Recommendations of the Expert Panel to Define Removal Rates for Erosion and Sediment Control Practices

Presented to Watershed Technical Workgroup

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Charge of the Panel

- Evaluate how construction sites are simulated in the context of CBWM version 5.3.2
- Review available literature on the nutrient and sediment loading rates associated with construction sites, and the effect of conventional and enhanced ESC practices in reducing them.
- Provide specific definitions of "enhanced" and "conventional" ESC practices, and describe the qualifying conditions under which a locality can receive a nutrient and/or sediment reduction credit for each.
- Critically analyze any unintended consequences associated with the sediment and nutrient removal rates and any potential for double or over-counting of the credit.

Charge of Panel

Evaluate whether the existing CBP approved nutrient removal rates for conventional ESC practices developed in 2007 are still reliable, and evaluate the interim rate requested by WV in 2011.

Removal Rates for ESC Practices for Construction Sites			
	TSS	TP	TN
Existing CBP-Approved Rate [1]	40	40	25
Interim Rate Requested by WV [2]	80	80	80
[1] approved by USWG, August 15, 2007 [2] interim rate requested by WV 9/15/2011 for enhanced ESC controls (see Appendix E)			

Recommend procedures to report, track, and verify that conventional and enhanced ESC practices are actually being implemented and maintained until the site is fully stabilized.

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)

Nutrient Recommendations

- Existing CBWM construction site nutrient loading rates confirmed by mass balance analysis
- No clear evidence that ESC practices 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.

Reporting, Tracking and Verification

Existing regulatory and self-inspection programs at Bay construction sites are more than sufficient for BMP verification for the TMDL, and no new field verification protocols are needed

States have two options for reporting their annual state-wide construction acres:

- Existing CBP ratio based on new impervious cover
- Submit aggregate data from Construction General Permit (CGP) state-wide databases

Local governments have no new reporting requirements, beyond existing MS4 permits and/or state regulations

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

Comparison of Edge of Field Sediment Loads By Land Use in the Bay Watershed (CBWM 5.3.2)

Bay Model Land Use Category	Annual EoF Sediment Load (tons/acre/year)
Construction Sites, No ESC Practices	**24.4**
Construction Sites, with ESC Practices [1]	**14.6**
Degraded Riparian Pasture	14.0
Extractive, Uncontrolled	10.0
Crops, Conventional Till	5.8
Urban Impervious Cover	5.0
Crops, Conservation Till	3.9
Pasture	1.6
Hay	1.5
Urban Pervious Cover	1.2
Forest (un-harvested)	0.3

Sources: Table 9-1 and 9.12 in Chesapeake Bay Phase 5.3 Community Watershed Model (EPA CBP, 2011)
Note: Application of BMPs can reduce sediment loads as shown above
[1] ESC practices are assumed to have a 40% removal rate, per the existing CBP-approved removal rate

