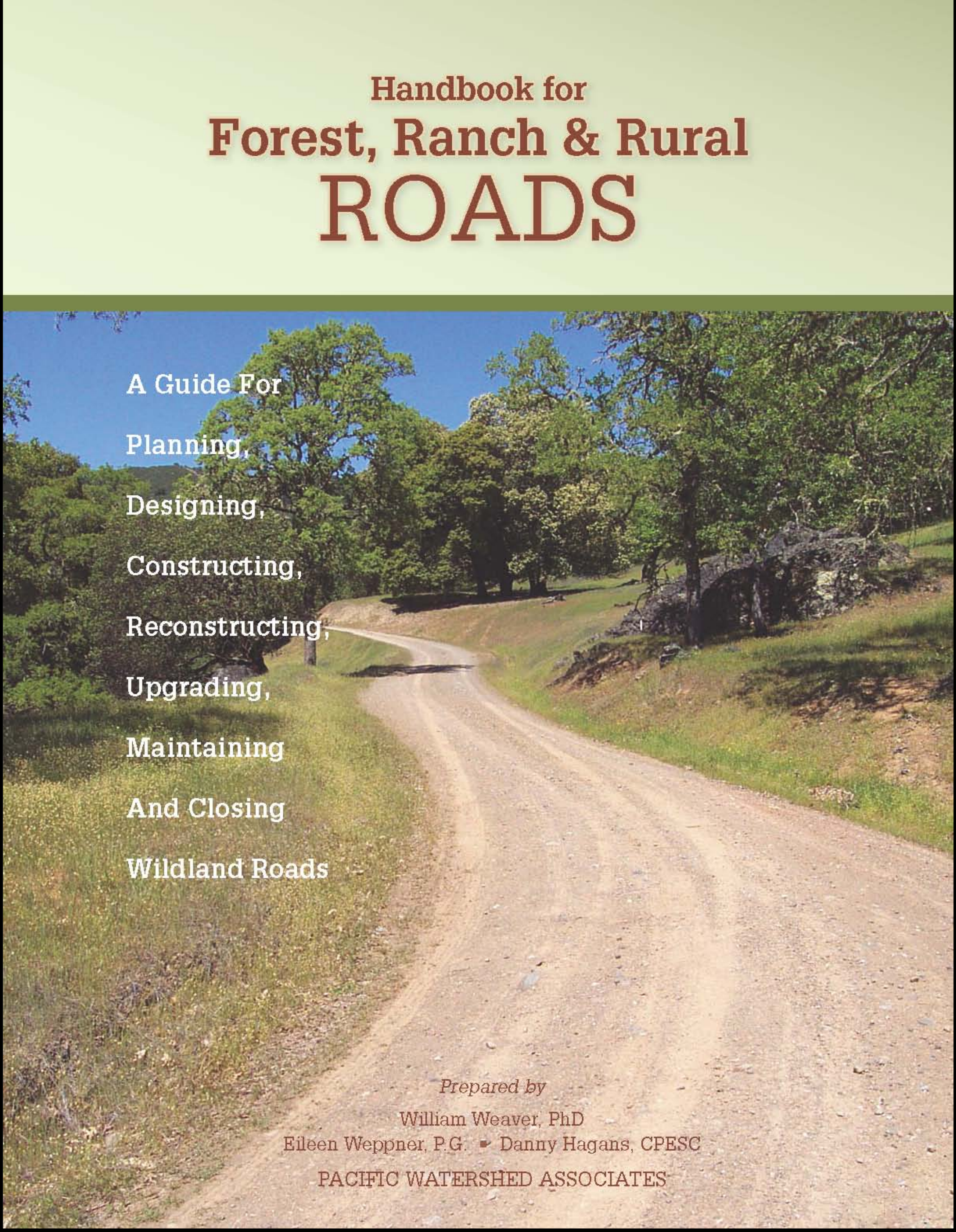
Monitoring Study Group
Willits, CA
12/18/14

Handbook for Forest, Ranch and Rural Roads:

Focus on stream crossings and hydrologic connectivity

William Weaver
Pacific Watershed Associates



Handbook for

Forest, Ranch & Rural ROADS

A Guide For Planning, Designing, Constructing, Reconstructing, Upgrading, Maintaining and Closing Wildland Roads

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FOR:
THE MENDOCINO COUNTY RESOURCE CONSERVATION DISTRICT

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'The real voyage of discovery consists not in seeking new landscapes but in having new eyes.'

Marcel Proust 1871 - 1922

CONTENTS

CHAPTER 5 CONSTRUCTION

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Part 1: Road / Crossing Techniques:

MSG Meeting

Willits, CA

December 18, 2014

2014 Road rules addressing stream crossing problems

Stream crossing work shall avoid or substantially lessen significant adverse impacts

Identify and evaluate all logging roads, landings and appurtenant roads, for evidence of significant existing and potential erosion sites, including stream crossings.

Construct/reconstruct permanent crossings to accommodate the estimated 100-year flood flow, ***including debris & sediment loads***.

Install culverts at or close to the natural grade and alignment of the natural channel, and long enough to prevent fill erosion.

Construct and maintain crossings to prevent stream diversion, and to minimize fill erosion during overtopping.

Stream crossing road rules (continued)

During crossing reconstruction or abandonment, remove or stabilize significant volumes of stored sediment to the extent feasible

At large crossing fills, or where crossing have a frequent failure history, they shall be oversized, designed for low maintenance, reinforced, or removed before the completion of timber operations

Culvert sizing - Where culverts are used, and fills are large, Cafferata et al. (2004) recommend that the diameter of the culvert be increased by 6 inches for every 5 feet of fill above the culvert on the discharge side of the crossing. (TRA #5)

Guidance on reducing the potential for failure at high risk watercourse crossings may be found in the Board's Technical Rule Addendum Number 5.

Various new standards for stream crossing abandonment (decommissioning)…

Predict, Prevent, Mitigate, Abandon, Relocate

- **Predict** – *identify at-risk crossings subject to predictable failure*
- **Prevent** – *design and apply treatments to prevent or reduce the likelihood of failure*
- **Mitigate** – *reduce the current and potential impact of stream crossing processes*
- **Abandon** – *if prevention or mitigation is not possible, consider abandonment*
- **Relocate** – *develop transportation planning that will allow for relocating access*

Identify High Risk Roads/Crossings

- A road that contains one or more existing or potential sources of sediment that:
  - Have a high potential to erode or fail
  - Contains or would generate large volumes of deliverable sediment
  - Contains or would deliver deleterious volumes or sizes of sediment during biologically sensitive periods

Predict, prevent, mitigate

Types of road storm proofing

Road Abandonment

Road Upgrading

Stream crossing types

There are three basic subcategories of both permanent and temporary stream crossings:

1) bridges and arches,
2) fords and armored fills, and
3) culverts.

Stream crossing design

Stream crossings should be designed (or redesigned) for:

- adequate fish passage (even where fish could be seasonally present),
- minimum impact on water quality, and
- to handle peak runoff and flood waters, including sediment and debris.

Reducing stream crossing vulnerability

- **Culverted stream crossings** are naturally susceptible to failure. Failures include:
  - Plugging and overtopping
  - Washout (erosion from various causes)
  - Stream diversion*
- **Bridges and fords** are usually designed to minimize failure potential

**Stream diversions cause from 2 to 10 times the volume of erosion and downstream sediment delivery (through gullying and landsliding) compared to simply eroding and washing out a stream crossing fill.*

Culverted stream crossing failures

Wash out (eroded) stream crossing

Stream diversion

Reducing stream crossing vulnerability

New culverts can be **sized** and **designed** (shaped) to reduce the risk of plugging.

In-channel and **drainage structure** treatments can be applied to new and *existing culverted stream crossings* to reduce the chance that a culvert will become plugged, with subsequent flood flows overtopping or diverting down the road.

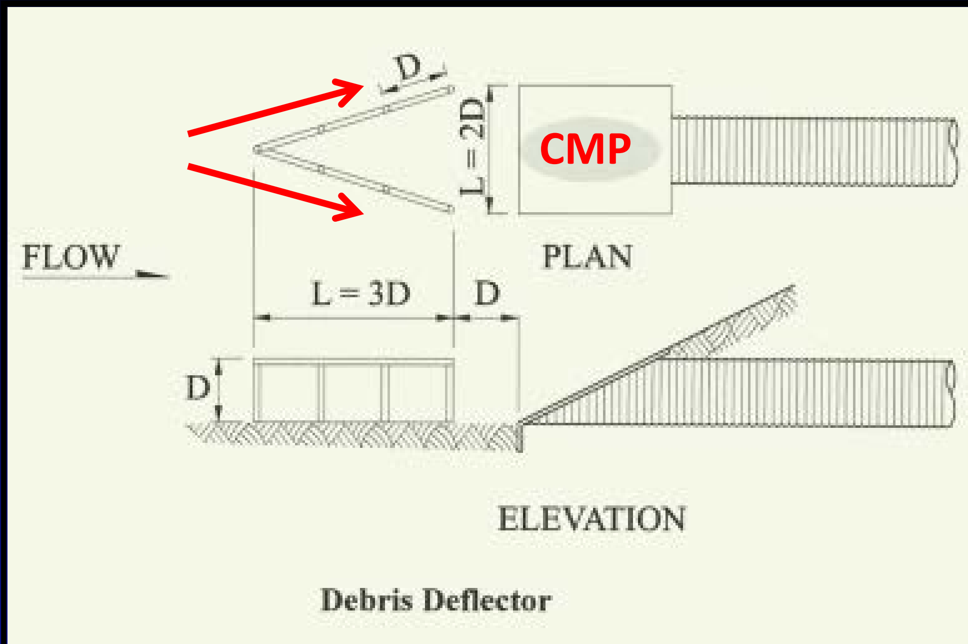
Reducing stream crossing vulnerability

Common techniques for reducing the risk of stream crossing failure:

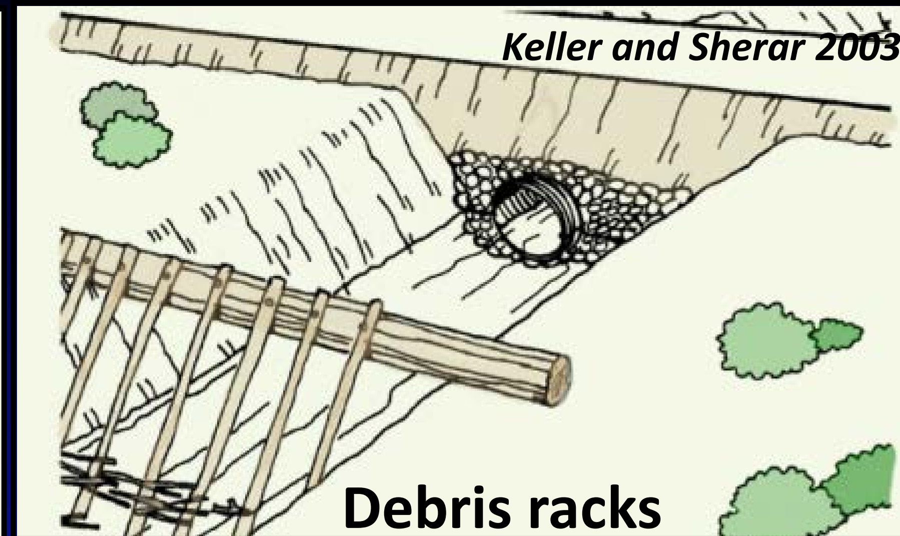
- Culvert upsizing
- Culvert widening (width and shape)
- Installing wingwalls, flared inlets, mitered inlets and/or beveled inlets
- Installing debris barriers or debris deflectors
- Installing emergency overflow culverts and/or snorkels
- Replacing the culvert with a bridge
- Decommission (abandon) the crossing

Some measures used to reduce the risk of crossing failure

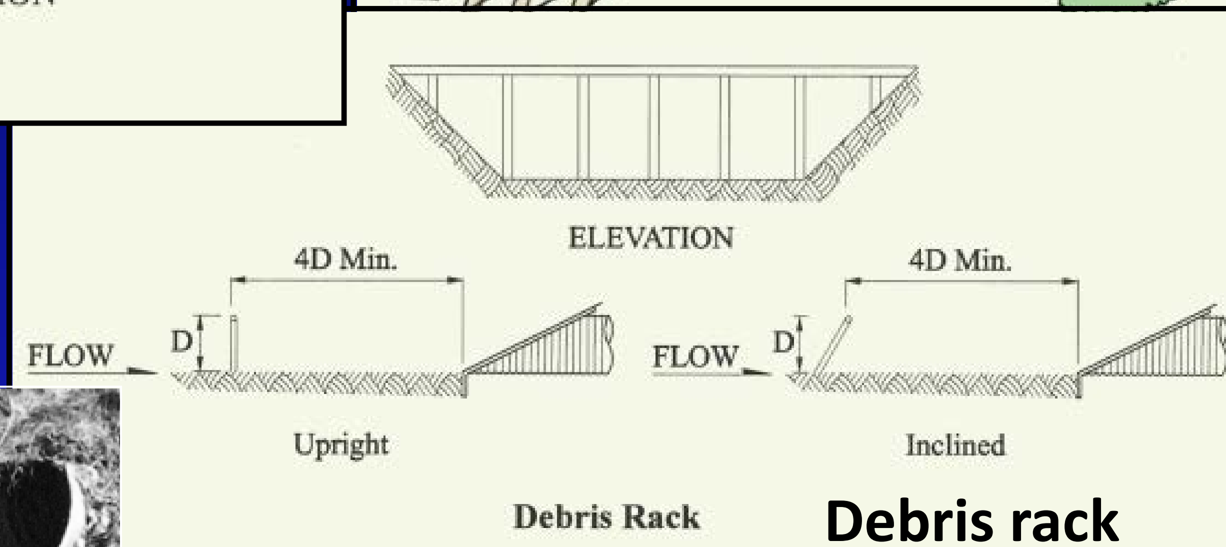
Reducing the risk of stream crossing failure



