Best management practices for low-impact development

Eric Berntsen

stormwater program / SWRCB

growth

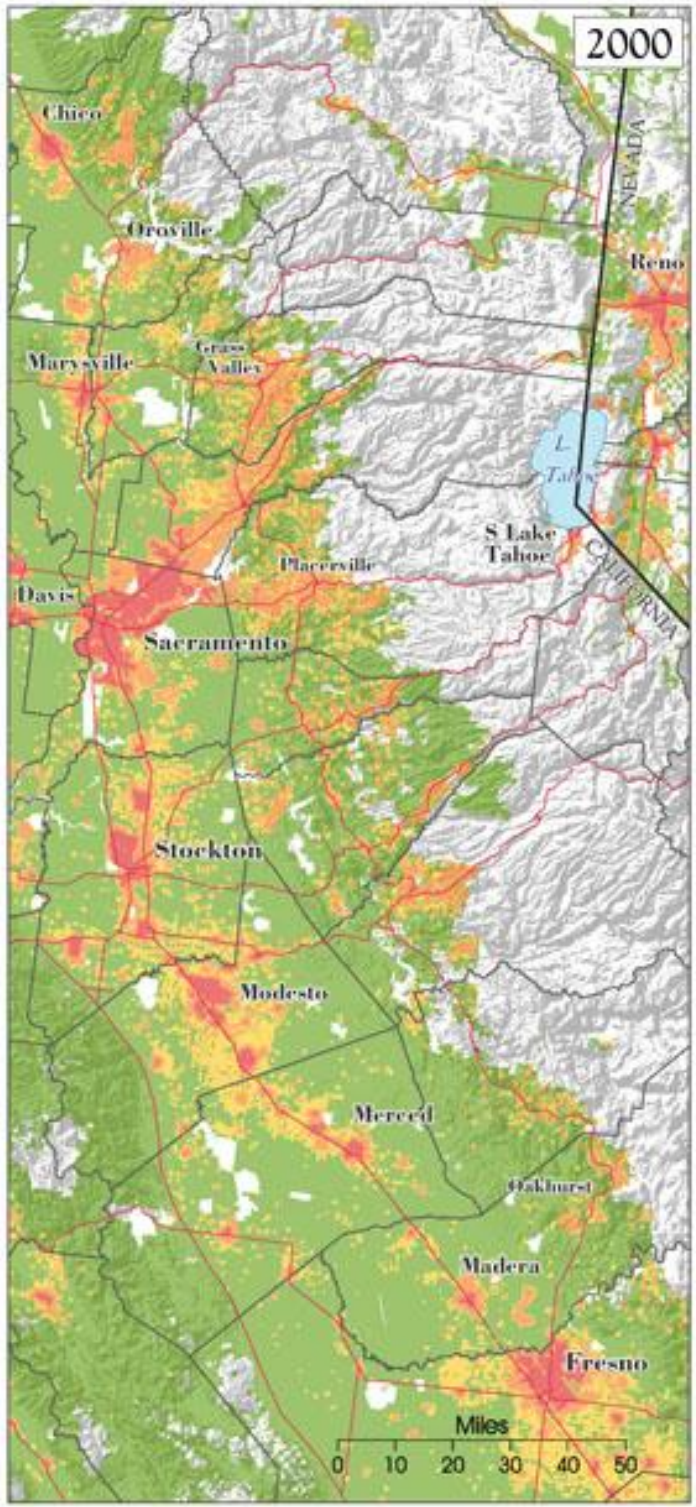
…happens

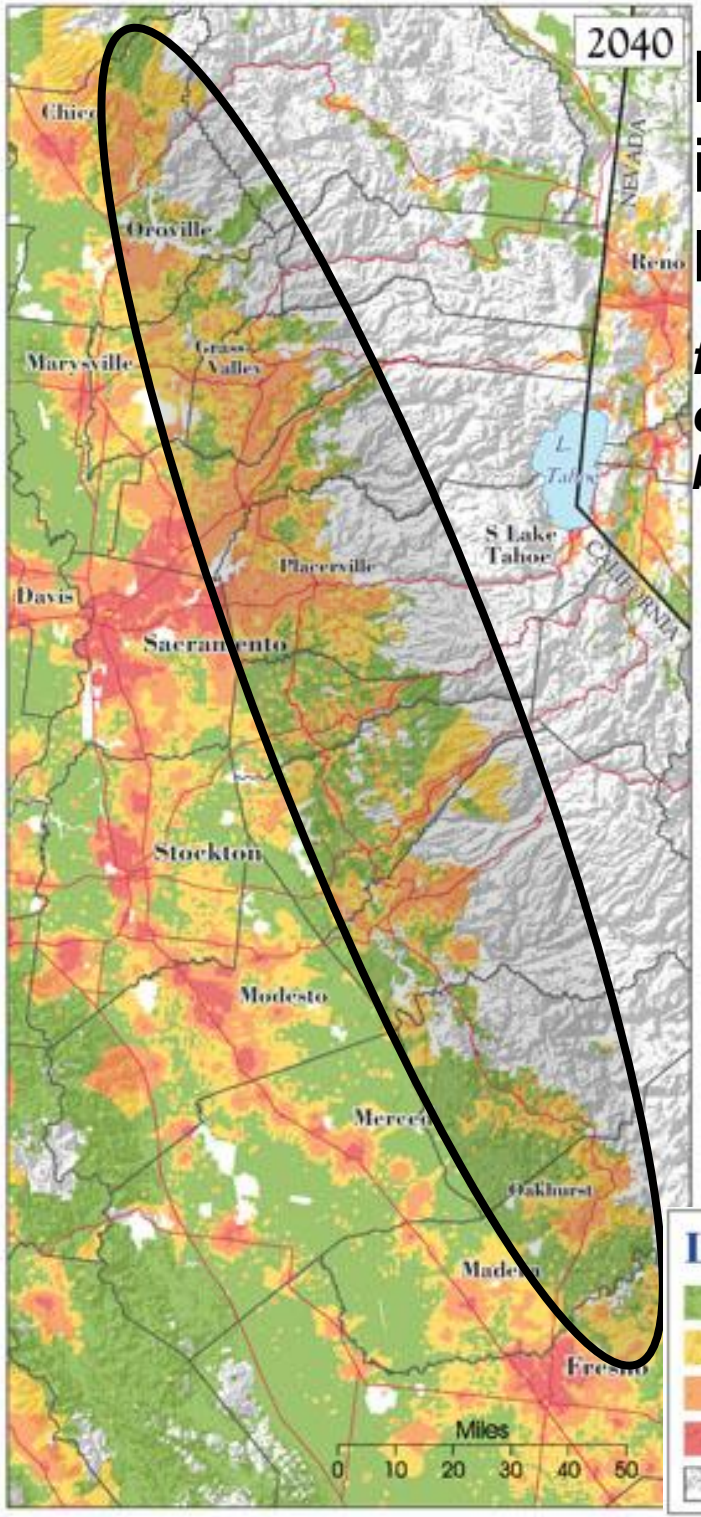
the problem is not growth

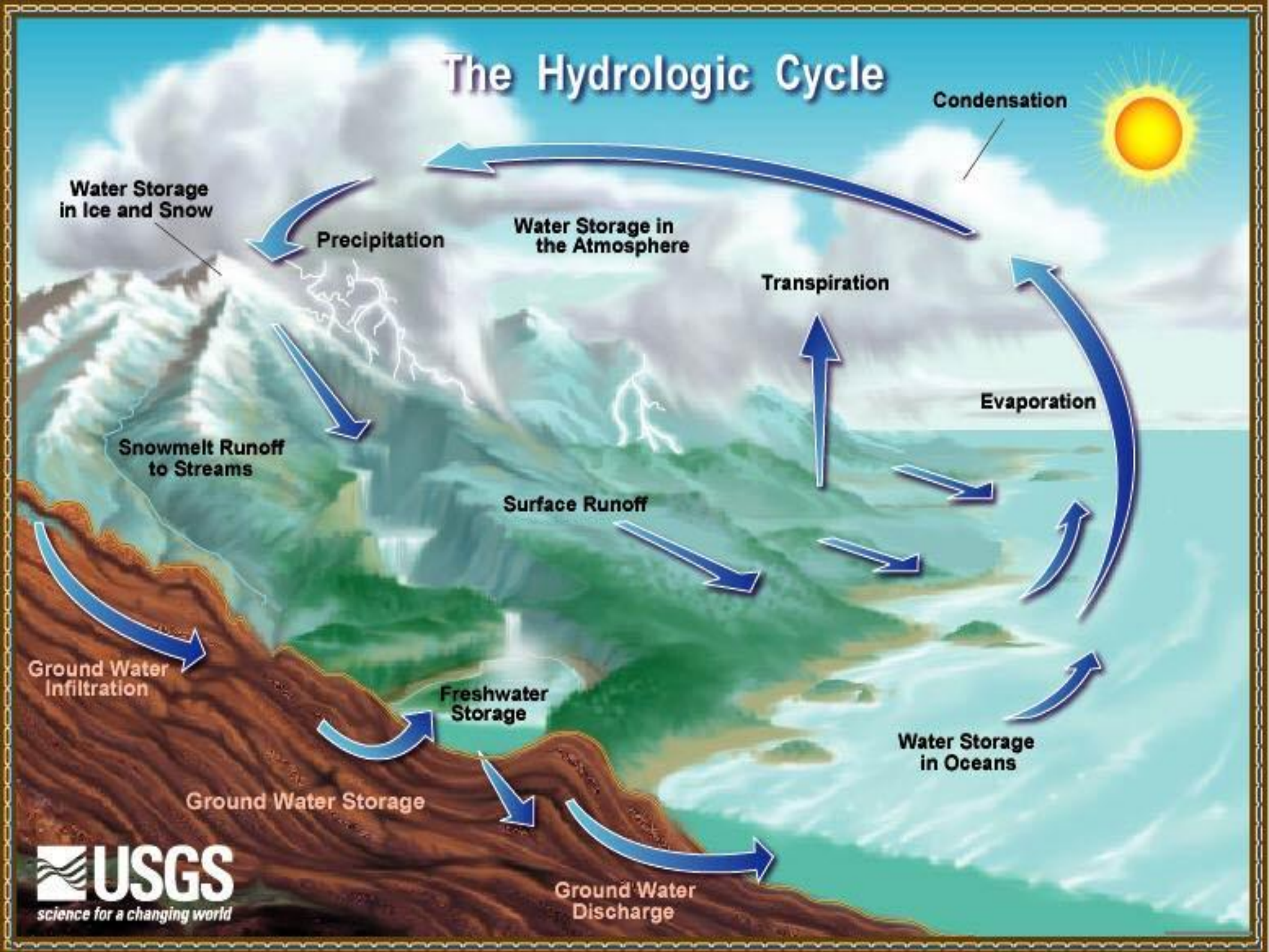
it's how we modify the landscape

Exurbanization in the Sierra Foothills

from "New Geographies of the American West" by William Travis






The Hydrologic Cycle
Condensation
Water Storage in Ice and Snow
Precipitation
Water Storage in the Atmosphere
Transpiration
Evaporation
Snowmelt Runoff to Streams
Surface Runoff
Ground Water Infiltration
Freshwater Storage
Water Storage in Oceans
Ground Water Storage
Ground Water Discharge
USGS
science for a changing world

