# Recommendations of the Expert Panel to Define Removal Rates from Construction Sites with Erosion and Sediment Control Practices

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# Construction In the Bay Watershed

- Highest Unit Area Sediment Load of any Bay Land Use (Edge of Field)
- About 84,500 acres of construction in any given year
- CBWM: 16% of delivered sediment load from urban sector

# Construction Sites are More than Bare Ground

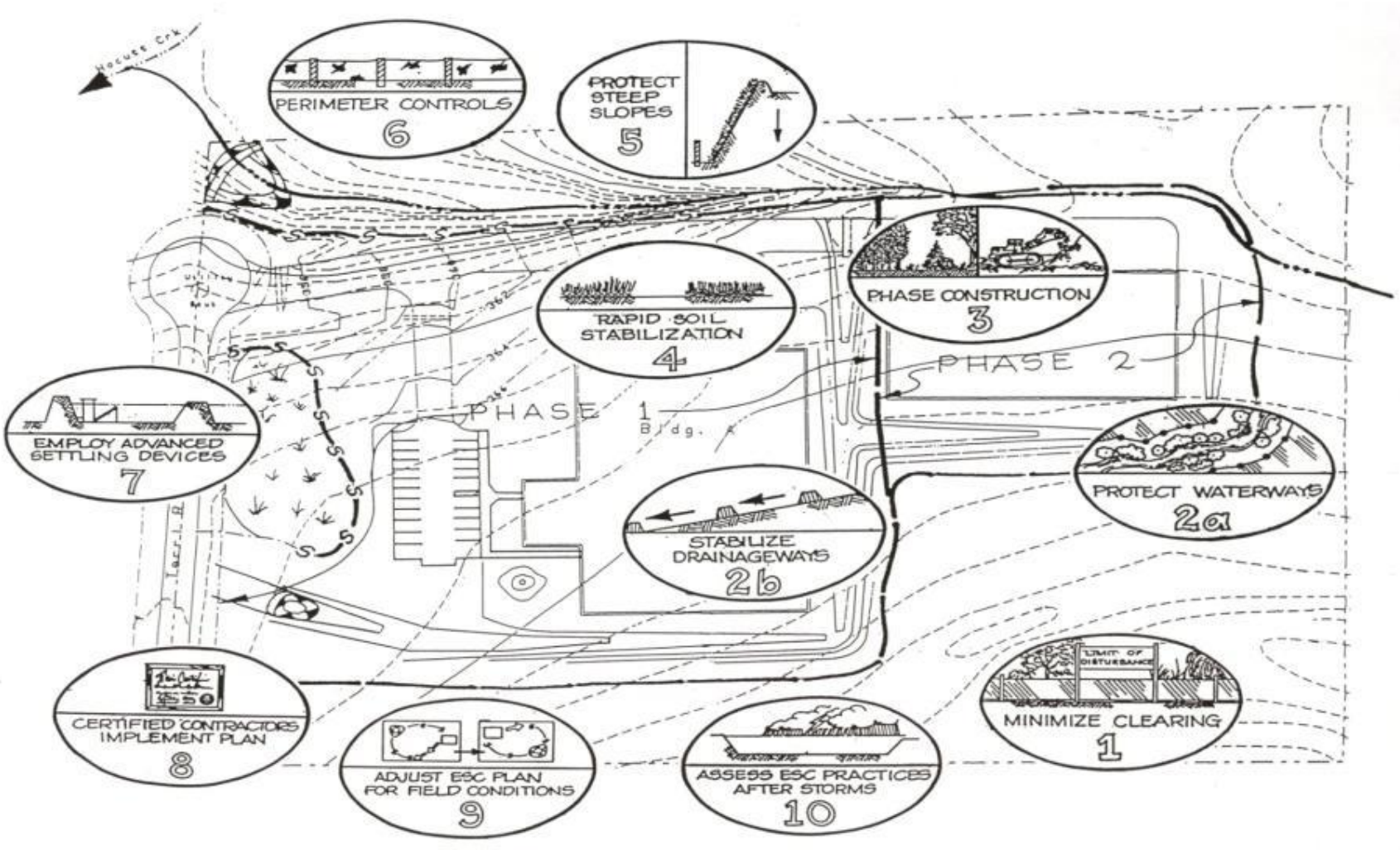

# Construction Sites are Highly Dynamic

Construction process involves initial clearing and grading, earth-moving, installation of streets and storm drains, building construction and finally, the final stabilization of the site.

