Low Impact Roads

Workshop funding provided by a grant from US EPA

Natural Resource Concerns

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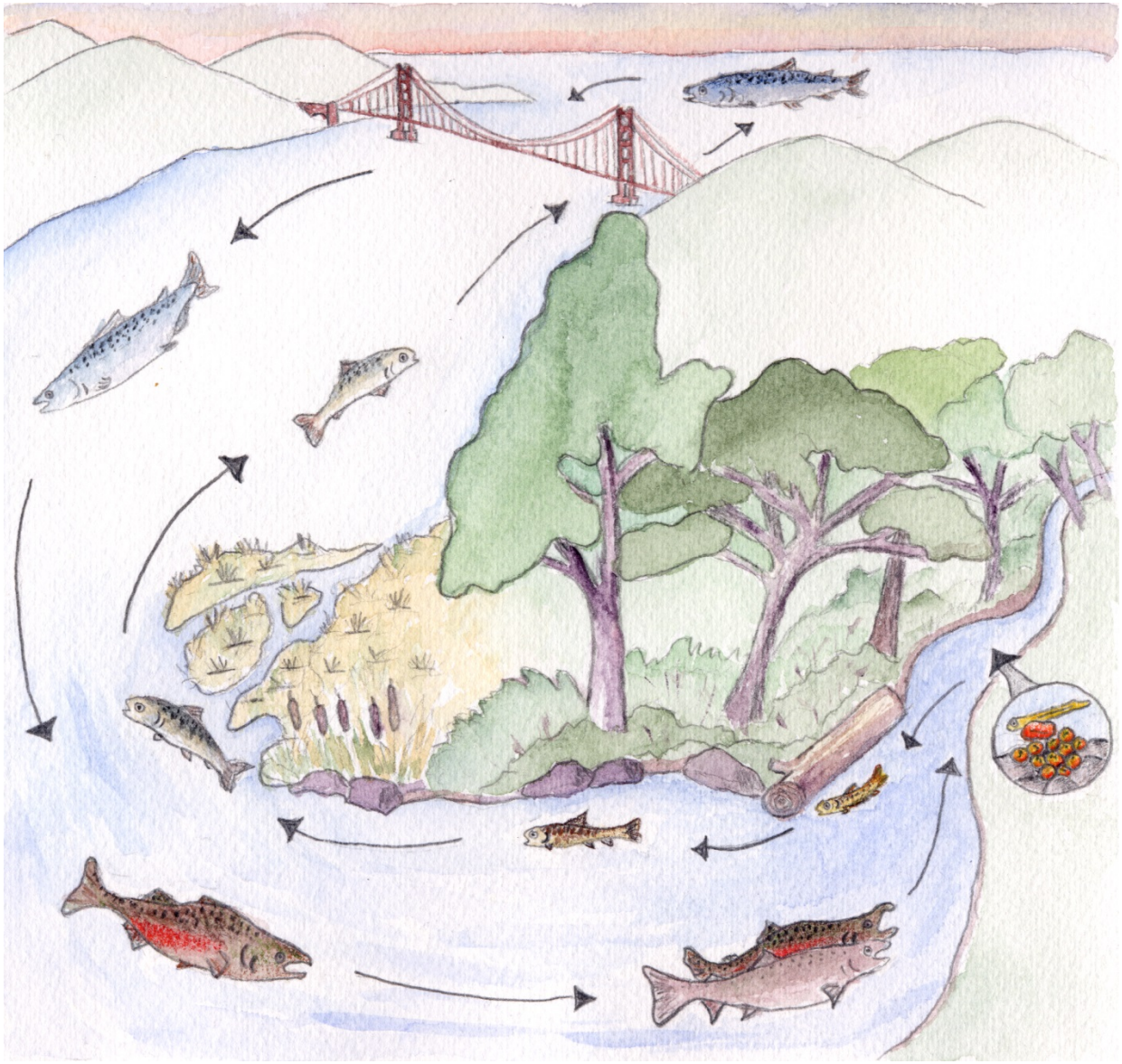
Salmonids and Anadromy



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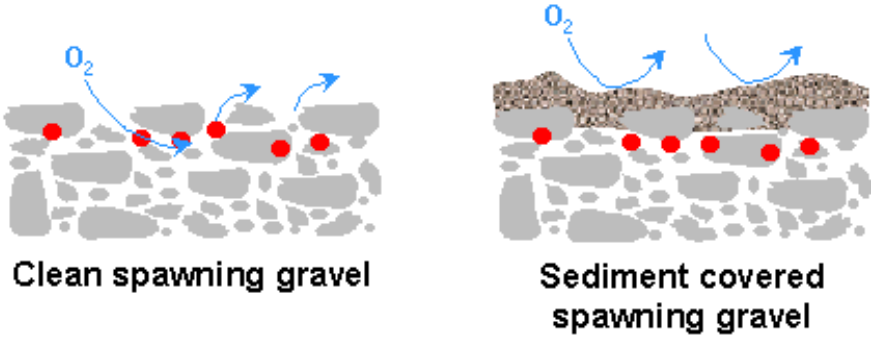
Sediment Impairs Reproduction



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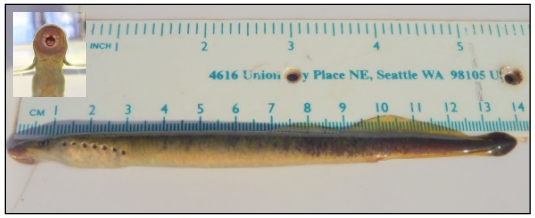
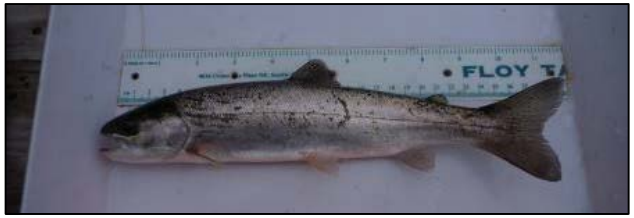
Monitoring Fish in Streams





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Fish Barrier Removal

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Roads and the Watershed

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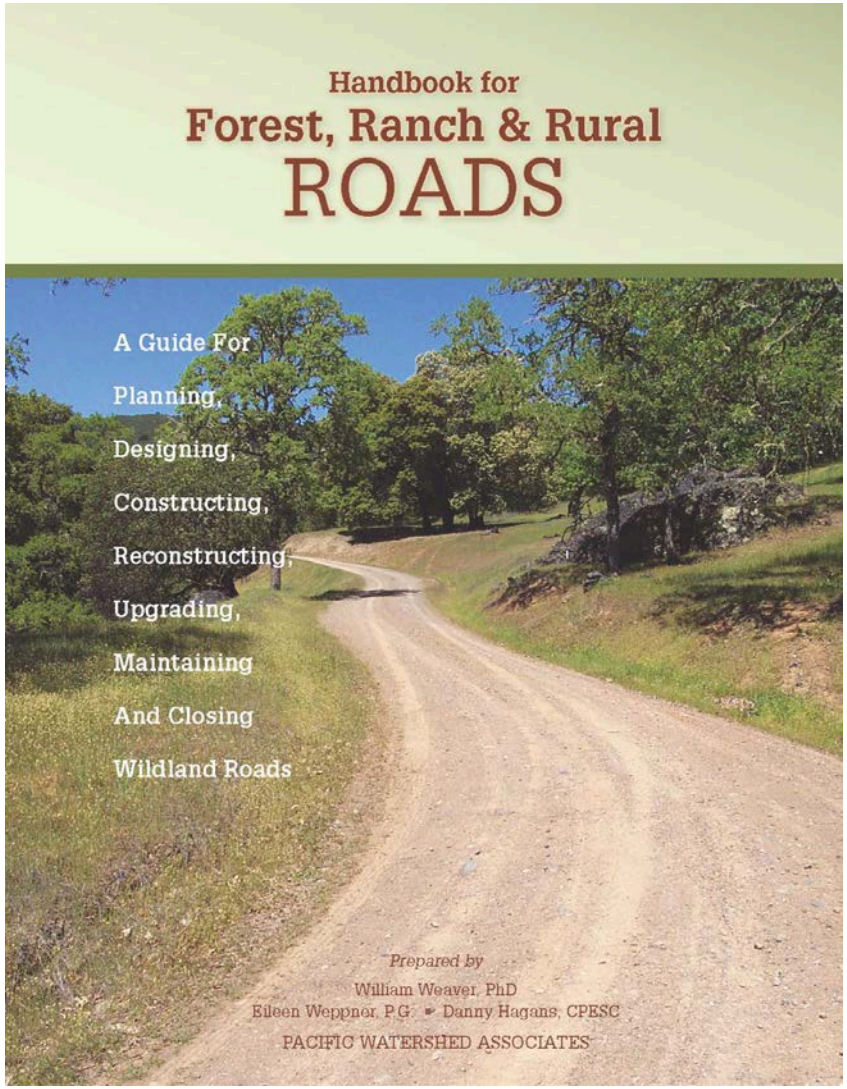
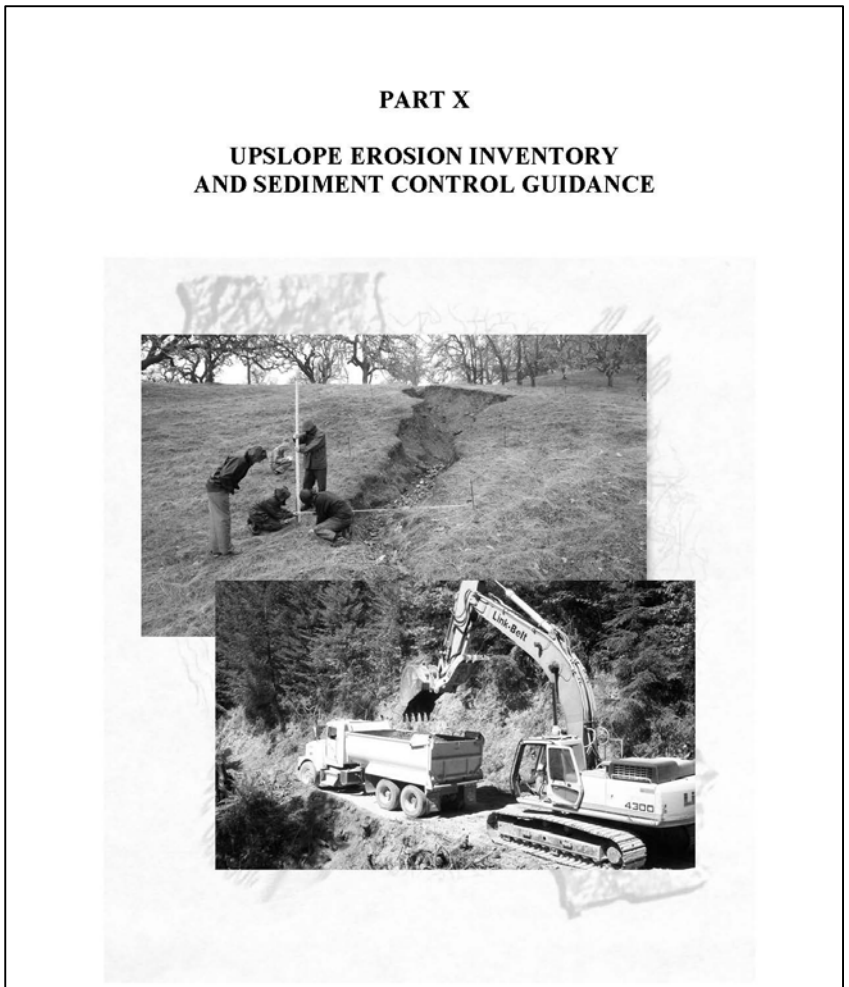
Outline of Today's Presentation:

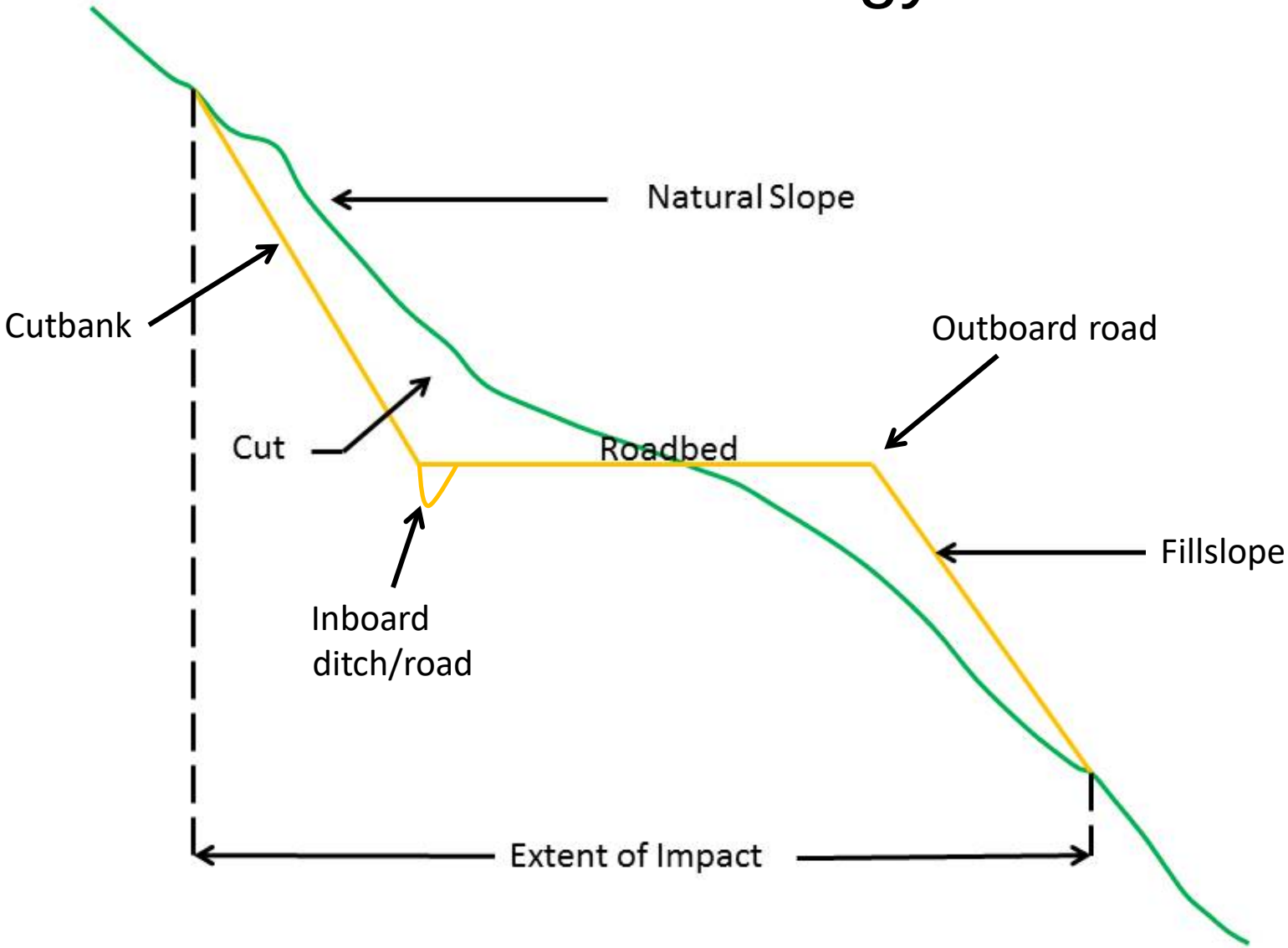
- 3 Major Impacts of Roads on Watersheds
  - Hydromodification
    - Treatments to 'normalize the hydrology'
  - Chronic erosion
    - Treatments to reduce chronic sediment inputs
  - Episodic erosion
    - Fail safe mechanisms at culverted stream crossings
- Road surface materials