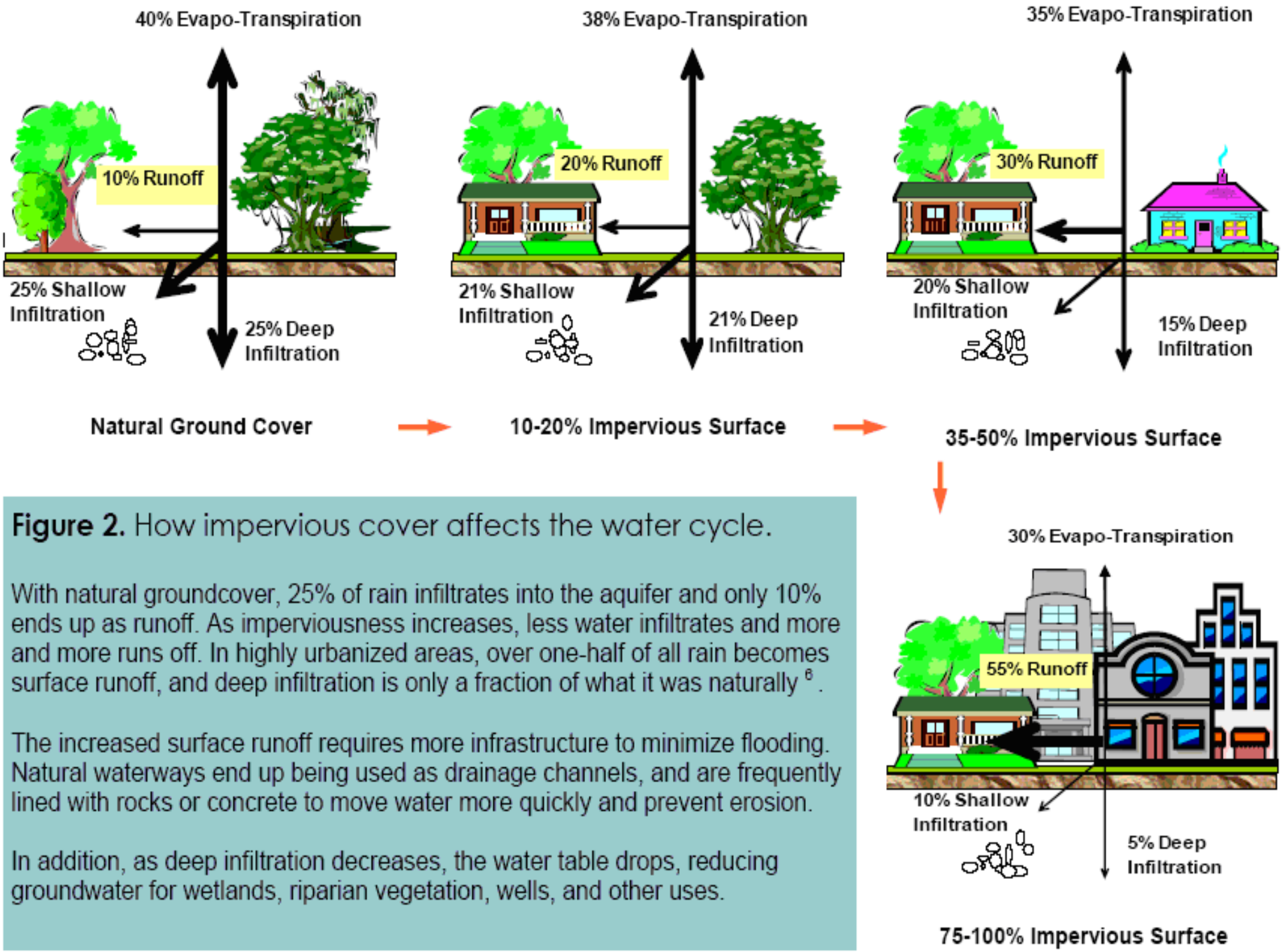


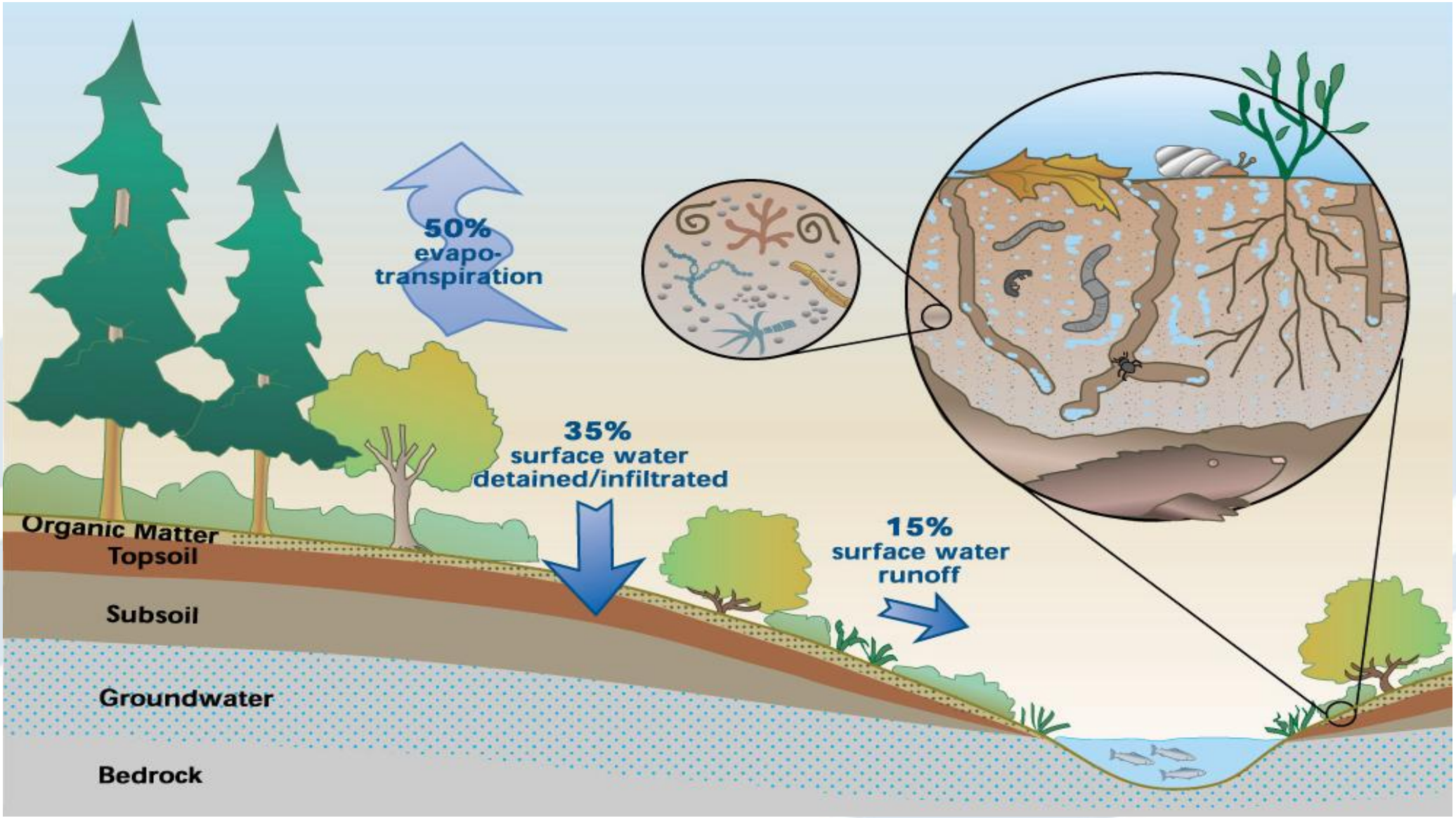
Figure 2. How impervious cover affects the water cycle.

With natural groundcover, 25% of rain infiltrates into the aquifer and only 10% ends up as runoff. As imperviousness increases, less water infiltrates and more and more runs off. In highly urbanized areas, over one-half of all rain becomes surface runoff, and deep infiltration is only a fraction of what it was naturally [6].