The hydrology of a construction site constantly changes, based on soil exposure, new slopes, the growing season, grass cover, addition of hard surfaces, stormwater conveyance, and the condition and performance of ESC practices.

Construction site erosion potential changes constantly over time, although significant soil loss is always expected during heavy or intense rainfall events.

# Erosion and Sediment Control Practices



# Level 1 ESC Practice

- Historical Level of Practice (2005 and before)
- Assumed Performance for CBWM Calibration (1990-2005)
- Less stringent sizing, technology and inspection requirements
- No Bay states currently operate at this level of practice

# Level 2 ESC Practice

- Reflects more stringent ESC regulations and permits adopted in recent years
- Improved sizing, stabilization, phasing and inspection requirements
- All Bay states now safely operating at Level 2 ESC

# Level 3 ESC Practice

- ESC Practice Level 2, plus additional passive chemical treatment to reduce turbidity, with a reliance on polyacrylamide (PAM) and other flocculants
- Enhanced design features on ESC practices to improve performance
- No Bay states are currently operating at this level, although several states are shifting toward it

# Level 4 ESC Practice

- Best available technology for turbidity control to achieve low numerical turbidity standards
- Has been piloted at some sites in Pacific Northwest
- Involves expensive Active Treatment Systems that pump, treat and filter construction site runoff
- No Bay state is operating at this level

# Monitored Construction Site Hydrology

| 106 storms by Line and White (2007) NC Piedmont [5] | | |
|---|---|---|
| STAGE | Runoff Coefficient | TSS (tons/acre) |
| Construction [1] | **0.50** | 13 |
| Establishment [2] | **0.60** | 2.8 |
| Post Construction [3] | **0.55** | 0.9 |
| Undeveloped [4] | 0.21 | 0.16 |

[1] from initial clearing , grading, installation of infrastructure and seeding (0.7 years)

[2] Most homes constructed, and lawns and landscaping are becoming established (1.4 years)

[3] After home build out (3.6 years)

[4] Undeveloped reference watershed

[5] 6 years of sampling during and after construction at a 10 acre residential subdivision, compared to an undeveloped reference forest catchment less than a mile away (also sampled for same 5.6 years)

# Modeled Rv's (EPA, 2009)

| Reported Volumetric Runoff Coefficient (Rv) for Construction Sites by Hydrologic Soil Groups (EPA, 2009) | | | | |
|---|---|---|---|---|
| | HSG A | HSG B | HSG C | HSG D |
| Annual Rv [1] | 0.15 | 0.27 | 0.39 | 0.49 |
| Rv for 2 year Design Storm | 0.37 | 0.57 | 0.70 | 0.79 |
| [1] for the technical assumptions, see Section 9 and 10 of EPA (2009) | | | | |

| Percent of each of the 4 HSG's in each Bay State [1] | | | | |
|---|---|---|---|---|
| Bay State | HSG A | HSG B | HSG C | HSG D |
| Delaware | 21% | 31% | 13% | 35% |
| Maryland | 10 | 39 | 26 | 25 |
| Pennsylvania | 6 | 28 | 54 | 12 |
| New York | 10 | 19 | 51 | 21 |
| Virginia | 2 | 54 | 32 | 12 |
| West Virginia | 7 | 22 | 54 | 17 |
| Mean of States [2] | **9%** | **32%** | **38%** | **21%** |
| Bay-Weighted MEAN [3] | **6%** | **38%** | **40%** | **16%** |