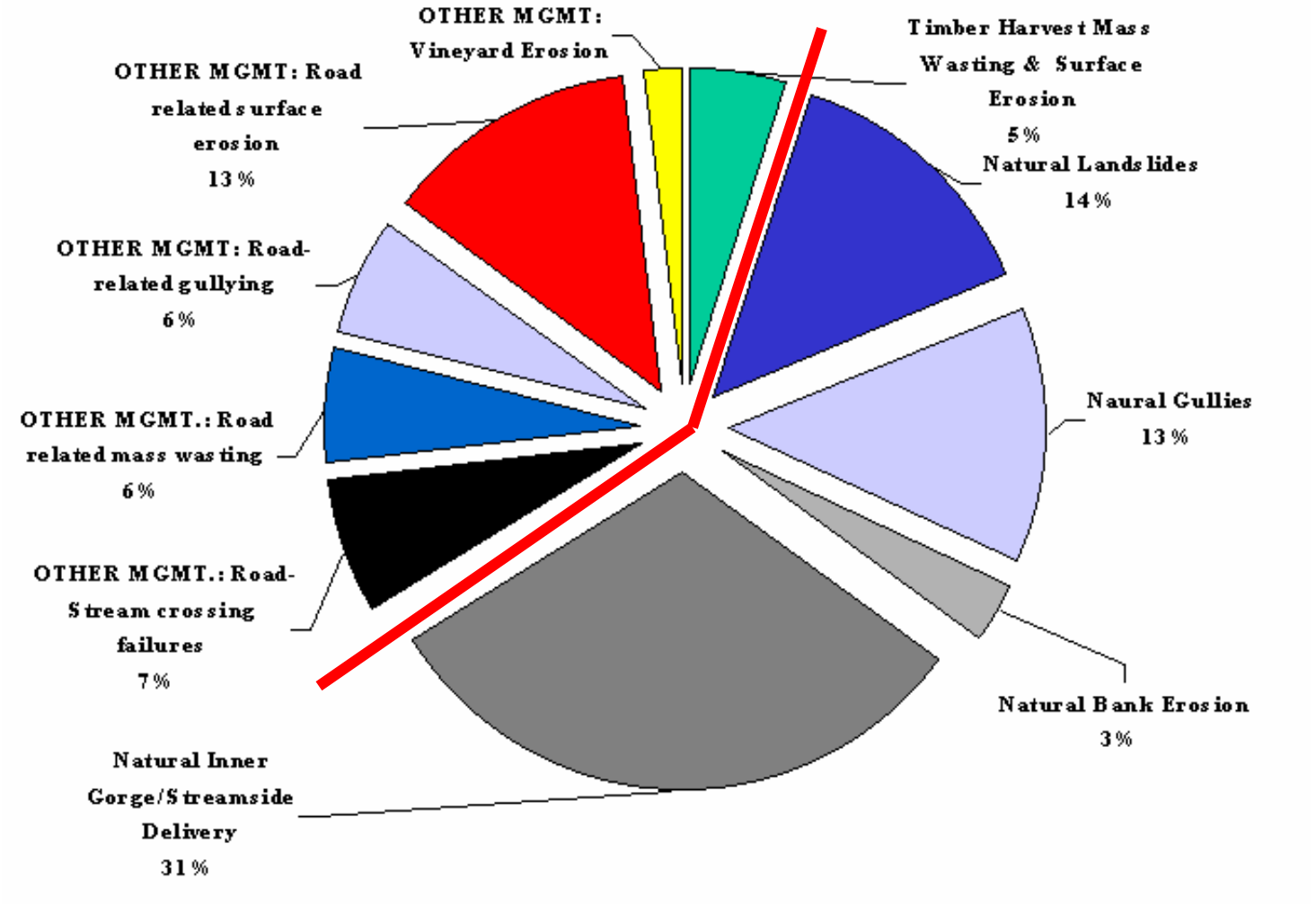
CALFIORNIA SALMONID STREAM
HABITAT RESTORATION MANUAL

Road Terminology



Erosional Processes in the Watershed

Natural (~60%) vs. Anthropogenic (~40%)



Navaro River watershed, 1975-1998. *Source*: USEPA 2000.

Napa River TMDL for Sediment Identifies Roads as Significant Source

- Road-related erosion is the largest sediment source associated with land-use activities in the Napa River watershed, ***and perhaps the most cost effective source to treat.***

- Estimated average rate of **50 cubic yards of sediment per mile per year** delivered to streams.

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3 Major Impacts of Roads on Watersheds

- HYDROMODIFICATION
  - Poorly constructed roads tend to collect surface flow from the landscape and concentrate that runoff into discrete discharge points thereby increasing the flow volumes that the stream channel would normally experience during the storm event.
- CHRONIC erosion
  - Sediment production from road surfaces, inboard ditches, and cutbanks that collect runoff and deliver it to the stream system. This erosional process is chronic because it occurs during any storm that produces runoff.
- EPISODIC erosion
  - Sediment delivery is *episodic* when it occurs as soils fail in response to storm events or other triggers. The delivery from a site may occur once, or in pulses over an indeterminate time period. These erosion volumes are a **potential** volumes that may or may not occur during a given storm event.

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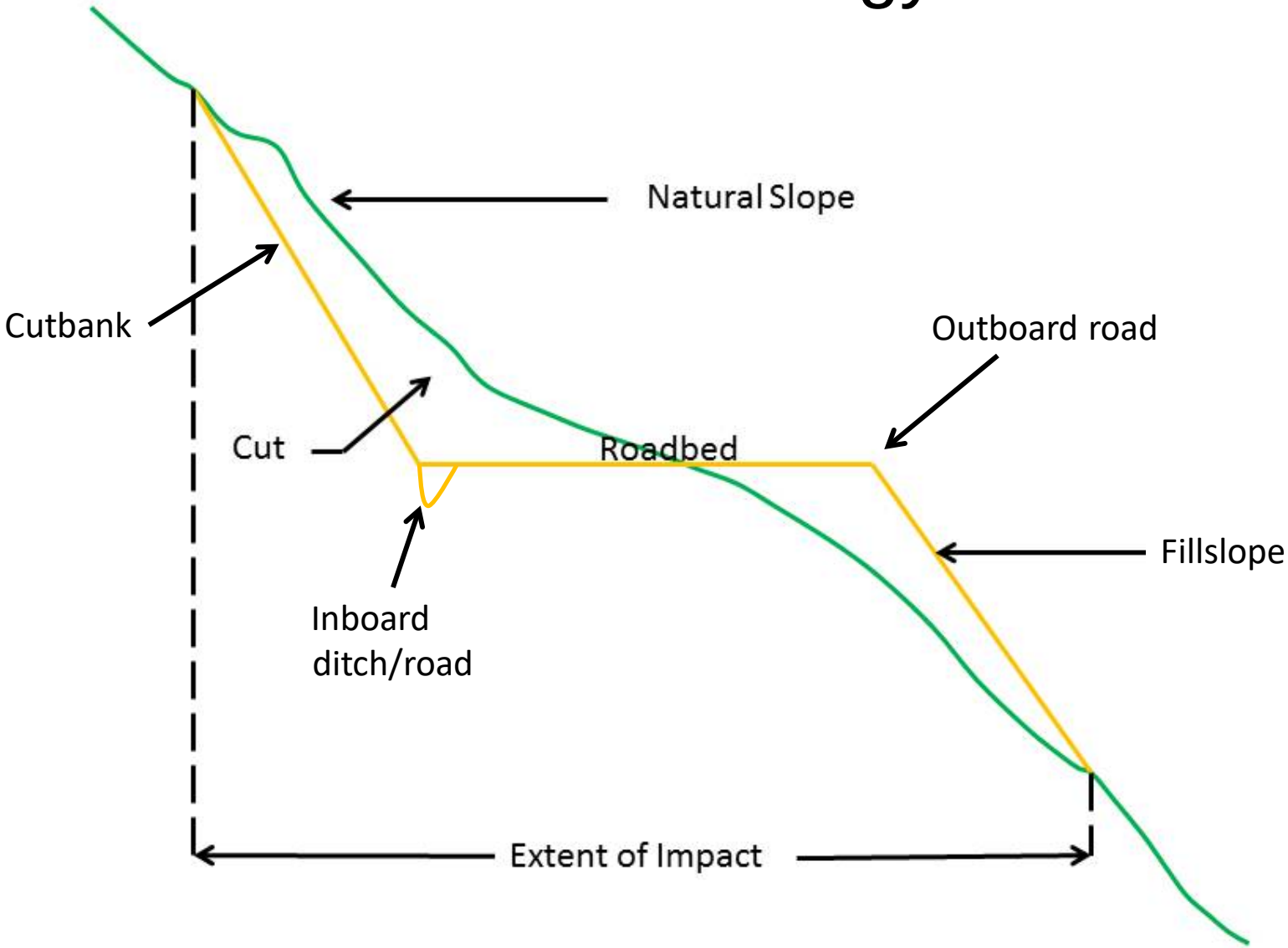
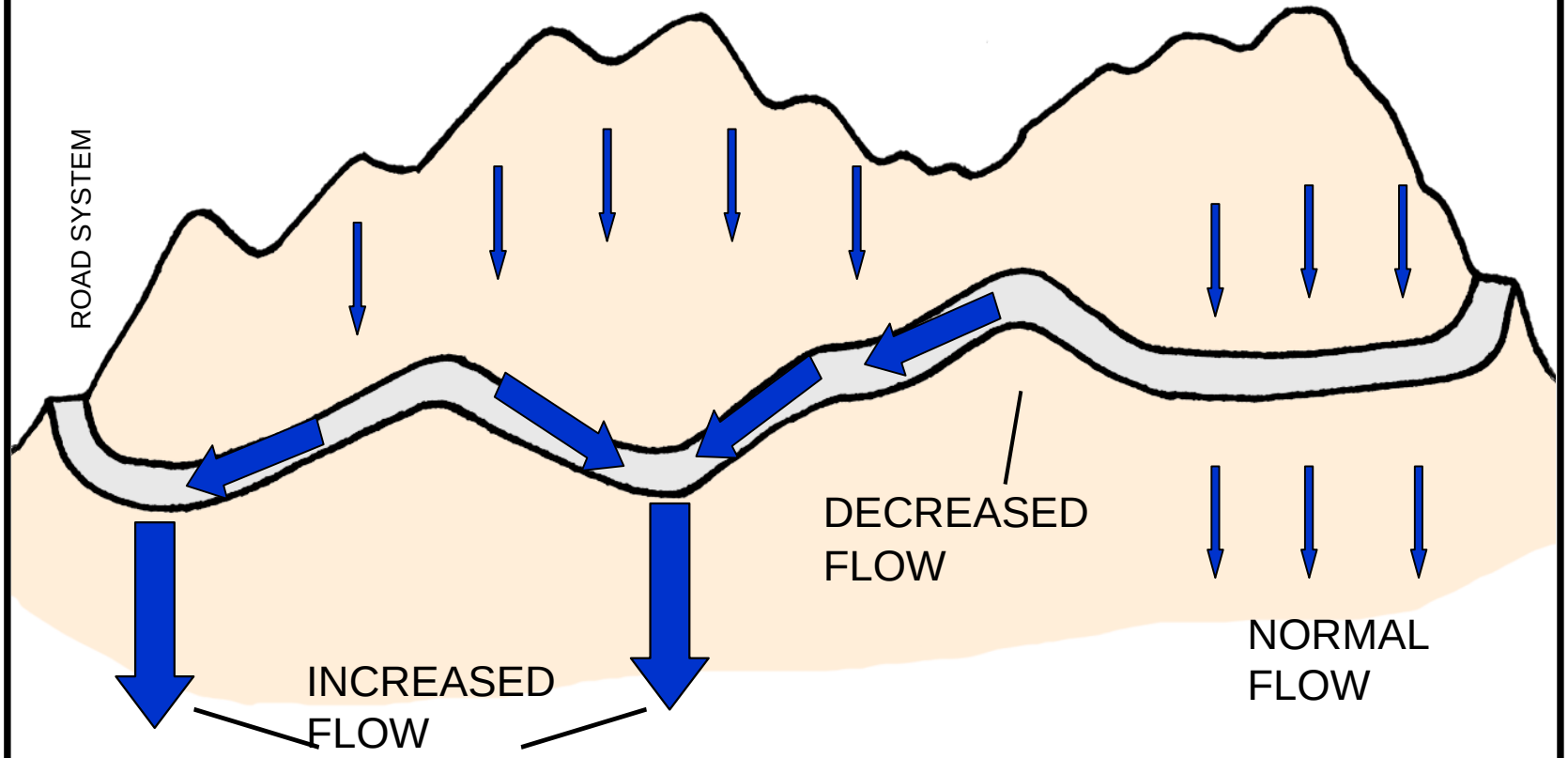
Road Terminology