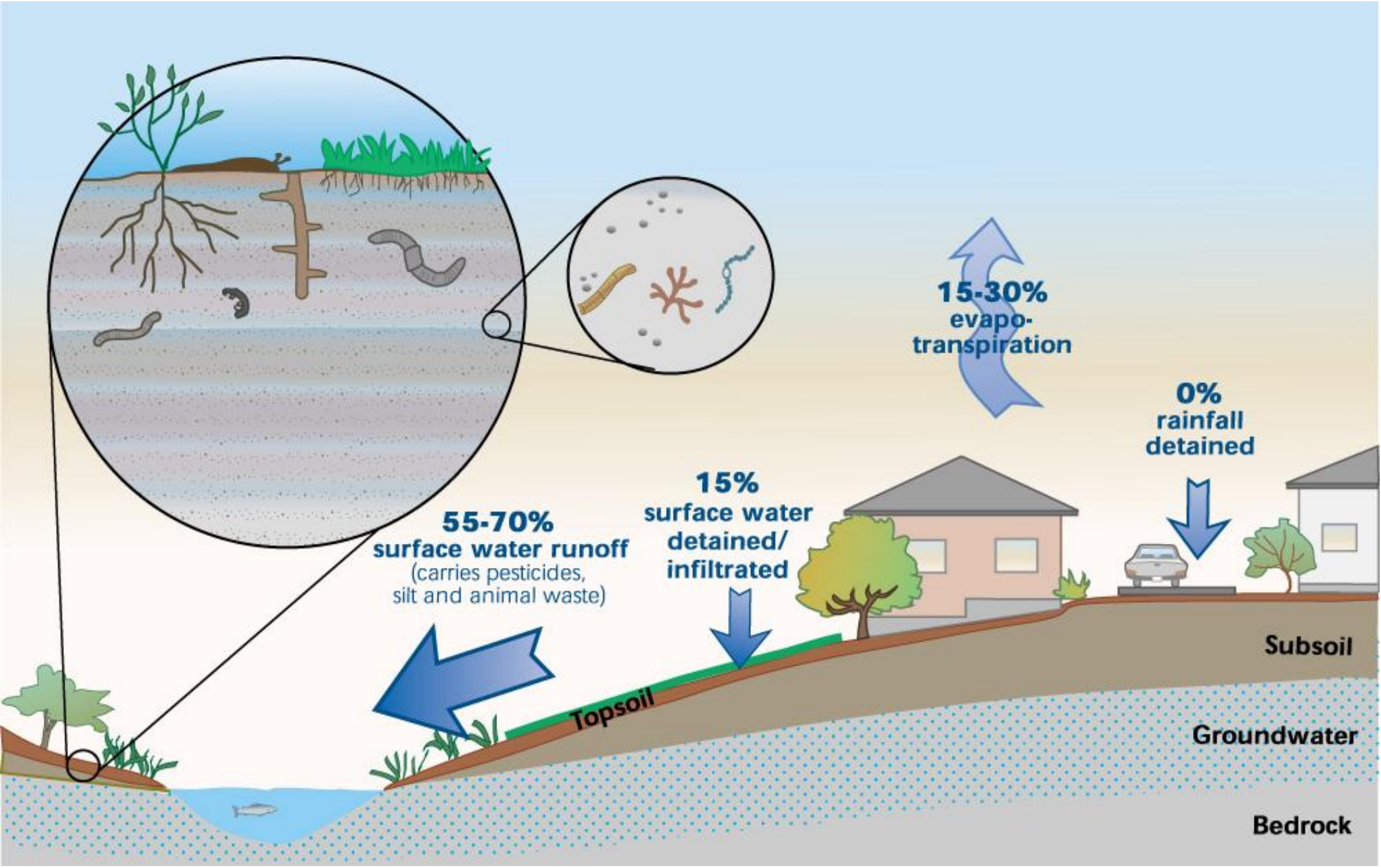
The increased surface runoff requires more infrastructure to minimize flooding. Natural waterways end up being used as drainage channels, and are frequently lined with rocks or concrete to move water more quickly and prevent erosion.

In addition, as deep infiltration decreases, the water table drops, reducing groundwater for wetlands, riparian vegetation, wells, and other uses.

Native Soil


50%
evapo-
transpiration
35%
surface water
detained/infiltrated
15%
surface water
runoff
Organic Matter
Topsoil
Subsoil
Groundwater
Bedrock

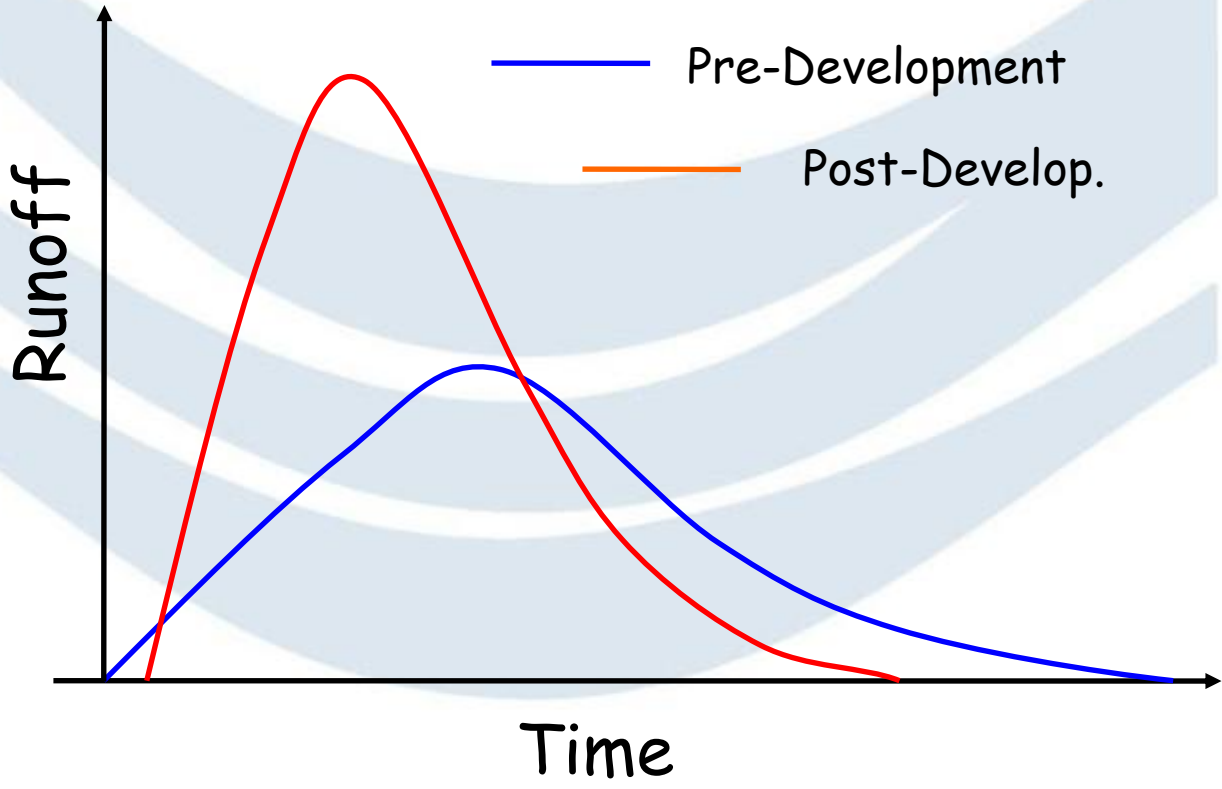
Disturbed Soil



Hydrologic Changes

Urbanization tends to increase storm water runoff:

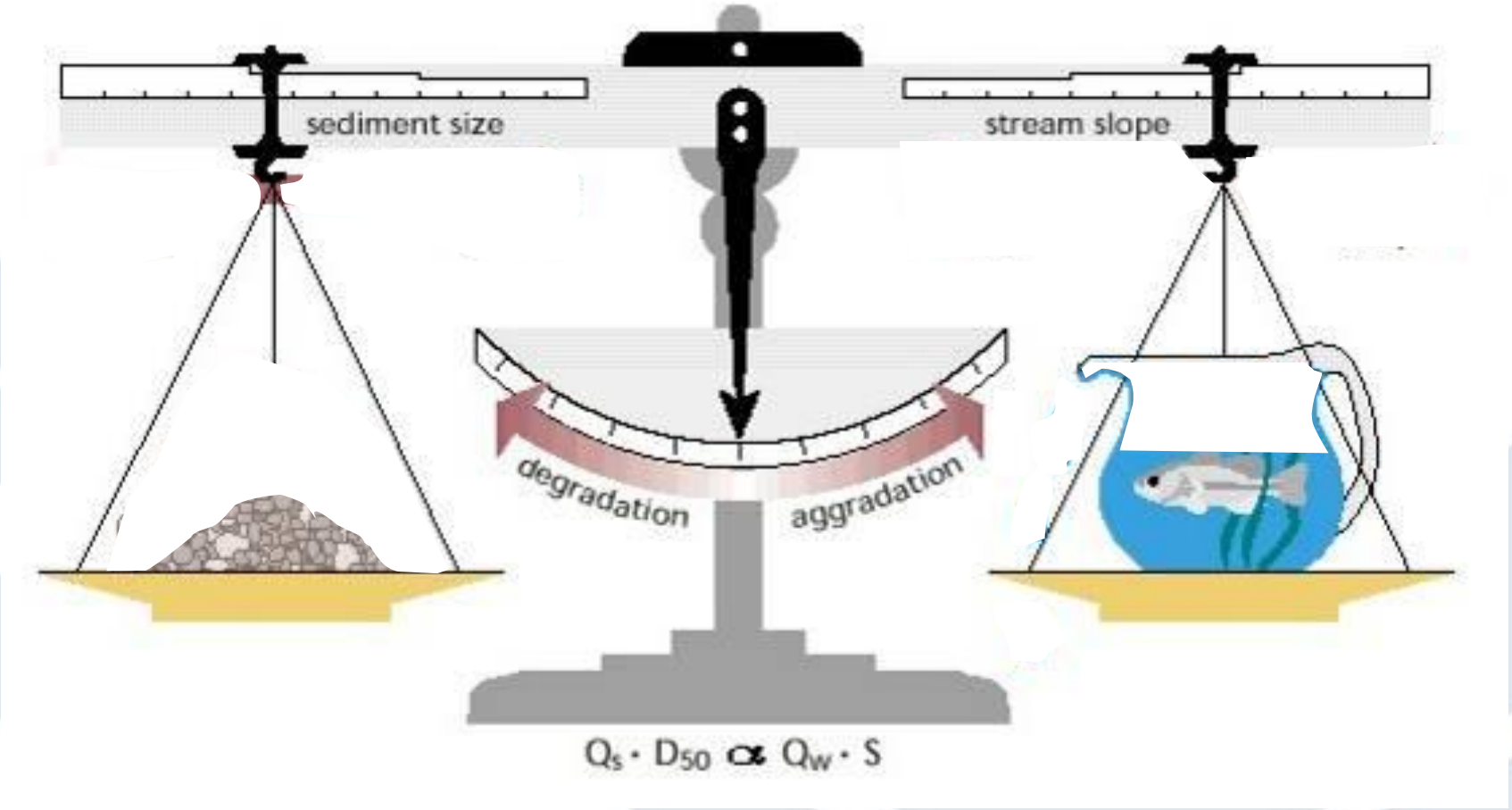
- peak flows
- volume
- frequency



From Haltiner (2006)