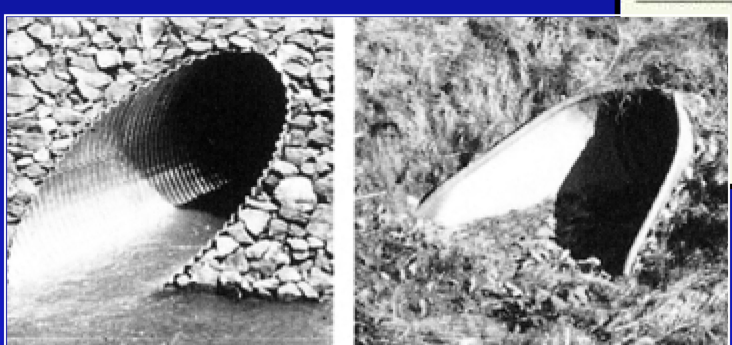
Debris deflector



Debris racks



Debris rack



Mitered and flared inlet

Reducing failure risk

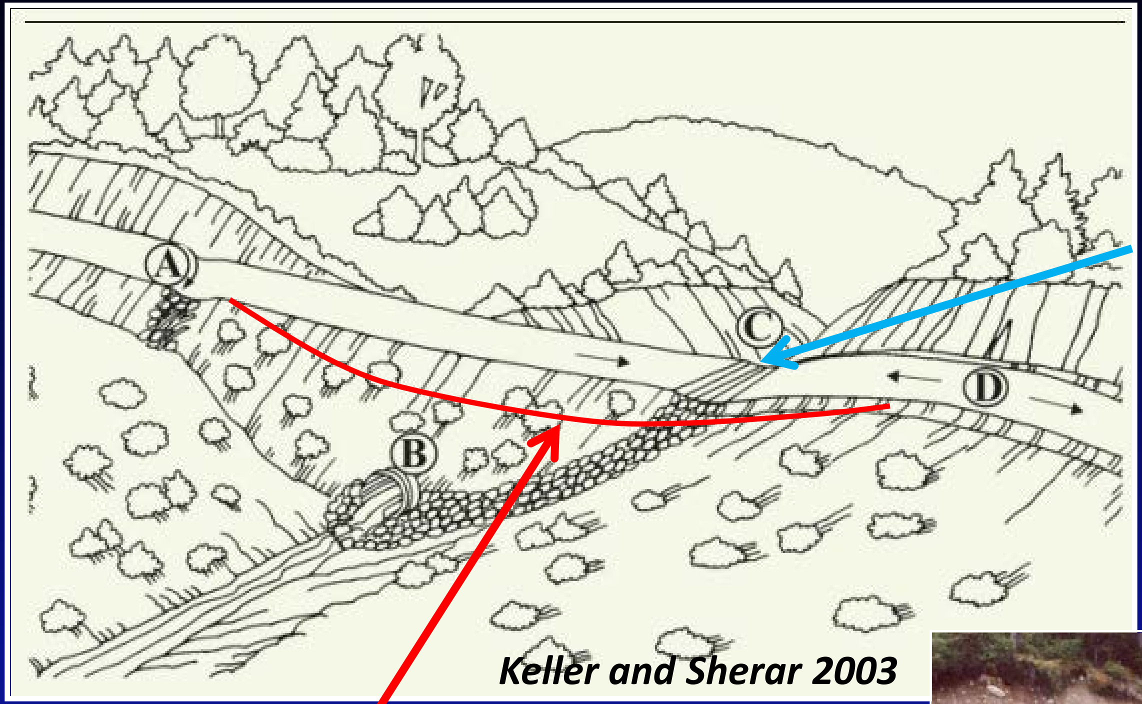
Culvert upsizing

Reducing stream crossing vulnerability

Common techniques for reducing the risk of stream diversion:

- Install a critical dip (properly designed)
- Dip the entire stream crossing fill (lower the fill)
- Install an emergency overflow culvert, with downspout

Reducing (eliminating) risk of stream diversion



Critical dip

Lowered fill

Critical dip

Predict, prevent, mitigate

Reducing stream crossing vulnerability

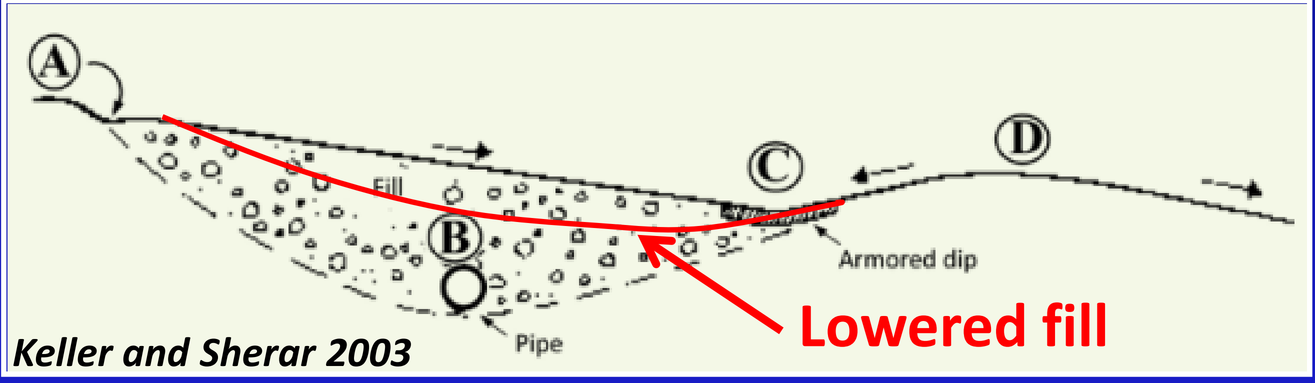
Common techniques for reducing the magnitude of stream crossing failures:

- Minimize the erodible fill volume (dip or lower the entire crossing fill)
- Minimize overtopping erosion rates (ensure overtopping occurs at a hardened or resistant location – usually the down-road hingeline)
- Armor or harden the overflow spillway (armor the axis of the overflow dip, down the fill face (used only where overtopping is common))

Reducing the magnitude of crossing failure

Reducing erodible fill volume

Reducing overtopping erosion rates



Keller and Sherar 2003

Measures of success

- Road upgrading
  - Decreased culvert plugging
  - No unexpected stream diversions
  - Lower frequency of stream crossing washout
  - Lower sediment delivery from crossing failure
  - Lower frequency and delivery from road fill failures
  - Hydrologic connectivity reduced to ≤ 10% to 20%
- Road abandonment
  - Excavated stream crossings exhibit less than 5%, preferably less than 2%, loss of erodible fill volume
  - Lower frequency & delivery from road fill failures
  - Hydrologic connectivity reduced to less than 5%

Fish passage at stream crossings

Preferred stream crossing designs for fish-bearing streams (NMFS):

- **Preferred** - No stream crossing structure (find another place for the road or decommission the existing crossing)
- Bridge (channel spanning)
- Bottomless arch, embedded culvert, embedded or high VAR vented ford (channel width with natural streambed)
- Non-embedded culvert or hydraulic design (low gradient channels only)
- **Least preferred** - On steeper gradient channels, install baffled culvert or a structure with a designed fishway.

Stable stream crossing fills

Designing stable stream crossing fills:

- Avoid clay rich or cohesionless soils
- Fills should be compacted during optimal moisture content (moist) in 6” to 12” lifts; Fill face compaction is achieved through excavation of the compacted fill
- Vibratory rollers are used for low cohesion soils, sheeps foot rollers for cohesive soils, and mechanical tampers for cohesive soils along the culvert bed and flanks; *Field compaction* using rubber tired equipment and dozer tracking may be acceptable under ideal moisture conditions
- Strive for fillslope angle less than 1½:1, preferably 2:1 or less, or buttress/armor the slope
- Revegetate fillslopes, divert road surface runoff, and armor culvert outlet and fillslopes where necessary (steep fillslopes)

Stable stream crossing fills

Vegetated 2:1 fillslope with extended culvert outlet and minimal armor

Armored 1:1 fillslope, with dense internal compaction, on steep Class III channel

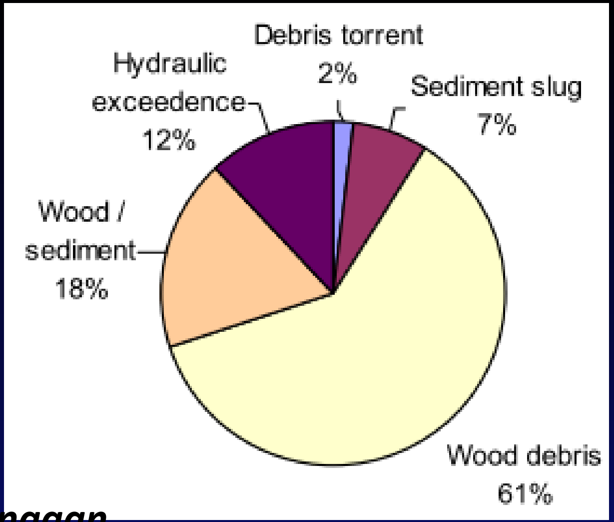
Predict, prevent, mitigate

Stream crossing culverts

- **Culvert materials**: steel, aluminum, plastic (HDPE), concrete
- **Durability**: abrasion, corrosion
- **Sizing**: Rational, USGS Magnitude and Frequency, Flow transference
- **Alignment and length**: vertical, horizontal
- **Debris treatments**: Debris rack (barriers and screens), debris deflectors, snorkels and risers
- **Inlet treatments**: mitered inlet, tapered inlet, flared inlet, beveled inlet, slope collars, headwalls, snorkels, risers
- **Emergency overflow culverts:** sizing and design

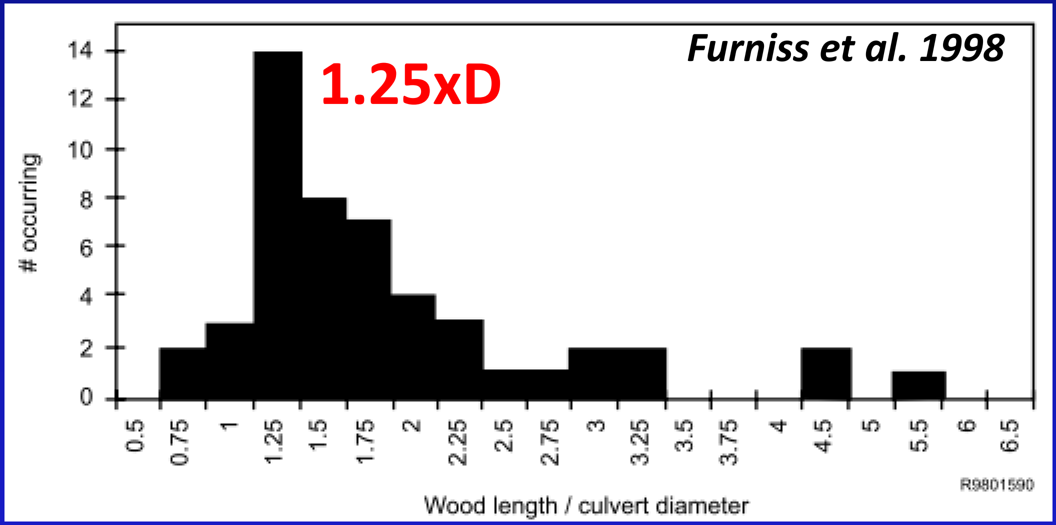
Predict, prevent, mitigate

Sizing culverts for peak flows,
…including sediment and debris



Flanagan

- Increase culvert diameter to account for debris (so HW/D = 0.67) (per Cafferata, et al. 2004)
- Install a wider culvert (oval or arch)
- Install flared or mitered inlet
- Install tapered inlet
- Install trash barrier or deflector
- Install overflow culvert or snorkel
- Install arch or bridge