Water Flows Downhill

- Cause channel incision
- Reduced ground water recharge
- Decreased dry season flows



WORST CASE

BEST CASE

From Lee Benda

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Hydromodification

3 Major Impacts of Roads on Watersheds

- HYDROMODIFICATION
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Chronic Sources of Erosion

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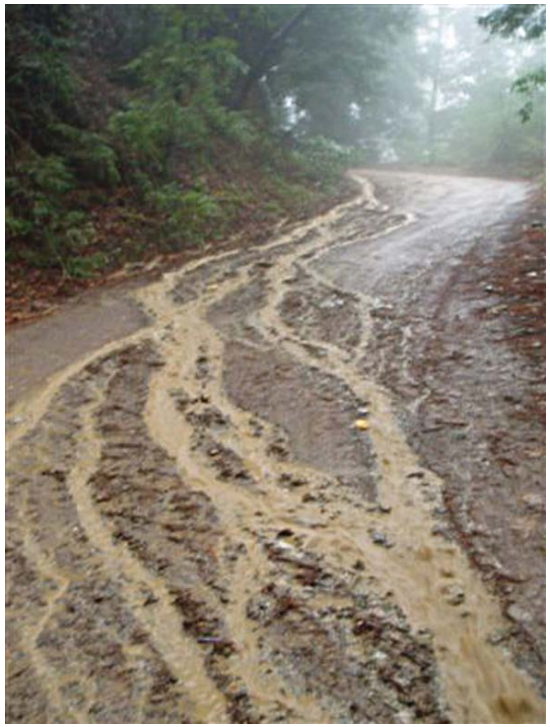
This is what happens to that powdery dust when it rains



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Physical features showing that chronic erosion or ‘surface lowering’ over time

Addressing Chronic Sediment Sources & Peak Flows

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Reasons to Focus on Chronic Delivery

- Treats erosion that is occurring annually and normalizes hydrology
- Cost effective:
  - Reduces materials needs
  - No dewatering of stream channels
  - Fewer permits (1602, 401, 404)
- Strom proofing of the road surface. Reduces future road surface maintenance needed

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Goals for Road Shaping

- Safety first for the user
- Mimic natural drainage patterns
- Ensure no single drainage feature receives too much runoff

811®

Know what's **below.**
Call before you dig.

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A Tale of Two Road Shaping Approaches

Insloped road, inboard ditch, and berm, – 100% connectivity of sediment and runoff

Outsloped road, removed berm & ditch, with rolling dips – Significantly reduced connectivity

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Rolling Dips Drain Road Surface Frequently

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Rule of Thumb for Rolling Dip Spacing

Table 3. Maximum distance between waterbreaks on roads and trails (feet)[1]				
Erosion Hazard Rating (for surface erosion)	**Road Gradient (%)**			
	10%, or less	**11-25%**	**26-50%**	**over 50%**
Extremely high	100'	75'	50'	50'
High	150'	100'	75'	50'
Moderate	200'	150'	100'	75'
Low	300'	200'	150'	100'

[1] *from California Forest Practice Rules. This is the* <u>*maximum distance between waterbreaks:*</u> *when in doubt, reduce the spacing. Soils are non- renewable and waterbars are inexpensive.*

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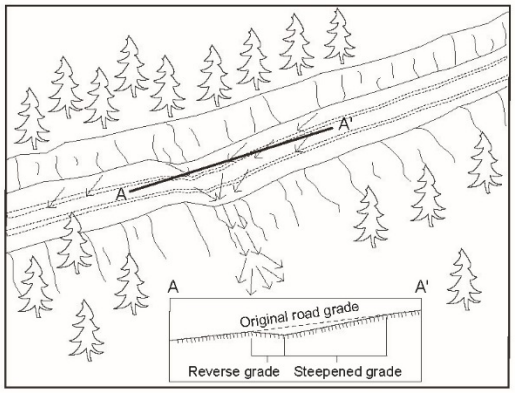
Typical Road Surface Drainage by Rolling Dips



Rolling dip installation:

1. Rolling dips will be installed in the roadbed as needed to drain the road surface.
2. Rolling dips will be sloped either into the ditch or to the outside of the road edge as required to properly drain the road.
3. Rolling dips are usually built at 30 to 45 degree angles to the road alignment with cross road grade of at least 1% greater than the grade of the road.
4. Excavation for the dips will be done with a medium-size bulldozer or similar equipment.
5. Excavation of the dips will begin 50 to 100 feet up road from where the axis of the dip is planned as per guidelines established in the rolling dip dimensions table.
6. Material will be progressively excavated from the roadbed, steepening the grade unitl the axis is reached.
7. The depth of the dip will be determined by the grade of the road (see table below).
8. On the down road side of the rolling dip axis, a grade change will be installed to prevent the runoff from continuing down the road (see figure above).
9. The rise in the reverse grade will be carried for about 10 to 20 feet and then return to the original slope.
10. The transition from axis to bottom, through rising grade to falling grade, will be in a road distance of at least 15 to 30 feet.

Table of rolling dip dimensions by road grade

Road grade %	Upslope approach distance (from up road start to trough) ft	Reverse grade distance (from trough to crest) ft	Depth at trough outlet (below average road grade) ft	Depth at trough inlet (below average road grade) ft
<6	55	15 - 20	0.9	0.3
8	65	15 - 20	1.0	0.2
10	75	15 - 20	1.1	0.01
12	85	20 - 25	1.2	0.01
>12	100	20 - 25	1.3	0.01

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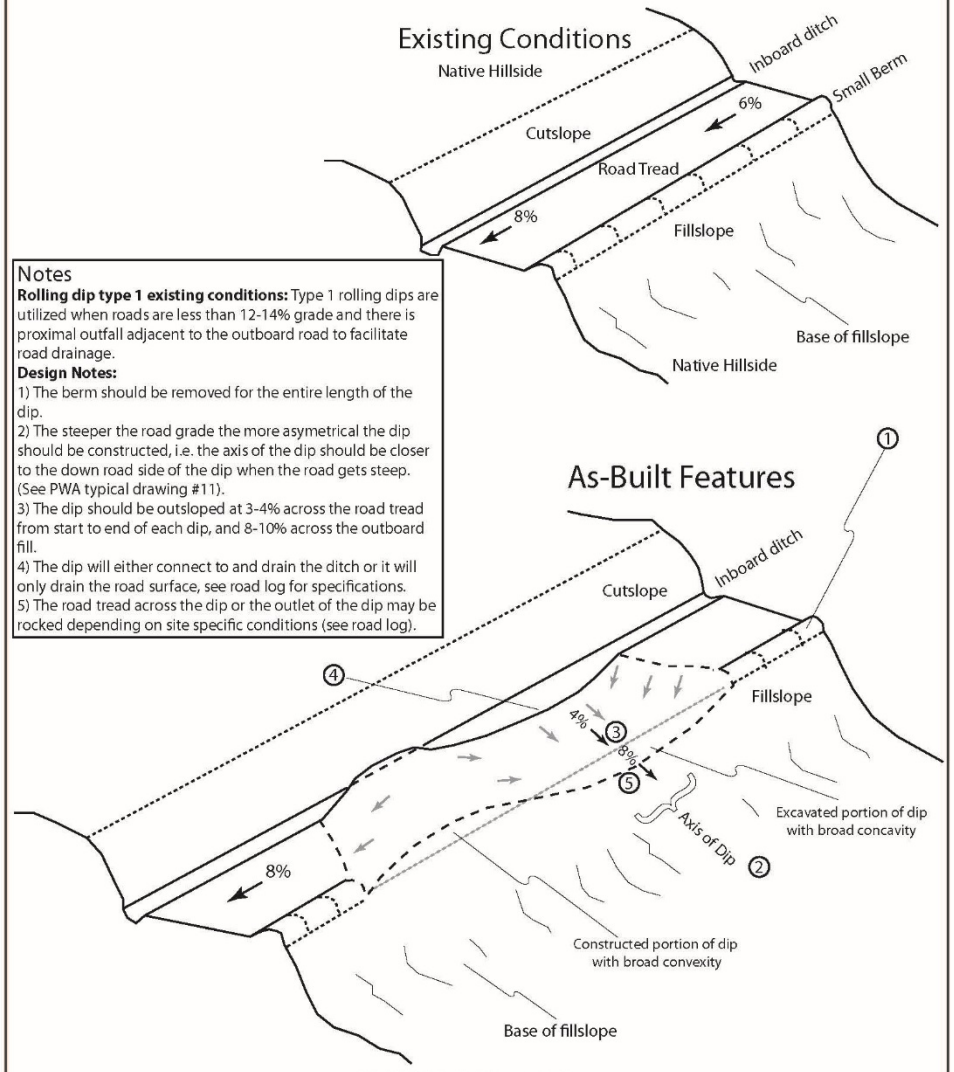
Typical Drawing #'

Standard (Type 1) Rolling Dip Construction



Notes

Rolling dip type 1 existing conditions: Type 1 rolling dips are utilized when roads are less than 12-14% grade and there is proximal outfall adjacent to the outboard road to facilitate road drainage.

