Erosion Control Strategies for Islands
Effect of Erosion and Sediment Control Measures On Suspended Sediment Concentrations From Piedmont Construction Sites

Storm Median Sediment Concentration (mg/l)

- Uncontrolled = No Erosion or Sediment Control
- Erosion = Erosion Control Only
- Sediment = Erosion and Sediment Control
- Urbanized = Post Construction Sediment Levels (NURP, 1987)
- Natural = Predevelopment, Prior to Construction

Source: Schueler and Lugbill, 1990
10 Elements of an Effective ESC Plan
MINIMIZE CLEARING 1

LIMIT OF DISTURBANCE
1. Minimize Site Clearing

Objectives:
- Prevent erosion by never clearing/grading portions of the work site
- Protect sensitive areas from grading
- Preserve natural vegetation/forest

Techniques:
- Site fingerprinting
- Clearing Restrictions
Clearing Restrictions

Areas never cleared or activities sharply restricted:

- Stream buffers
- Wetlands, springs and seeps
- Steep slopes, highly erodible soils
- Drainage ways
- Planned areas for infiltration and bioretention
- Minimum % of Site (10 to 75%, depending on lot size)

ESC plans should clearly show limits of disturbance (LOD)
And means to keep heavy equipment out
Stormwater Haiku

If your Inspectors
Cannot tell brown from green
Dump Infiltration!
Sequencing Stormwater in Construction

OK to install curb, gutters and storm drain and discharge to sediment basin

Do not clear locations of stormwater practices (protect them with silt fence—outside LOD)

Do not install permanent BMPs (including perforated pipes for peak discharge control) until contributing area is fully stabilized.
Reforestation is proactive erosion and sediment control strategy—link violations to tree planting
Site Fingerprinting

- Reduce grading to building pad, roadway, utilities and septic areas
2a. Protect Waterways

Objective:
- Protect streams and waterways from sedimentation during construction

Techniques:
- Restrict clearing within 25 feet of waterway
- Special crossings required if work is planned across the waterway
Most Maui streams don’t have this much Vegetative cover— but still should be located Well outside LOD to prevent erosion
STABILIZE DRAINAGEWAYS 2b
2b. Stabilize Drainage Ways

Ditches draining dirt roads are major source of sediment in most islands.

Road ditches are the most important drainage-way to stabilize.

Techniques:
- Checkdams
- Water Bars & Broad-based Dips
- Cross drains and pipe culverts
It starts with good road design

- Maximum grade: 10%
- Gravel cover at key points
- Grass channels for ditches 1 to 5% slopes
- Stable channels with check dams for 5 to 10%
- Non-eroding channels above 10%
- Care taken at stream crossings
Design of Grass Channels

- Gentle grades and side slopes
- Warm season grasses with some perennial rye
- Erosion control fabric
- May need some topsoil, fertilization and liming to get grass started

Also may be converted into permanent stormwater practice
Design of check dams

Stone or coir logs to reduce flow velocities in channels
Spacing similar to water bars
Provide limited sediment trapping
Ineffective on slopes > 10% or if not regularly cleaned out
Checkdams

Direction of Flow

Source: MDE, 2001
Design of Water Bars

Slope approaches gently as required for vehicle access.

Waterbars are installed to divert surface flows only; they are not intended to intercept ditchline.

Construct berm on downgrade side or excavate to necessary depth for expected flow.

Reverse Waterbar (skew to direct water to ditch)

Outlet to be unobstructed and protected from erosion as necessary.

Skew as required (30 degrees typical)

Downgrade (favourable)
Design of Water Bars

- Move shallow concentrated flows across road to safe discharge point
- Divert runoff away from ditches to reduce flow in downstream ditch
- 1 foot mound over 8 to 12 feet
- 30 degree angle
- Spacing of bars based on road grade
- Crushed stone on dip and mound
## Recommended Spacing Between Water Bars

<table>
<thead>
<tr>
<th>Grade of Road</th>
<th>Space Between Water Bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>250 ft</td>
</tr>
<tr>
<td>5%</td>
<td>135 ft</td>
</tr>
<tr>
<td>10%</td>
<td>80 ft</td>
</tr>
<tr>
<td>15%</td>
<td>60 ft</td>
</tr>
<tr>
<td>20%</td>
<td>45 ft</td>
</tr>
<tr>
<td>25%</td>
<td>40 ft</td>
</tr>
<tr>
<td>30%</td>
<td>35 ft</td>
</tr>
<tr>
<td>40%</td>
<td>30 ft</td>
</tr>
</tbody>
</table>

