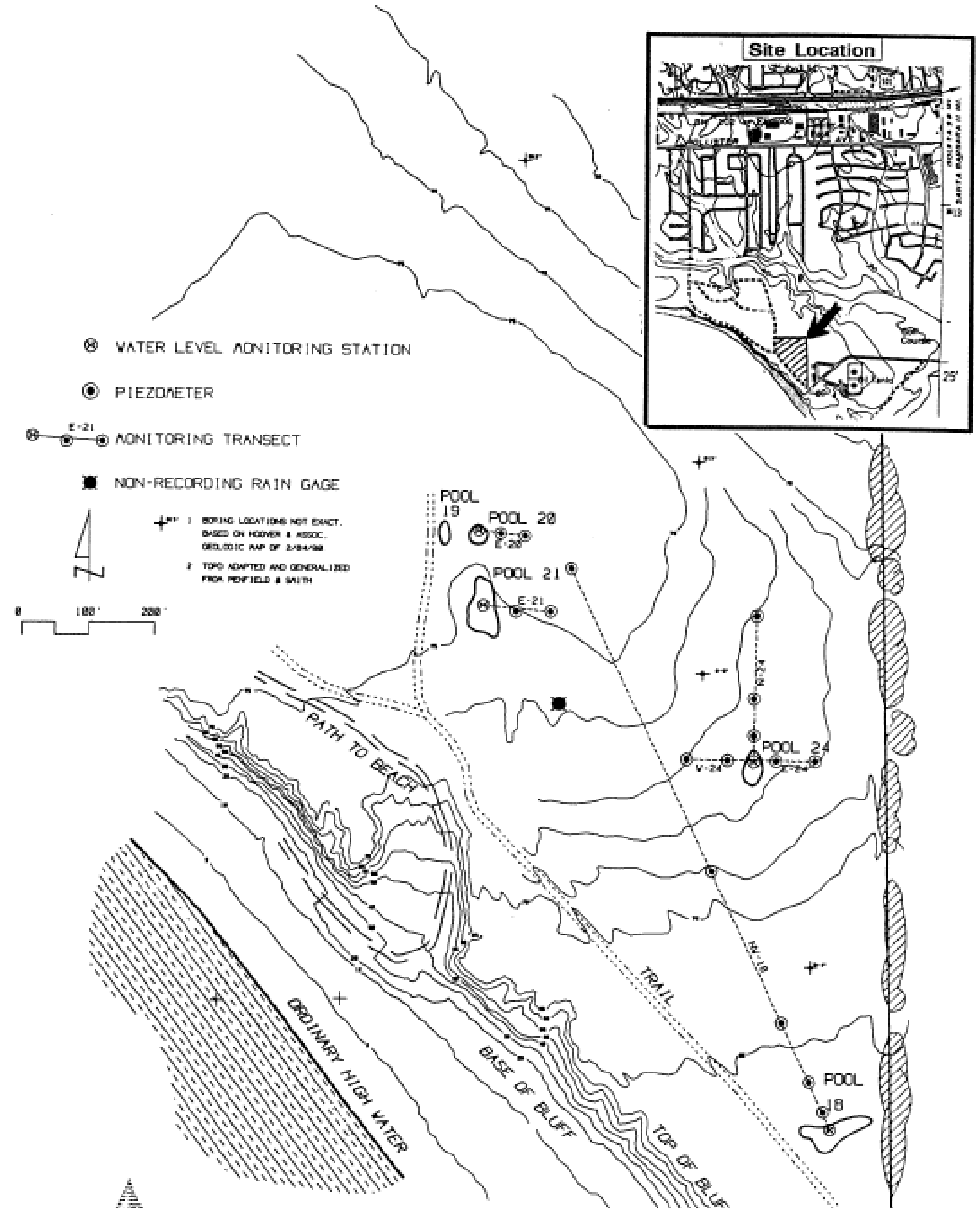

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Figure 1. Vernal Pool Monitoring Network