Design Notes:

1) The berm should be removed for the entire length of the dip.
2) The steeper the road grade the more asymetrical the dip should be constructed, i.e. the axis of the dip should be closer to the down road side of the dip when the road gets steep. (See PWA typical drawing #11).
3) The dip should be outsloped at 3-4% across the road tread from start to end of each dip, and 8-10% across the outboard fill.
4) The dip will either connect to and drain the ditch or it will only drain the road surface, see road log for specifications.
5) The road tread across the dip or the outlet of the dip may be rocked depending on site specific conditions (see road log).

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PWA Typical Drawing #19a

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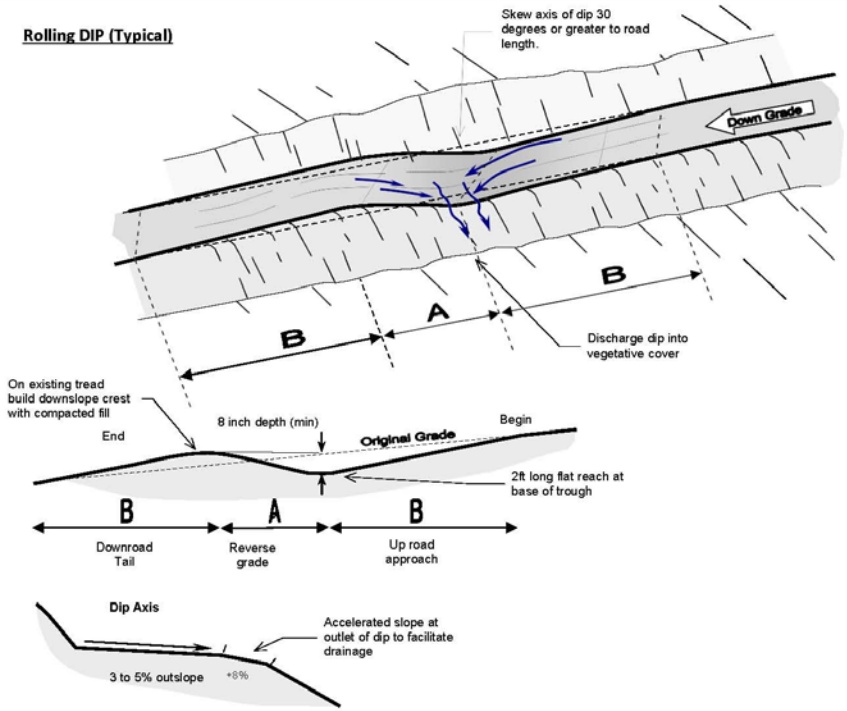
Rolling DIP (Typical)



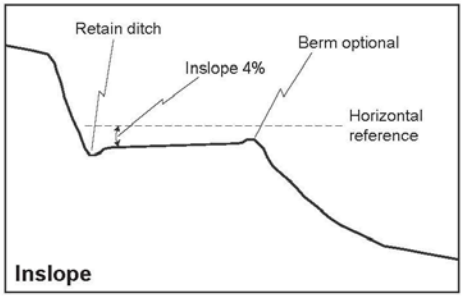
ROAD GRADE (%)	TROUGH	A: REVERSE GRADE	B: UP ROAD APPROACH DOWN ROAD TAIL	
	Minimum depth below downslope crest	Minimum distance and grade from trough axis to downroad crest (ft)	Distance from up-road start of rolling dip to trough axis (ft)	Grade (%)
<5%	8 inches	15 feet at 5%	50	10%
10%			50	15%
15%			30	20%
>15%		7 feet at 10%	30	25%

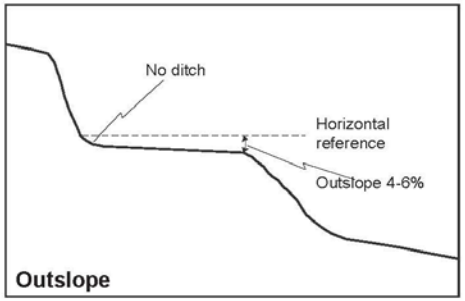
Rolling dip instructions:

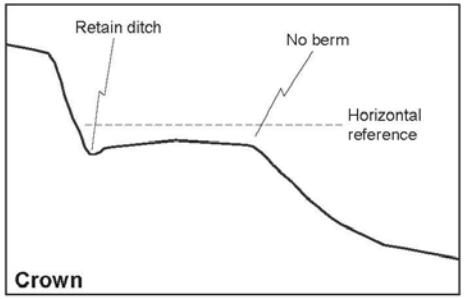
- A rolling dip is a long, permanent dip constructed into native soils. The dip can be constructed to drain the inboard ditch or just the road surface.
- On existing roads the cut of the dip should start 30-50 feet upslope of the trough, with an outslope of 2-4%.
- Dip axis should be skewed down road at 30 degree off of centerline of road length – this will facilitate in efficiently draining the road without buildup of sediments in trough and makes the dip more drivable (i.e. the "roll" of the dip)
- The trough of the dip should be outsloped 3-5% with a flat reach of 2 feet.
- The reverse grade of the dip shall generally be sloped 5% for a minimum of 15 feet to form a minimum 8 inch deep dip. Road surface, where fill material will be placed, should be ripped first to ensure fill material interlocks with existing tread.
- The crest of the reverse grade should be a 2 foot long flat reach and the fill material should continue for a minimum of 30-50 feet before tapering to original grade.
- On roads steeper than 15% a steeper/shorter reverse-grade dip may be required.
- Dips shall be placed as specified in the plans. If not specified, then dips shall be placed at maximum 150-200 foot spacings.

Typical Drawing #11b

Typical Designs for Using Road Shape to Control Road Runoff







Outsloping Pitch for Roads Up to 8% Grade		
Road grade	**Unsurfaced roads**	**Surfaced roads**
4% or less	3/8" per foot	1/2" per foot
5%	1/2" per foot	5/8" per foot
6%	5/8" per foot	3/4" per foot
7%	3/4" per foot	7/8" per foot
8% or more	1" per foot	1 1/4" per foot

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Typical Drawing #9

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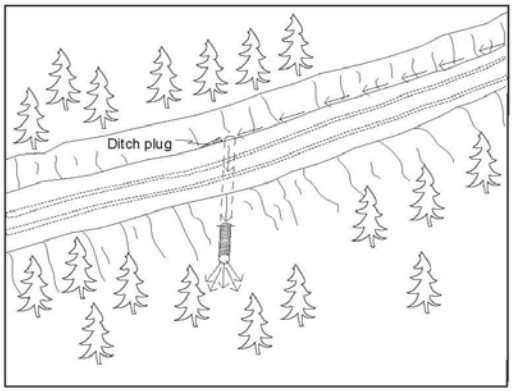
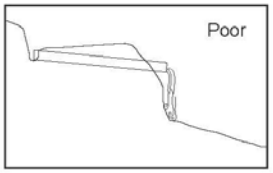
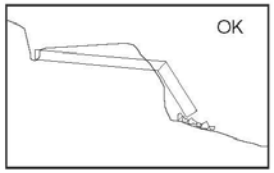
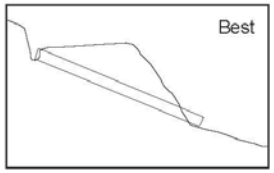
Typical Ditch Relief Culvert Installation









Ditch relief culvert installation

1) The same basic steps followed for stream crossing installation shall be employed.
2) Culverts shall be installed at a 30 degree angle to the ditch to lessen the chance of inlet erosion and plugging.
3) Culverts shall be seated on the natural slope or at a minimum depth of 5 feet at the outside edge of the road, whichever is less.
4) At a minimum, culverts shall be installed at a slope of 2 to 4 percent steeper than the approaching ditch grade, or at least 5 inches every 10 feet.
5) Backfill shall be compacted from the bed to a depth of 1 foot or 1/3 of the culvert diameter, which ever is greater, over the top of the culvert.
6) Culvert outlets shall extend beyond the base of the road fill (or a flume downspout will be used). Culverts will be seated on the natural slope or at a depth of 5 feet at the outside edge of the road, whichever is less.