[1] State-wide from STATSGO
[2] Value shown is simply the mean of the six Bay states, including non-Bay watershed area
[3] Mean adjusted to account for fraction of total state area that is located in Bay watershed

| Computed Annual Construction Rv Using the EPA (2009) method | |
|---|---|
| State | Annual Rv |
| Delaware | 0.34 |
| Maryland | 0.34 |
| Pennsylvania | 0.35 |
| New York | 0.37 |
| Virginia | 0.33 |
| West Virginia | 0.36 |
| Mean of States [2] | **0.35** |
| Bay-Weighted MEAN [3] | **0.35** |

# Sediment Loads Discharged from Construction Sites

- Review of about 25 recent and historical studies

# Measured Sediment Loading Rates for Construction Sites, w/ or w/o ESC

| Study | Region | Tons/acre/year | ESC Used? | Notes |
|---|---|---|---|---|
| CBWM | Bay | 24.4 | No | Model Assumption |
| Yorke and Herb, 1978 | MD | 33 | No | |
| Nelson, 1984 | SE US | 100 to 300 | No | |
| Cleaves et al, 1970 | SE US | 218.9 | No | |
| Likens and Borman, 1974 | NE US | 48.4 | No | |
| Cywin and Hendricks, 1969 | SE US | 134 | No | |
| Line and White,2007 | NC | 13.0 | Yes | Residential |
| Daniel et al, 1979 | WI | 7.8 | Yes | Residential |
| Line, 2007 | NC | 18.5 | Yes | Highway |
| Line and White, 2001 | NC | 4.4 | Yes | Residential |
| Owens et al, 2000 | WI | 1.7-6.7 | Yes | Resid./Comm. |
| Lee and Ziegler, 2010 | KS | 0.5 to 2.5 | Yes | Residential |

# Sediment Discharged From Construction Sites

| Mean TSS Inflow and Outflow Concentrations in Relationship to ESC Practice Level | | | |
|---|---|---|---|
| ESC Level | TSS IN (Mg/l) | TSS OUT (Mg/l) | Sediment Removal Efficiency |
| **LEVEL 1 ESC** | **1583** | **812** | **49%/50% [1]** |
| **LEVEL 2/3 ESC** | **6188** | **557** | **90%/83% [1]** |
| **Grand Mean** | **3598** | | |
| [1] First is based on level 1 means; second is mean percent removal | | | |
| Based on 13 research studies 1990 to 2008, N=6 for Level 1 and N=7 for Level 2/3 . | | | |