Coir Fiber Log as a Check Dam
What island materials can be used to shape wetland topography (coir fiber log)
Design of Broad-Based Dips

- Natural slope
- Inlet to be unobstructed and excavated to the base of the ditchline
- Compacted ditch block built up higher than road surface
- Roadcut
- Downgrade
- Road surface
- Armour base of cross-ditch if located in erodible material (unless otherwise directed)
- Construct compacted berm on downgrade side (optional)
- Natural slope
- Outlet to be unobstructed and armoured
- Coarse rock to prevent erosion at outlet
- Skew at least 30 degrees from perpendicular of road surface (unless otherwise directed)
Design of Broad Based Dips

- Similar to water bars but one foot dip occurs over 20 to 30 feet
- Allows vehicles to pass without jarring
- Dip also has a 30 degree angle
- Tie the hump into up-gradient road cut
- Only works up to 10 to 12% road grades
## Recommended Spacing for Broad-Based Dips

<table>
<thead>
<tr>
<th>Grade of Road</th>
<th>Space Between Dips</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>300 ft</td>
</tr>
<tr>
<td>4%</td>
<td>200 ft</td>
</tr>
<tr>
<td>5%</td>
<td>180 ft</td>
</tr>
<tr>
<td>7%</td>
<td>160 ft</td>
</tr>
<tr>
<td>8%</td>
<td>150 ft</td>
</tr>
<tr>
<td>10%</td>
<td>140 ft</td>
</tr>
<tr>
<td>12%</td>
<td>Do Not Use</td>
</tr>
</tbody>
</table>

Design of Cross-Drain Culverts
Design of Cross-Drain Culverts

- 12 inch minimum pipe diameter
- Larger pipes may be needed above 2 acre of contributing drainage area
- Pipes angled at 30 to 45%, and have 2% slope
- Armor both the entry and outlet of pipe with stone
- Make sure pipe is covered with fill at last one half its diameter
3. Phase Construction

Objective:
Reduce soil erosion by minimizing the amount of time and area of exposed soil
Grade only portion of site where construction is active (“just-in-time” grading)
15 acre threshold for phasing in MC
3. Phase Construction

- Can reduce erosion by 40% over traditional mass grading
- Requires careful planning
  - "Cut" soil matches "fill" requirement
  - temporary stockpiling and construction access
- Phases should correspond to existing and future drainage boundaries
Be Tough

- Suggest lowering area threshold or increasing temporary stabilization requirements to promote more phasing.
- No clearing on phase 2 until phase 1 completed and fully stabilized.
- Tougher ESC requirements the longer a site is open.
RAPID SOIL STABILIZATION
4. Rapid Soil Stabilization

Objective:
- Reduce soil erosion by minimizing the amount of time soil is exposed

Techniques:
- Seeding/Hydroseeding
- “straw” mulch
- Wood fiber mulch
4. Rapid Soil Stabilization

- Establish grass or mulch cover within two weeks of soil exposure
- Permanently stabilize disturbed areas at conclusion of construction
- Contingency line item for replacing cover that does not take
- Use native seeds and grasses
Notes on Seeding

- Poor quality of some island soils may require fertilization, liming and other soil amendments
- Take soil test
- Use only warm season grasses, with some annual ryegrass to get temporary stabilization
- Grasses vary greatly in tolerance for drought, and shade, and requirements for nitrogen and maintenance
- See CTHAR Turf Management Note 4.
Seeding

• Cost: $0.10/ square yard
• Nearly 100% effective for established grass, 80% for sparse cover
• Requires temporary irrigation to get cover
• $2200 to 3200 per acre (island)
• Should be considered for sensitive areas
Wood Fiber Mulch

- Cost: $0.25 to 0.50 per square yard
- Can be up to 90% effective
- Typically used in combination with hydroseeding
- Can apply with seeding in one step
- Not appropriate for steep slopes or long time periods

Appears to be too thinly applied on Maui—need an Inspection benchmark
Organic Mulch

- Shredded Coconut or Cane
- $0.35 per square yard
- Can be up to 95% effective
- Must be anchored to the soil surface
- Best if used in combination with seeding
- Best for slopes flatter than 3:1
PROTECT STEEP SLOPES

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5. Protect Steep Slopes

Objective:
- Reduce erosion from steep slopes

Techniques:
- Limit clearing of steep slopes (25%)
- Divert upland flow using earthen dike, temporary swale or pipe slope drain
- Use upslope line of silt fence
- Erosion control blankets with seed
- Sod (island available?)
Stabilize Steep Slopes