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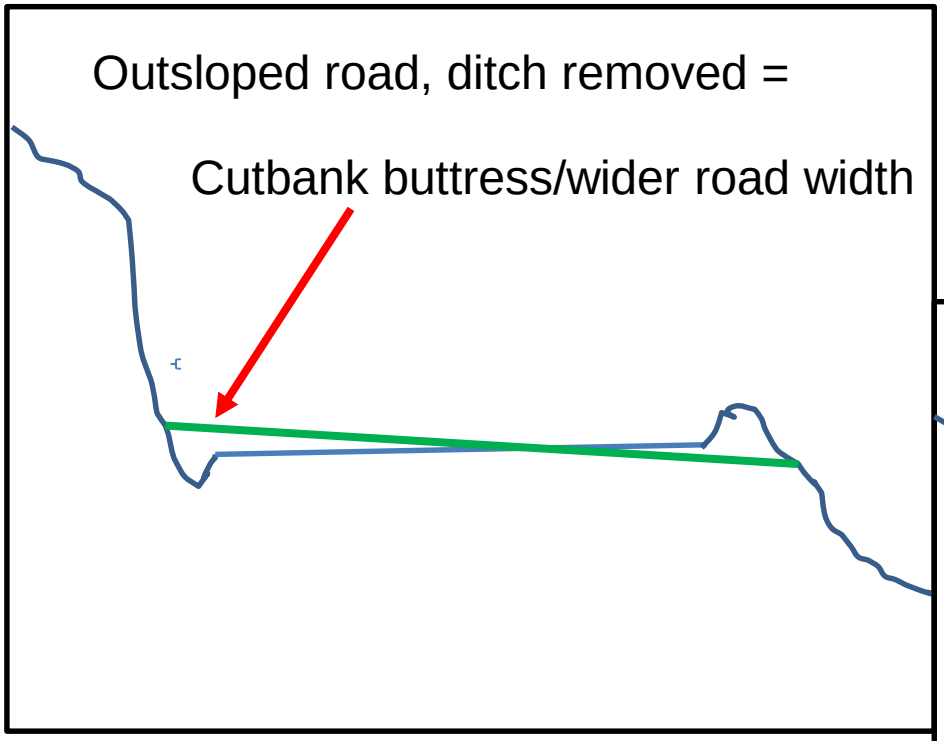
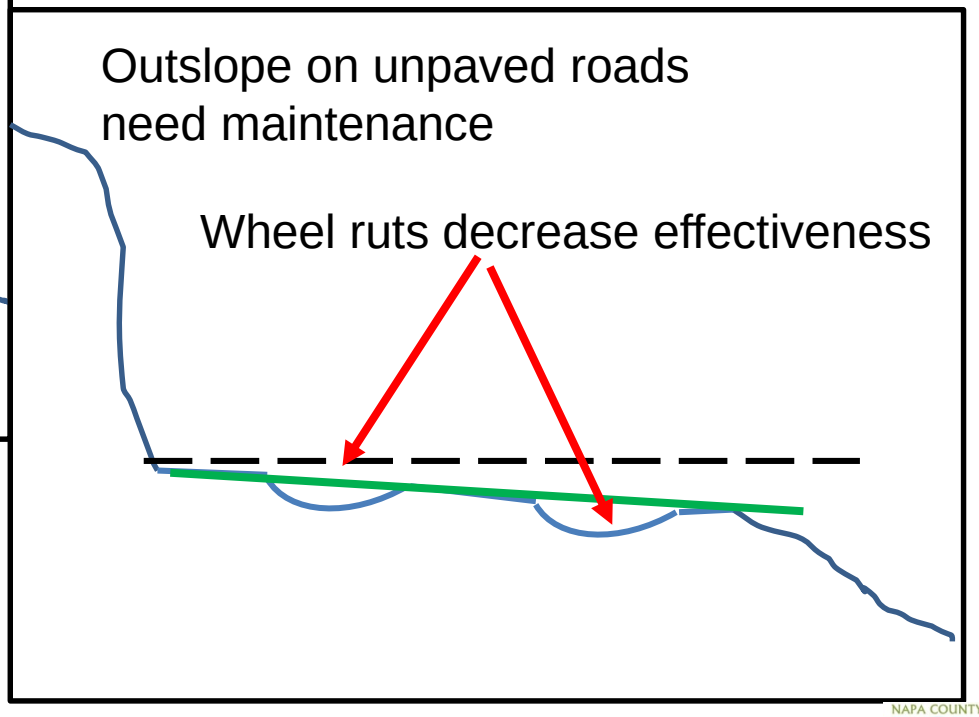
Typical Drawing #8

Benefits of Outsloping-Rolling Dip Combination





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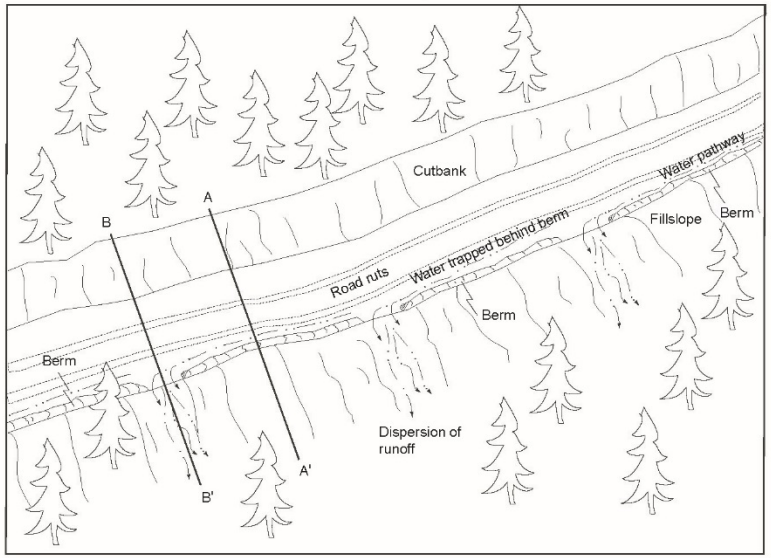
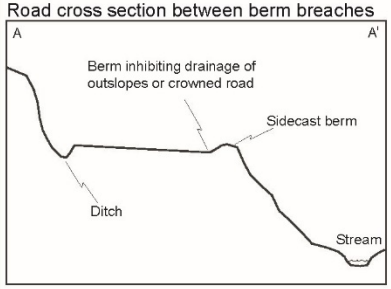
Outsloped road concentrating flow along outboard road

Typical Sidecast or Excavation Methods for Removing Outboard Berms on a Maintained Road

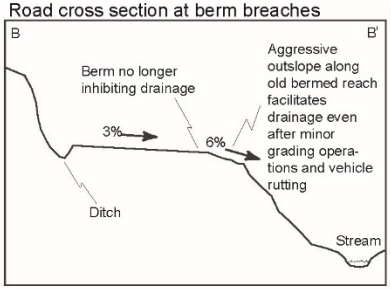
1. On gentle road segments berms can be removed continuously (see B-B').
2. On steep road segments, where safety is a concern, the berm can be frequently breached (see A-A' & B-B') Berm breaches should be spaced every 30 to 100 feet to provide adequate drainage of the road system while maintaining a semi-continuous berm for vehicle safety.



Road cross section between berm breaches



Road cross section at berm breaches



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Typical Drawing #12

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How Long Does it Take to Reshape the Road?

NCRCD Estimated heavy equipment and labor hours Assumptions for road shaping treatments					
Treatment type	Backhoe	Dozer	Water Truck	Roller	Labor
Rolling dip*	0	2	2	0.5	0
Ditch relief culvert	3	0	0.5	0.25	3
Critical dip	0	1	1	0.5	0
Outlsope road fill ditch	0	500 ft/hr	500 ft/hr	1,500 ft/hr	0
Outslope road keep ditch	0	300 ft/hr	300 ft/hr	1,500 ft/hr	0
Inslope road	0	300 ft/hr	300 ft/hr	1,500 ft/hr	0
Crown Road	0	300 ft/hr	300 ft/hr	1,000 ft/hr	0
Remove berm	500 ft/hr	1,000 ft/hr	1,000 ft/hr	0	0
Rock road surface	0	1,500 ft/hr	1,500 ft/hr	1,500 ft/hr	0

* These production rates do not include time for moving between treatment areas and assumes a 12-15 foot road width. Assume lower productivity if underground utilities exist and/or traffic control needs to be managed. Water truck will most likely be used for only half the time that the dozer are doing road shaping and Ditch relief culvert installation.