# Panel Best Estimates of Base Construction Site Sediment Loads

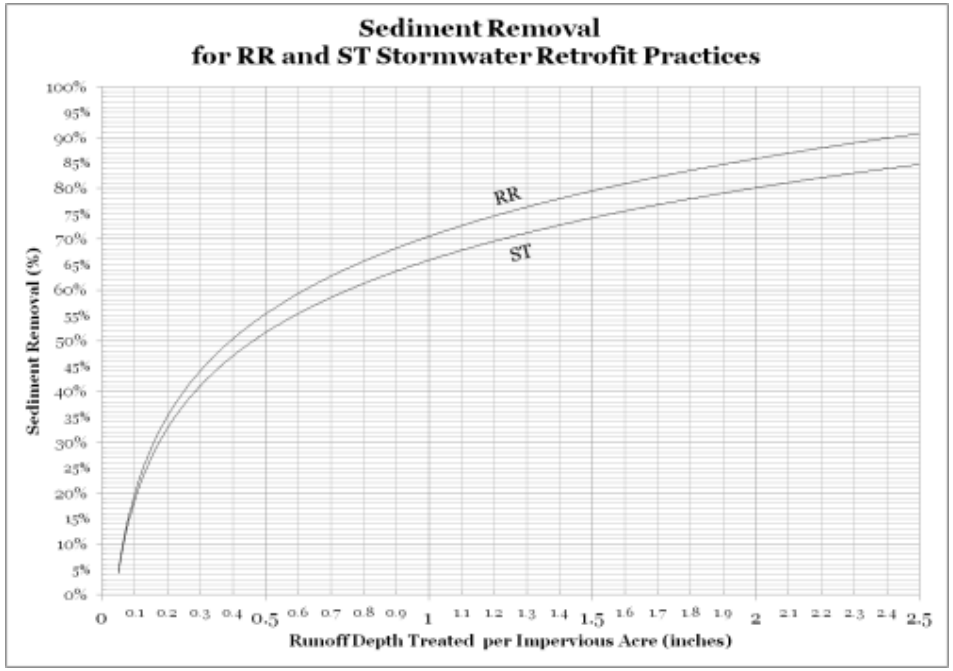
| **Table 16** Comparative Summary of ESC Scenarios (tons/ac/yr) | | | | |
|---|---|---|---|---|
| **ESC Scenario** | Worst Case | Mid-point | Best Case | **Best Estimate** |
| Construction w/o ESC | 22.3 | 8.6 | 5.1 | **12.0** |
| Sites Operating at Level 1 | 2.5 | 1.8 | 1.1 | **1.8** |
| Sites Operating at Level 2 | 1.6 | 1.0 | 0.7 | **1.1** |
| Sites Operating at Level 3 | 1.05 | 0.57 | 0.31 | **0.65** |
| Sites Operating at Level 4 | ND | ND | ND | **ND** |
| *Important Note*: Actual sediment loads for all 4 ESC levels will be higher when moderate and extreme storms exceed or overwhelm ESC capacity, and thus create functional deficiency, and much lower removal rates. ND= No data | | | | |

See Appendix A for technical assumptions for each load calculation

# Defining Functional Deficiency

# Accounting for Functional Deficiency

| Computation of Sediment Removal Rates for Four Levels of ESC | | | | |
|---|---|---|---|---|
| ESC Scenario | Discharged Load [1] | Removal Rate | MFD [2] Adjustment | Effective Removal Rate [3] |
| Sites Operating at ESC Level 1 | 1.8 | 85% | 3.1 | **74%** |
| Sites Operating at ESC Level 2 | **1.1** | **92%** | **1.8** | **85%** |
| Sites Operating at ESC Level 3 | 0.6 | 95% | 1.3 | **90%** |
| Sites Operating at ESC Level 4 | ND | ND | ND | **ND** |




Level 1: = 25% of time in MFD
Level 2/3 =15% of time in MFD

# Summary of Key Recommendations

- Current Level 2 ESC Practices Provide a High Level of Sediment Removal From Construction Sites

| ESC Scenario | Discharged Load | Effective Removal Rate |
|---|---|---|
| ESC Sites Operating at Level 1 | 3.1 t/ac/yr | 74% |
| **ESC Sites Operating at Level 2** | **1.75 t/ac/yr** | **85%** |
| ESC Sites Operating at Level 3 | 1.25 t/ac/yr | 90% |
| ESC Sites Operating at Level 4 | No estimate | No estimate |

- Recommended to be applied to construction site acreage in current version of CBWM (5.3.2)s

# Turbidity Discharged From Construction Sites

| Turbidity in relationship to ESC Practice Level, Summary of Literature | | | | |
|---|---|---|---|---|
| Summary of Research | Turbidity IN (NTUs) | Turbidity OUT (NTUs) | Removal Efficiency % | Notes |
| LEVEL 1 and 2 MEANS | **2327** | **1919** | **~ 25** | NO PAM |
| LEVEL 3 MEANS | **1423** | **165** | **80-90** | PAM |

# Turbidity Findings

- Level 1 and 2 ESC practices have little capability to reduce turbidity
- Concern on turbidity's impact to aquatic health in streams, lakes, rivers and estuaries
- Turbidity indicates fine sediments might have a higher delivery ratio to the Bay
- Recommend shift to Level 3 ESC Practice to provide more effective turbidity control