Other stream crossing structures

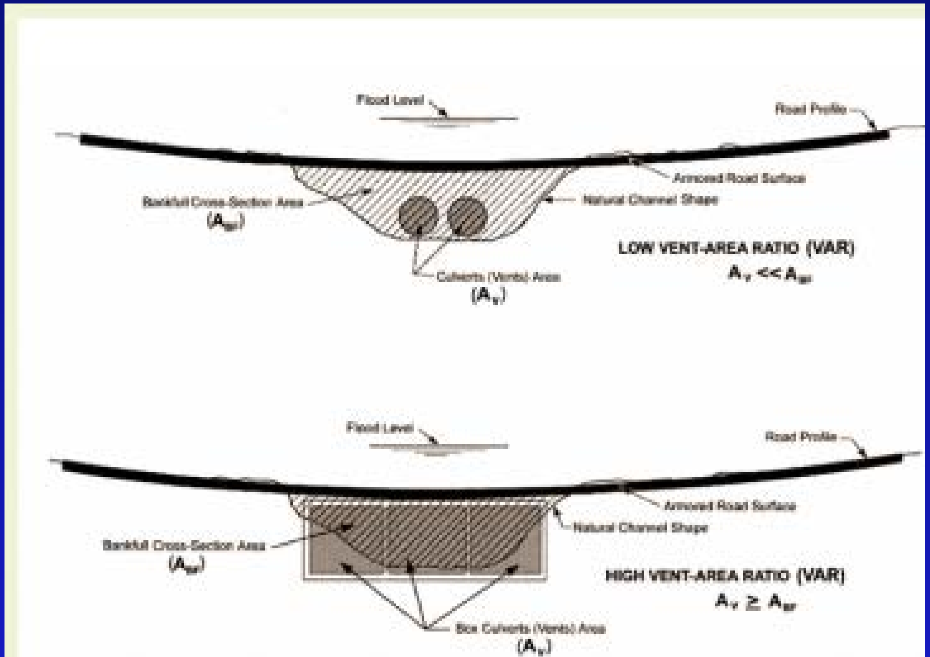
- Bridges: Log stringer (no longer common), I-beam (engineered), truss (Bailey)(up to 200’), and rail car (up to 90’)
- Armored fills and vented fills
- Fords (native), hardened fords, and vented fords
- Temporary stream crossings (fill, culverted fill, log, and bridge)

Other stream crossing structures

Other stream crossing structures

I-beam bridge


Armored fill



Vented ford

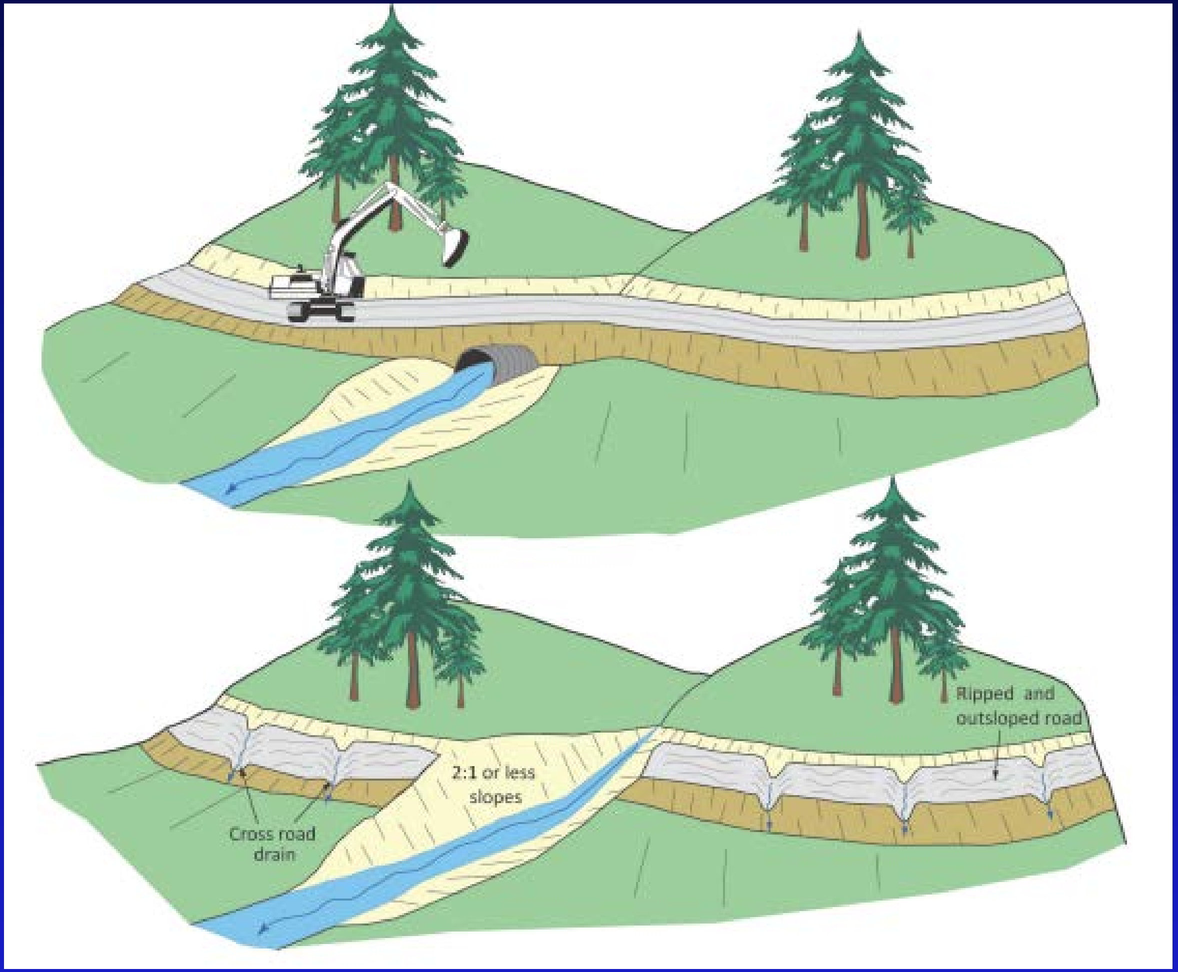
(Keller and Ketcheson, 2012)


Armored ford

Abandon, relocate

If you cannot prevent or mitigate a stream crossing threat, then one option is to abandon and relocate it.

Stream crossing abandonment



Abandon, relocate

Abandon, relocate

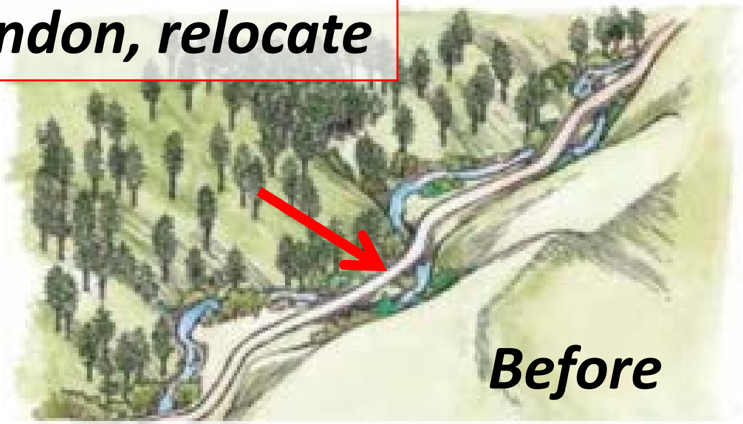
Stream crossing abandonment

Before

After

Abandon, relocate

Riparian

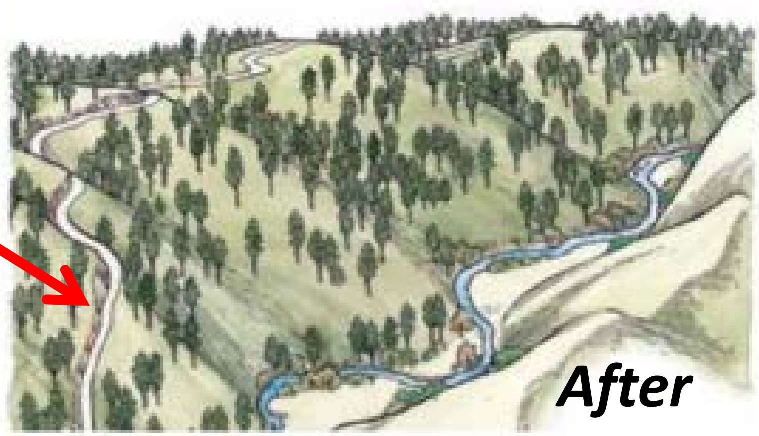


Unacceptable option: Roads should not be built or reconstructed next to stream channels where multiple crossings are required. Many older roads may have been built in these locations and they are expensive to maintain and can greatly impact the stream. Whenever possible, these roads should be decommissioned and moved to more favorable locations.

Inner gorge

Least preferred option: Roads built on steep or inner gorge slopes near streams should be avoided if possible. If not, they may require special construction techniques, such as full bench endhauling. Roads will require high maintenance and slopes in these areas may be unstable and prone to road failures that impact streams.

Ridge



Preferred option: Roads should be aligned to take advantage of benches, low gradient slopes, upper hillslope areas and ridges. Generally, roads in these locations will be farthest from streams, have the fewest stream crossings, cost less to construct, be easier to drain, and require less maintenance.

(Modified from Adams and Storm, 2011)

Predict, Prevent, Mitigate, Abandon, Relocate

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Part 2: Road Drainage and Hydrologic Disconnection

MSG Meeting

Willits, CA

December 18, 2014

Long term road drainage

"When considering road prism design, it is impossible to overemphasize the importance of drainage in maintaining stable roads and protecting water quality."

Handbook for Forest, Ranch and Rural Roads

Road drainage effectiveness

A road drainage system must satisfy two main criteria if it is to be effective throughout its design life:

1) It must allow for a minimum of disturbance of the natural drainage pattern.

2) It must drain surface and subsurface water away from the roadway and dissipate it in a way that prevents excessive collection of water in unstable areas and subsequent downstream erosion.

FAO, 2014

Characteristics of effective road drainage

- Invisibility and minimum effect on hillslope hydrology (surface and subsurface)
- Permanence and resiliency to flood events
- Minimal effect on erosion, landsliding and sediment delivery to streams, lakes, & wetlands
- Minimal effect on water quality and aquatic habitat
- Self maintaining features or drainage features requiring minimal maintenance
- User safety, drivability, easy maintenance, and long term cost-effectiveness

Long term road drainage

Road drainage includes:

1) **hillslope drainage** (including drainage from large springs, gullies and streams which cross the road alignment), and
2) **road surface drainage** (including drainage which originates from the cutbank, road surface and fill slope).

Definition:

A Hydrologically-Connected Road is:

Any road segment that has a continuous surface flow path between any part of the road prism and a natural stream channel during a 'design' runoff event.

(Furniss et al., 2000)

Hydrologic Connectivity concepts

- Hydrologic connectivity refers to the length or proportion of a road or road network (or bare soil area) that drains runoff directly to streams or other water bodies during the design event.
- A suitable "design" runoff event has been suggested to be the ***1-year, 6-hour storm***, with antecedent moisture conditions corresponding to the wettest month of the year.
- Roads increase connectivity compared to undisturbed hillslopes

Hydrologic Connectivity

(direct sediment delivery)

Designing, upgrading, and maintaining roads to minimize hydrologic connectivity and protect water quality

Roads and Surface Erosion:

Road Surface, Cutbank

and Ditch Erosion

Identifying the problem:
Hydrologically connected surface erosion

- Bare soils areas only
- Greatest in fine granular soils
- Delivers fine sediment
- Sediment moves short distances, unless channeled in rills, gullies or ditches
- *Delivery requires connectivity to streams*
- Small at site level; but may be large in a watershed

What to look for… *(identifying connectivity)*

- Road surface and/or ditch draining into or leading to a stream crossing drainage structure inlet or outlet;
- Evidence of surface flow between the drainage structure outlet and a natural stream channel/flood prone area;
- A channel or gully that extends from a road drainage structure outlet to the high water line of a defined channel or a flood prone area;
- A sediment deposit that reaches the high water line of a defined channel or a flood prone area;
- Observation of turbid water reaching the watercourse during runoff events; or
- Indications of channel widening and/or incision below a drainage structure resulting from increases in flow.