Fail-safe Mechanisms at Culverted Stream Crossings

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3 Major Impacts of Roads on Watersheds

- HYDROMODIFICATION
  - Poorly constructed roads tend to collect surface flow from the landscape and concentrate that runoff into discrete discharge points thereby increasing the flow volumes that the stream channel would normally experience during the storm event.
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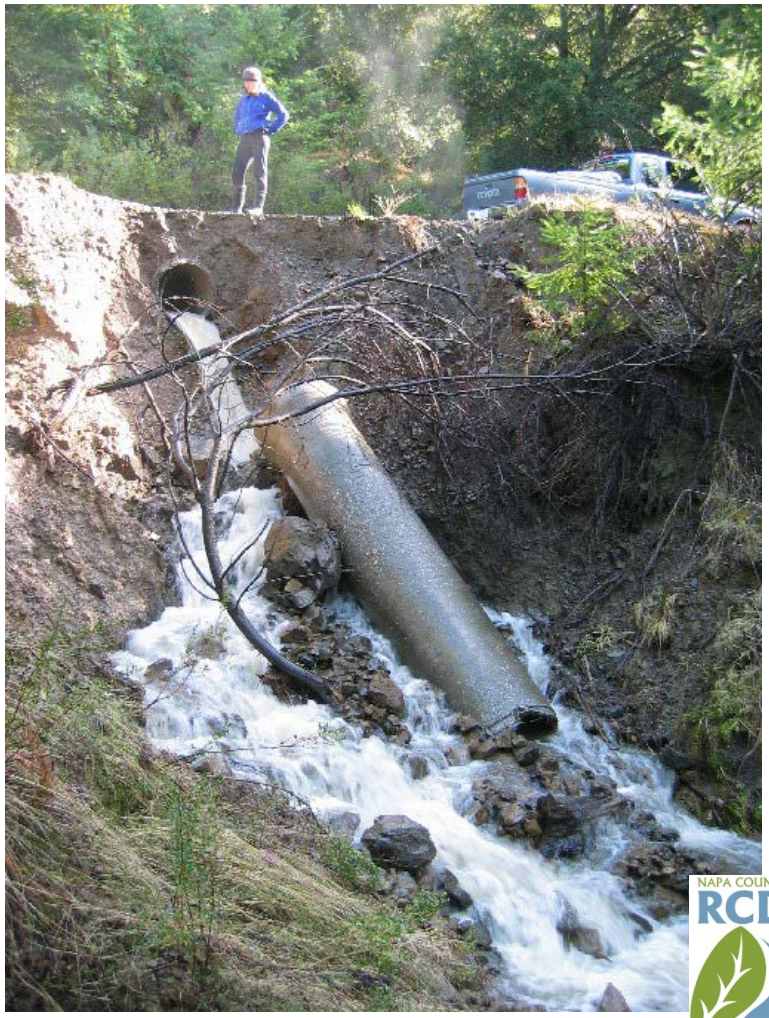
Examples of Episodic Erosion at Stream Crossings



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Stream Crossing Types

Culverted Stream Crossing

- Earthen dam with a hole in it
- Culvert bottom width
- Fish passage requirements

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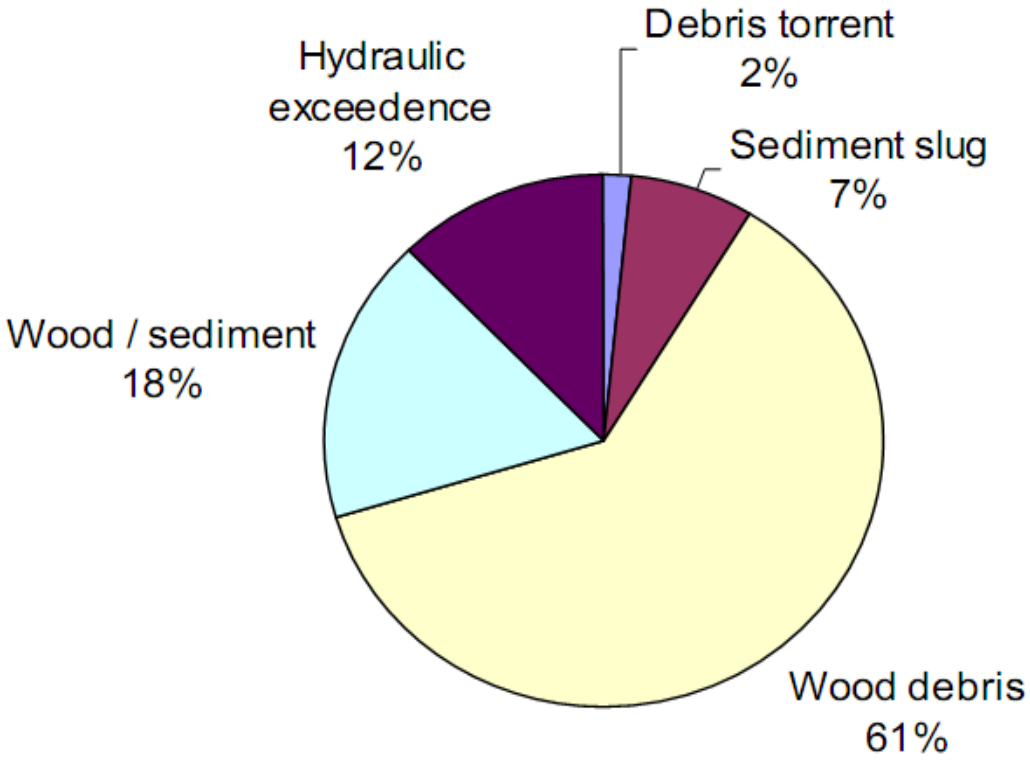
Culverts fail for several reasons

Furniss et al. 1998

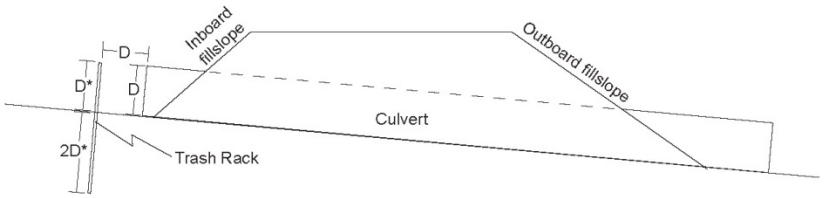
Failure mechanisms for <12 year storm events in Northwest CA



In storm events (< 12 yr RI), over 99% of woody debris transported is shorter than the active channel width

Typical Design of a Single-post Culvert Inlet Trash Rack

Cross section view



D - Culvert diameter

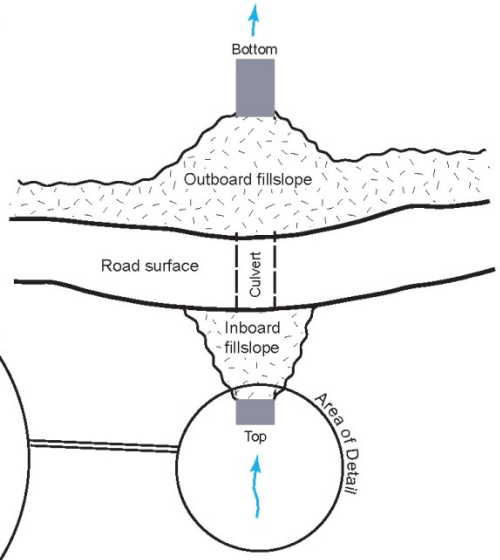
D* - If the culvert is designed for the 100-year peak storm flow, the trash rack height above the streambed should equal D.
If the culvert is undersized, then the trash rack needs to be extended vertically above the streambed to match or exceed the expected headwall height.

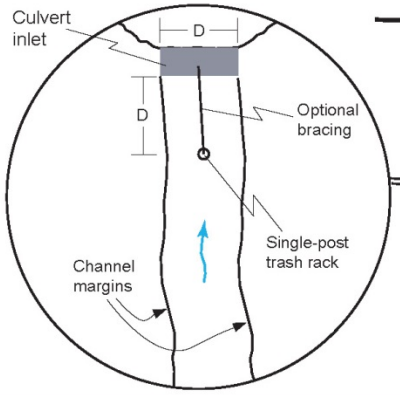
Plan view

Notes:

1. Many materials can be used for a single-post trash rack including old railroad track, galvanized pipe, and fence posts.

2. The diameter of single-post trash racks should be sized based on the size of expected woody debris. As a basic rule of thumb, the diameter of the trash rack should be equal to the diameter of the expected woody debris up to 4 inches.





Pacific Watershed Associates Inc.