# Nutrient Dynamics At Construction Sites

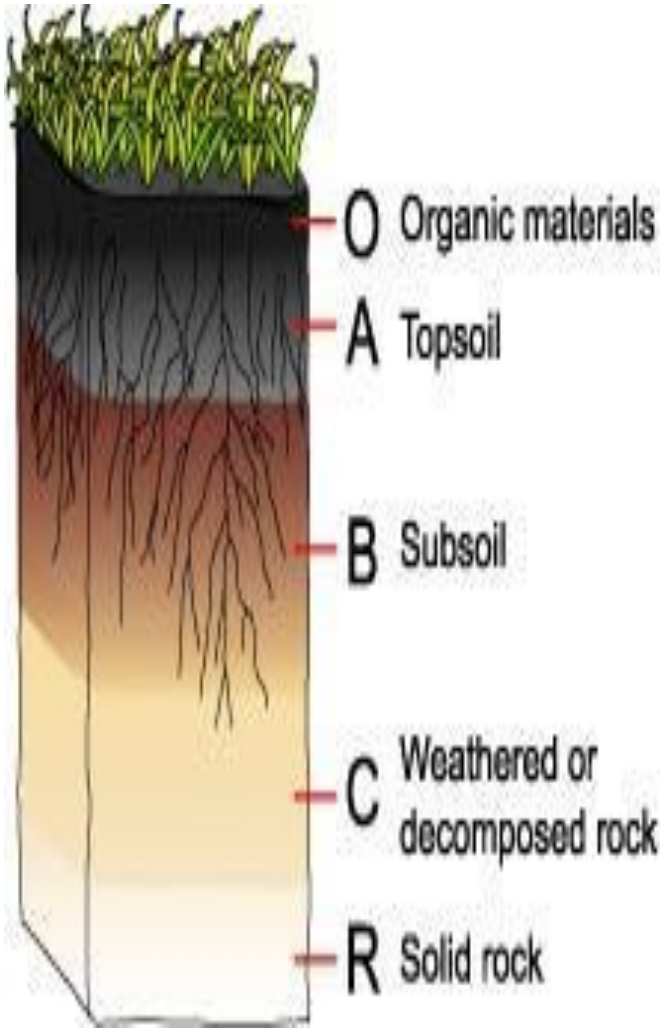
Five pathways for nutrient export from construction sites:

1. Nutrients attached to eroded soils
2. Wash off of fertilizer due to hydro-seeding and permanent stabilization
3. Wash-off of nutrients deposited from the atmosphere
4. Decay of organic material used to cover soil (i.e., compost, mulches, erosion control blankets, etc)
5. Leaching into groundwater (primarily nitrate).

# Bi-Modal N/P Concentrations in Construction Site Runoff

| Comparison of nutrient concentrations in construction site runoff (mg/l) | | | | |
|---|---|---|---|---|
| Study | TN | DIN | TP | Notes |
| Kayhanina et al 2001 | 3.5 | 1.06 | 0.95 | California, N=72 Highway |
| Line, 2007 | 1.7 | | 0.47 | NC, N=16 |
| Cleveland and Fashokun, 2006 | | 1.26 | 0.47 as $PO_4$ | Above basin |
| Cleveland and Fashokun, 2006 | | 1.57 | 0.21 as $PO_4$ | Below basin |
| Kalanaisan et al 2008 | | | 0.72 as $PO_4$ | Below basin |
| Soupir et al 2004 | **57.5** | **15.96** | **5.6** | Fertilized test plot |
| Faucette et al 2008 | Nd | Nd | **31.8** | Fertilized test plot |
| McLaughlin and King, 2008 | 5.18 | Nd | 3.1 | JACK |
| McLaughlin and King, 2008 | **19.8** | | **34.6** | BUNC |
| McLaughlin and King, 2008 | 3.78 | | 0.3 | WAKE |
| Horner et al, 1990 | -- | -- | In: **12.3/2.25**/0.55<br>Out: 0.44/0.6/0.14 | 3 basins in Seattle |