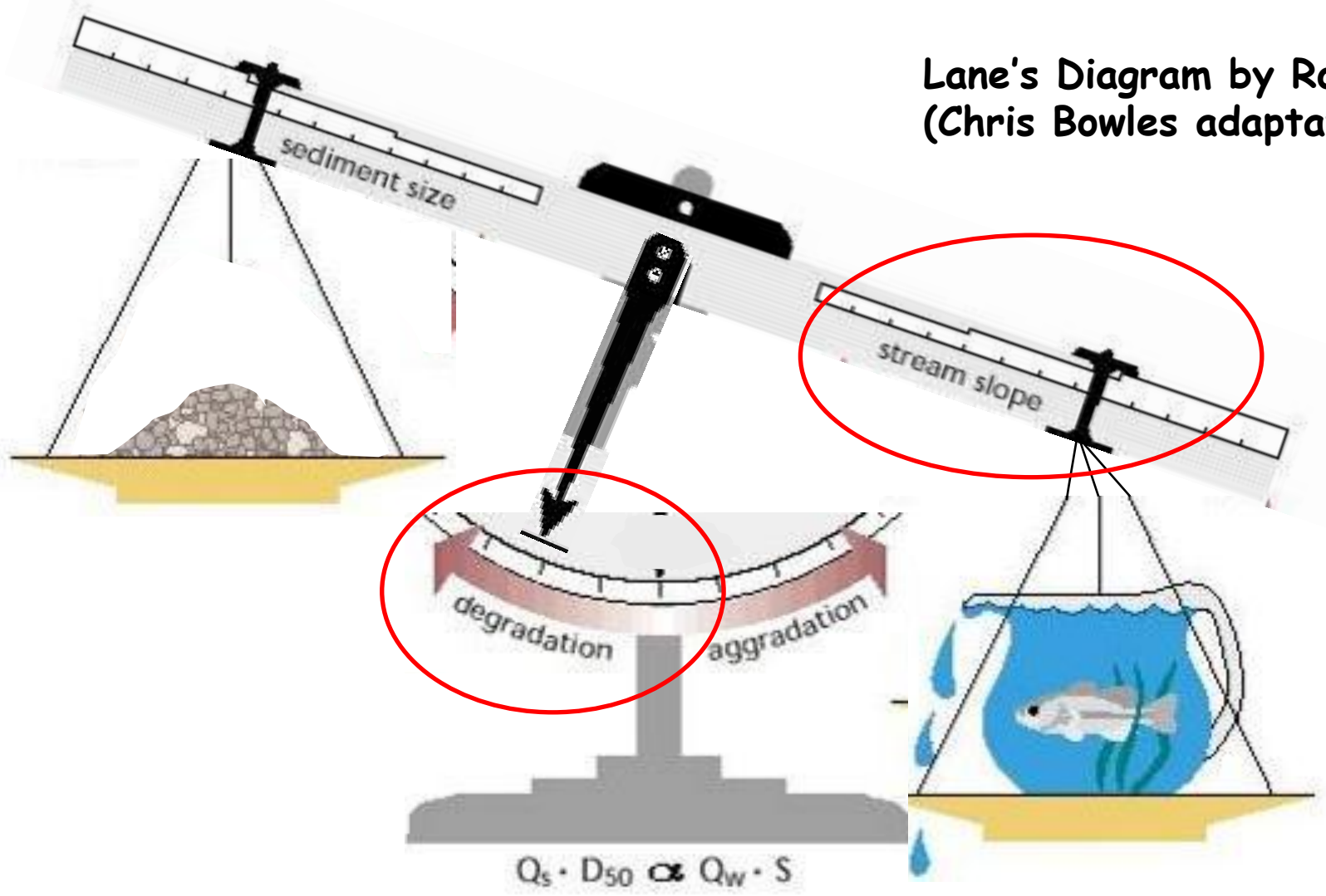
Geomorphic Processes 101

Lane's Diagram by Rosgen, 1996
(Chris Bowles adaptation)

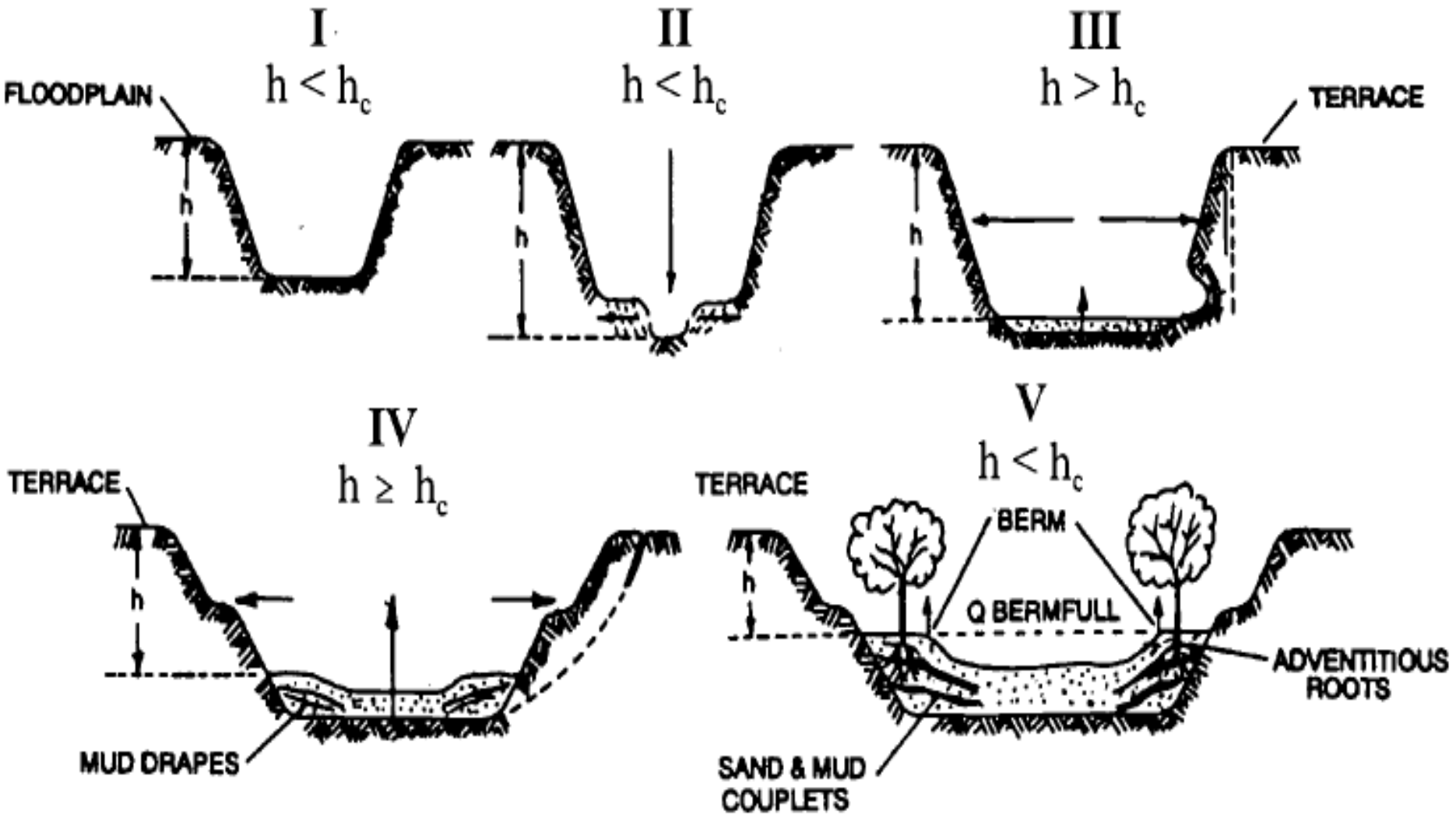


Over time channel geometry (width, depth, gradient) adjusts to be in equilibrium with water and sediment load

Lane's Diagram by Rosgen, 1996
(Chris Bowles adaptation)