TRA #5

Road surface erosion is caused by mechanical abrasion and poor road surface drainage…

Sedimentdelivery occurs where the road prism, including road surfaces and ditches, are “hydrologically-connected” to stream channels

Symptoms, examples and evidence of poorly drained and/or hydrologically connected roads

Pot holes – poor road drainage

Road Surface Erosion

Road Surface Erosion

Road Surface Erosion

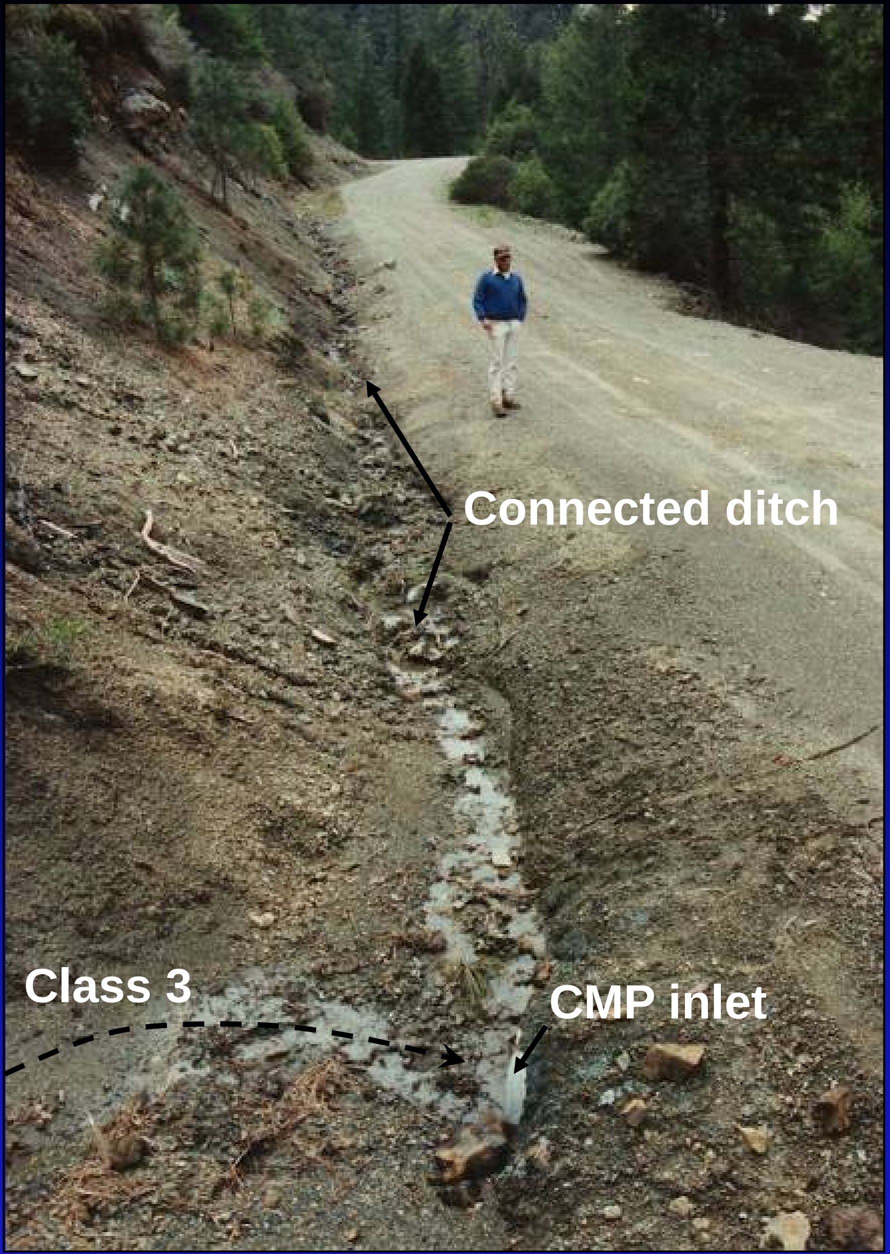
Road Surface: Mechanical Abrasion

Hydrologically Connected Road Surfaces and Ditches

Road surfaces and eroding cutbanks feed active ditches…

Classical Road Drainage Engineering:

Connected Road, Cutbank and Ditch



Connected!

Turbid inside ditch on insloped road

Intentionally Connected Road Surface

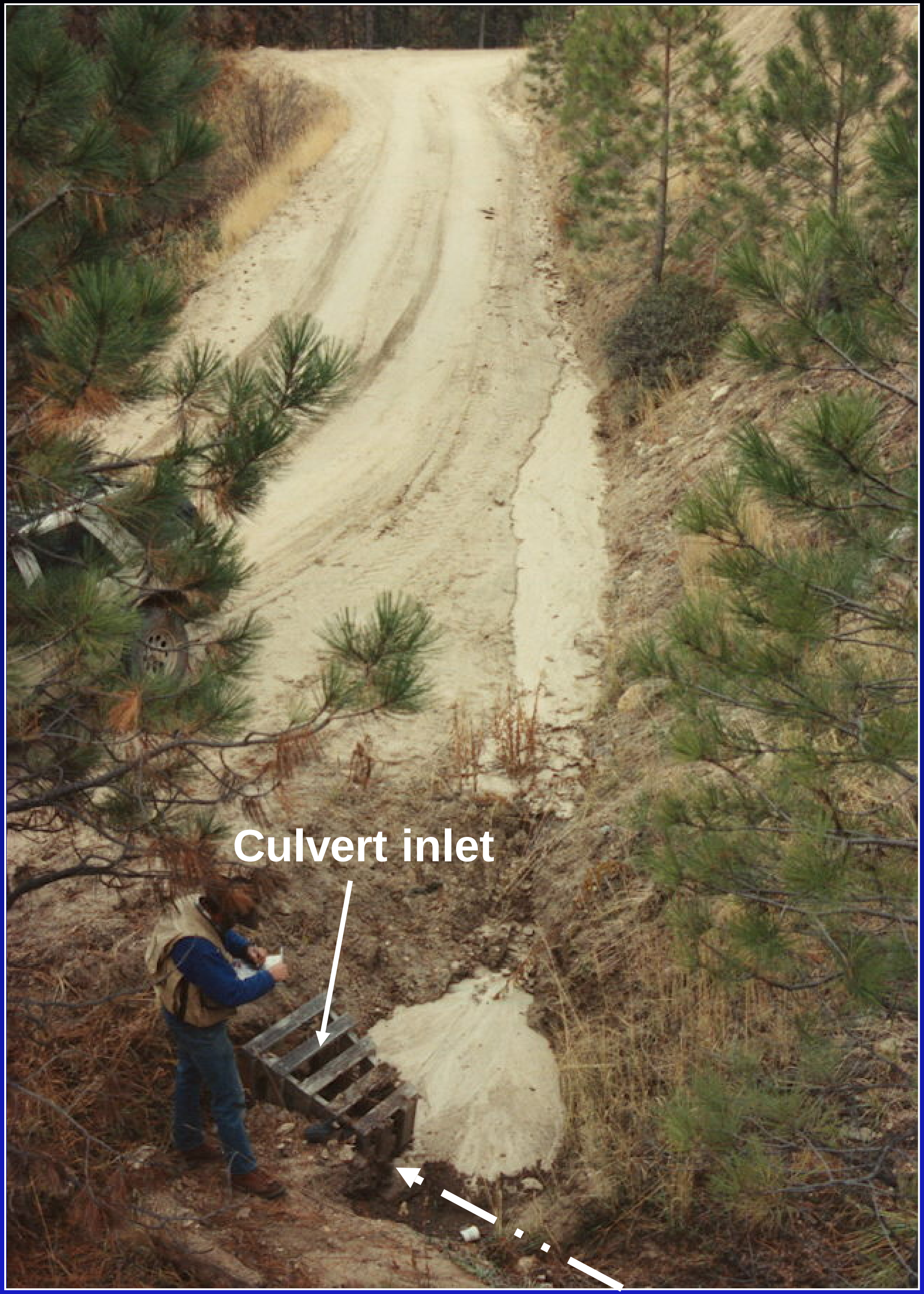
Ford with connected approaches

Fine sediment discharge from road surfaces

Hydrologic Connectivity of Roadside Ditches

Hydrologic Connectivity
Delivery from road surfaces and ditches

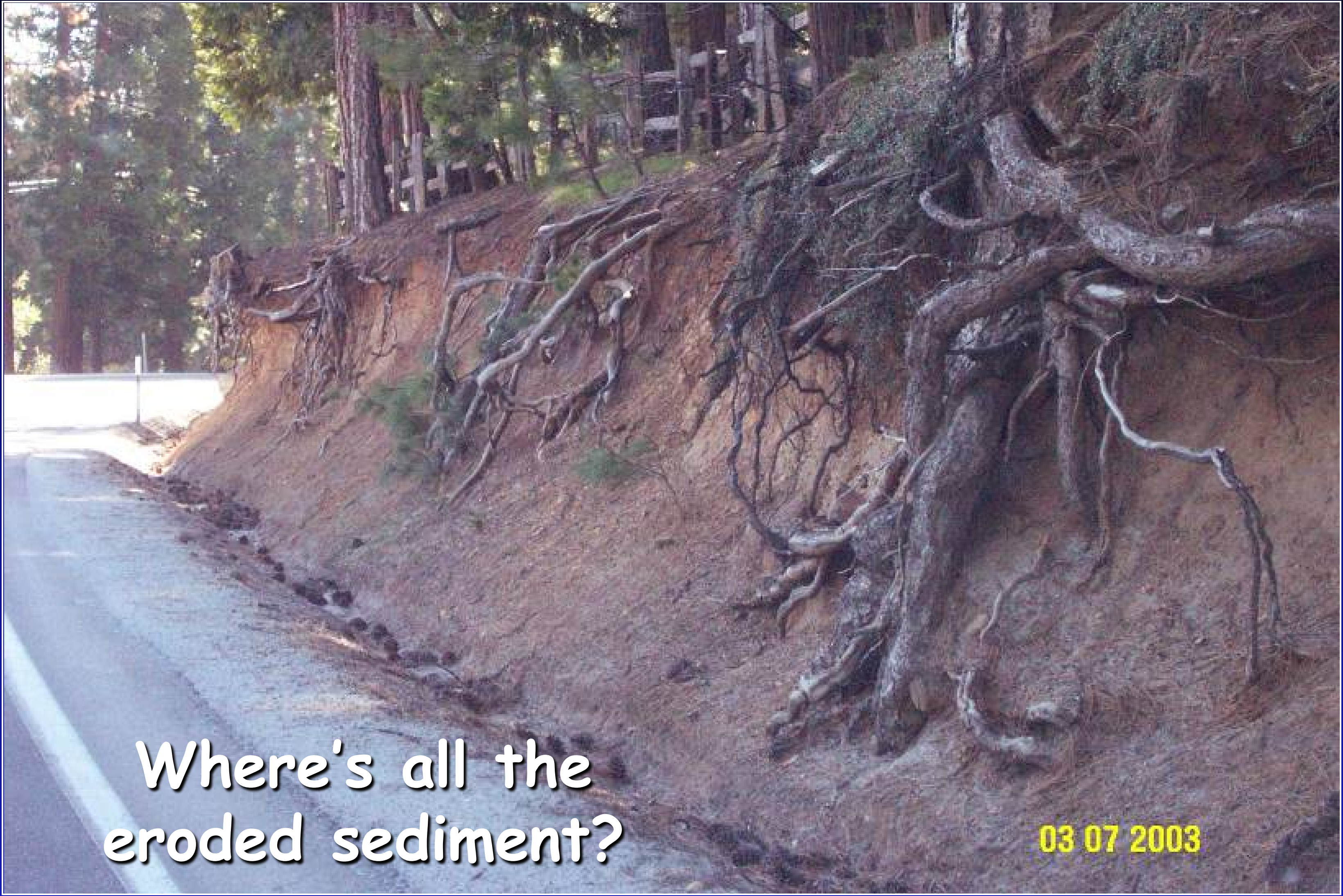
Sedimentation from Connected Ditch



Connected!

Cutbank erosion:
Is there sediment delivery?

Cutbank Erosion



Ditch Relief Culvert: Obvious Direct Connectivity

Unchanneled sheetflow connectivity from upslope ditch relief culvert

Hydrologically Connected Gullies

- Can produce both chronic and episodic erosion
- Stable gullies can still be conduits for road sediment delivery
- Gullies are very efficient delivery mechanisms
- Gullies in rocky soils usually self-armor
- Gullies can be small…or huge