Steeply sloping terrain is poorly vegetated for several thousand feet of elevation

- Source of sediment during extreme rainstorms
- Steep slopes are extremely hard to revegetate
Steep Slope Challenges

Tough planting conditions

- Poor water holding capability
- Exposure to sun and wind
- Thin, nutrient poor soils
Steep Slope Solutions

Some strategies

- Erosion control fabrics (small slopes)
- Hill Slope Bioengineering
- Better Design for Road Construction on Steep Slopes
Consider for All cut/fill slopes 15% or more

Coconut, wood fiber or coir products work better than Man-made geotextiles
Fig. 6.02 Wattle fences are short retaining walls constructed of living cuttings. They are used to provide terraces that will support plant growth where eroding oversteepened slopes are limiting plant establishment. The section on the right shows the spacing of wattle fences with increasing slope gradient.
Stabilizing steep gullies and guts.

Fig. 6.13 Live silt fences can be used to provide a willow coppice in small streams and ditches. They act by slowing the velocity of the water and allowing sediment to settle out. The cuttings can be either in single rows (as shown) or multiple rows in each fence.
Poor slope drainage control results in the formation of rills and gullies.
Pipe Slope Drain

- Cost: $5-6 per linear foot
- Used to convey runoff past steep slopes.
- Limited to <3 acres for each 24” pipe.
- Effective in combination with a sediment trap or basin.
- Requires stable outlet.
Coconut, wood fiber or coir products work better than Man-made geotextiles.
Fig. 6.02 Wattle fences are short retaining walls constructed of living cuttings. They are used to provide terraces that will support plant growth where eroding oversteepened slopes are limiting plant establishment. The section on the right shows the spacing of wattle fences with increasing slope gradient.
6. Perimeter Controls

Objective:
- Retain or filter runoff before it leaves the site.

Techniques:
- Earth dikes or diversions.
- Silt fences.
- Stabilized construction entrances.
Silt Fences

Popular practice due to low cost: $3.50 per linear foot (mainland).
Between 65% and 85% TSS removal in field studies.
Ongoing maintenance can cost as much as original installation over project life.
Silt Fences

Silt fences are often poorly located, installed or maintained:

Mainland data:

- Only 67% of silt fences on the ESC plan were installed.
- Only 58% were installed correctly.
- Only 34% were adequately maintained.
Use of a silt fence to capture runoff from this steep slope resulted in gully formation.
Improper installation below a pipe outlet.
EMPLOY ADVANCED SETTLING DEVICES
7. Employ Advance Settling Devices

Objective:
- Trap sediment in runoff before it leaves the site

Techniques:
- Sediment traps
- Sediment basins
Settling Devices

- TSS removal varies between 50% to 90%
- Trapping limited by
  - Difficulty in settling fine-grained soils
  - Simplistic design of existing basins
Most sites larger than 5 acres should have a trap or basin at downgradient end sized for WQv.
Sedimentation basin with standpipe encased in gravel.
Berm dividing a multiple cell sedimentation basin.
8. Certify Contractors and Inspectors

Objectives:
- Ensure proper installation and maintenance.
- Train contractors and inspectors

Techniques:
- Mandated ESC training.
- Applies to contractors responsible for installation and maintenance of ESC devices.
- Pre-construction meetings.
Need for greater training for designers and contractors
ADJUST ESC PLAN FOR FIELD CONDITIONS
The Subcontractors Trash My Controls!
ASSESS ESC PRACTICES AFTER STORMS
Maui Recommendations

- More Training
- Better Inspection Benchmarks
- Update specs in consultation w/ engineers
- Simple general permits for single lot construction
- Tougher phasing requirements
- Investigate island mulch
Reasons Silt Fences Fail

1. Slope to length ratio too high.

2. Installation does not account for construction traffic.
3. Edges not pointed uphill (ponding).

4. Contributing length greater than 100’ or placed in concentrated flow location.
Reasons Silt Fences Fail

5. Fence is not installed parallel to contours.

6. Bottom of fabric is not properly entrenched.
Reasons Silt Fences Fail

7. Distance between posts > 8’.

8. Silt fence installed below a pipe outlet.
Reasons Silt Fences Fail

9. Silt fence receives concentrated flow.

10. Silt fence installed uphill of disturbed area.
11. Sediment buildup behind fence reduces treatment capacity.

12. Silt fence alignment reflects property line, not ESC needs.
Breached Curb Inlet Protection