Channel Changes Associated with Urbanization




1950's – Sacramento Area


2000's – Sacramento Area

Post-Construction Impacts

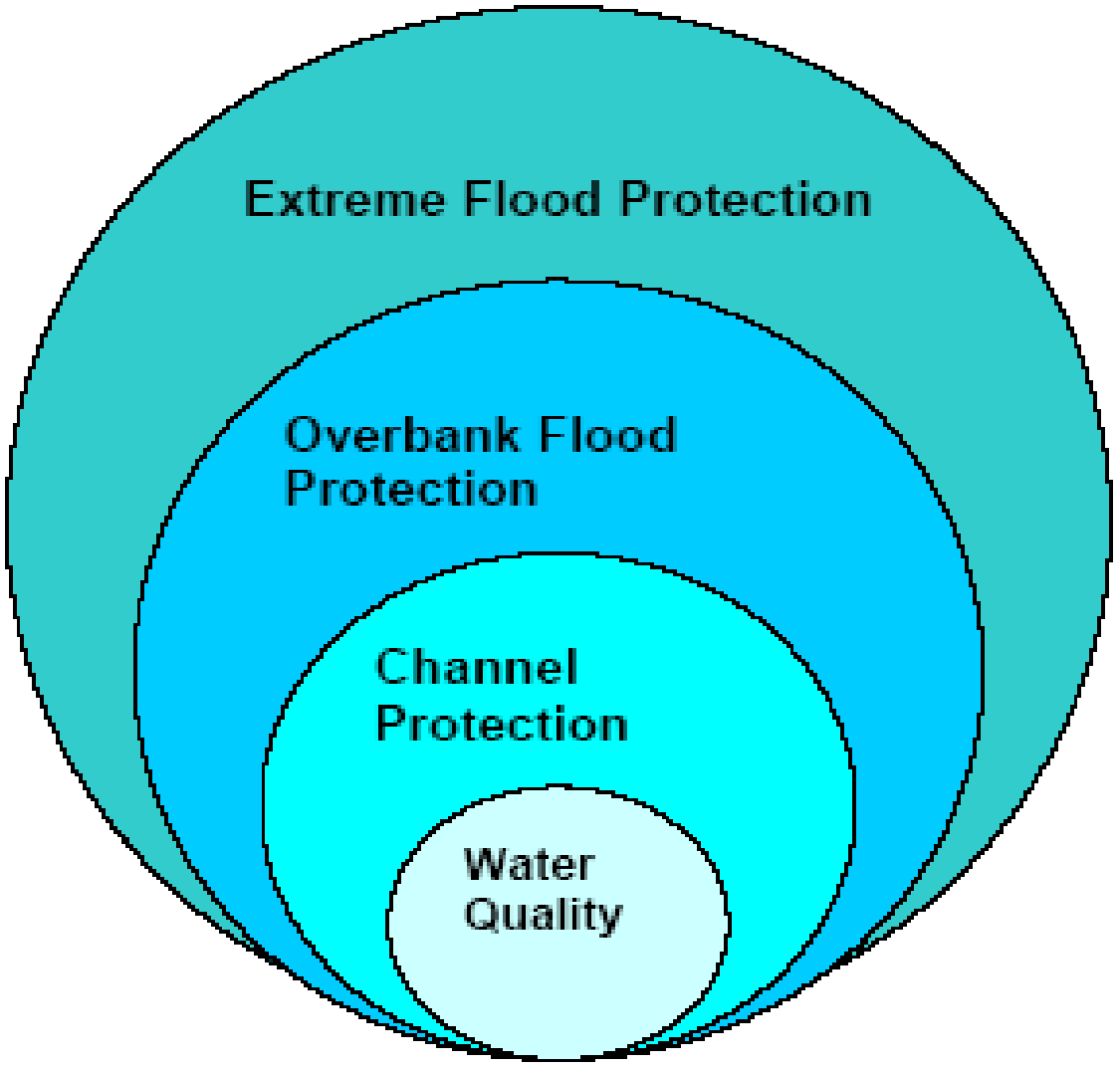
California Waterbodies Impaired by Urban Stormwater

Year	Acres_Impaired	Miles_of_Streams/Rivers_Impaired
1992	240,056.00	633.00
1994	254,197.00	739.00
1996	262,457.00	1,351.00
1998	520,949.00	1,238.36
2002	781,780.33	3,845.33
2006	806,817.83	4,582.79
2010	871,144.77	5,037.70

Post-Construction Impacts

Sources of Impairment (USEPA 2006)

	Rivers and Streams	Lakes, Ponds, and Reservoirs	Estuaries
Sources[b]	Agriculture (48%)[a]	Agriculture (41%)	Municipal Point Sources (37%)
	Hydrologic Modification (20%)[c]	**Hydrologic Modification (18%)**	Urban Runoff/Storm Sewers (32%)
	Habitat Modification (14%)[d]	Urban Runoff/Storm Sewers (18%)	Industrial Discharges (26%)
	Urban Runoff /Storm Sewers (13%)	Nonpoint Sources (14%)	Atmospheric Deposition (23%)
	Forestry (10%)	Atmospheric Deposition (13%)	Agriculture (18%)
	Municipal Point Sources (10%)	Municipal Point Sources (12%)	**Hydrologic Modification (14%)**
	Resource Extraction (10%)	Land Disposal (10%)	Resource Extraction (12%)



From Georgia Stormwater Manual

Low Impact Development (LID) Principles

LID's goal is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source.

LID Benefits

- **Multifunctionality** – landscaping costs also serve as stormwater treatment costs, etc.
- **Lower lifetime costs** – e.g., lower overall operation, repair, maintenance, and decommissioning costs

- **Additional environmental and social benefits** – multiple objectives met

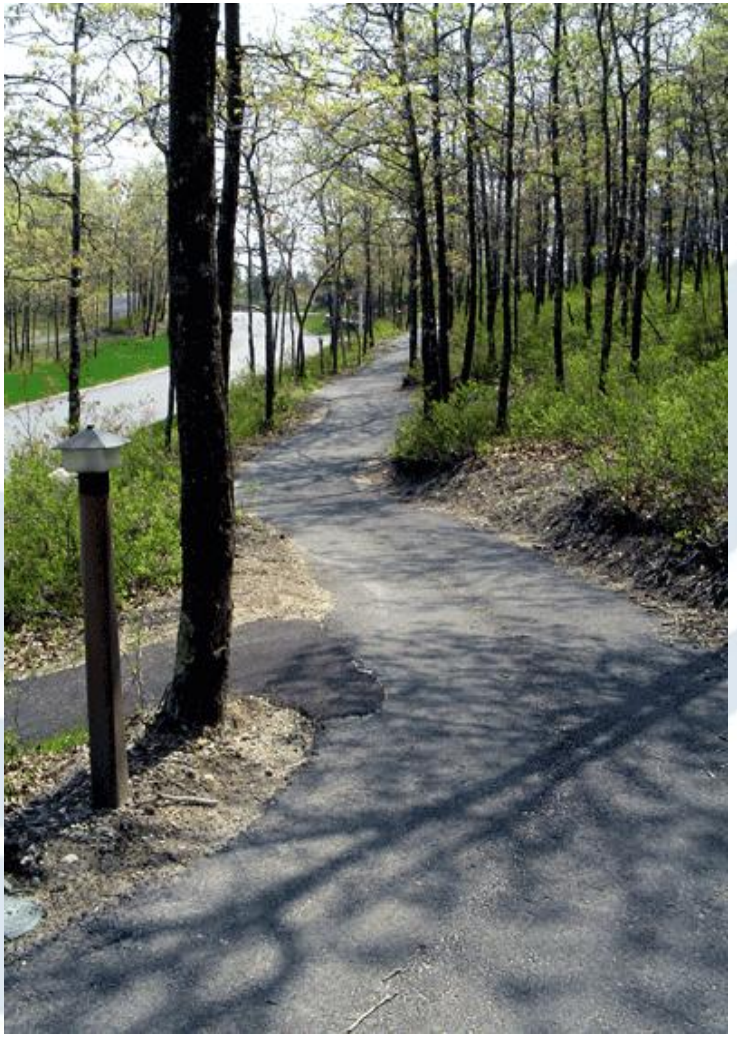
- **Reduced offsite costs** – fewer offsite sewer collection and treatment costs
- **Functional use of open space land** – LID practices can be put in open space, thereby not reducing developable land

LID is Cost Effective

TRADITIONAL DEVELOPMENT	LID
$ Pay to Pipe / Pump offsite $ Risk onsite WQ violations / fines	→ Treat onsite
$ Pay to treat at end of Pipe	→ Reduced piping / pumping costs
$ Excavate, grade site and haul away materials	→ Utilize natural terrain / preserve natural channels

Ways to mimic pre-development hydrology

- Soil quality improvement (porosity)
- Native and drought tolerant vegetation
- Trees
- Permeable pavement
- Riparian buffers
- A general reduction of connected, impervious surfaces in runoff pathways
- Bioretention
- Disconnected downspouts/rain chains/rain barrels



Benefits of Rainwater Harvesting

- Minimize Pollution
  - Keep clean rainwater from coming in contact with polluted surfaces (driveways, roads, etc.). **Source control**

- Supplement Dwindling Water Supplies
  - Create/use supply of free irrigation water that is better for plants (no salt, contains sulfur, lacks calcium carbonate and magnesium – “soft”)

We're already doing it elsewhere

- Australia
- Malaysia
- Germany
- City of Tucson
- City of Santa Fe
- Case studies presented at this workshop

Eight Principles of Successful Rainwater Harvesting

(from Brad Lancaster)

- Begin with long and thoughtful observation
- Start at the top of your watershed (usually the roof) and work your way down
- Start small and simple
- Spread and infiltrate the flow of water

Eight Principles of Successful Rainwater Harvesting cont'd

- Always plan an overflow route, and manage that overflow as a resource
- Maximize living and organic groundcover
- Maximize beneficial relationships and efficiency by "stacking functions"
- Continuously reassess your system: the "feedback loop"