Gully erosion caused by road surface runoff

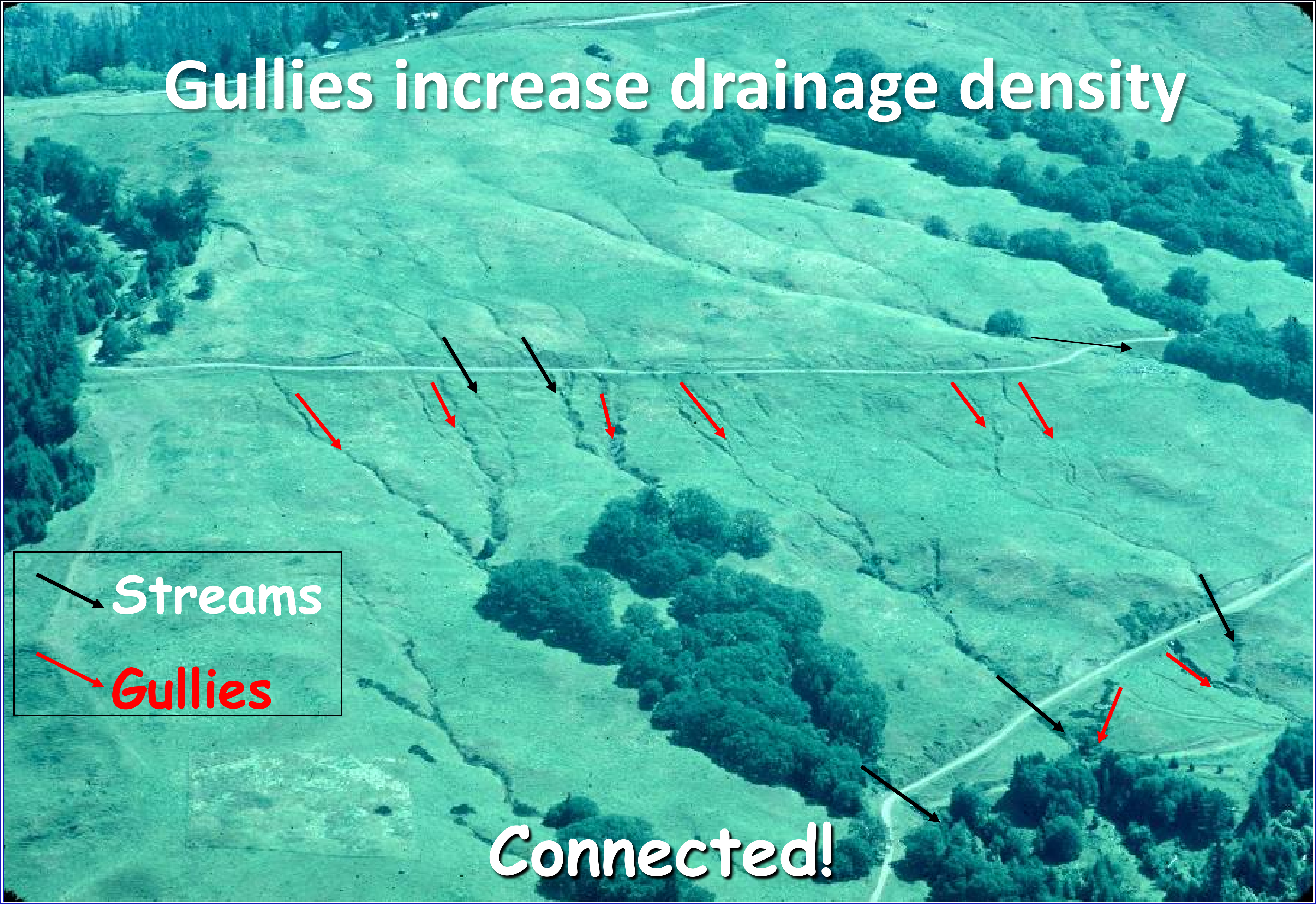
Connected!

Ditch Relief Culvert:

Connectivity through Gullies

Connectivity through Mature Gully

Gullies increase drainage density



Broad patterns of hydrologic connectivity in forested watersheds…

Example Connectivity Results

Road-stream connectivity values reported in the literature

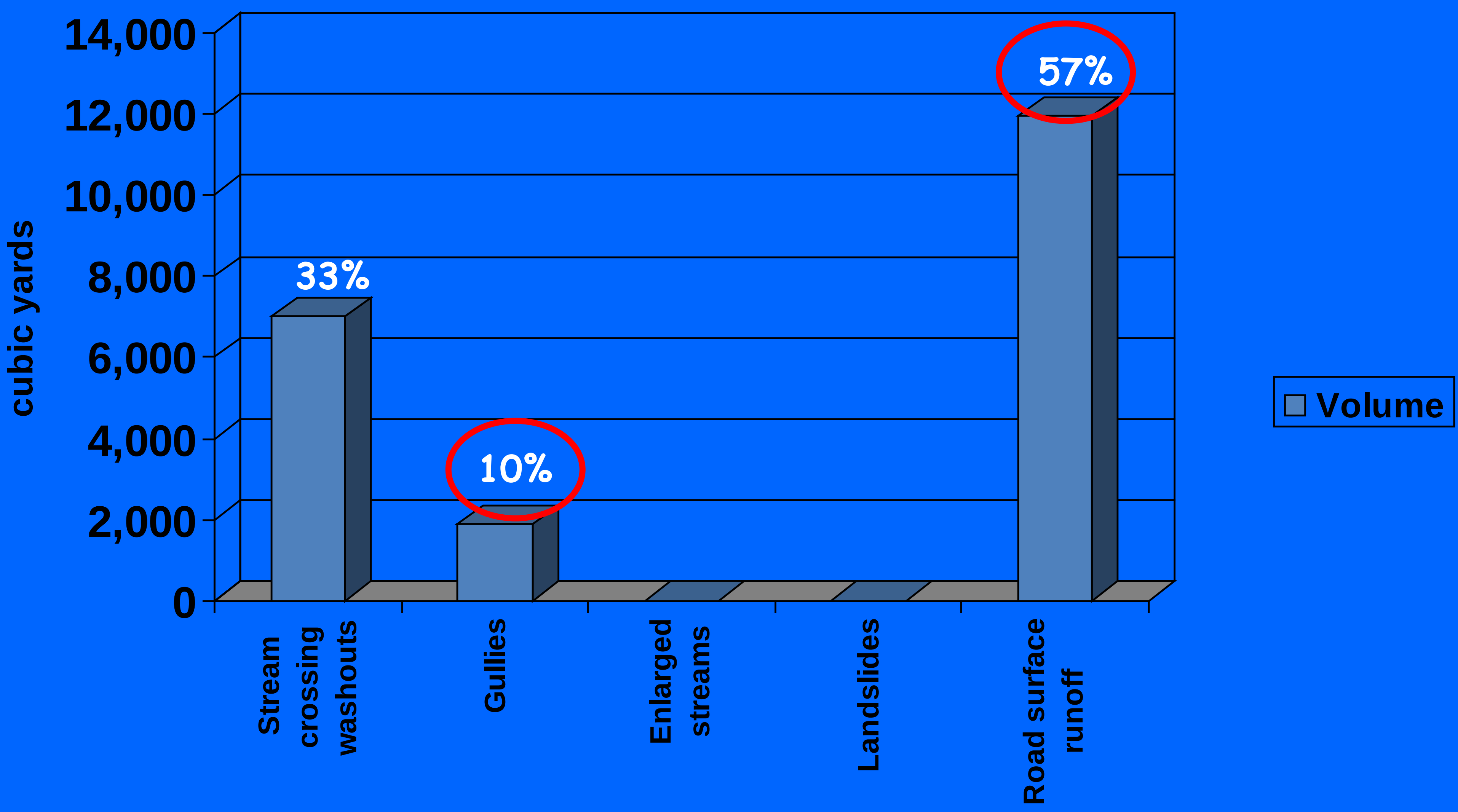
Watershed or Area	Road Length (mi)	Hydrologic Connectivity (%)	Reference
Clearwater basin, Olympic Mountains, Washington	350.0	75	Reid and Dunne, 1984[1]
Blue River, Oregon (Cascades)	38.5	57	Wemple, 1994; Wemple et al., 1996
Deschutes River, Washington	13.7	45 - 57	Bowling et al., 1996; Bowling & Lettenmaier, 2001
Kilchis watershed, Oregon (Coast)	117.0	25 - 39	Mills, 1997
Oregon – All 5 Geo-Regions	285.0	25 - 31	ODF, 1996; ODF, 1998
Bear Creek, North Coastal California	15.9	28 - 35	PWA, 1998
Southwest Washington; Northern Oregon Cascades	453.0	34	Bilby et al., 1989
North Coastal California watersheds	518.0	33 (6-74)	PWA (unpubished)
Central Sierra Nevada, California	12.4	20	Coe & MacDonald, 2001
Total and mean values	1,803	42%	

“Inventoried” Sediment Delivery from “Hydrologically Connected” Roads over the next decade

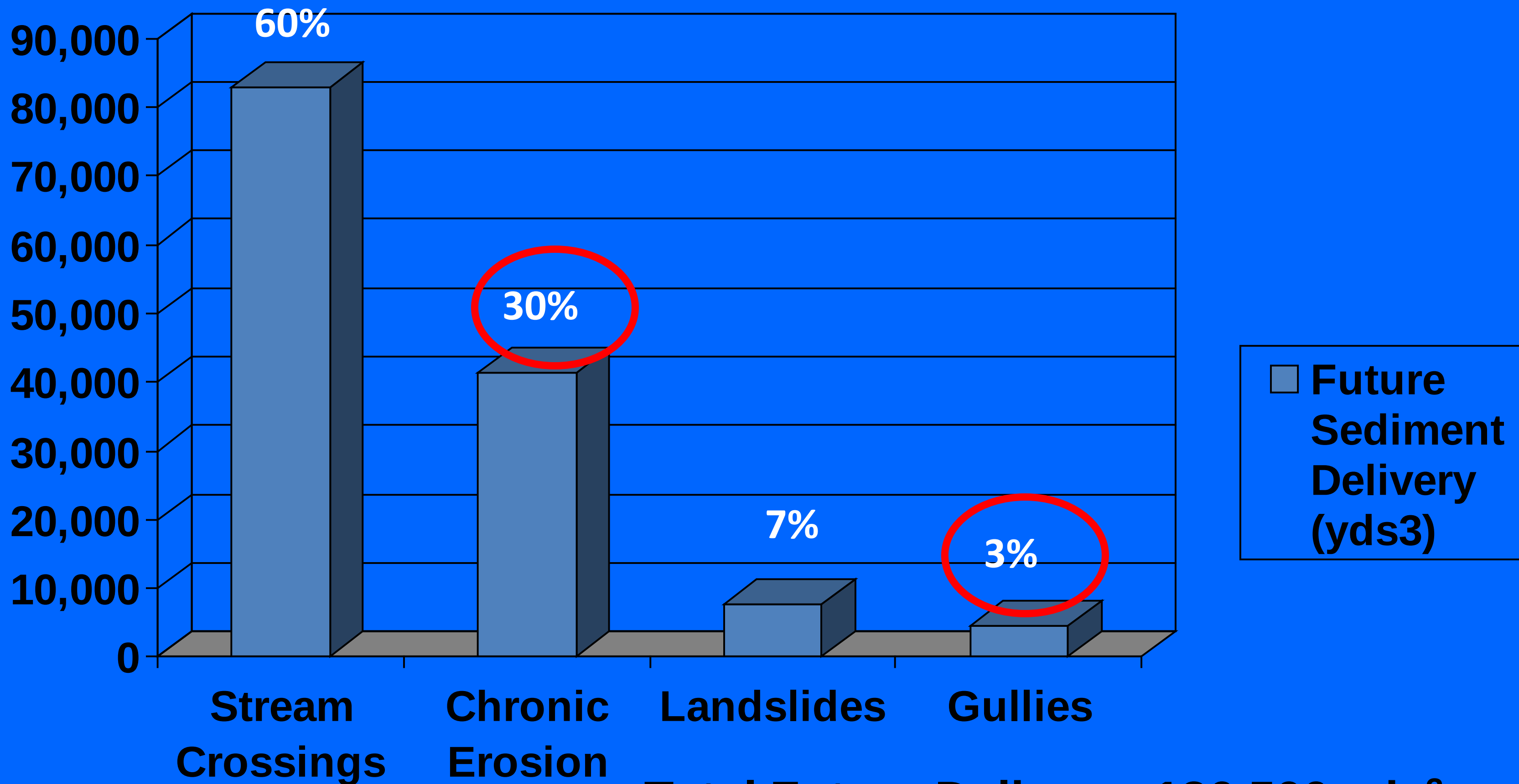
Project Area[1]	Watershed	County	Total Miles of Road	Total Sediment Delivery (yds³)	Total Road Connectivity Delivery (yds³)	Road Connectivity: % of Total Delivery
Biscuit Fire	Rogue	Siskiyou	135	389,000	101,000	*26%*
Wilson Creek	Klamath	Del Norte	109	252,000	85,500	*34%*
Reed Mt.	S.F. Eel	Humboldt	30	28,700	17,000	59%
Woodman Creek	Middle Eel	Mendocino	25	30,500	17,500	57%
Greenfield Ranch	Russian	Mendocino	33	14,300	8,800	62%
U.C. Hopland	Russian	Mendocino	36	24,900	16,000	64%
Navarro Ranch	Russian	Sonoma	71	80,500	37,000	46%
Garrapata Association	Garrapata Creek	Monterey	21	12,400	5,900	48%
Old Coast Road	Little Sur	Monterey	11	27,000	19,900	70%
Totals:			471	859,300	308,600	36%

1) PWA data, various road assessments

Sources and amounts of sediment produced from 9.1 miles of road in the Coast Road Watershed Erosion and Restoration Planning Project, Monterey County, CA