Geologic and Geomorphic Studies • Watershed Restoration • Wildland Hydrology • Erosion Control • Environmental Services

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Typical Drawing #3

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Trash racks reduce culvert plugging

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Grates can increase culvert plugging

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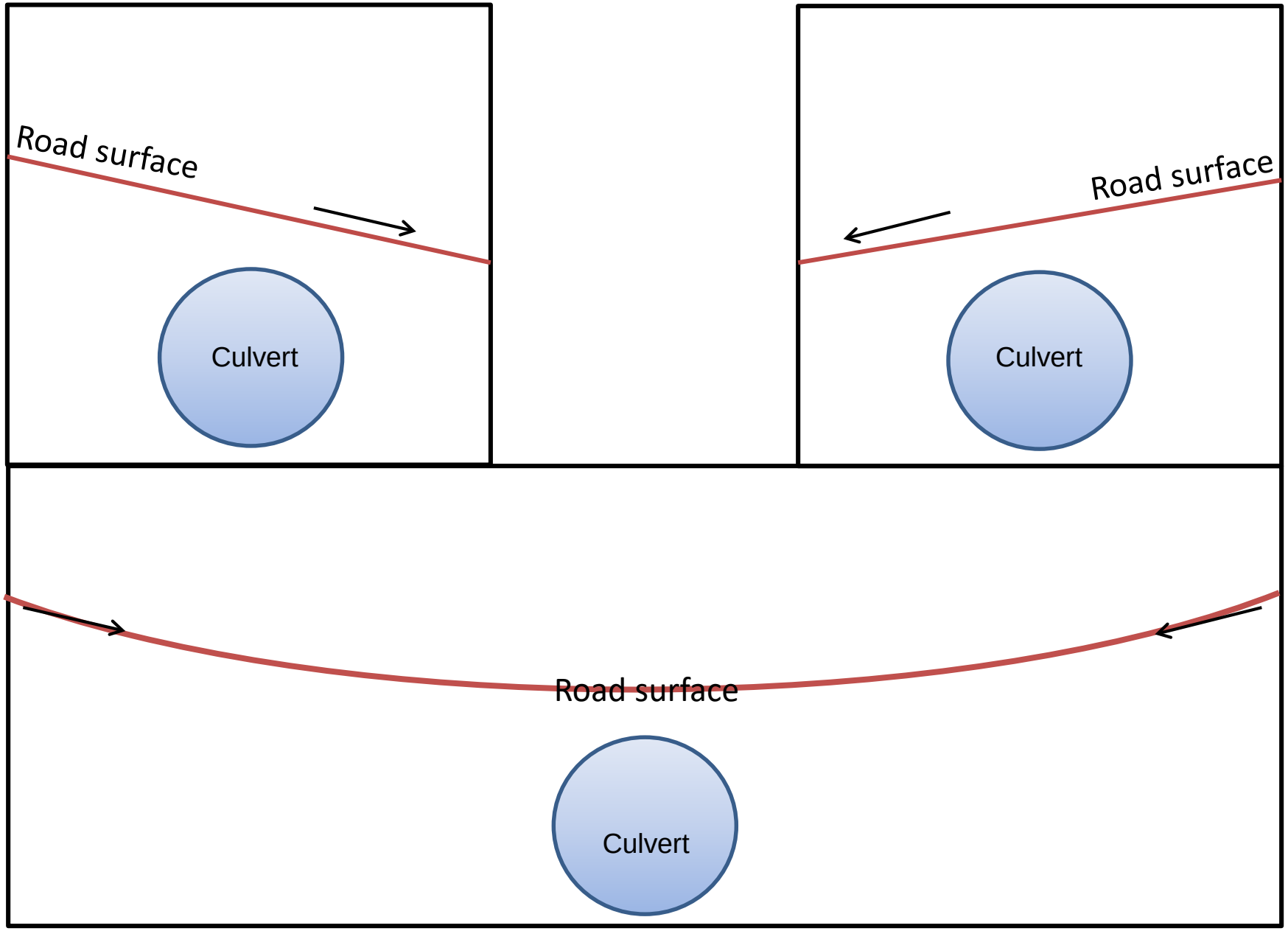
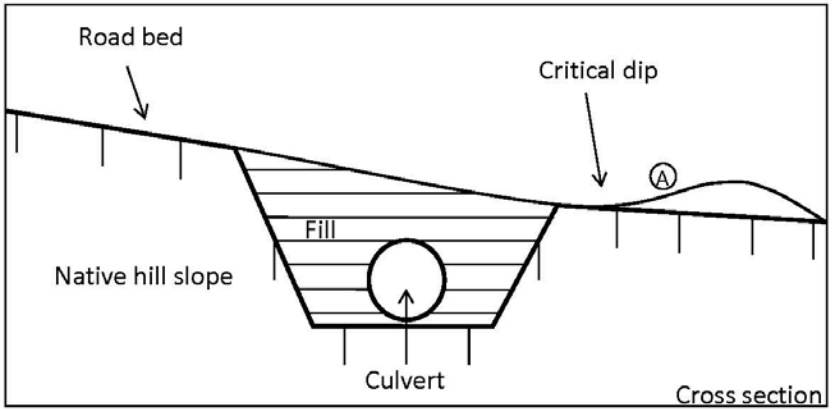
Diversion Potential at Culverted Stream Crossings

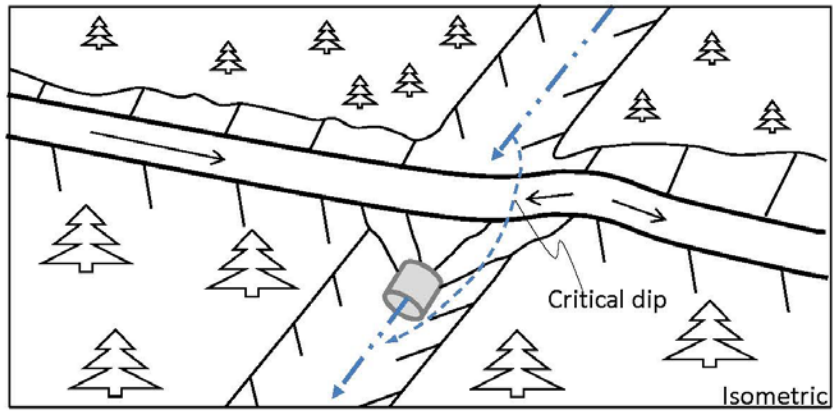


Diversion at Culverted Stream Crossings Can Cause Damage

NAPA COUNTY RCD
Resource Conservation District

Typical Critical Dip Design for Stream Crossings with Diversion Potential





Critical Dip Construction:

1. Critical dip will be constructed on the lower side of crossing.
2. Critical dip will extend from the cutbank to the outside edge of the road surface. Be sure to fill inboard ditch, if present.
3. Critical dip will have a reverse grade (A) from cutbank to outside edge of road to ensure flow will not divert outside of crossing.
4. The rise in the reverse grade will be carried for about 10 to 20 feet and then return to original slope.
5. The transition from axis of bottom, through rising grade, to falling grade, will be in the road distance of at least 15 to 30 feet.
6. Critical dips are usually built perpendicular to the road surface to ensure that flow is directed back into the stream channel.

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Typical Drawing # 1c

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Critical Dips Prevent Further Damage

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Crossing with Fail-safes Installed

Road Surface Materials

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Road surfacing with
1.5”minus aggregate base
(3” depth x 12’ width)

Power Screen

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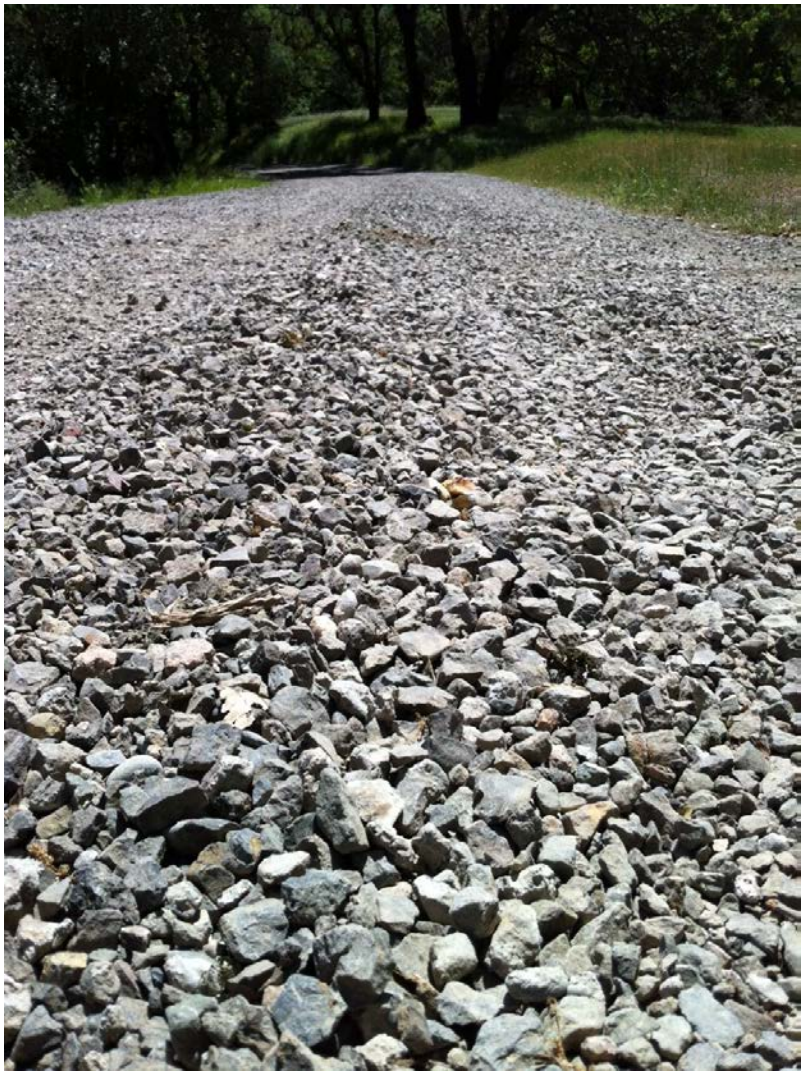

Promotes washboard
Chews up tires
Makes steep roads harder to drive
Doesn’t retain shape
Gets pushed out from driving surface

Good to use if it gets incorporated into existing fines
Good to use in spring wet areas.

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Grinds with Soil Tac

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