From Ann Riley

From Eric's Front Yard

PHOTO: RIVERSIDES STEWARDSHIP ALLIANCE

School Parking Lot, Portland OR

Riparian Buffers

- Riparian buffers

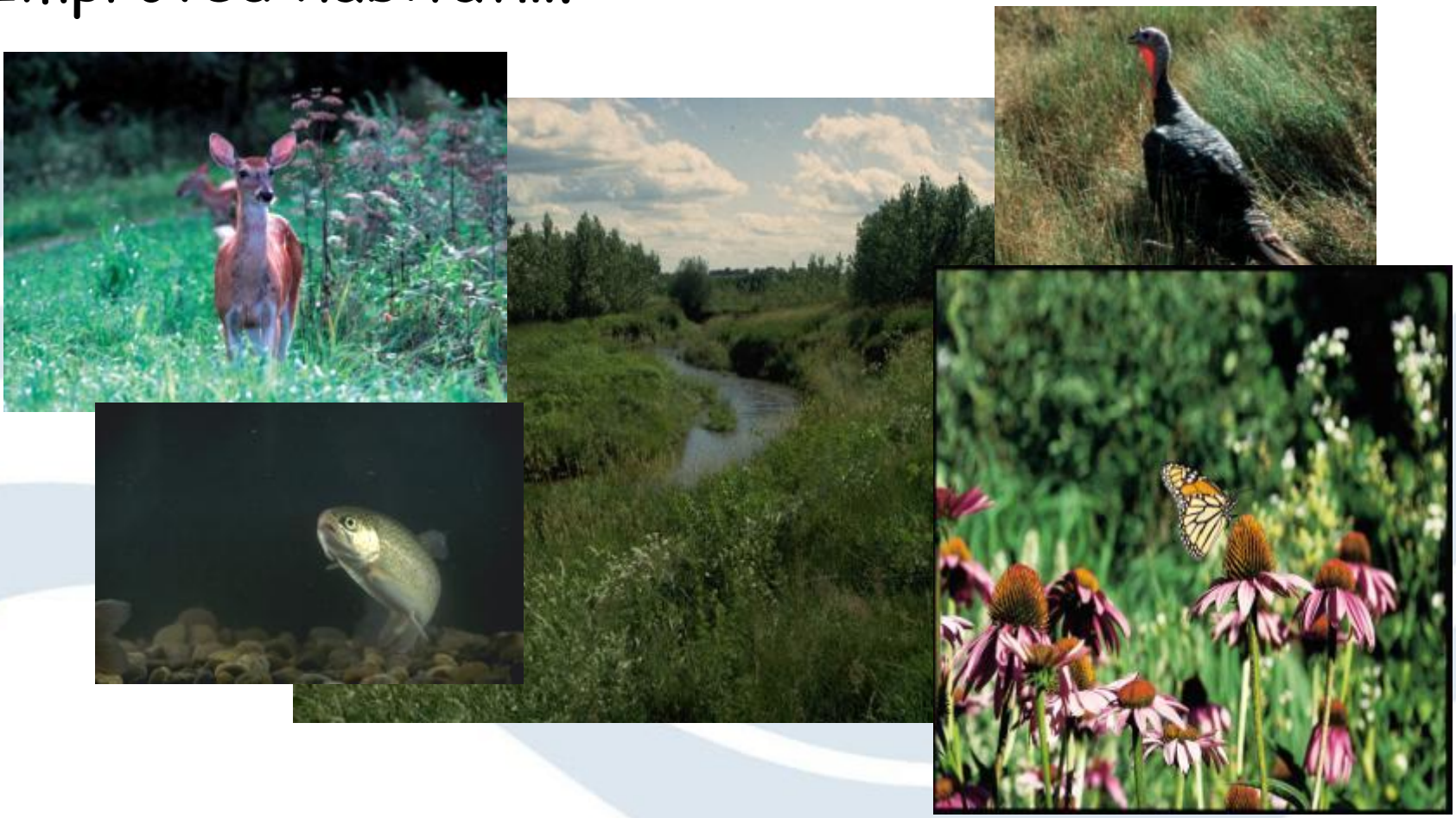
  A combination of trees, shrubs and grasses along a stream or around lakes that maintain natural hydrologic processes and filter out potential pollutants from runoff.

Riparian Buffers

- Reduced flooding and erosion

Riparian Buffers

- Improved habitat….



…for fish and wildlife

Riparian buffers in a system

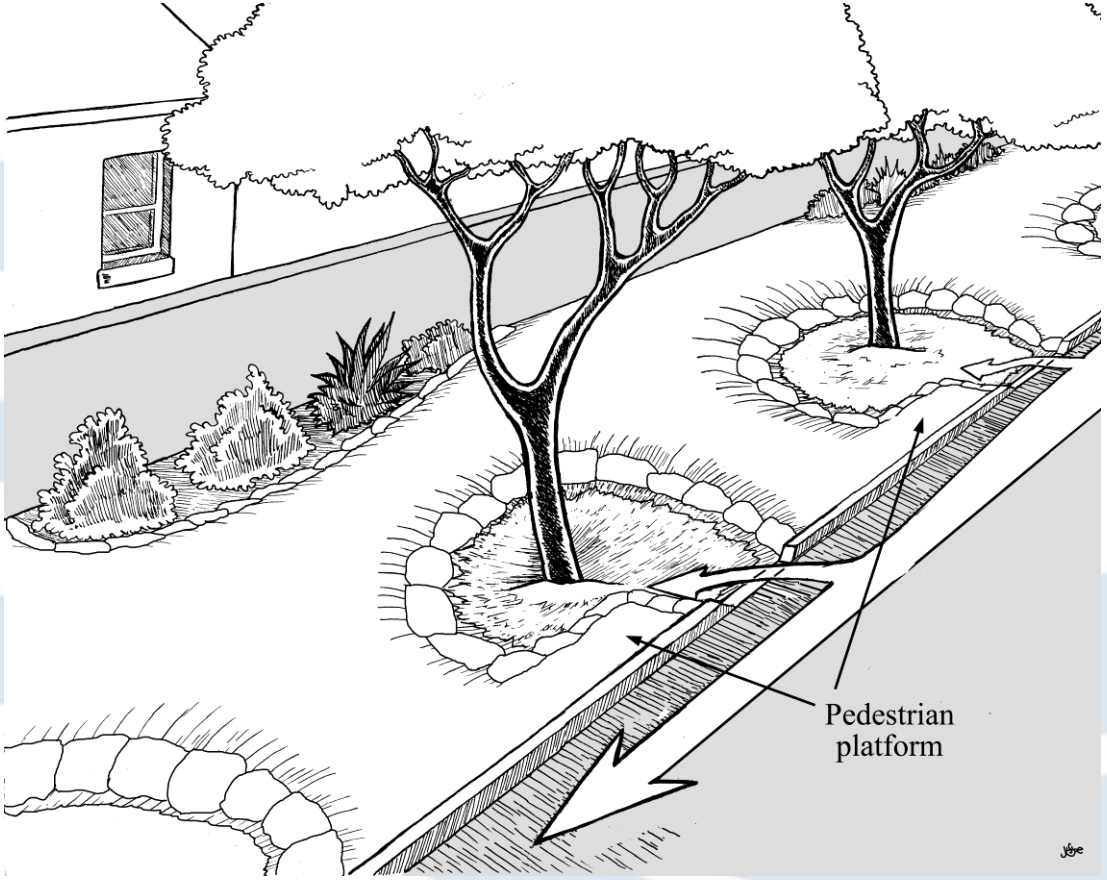
- Riparian buffers can't solve all problems alone
- Riparian buffers must be part of an integrated system