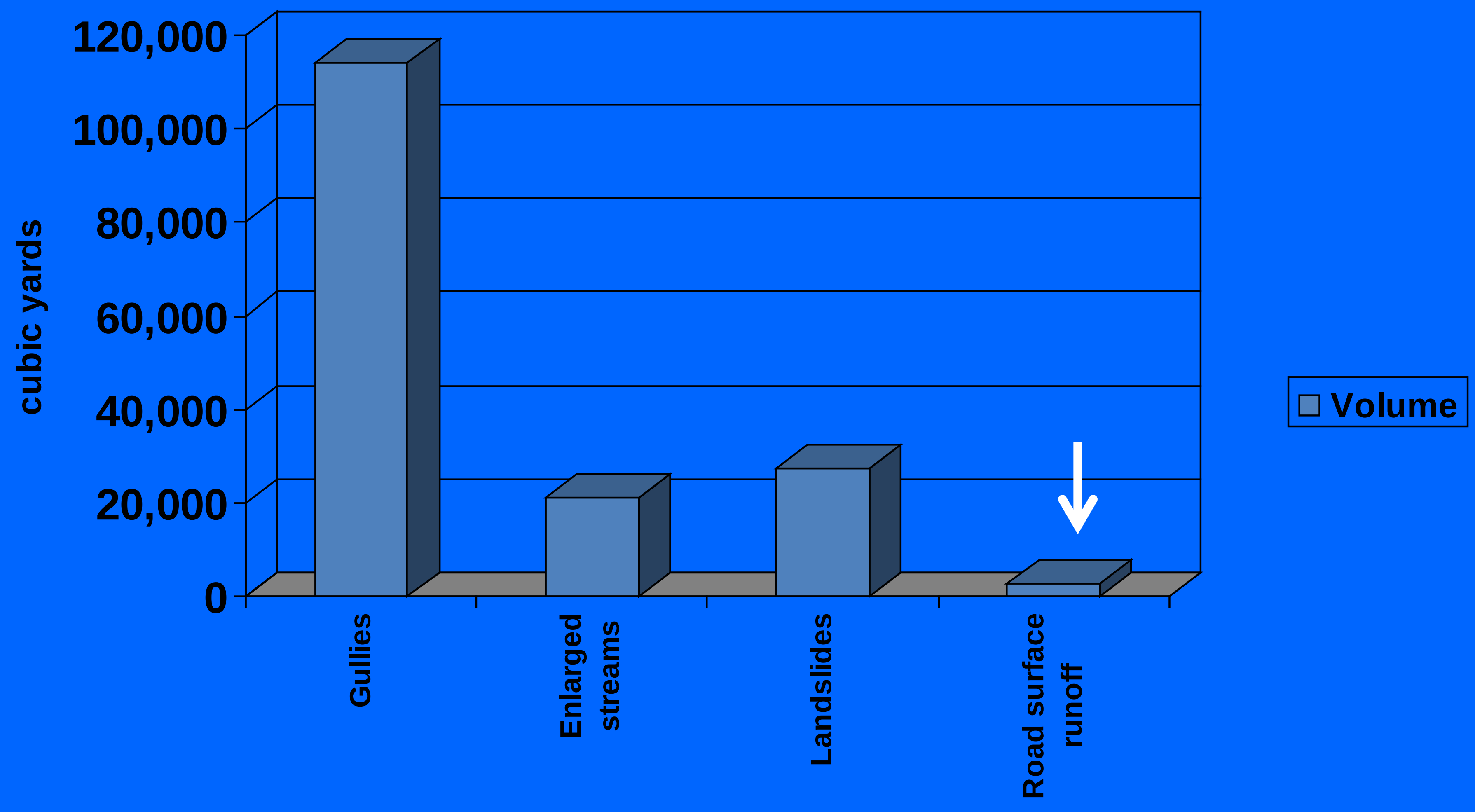


Hollow Tree Creek (20.8mi²), Future Sediment Delivery by Site Type



Total Future Delivery: 136,500 yds³

Sources and amounts of sediment produced from 6.7 miles of road in the South Copper Creek, Redwood Creek, Humboldt County, CA



Treatment of hydrologically connected roads and road reaches

Hydrologic Disconnection

The removal of direct routes of drainage or overland flow of road runoff to a watercourse or lake.

2014 Road Rules

Location, Design and Construction Road Rules

All logging roads and landings:

- Shall be hydrologically disconnected from watercourses and lakes *to the extent feasible*
- Shall be outsloped where feasible and drained with waterbreaks and/or rolling dips.
- Include adequate drainage structures and facilities necessary to prevent significant sediment discharge.

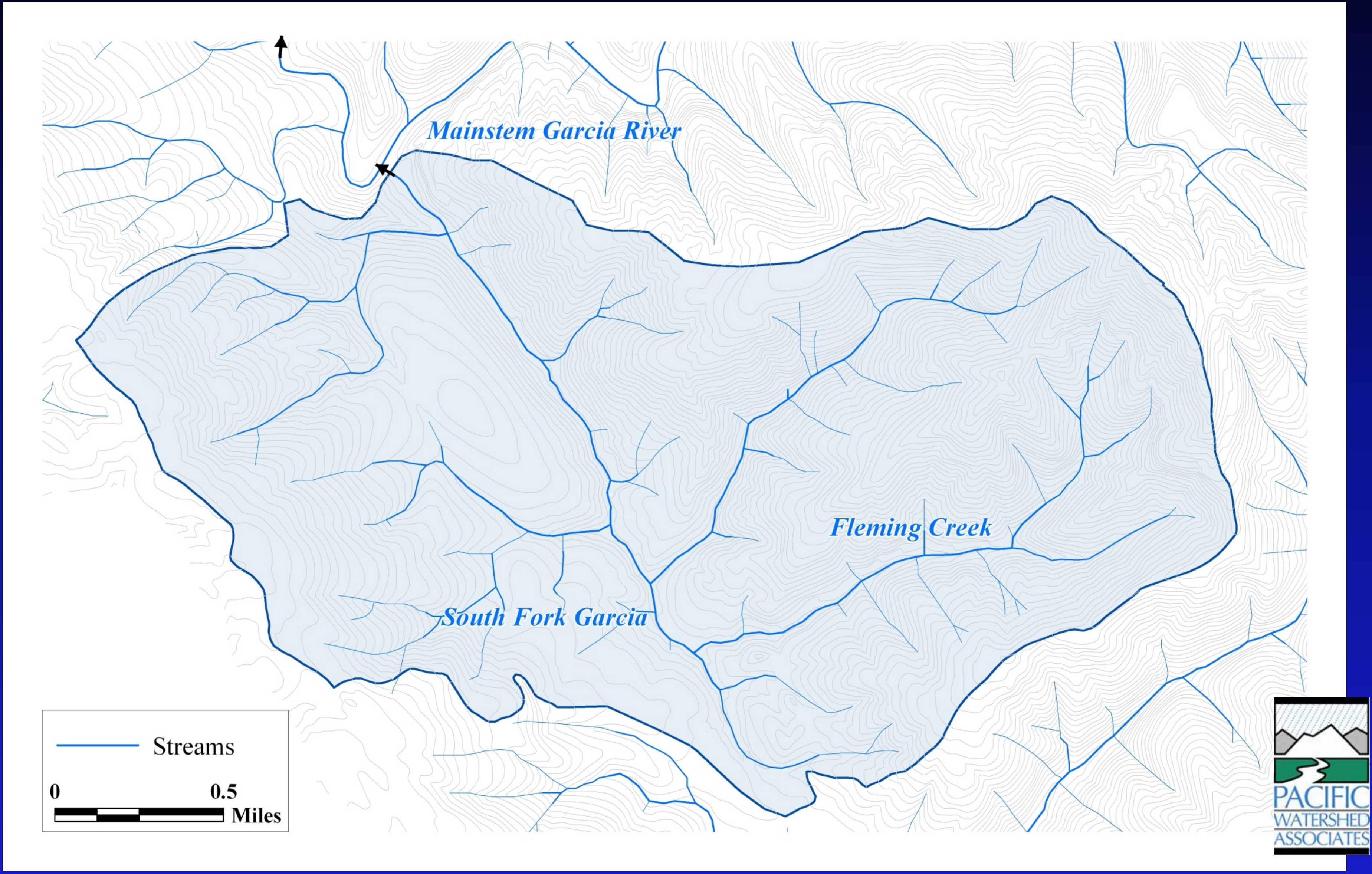
Regulatory Requirements for Fine Sediment

US-EPA / State Water Board TMDL's: Required Fine Sediment Load Reductions

Watershed	Area	Road Surface Erosion Reduction	Road Gully Erosion Reduction	Skid Trail Erosion Reduction
Redwood Creek	280 mi^2	85%	85%	85%
Mad River	480 mi^2	89%	89%	89%
Mattole River	296 mi^2	95%	94%	90%
Big River	181 mi^2	87%	---	57%
Albion River	43 mi^2	82%	---	29%
Garcia River	100 mi^2	73%	---	72%
Gualala River	300 mi^2	95%	95%	84%
Totals/ Averages	*1,680 mi^2*	*87%*	*91%*	*72%*