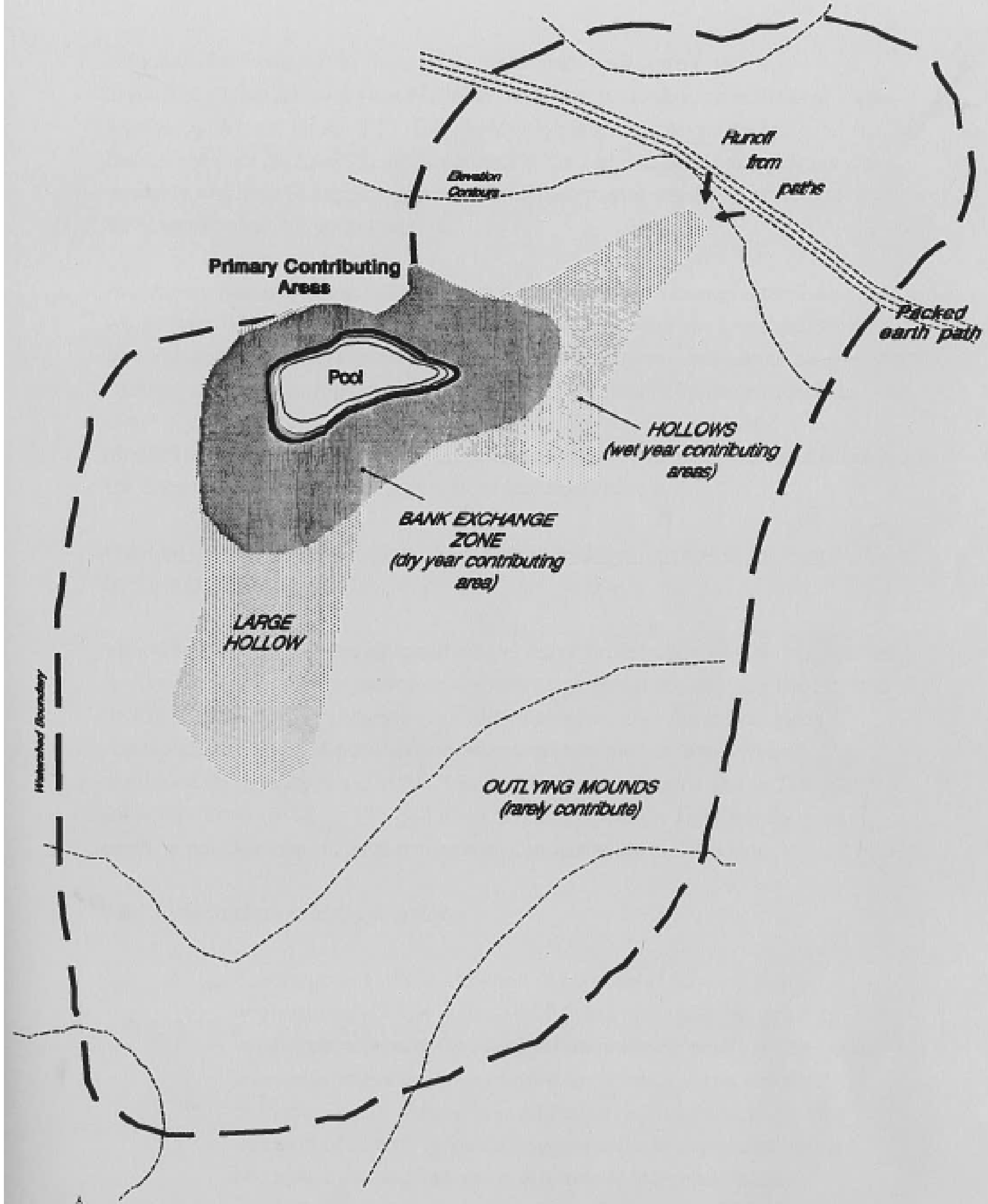

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Figure 7. Primary areas contributing runoff to isolated vernal pools: Schematic illustration appropriate to coastal Santa Barbara County.