Manzanita Village

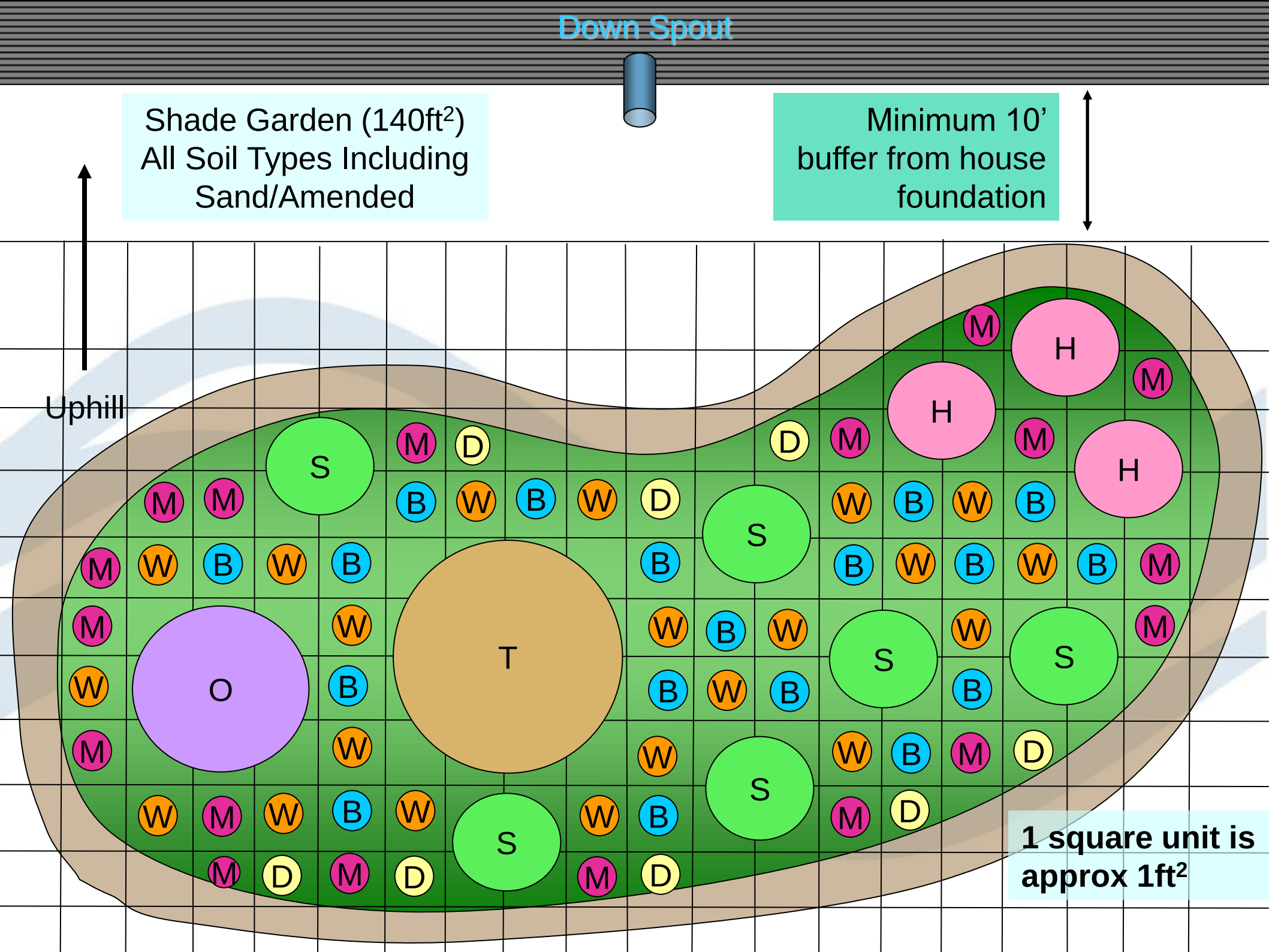
University of California Santa Barbara

Rain Gardens

Rain Gardens

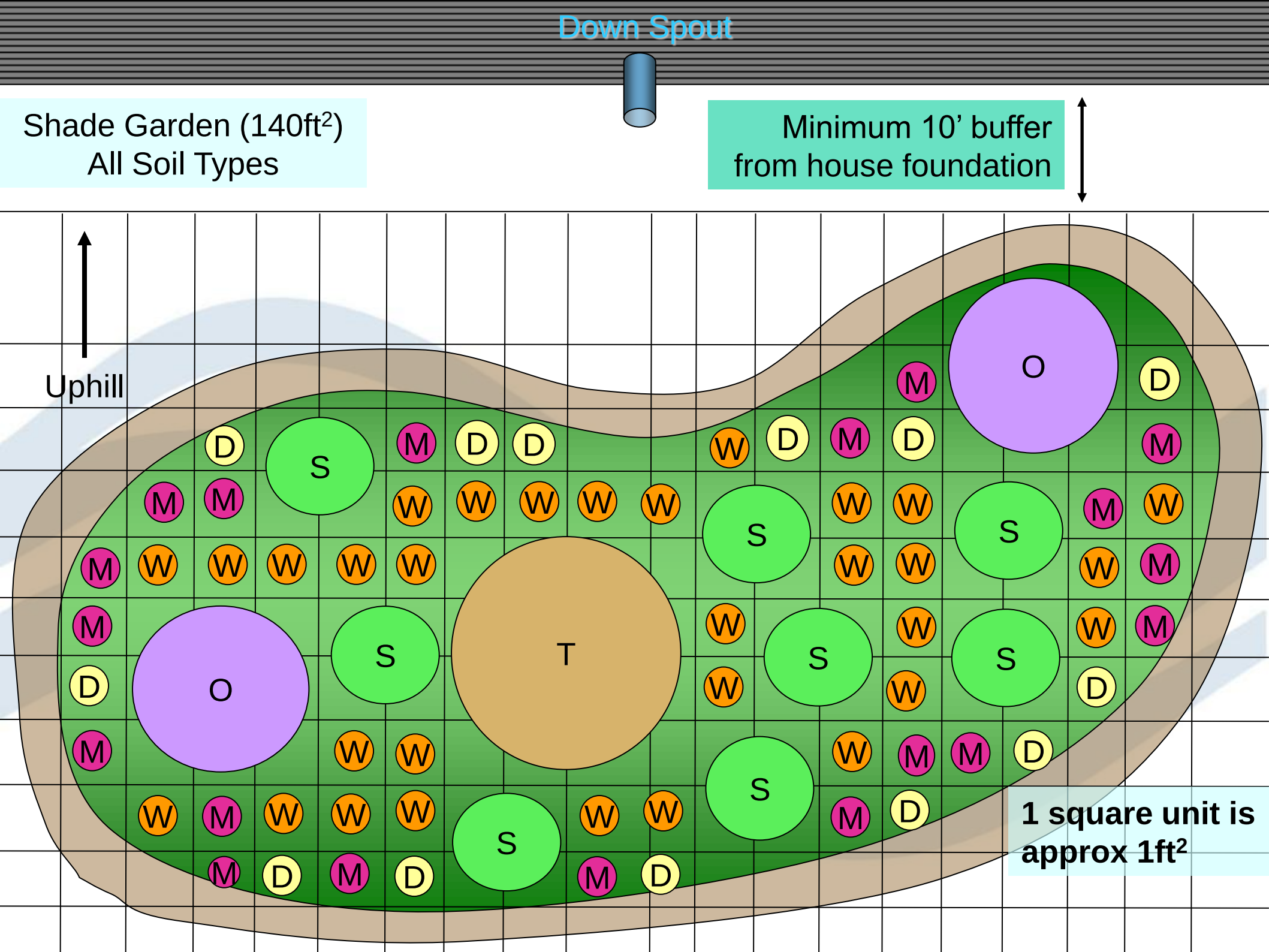


A 10’ wide paved street will drain 27,800 gallons of rainfall per mile
A 20’ wide paved street will drain 55,700 gallons of rainfall per mile
A 30’ wide paved street will drain 83,500 gallons of rainfall per mile


Down Spout
Shade Garden (140ft²)
All Soil Types Including
Sand/Amended
Minimum 10'
buffer from house
foundation
Uphill
1 square unit is
approx 1ft²

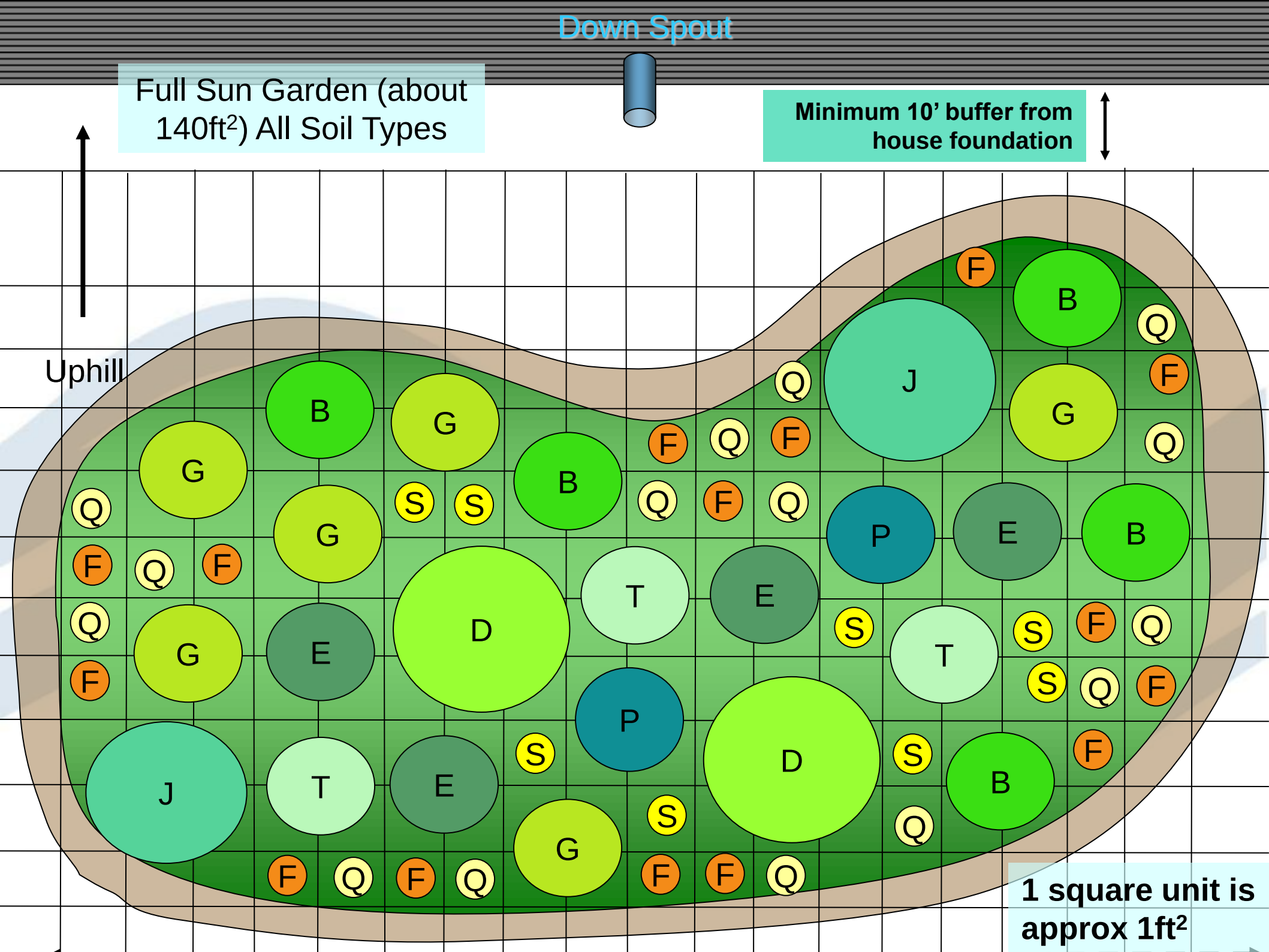
Specifications for the Shade Garden (All Soils Including Sand/Amended Soils Plants)

Symbol	Scientific Name & Common Name	Plant Count (140 ft^2 area)	Height	Soil Type/Drainage	Sunlight Requirements	Other
W	Genus: Helenium *Bigelovii* Bigelows Sneezeweed	21-25	2ft Tall	All Soil Types	Part Sun to Full Shade	Winter Dominant Forb. Can be inundated with water
S	Genus: Deschampsia *Elongata* Slender Hairgrass	6	1ft Tall	All Soil Types	Part Sun to Full Shade	Evergreen Grass. Can be inundated with water
O	Genus: Mahonia *Aquifolium* Creeping Oregon Grape	1	3ft Tall	All Soil Types	Part Sun to Full Shade	Evergreen Shrub
T	Genus: Cornus *Glabrata* Brown Twig Dogwood	1	5-18ft Tall	All Soil Types	Full Sun to Full Shade	Deciduous Shrub. Can be inundated with water
D	Genus: Oenothera *Macrocarpa* Ozark Sun Drops	8-10	.5ft Tall	All Soil Types	Full Sun to Part Sun	In high temperature climates, plant in partial shade
M	Genus: Mimulus *Cardinalis* Scarlet Monkey Flower	18-20	1ft Tall	All Soil Types	Full Sun to Full Shade	Winter dormant perennial. Scarlet flowers in summer.
H	Genus: Dicentra *Formosa* Bleeding Hearts	3-5	0.5ft Tall	Sand or Amended Soils	Full Sun to Full Shade	Winter Dominant Forb
B	Genus: Sisyrinchium *Bellum* Blue Eyed Grass	18-20	1ft Tall	Sand or Amended Soils	Full Sun to Part Sun	Evergreen Perennial Forb. Can be inundated with water