1998 South Fork Garcia River sediment source assessment

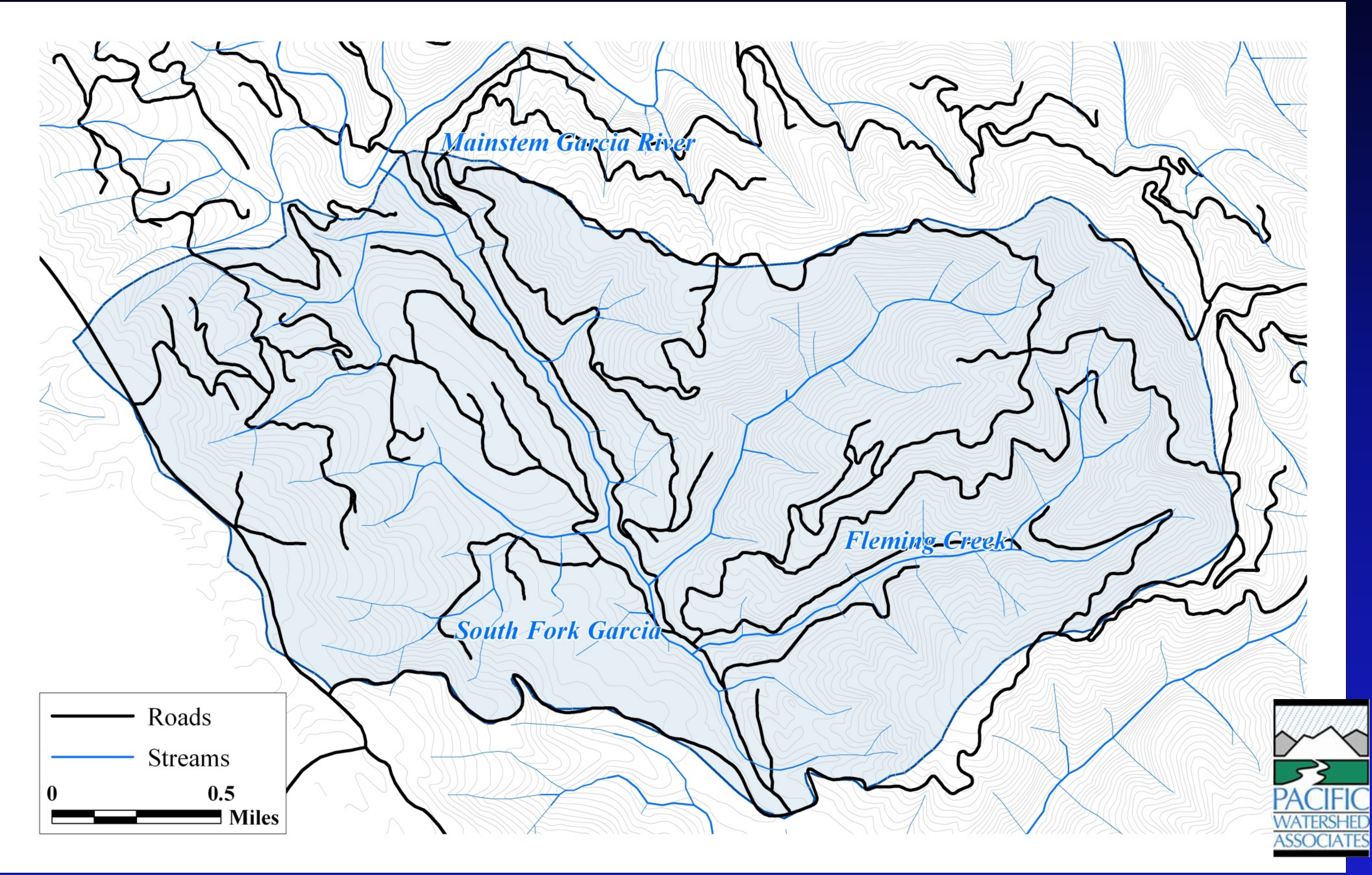
4.3 square mile watershed



Road construction history results

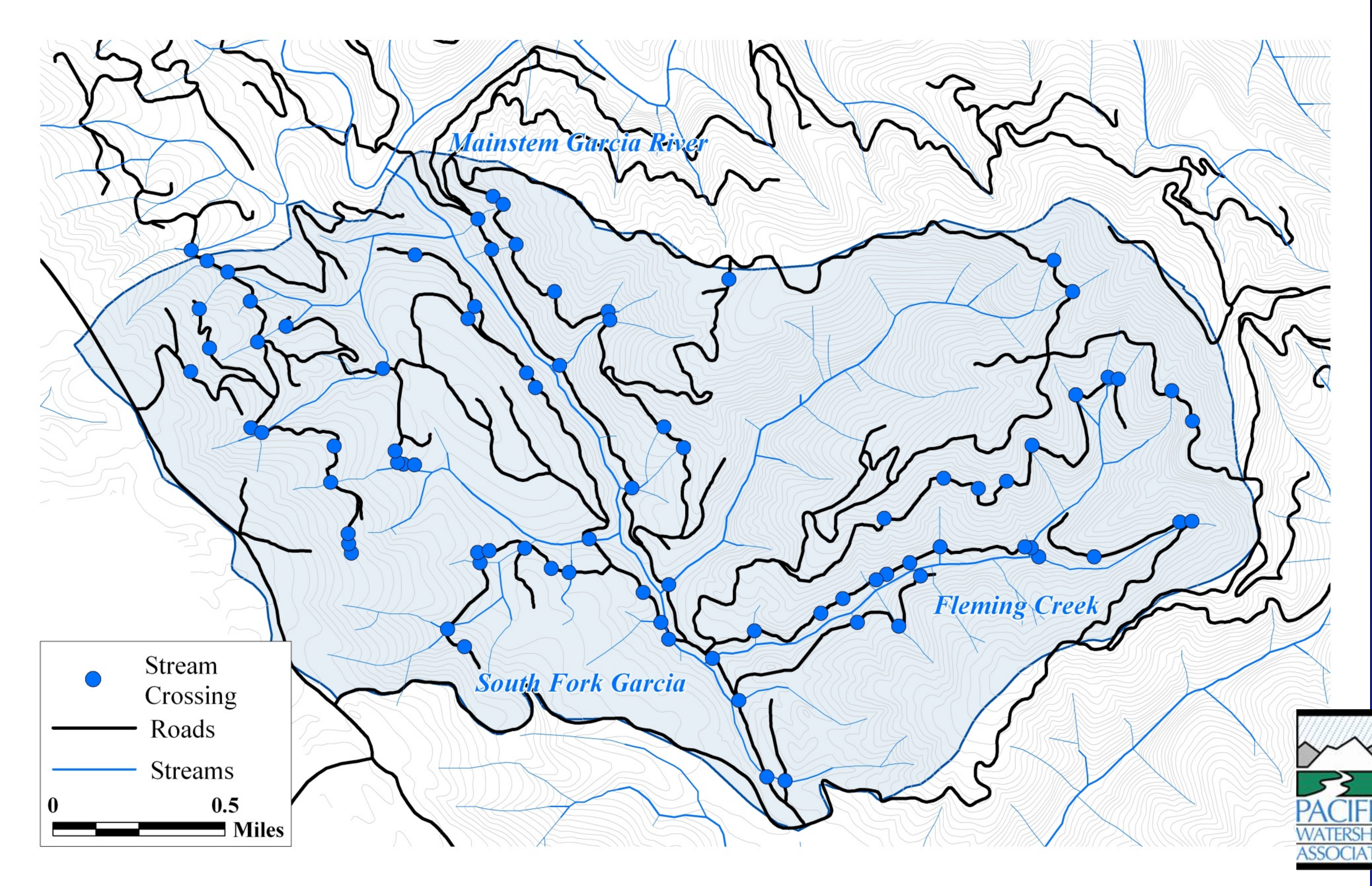
30.6 miles of road

7.1 miles of road/square mile



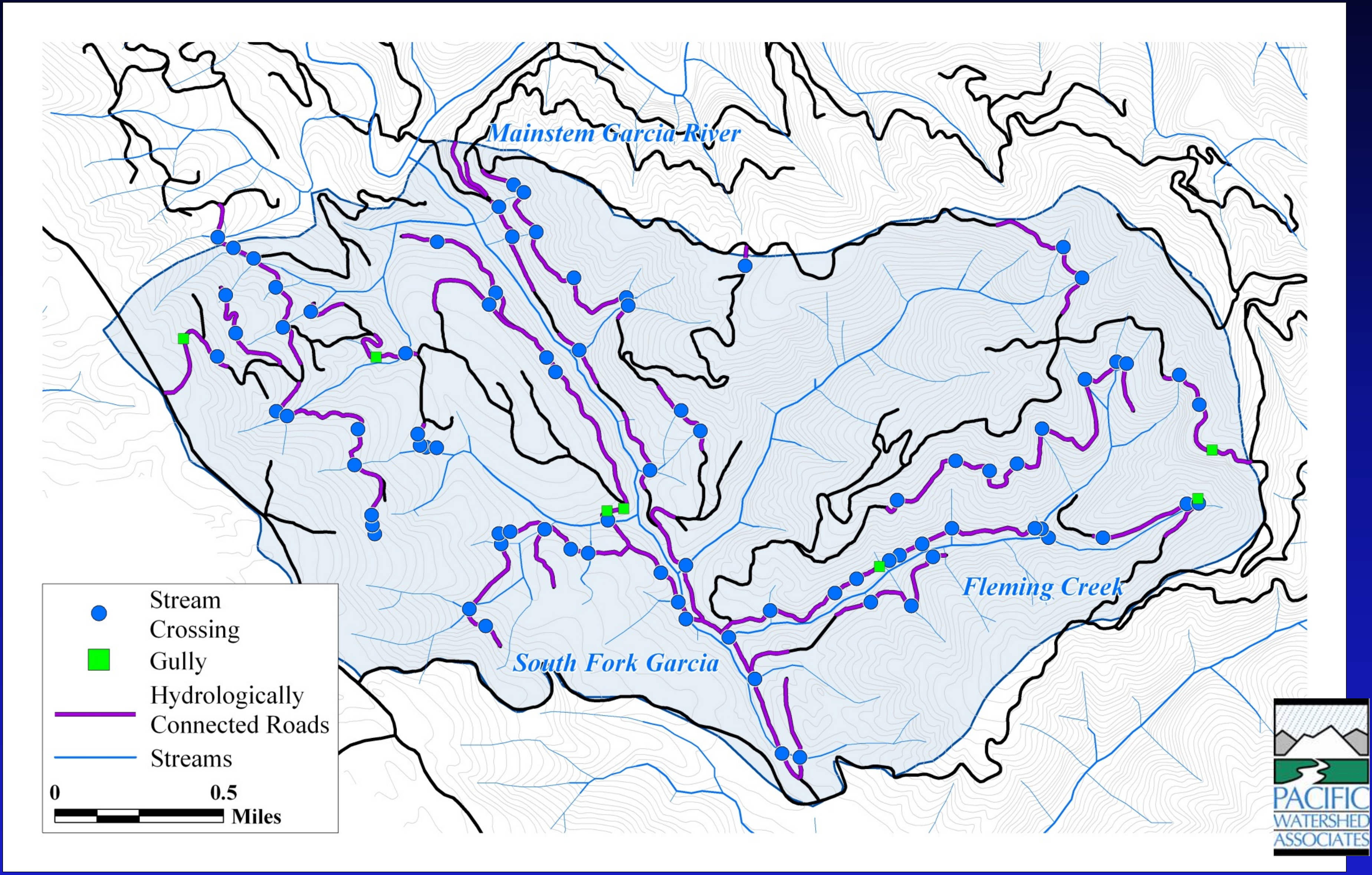
Sediment assessment results

84 stream crossings



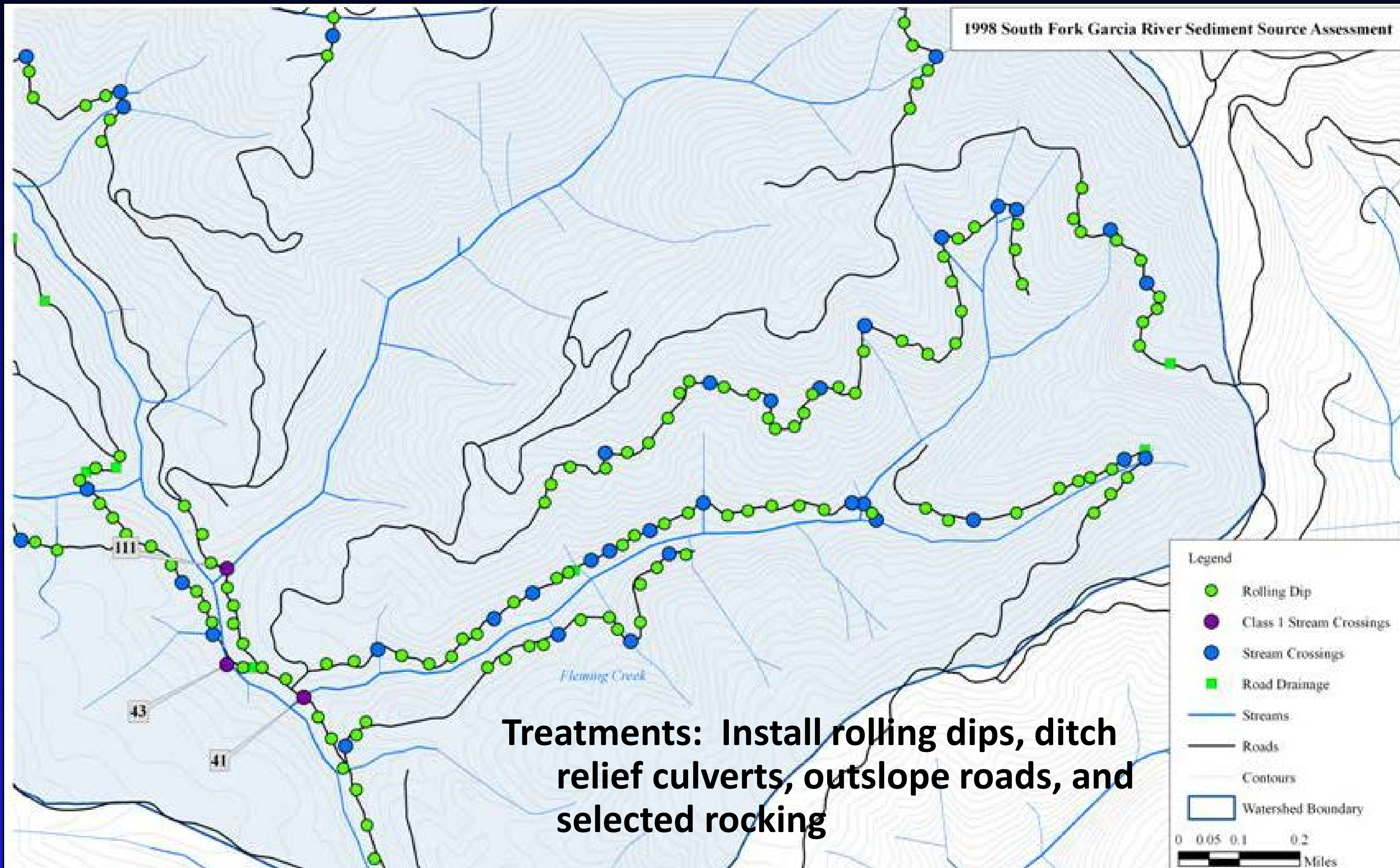
Assessment results (cont)

14.3 miles of hydrologically connected road surfaces and ditches



Treat all 12.9 miles of hydrologically connected roads:

Total *"Streamlined"* and "Complete" sediment control cost $80,000



Treatments: Install rolling dips, ditch relief culverts, outslope roads, and selected rocking

What to do about it…*(laundry list for treating connectivity)*

1) Install a "disconnecting" drainage facility or structure "close" to the watercourse crossing;
2) Increase the frequency of ditch relief culverts for connected roads with inside ditches;
3) Eliminate existing ditch relief culverts with connected gullies
4) Convert crowned or insloped roads with inside ditches, to outsloped roads with rolling dips;
5) Remove or breach outside berms on crowned or outsloped roads if they result in connectivity;
6) Avoid discharging concentrated runoff onto unstable areas.

TRA #5

Common issues with treating connectivity…

TRA #5: Not all road segments are hydrologically connected and complete hydrologic disconnection is not possible for most roads (typical levels).

Connectivity has two forms to be treated:

- **Hydrologic connectivity – the emergence, collection, rapid routing and discharge of road-related runoff to stream channels (channel stability and drought implications)**
- **Pollutant connectivity – the generation and transport mechanism for sediment and other pollutants to be delivered to streams, lakes and wetlands (aquatic habitat implications).**

Common issues with treating connectivity…

Connectivity is not linearly associated with sediment delivery volumes or rates.

- Some roads have low erosion rates, so significant connectivity may not result in a large volume of fine sediment delivery. The opposite is also true.
- Erosion and sediment generation on roads is a function of soil erodibility, road surfacing road grade, runoff volumes (contributing area and flow depth), as well as traffic types and traffic volumes.
- Some roads are located where climate/weather is extreme, while others are not.

Common issues with treating connectivity…

- DRC spacing must be based on ditch erosion, slope erosion and stream proximity; when "required spacing" (from tables) is too close!
- Drainage structure spacing will decrease as you approach a stream or stream crossing; second structure spacing is critical
- Not all filter strips are the same (when 100' ≠ 100')
- OS roads with inside ditches (when to use)
- Rolling dip spacing (should be performance-based):

Common issues with treating connectivity…

- Identifying the best discharge sites (rather than the table distance; e.g., through cuts, convex slopes, stable rocky slopes, flood plains and terraces, buffer characteristics, etc.). *Think performance!*
- Protecting the fillslope from erosion: Flumes and armor – Not all erosion is bad
- Are energy dissipators always needed? If they are, what does that tell you ? (too much water)
- When a road can't be drained… (through cuts, fall line roads)
- When a road shouldn't be drained (unstable areas, connected gullies, streamside roads

Common issues with treating connectivity…

The "feasibility" of hydrologic disconnection
or
When is enough?