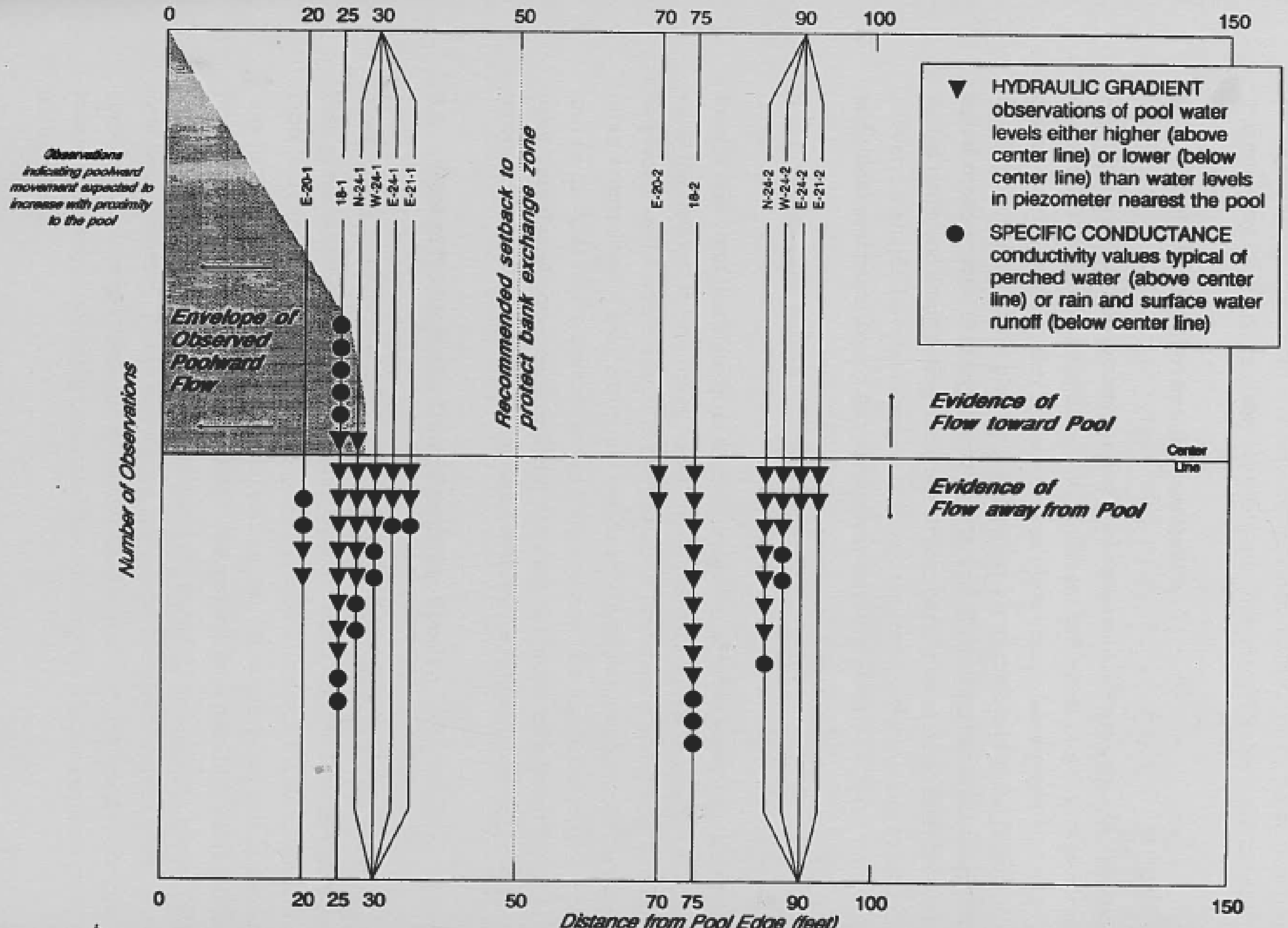

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Figure 8. **Variation in pool / bank exchange with distance from pool edge.** See section 5.2. Histogram shows number of observations indicating movement of perched water in banks toward or away from pools. Observations indicate occasional poolward movement of water within approximately 30 feet of the pool (under the range of conditions observed during 1991). Note that pool edges are often a diffuse belt, 10 to 15 feet wide.

Model Results Summary

Model Parameter	Tectogenic	Landslide Head Scarp	Mining or Quarry Depression	Instream Modified	Landslide Dammed*
Rainfall Fringe	4 – 6 x pond area	2 – 4 x pond area	2 x pond area	2 – 3 x pond area	
Leaky Pond	Moderately leaky	Moderately leaky	Very leaky	Varies	Moderately leaky
Deep Fault Groundwater	Yes, lag 7-8 months	When landslide co-located with fault	No	No	No
Bedrock Fracture Groundwater	Yes, lag 3-4 months, in dry years	Yes, in moderately wet years	Some active seeps	Some active seeps	No

**Only 1 landslide dammed pond in this study, so not all parameters are reported*