# Exposed Construction Site Soils Have Low Sediment Nutrient Content




| Nutrient Content by Soil Horizon in USDA Soil Survey | | |
|---|---|---|
| | Silt Loam | Loamy Sand |
| Organic Content | O Horizon: 5.5%<br>AB Horizon: 1.8% | O Horizon: 9.5%<br>AB Horizon: 1.4% |
| Total Nitrogen (mg/kg) | O Horizon: **2,900**<br>AB Horizon: **1,000** | O Horizon: **4,700**<br>AB Horizon: **700** |
| Total Phosphorus (mg/kg) | O Horizon: **35**<br>AB Horizon: **5** | O Horizon: **16**<br>AB Horizon: **2** |

# Typical Fertilization Rates at Construction Sites in Bay States to Achieve Vegetative Stabilization

| *ESC Stabilization Recommendations* | Formulation (N-P-K) | Application Rate lbs/ac | N Rate N lbs/ac | P Rate * P lbs/ac |
|---|---|---|---|---|
| Temporary Stabilization | 10-10-10 | 500-600 | **50** | **27** |
| Permanent Stabilization | 10-20-10 | 500-1000 | **65** | **48** |
| Total Fertilizer Application | | **600 to 1500** | **115** | **75** |

See Table 24 for variation among Bay States.
* Adjusted to convert phosphate $PO_4$ to TP
Suggested application rate in the absence of a soil test or urban nutrient management plan. May be replaced by mulching in the non-growing season.

- 3 to 4 week "hi risk window" for grass to germinate and achieve desired density, as well as 1 to 3 years "moderate risk window" for starter lawns

- Construction sites have 7 or more of the 12 fertilizer wash-off hi risk factors as defined by UNM Expert Panel

# Risk of Fertilizer Wash-off


# Mass Balance Comparison of all 5 Nutrient Export Pathways

| Comparison of Nutrient Loadings by all Five Pathways (low, medium or high) (lbs/ac/yr) | | | | | | |
|---|---|---|---|---|---|---|
| | Total Nitrogen | | | Total Phosphorus | | |
| | Low | Med | High | Low | Med | High |
| Pathway 1 | 2.8 | 11.2 | 16.8 | 0.08 | 0.30 | 0.46 |
| Pathway 2 | 1.1 | 5.7 | 11.4 | 0.7 | 3.7 | 7.4 |
| Pathway 3 | 1.3 | 3.9 | 6.5 | 0.07 | 0.2 | 0.4 |
| Pathway 4 | 0.7 | 2.8 | 4.2 | 0.2 | 0.8 | 1.2 |
| Total | **5.9** | **23.6** | **38.9** | **1.1** | **5.0** | **9.5** |
| CBWM | **26.4** | | | **8.8** | | |
| *Note:* Pathway 5 "N migration to groundwater" was not included in the analysis, so N load mass balance may be conservative. | | | | | | |

# Nutrient Recommendations

- Existing CBWM construction site nutrient loading rates confirmed by mass balance analysis
- No clear evidence that ESC practices can actually reduce nutrients
- Some evidence that they may actually be nutrient sources.
- Zero nutrient removal efficiency for all four levels of ESC practice
- Recommend critical monitoring studies to reduce the risk of fertilizer wash-off.

# Future Research and Mgmt Needs

- The Panel urges funding for a short-term, intensive monitoring study
- Focus on sampling nutrient concentrations in construction site discharges during the period of high fertilizer wash-off risk that occurs during and after site stabilization.
- Scope may involve a total of 100 - 200 flow-weighted composite samples to measure nutrient concentrations in 10 to 15 different construction sites in the Bay region to get more accurate EMC estimates for N and P.