Down Spout
Shade Garden (140ft²)
All Soil Types
Minimum 10' buffer
from house foundation
Uphill
1 square unit is
approx 1ft²

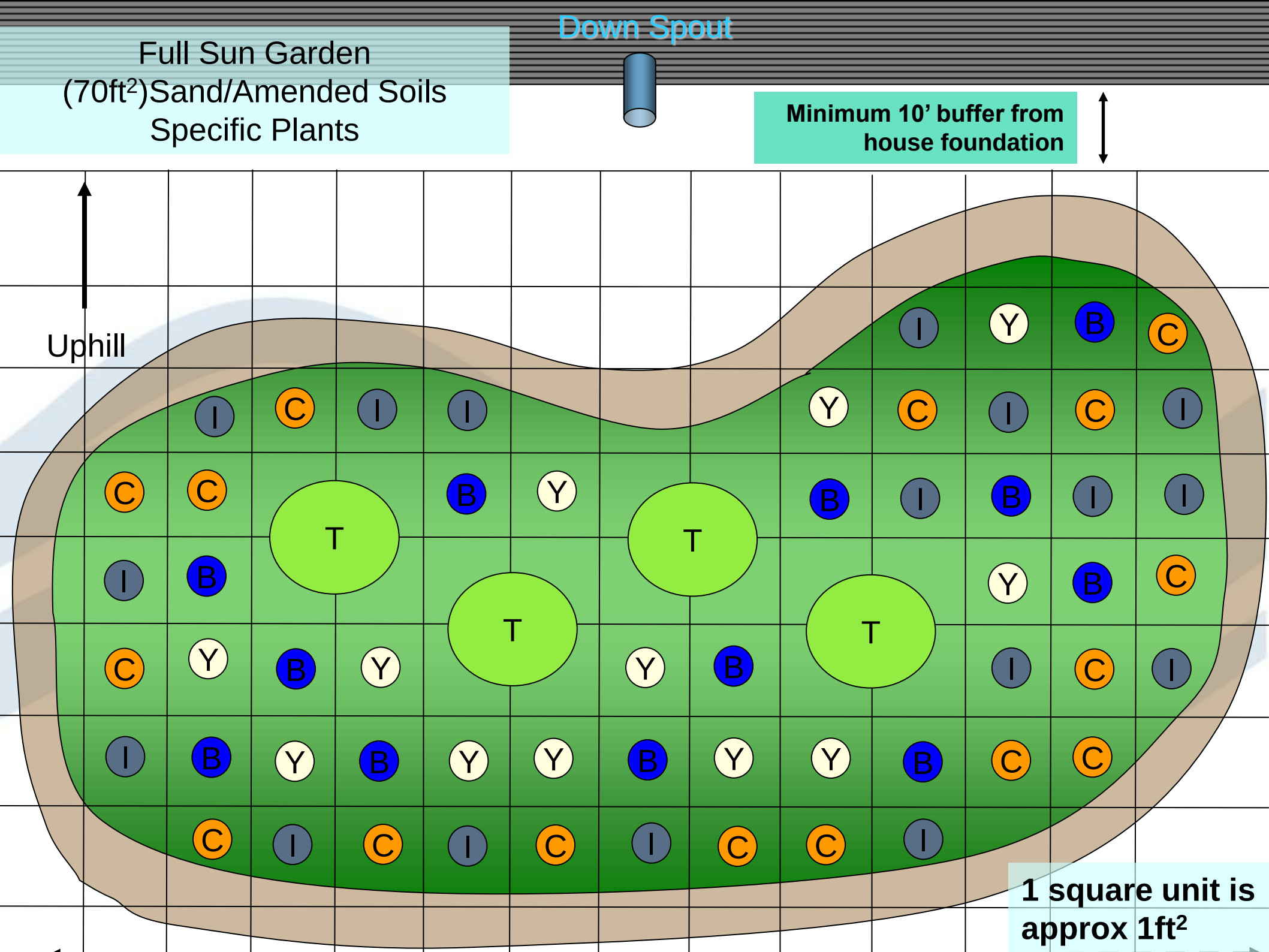
Specifications for the Shade Garden (All Soils)

Symbol	Scientific Name & Common Name	Plant Count ($140ft^2$)	Height	Soil Type/Drainage	Sunlight Requirements	Other
W	Genus: Helenium *Bigelovii* Bigelows Sneezeweed	31-35	2ft Tall	All Soil Types	Part Sun to Full Shade	Winter Dominant Forb. Can be inundated with water
S	Genus: Deschampsia *Elongata* Slender Hairgrass	8-10	1ft Tall	All Soil Types	Part Sun to Full Shade	Evergreen Grass. Can be inundated with water
O	Genus: Mahonia *Aquifolium* Creeping Oregon Grape	2	3ft Tall	All Soil Types	Part Sun to Full Shade	Evergreen Shrub
	Genus: Cornus *Glabrata* Brown Twig Dogwood	1	5-18ft Tall	All Soil Types	Full Sun to Full Shade	Deciduous Shrub. Can be inundated with water
T	Genus: Oenothera *Macrocarpa* Ozark Sun Drops	13-16	.5ft Tall	All Soil Types	Full Sun to Part Sun	In high temperature climates, plant in partial shade
D	Genus: Mimulus *Cardinalis* Scarlet Monkey Flower	19-22	1ft Tall	All Soil Types	Full Sun to Full Shade	Winter dormant perennial. Scarlet flowers in summer.
M						


Down Spout
Full Sun Garden (about 140ft²) All Soil Types
Minimum 10' buffer from house foundation
Uphill
1 square unit is approx 1ft²

Specifications for the Full Sun Garden (All Soils)

Symbol	Scientific Name & Common Name	Plant Count (140 ft² area)	Height	Soil Type/Drainage	Sunlight Requirements	Other
B	Genus: Carex *Tumulicola* Berkeley Sedge	5-7	2ft Tall	All Soil Types	Full Sun	Evergreen Grass-Like. Can be mowed to about 8".
D	Genus: Mulenbergia *Rigens* Deergrass	2-3	5ft Tall	All Soil Types	Full Sun	Evergreen Grass. Can be inundated with water. Recommend some summer irrigation to maintain appearance.
E	Genus: Juncus *Effusus* Common Rush	4-6	4ft Tall	All Soil Types	Full Sun	Evergreen Grass-Like. Requires summer irrigation. Can be inundated with water.
F	Genus: Mimulus *Guttatus* Seep Monkey Flower	15-20	1ft Tall	All Soil Types	Full Sun	Annual or winter dormant perennial. Requires summer irrigation. Yellow flowers in spring.
G	Genus: Carex *Elata* Bowles Golden Grass	6-8	2.5ft Tall	All Soil Types	Full Sun	Needs ample moisture. Will grow in standing water.
J	Genus: Koeleria *Macrantha* June grass	2	2ft Tall	All Soil Types	Full Sun	Perennial. Recommend occasional summer irrigation for appearance.
P	Genus: Juncus *Patens* Common Rush	2-3	2.5ft Tall	All Soil Types	Full Sun	Evergreen grass-like plant. Requires summer irrigation. Can be inundated with water.
Q	Genus: Potentilla *Glandulosa* Sticky Cinquefoil	15-18	2ft Tall	All Soil Types	Full Sun	Perennial. Requires summer irrigation. White to yellow flowers in spring.
S	Genus: Bidens *Laevis* Joaquin Sunflower	8-10	1ft Tall	All Soil Types	Full Sun	Annual or perennial. Requires summer irrigation. Small yellow flowers in summer. Can be inundated with water
T	Genus: Deschampsia *Caespitosa* Tufted Hair Grass	3-4	2ft Tall	All Soil Types	Full Sun	Evergreen grass. Requires summer irrigation. Can be inundated with water


Full Sun Garden
(70ft²)Sand/Amended Soils
Specific Plants
Down Spout
Minimum 10' buffer from house foundation
Uphill
T
T
T
T
1 square unit is approx 1ft²

Specifications for the Full Sun Garden (Sand/Amended Soil Specific Plants)

Symbol	Scientific Name & Common Name	Plant Count (70 ft^2 area)	Height	Soil Type/Drainage	Sunlight Requirements	Other
B	Genus: Sisyrinchium *Bellum* Blue Eyed Grass	12-15	1ft Tall	Sand or Amended Soils	Full Sun to Part Sun	Evergreen Perennial Forb. Can be inundated with water
C	Genus: Eschscholzia *E. Californica* California Poppy	16-18	<1ft Tall	Sand or Amended Soils	Full Sun	Annual or Biennial. Will stay green with summer water. Orange flowers in spring.
I	Genus: Festuca *Idahoensis* Idaho Fescue	17-20	1ft Tall	Sand or Amended Soils	Full Sun	Perennial. Recommend occasional summer irrigation for appearance
T	Genus: Deschampsia *Caespitosa* Tufted Hair Grass	4-5	2ft Tall	All Soil Types	Full Sun	Evergreen grass. Requires summer irrigation. Can be inundated with water
Y	Genus: Anemopsis *A. Californica* Yerba Mansa	12-15	.8ft Tall	Sand or Amended Soils	Full Sun	Evergreen ground cover. Requires summer irrigation. White flowers in late spring.

Examples of LID in State Board Programs

- State Board's Sustainability Resolution (Resolution 2005-0006)
- North Coast and San Francisco Bay RWQCB's Wetland and Stream Protection Policy
- State Board's Wetland and Stream Protection Policy

LID Regulatory Review

A REVIEW OF LOW IMPACT DEVELOPMENT POLICIES: REMOVING INSTITUTIONAL BARRIERS TO ADOPTION

Commissioned and Sponsored by:
California State Water Resources Control Board
Stormwater Program
And The Water Board Academy

Prepared by:
Low Impact Development Center
Beltsville, Maryland
www.lowimpactdevelopment.org

The Low Impact Development Center, Inc.