Road Rules:

- **All logging roads and landings shall…be hydrologically disconnected to the extent feasible.**
- **Where logging road and landing surfaces, road approaches, inside ditches and drainage structures cannot be hydrologically disconnected, *and where there is existing or the potential for significant sediment discharge, necessary and feasible treatments to prevent the discharge shall be described in the plan.*** [my emphasis]

Maintaining disconnected roads…

Road Rules: Logging road and landing surfaces shall be monitored and maintained to ensure hydrologic disconnection to the extent feasible

- Inspection and maintenance of connectivity treatments (road shape and drainage structure longevity and effectiveness)
- Maintained roads – treatments, treatment limitations, and expected effectiveness (WB vrs RD)
- Closed ("abandoned" or decommissioned) roads – treatments, treatment limitations, and expected effectiveness (≤5%)

Control and prevention of surface erosion

- <u>Minimize bare soil</u>
- <u>Cover bare soil</u> – mulch or revegetate
- <u>Disperse runoff</u> from bare soil areas
- Direct concentrated runoff to vegetation
- Break up bare soil areas into smaller areas
- <u>Disconnect</u> and disperse flow paths (e.g., road surfaces) and ditches

Control and prevention of gully erosion

- Prevent gullies by <u>dispersing runoff</u>
- Direct concentrated flow from bare areas into <u>buffers and flat areas</u>
- <u>Dewater active gullies</u>
- <u>Secondary treatments</u>, including channel armor and grade control, are <u>the last option</u>

Treating Hydrologic Connectivity

<u>Hydrologic connectivity is treated</u> by road surface shaping and the installation of road surface and ditch drainage structures

Treatments for connected roads and ditches…

(how they work and when the don't)

- Connected stream crossing approaches (road shape, berms, relief culverts, rolling dips, and road surfacing)
- Ditch drainage structures (ditch relief culverts, rolling dips, sediment basins)
- Road shaping (insloped, crowned, outsloped)
- Road surface drainage structures (road dips, rolling dips, waterbars and rubber waterbars, open top box culverts, berms, critical dips)
- Leadout ditches (for switchbacks, crowned roads, through cuts, fall line roads)
- Berm removal and berm breaks
- Abandonment treatments (ripping, cross road drains, outsloping, crossing excavation, fillslope excavation)

ROAD DRAINAGE TREATMENTS

Road shaping

Road shape conversion

Insloped with ditch, wheel ruts & berm – Gullied with 100% connectivity

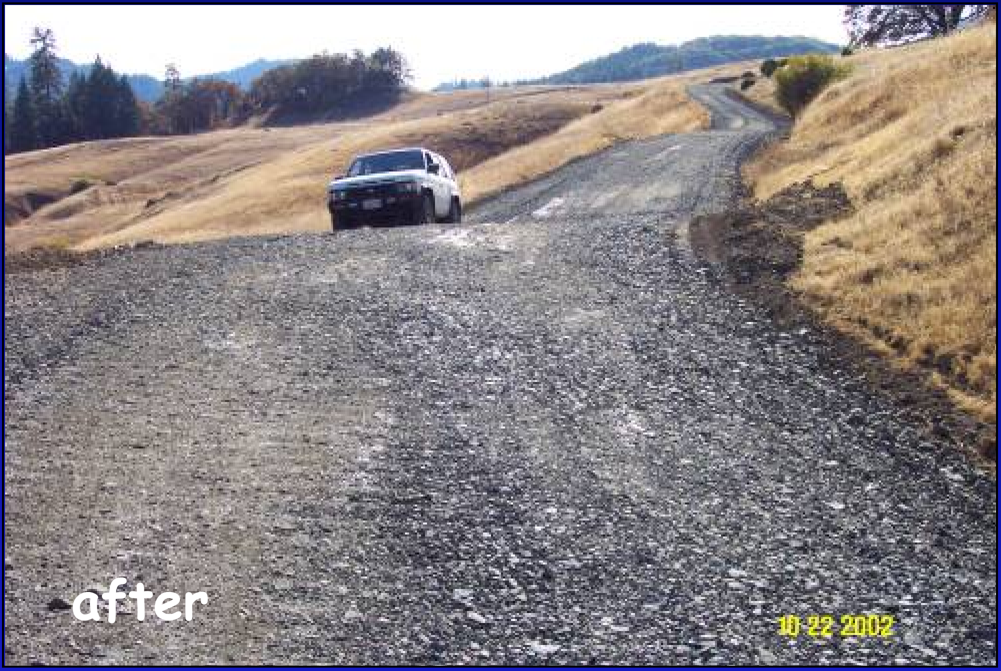
Outsloped with rolling dips – No connectivity

Seasonal use roads with outsloped shapes and rolling dips (no berm or inboard ditch)

Road shape conversion

Insloped
with ditch –
100% connectivity

Outsloped with
rolling dips –
No connectivity



Driveability, Functionality and Safety

Treated Road - Clean Connectivity

ROAD DRAINAGE STRUCTURES

Rolling grade, rolling dips, ditch relief culverts and berm breaks

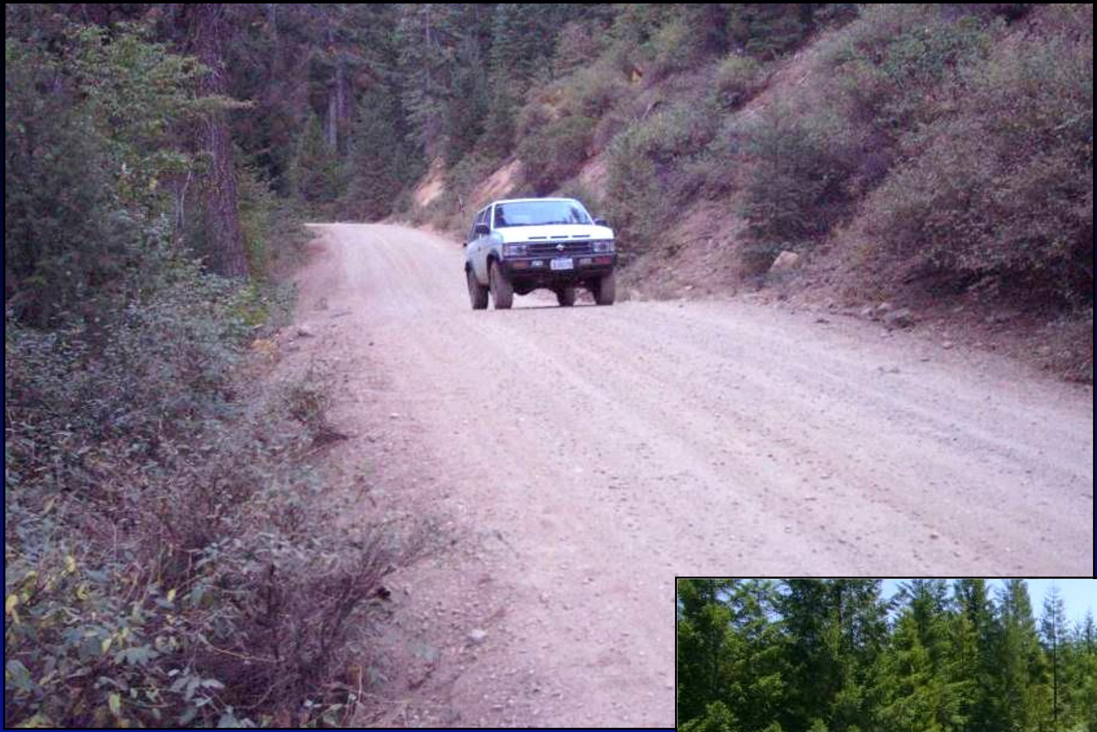
Road with rolling grade

Outsloped roads with Rolling dips

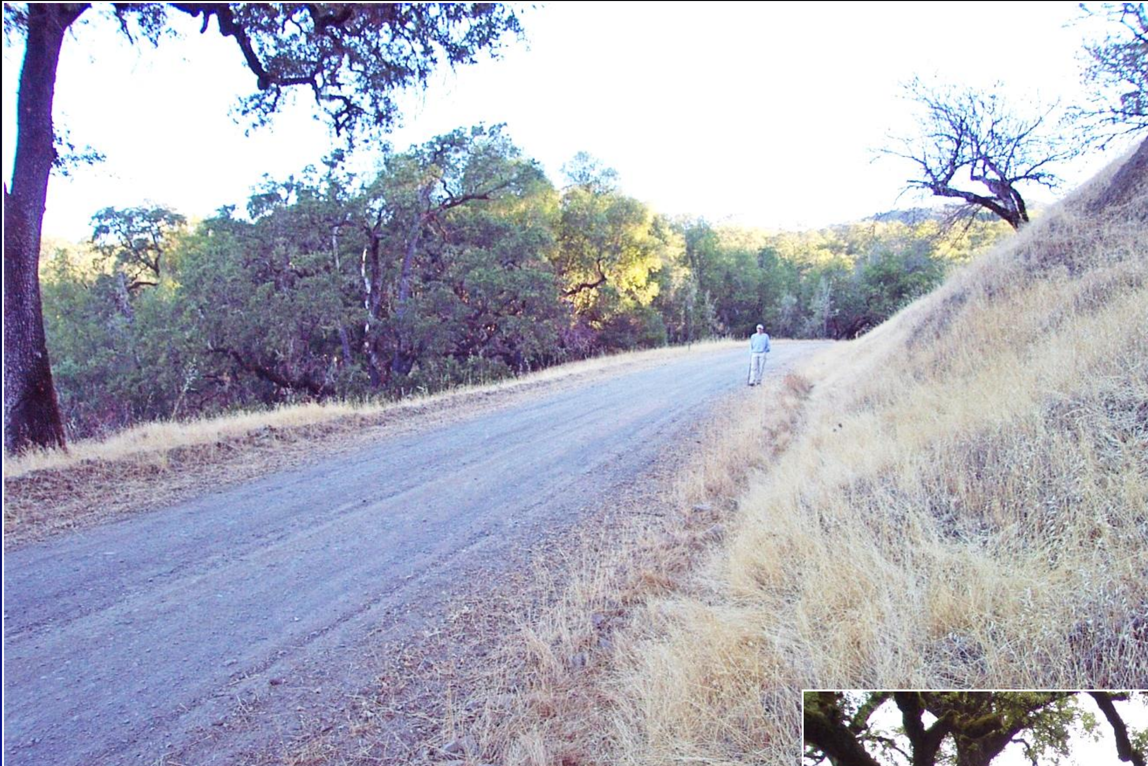
Rural subdivision

Logging haul road

Road erosion treatments - upgrading



Outsloped with rolling dips – ditch eliminated



Insloped road with ditch – hydrologically connected

Outsloped road with rolling dips – ditch retained

Lead-out ditch or cut drains road rut

Berm breaks on a fall-line road

Road drainage structures

Control and prevention of surface erosion

- Minimize bare soil
- Cover bare soil – mulch or revegetate
- Disperse runoff from bare soil areas
- Direct concentrated runoff to vegetation
- Break up bare soil areas into smaller areas
- Disconnect and disperse flow paths (e.g., road surfaces) and ditches
- Feasible Target: $\leq$10-20% of road network; less on upper hillslopes; abandoned rds $\leq$ 5%

Recommendations to reduce or eliminate roads as a source of fine sediment:

- Construct outsloped road shapes with no berms, and periodic rolling dips, disconnecting crossing approaches,
- Utilize inboard ditches only where springs are present along the cutbank, or to collect runoff from upslope,
- Disconnect ditches using frequent ditch drains,
- Minimize ditch grading; revegetate connected ditches
- Avoid through-cut roads & roads down the axis of swales,
- Do not pipe riparian road runoff directly to streams; use perforated flex pipe on contour to disperse flow,
- Culvert spacing should result in no hillslope gullies,
- Dewater connected gullies, even if they are stable, and
- Construct properly designed and sized sediment basins.

Road connectivity comparison following road storm-proofing along 15.2 miles of forest roads.

Connectivity site type	1998 Connectivity (pre-treatment) (ft)	Connected road/ditch length of forest roads (ft)		Average connected length as of 2005
		2004	2005	
Stream crossing approach	23,930	14,100	3,630	84 ft
Ditch relief culvert	27,000	9,450	1,600 [1]	178 ft
Gully/rolling dips	3,860	5,325	800 [1]	200 ft
Other	6,350	825	0	0 ft
Total (15.2 mi):	61,140'	29,700'	6,030'	108 ft
Connectivity	76.2%	37.0%	7.5%	--

[1] Eliminating these connected sources would reduce overall connectivity to 4.5%

EL LIBRO VERDE

MANUAL DE CAMINOS FORESTALES Y RURALES

Una guía para

planificar,

diseñar,

construir,

reconstruir,

mejorar,

mantener

y cerrar

caminos forestales

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