# Longer Term Study

- Investigate whether fertilization rate/formulation recommendations, vegetative stabilization methods and/or down-gradient ESC practices could be modified in order to reduce nutrient export…….while still maintaining effective vegetative and soil cover during the entire construction process.

- Potential benefits of incorporating low doses of PAM to hydro-seeding mixes on erosion-prone soils should be sampled

# Panel Modeling Recommendations

- In next version, either drop the sediment target load for the no-ESC condition to 12 tons/ac/yr, or shift to explicitly simulating construction sites as its own land use, based appropriate target load for the prevailing ESC level
- Incorporate all important nutrient export pathways (especially fertilizer application) in the model simulation of construction sites
- Consider lower sediment loads for low slope coastal plain terrain

# WQGIT Decision on Phasing of Recommendations

| Practice Type | Sediment | | Nitrogen | | Phosphorus | |
|---|---|---|---|---|---|---|
| | Phase 5.3.2 | Phase 6 | Phase 5.3.2 | Phase 6 | Phase 5.3.2 | Phase 6 |
| **Level 1** | | 74 | | 0 | | 0 |
| **Level 2** | | 85 | | 0 | | 0 |
| **Level 3** | | 90 | | 0 | | 0 |

1. Honor the panel recommendations as the accumulation of the best science

# Relating Recs to Calibration

| Practice Type | Sediment | | Nitrogen | | Phosphorus | |
|---|---|---|---|---|---|---|
| | Phase 5.3.2 | Phase 6 | Phase 5.3.2 | Phase 6 | Phase 5.3.2 | Phase 6 |
| **Level 1** | 40 | 74 | 25 | 0 | 40 | 0 |
| **Level 2** | | 85 | | 0 | | 0 |
| **Level 3** | | 90 | | 0 | | 0 |

2. Ensure that we are modeling in a way that best measures real changes on the ground

# Relating Recs to Each Other

2. Ensure that we are modeling in a way that best measures real changes on the ground

| Practice Type | Sediment | |
|---|---|---|
| | Phase 5.3.2 | Phase 6 |
| **Level 1** | 40 | 74 |
| **Level 2** | | 85 |
| **Level 3** | | 90 |

L1 lets through 26%

L2 lets through 15%

L2 reduces the L1 sediment by 58% (15%/26%)

# Relating Recs to Each Other

2. Ensure that we are modeling in a way that best measures real changes on the ground

| Practice Type | Sediment | |
|---|---|---|
| | Phase 5.3.2 | Phase 6 |
| **Level 1** | 40 | 74 |
| **Level 2** | 65 | 85 |
| **Level 3** | | 90 |

L1 lets through 26%

L2 lets through 15%

L2 reduces the L1 sediment by 58% (15%/26%)

L2 reduces the L1 sediment by 58% (35%/60%)

# Tying it All Together

| Practice Type | Sediment | | Nitrogen | | Phosphorus | |
|---|---|---|---|---|---|---|
| | Phase 5.3.2 | Phase 6 | Phase 5.3.2 | Phase 6 | Phase 5.3.2 | Phase 6 |
| Level 1 | 40 | 74 ★ | 25 | 0 ★★ | 40 | 0 ★★ |
| Level 2 | 65 | 85 ★ | 25 | 0 ★★ | 40 | 0 ★★ |
| Level 3 | 77 | 90 ★ | 25 | 0 ★★ | 40 | 0 ★★ |

** The ultimate Phase 6 sediment loading rates will be selected by the Modeling Workgroup and will be subject to Water Quality GIT Approval.*

*** The Expert Panel proposed that the zero removal rate will be applied to the current target nutrient loading rates for construction land in Phase 6 of the CBWM, unless new monitoring data acquired between now and then provides evidence that the target nutrient loads from construction sites with Level 2 or Level 3 ESC practices should be increased or decreased. The ultimate Phase 6 target nutrient loading rates will be selected by the Modeling Workgroup and will be subject to Water Quality GIT Approval*