Construction Sites are More than Bare Ground

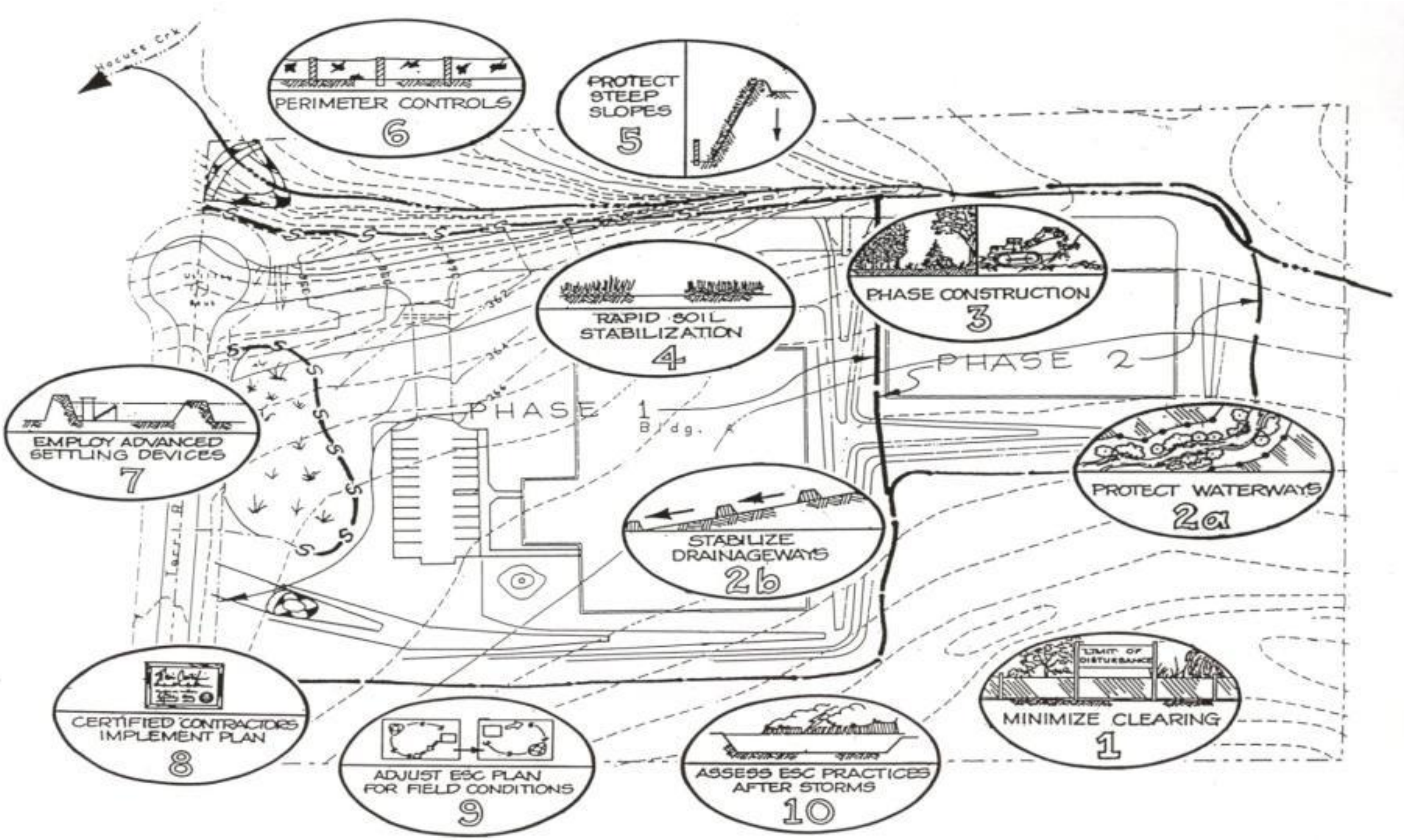
Construction Sites are Highly Dynamic

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



Four Levels of ESC Practice

Practices	Level 1 ESC	Level 2 ESC	Level 3 ESC
Protect Natural Resources	Locate natural areas and mark LOD (up to edge of natural area)	Do #1 and add buffers to LOD to prevent discharge to natural area	Do # 2, and provide enhanced perimeter controls at LOD boundary for sensitive areas
Minimize Disturbance	No numeric construction phasing requirement	Construction phasing required for largest projects (e.g., 25 + acres)	Construction phasing required for smaller projects
Stabilize Soils	Stabilize w/in 14 to 21 days	Stabilize w/in 7 -14 days	Stabilize w/in a week
Internal Drainage	Temporary swales	Swales/diversions with check-dams and erosion control blankets	Do #2, but enhance with passive use of polymer (e.g., floc logs or wattles)
Perimeter Controls	Standard Controls (e.g., hay bales, entrance stabilization)	Reinforced silt fence and berms/diversions	Enhanced perimeter controls (i.e., super silt fence, compost logs, and filtering practices).
Sediment Traps and Basins	Sediment traps, filters, and basins that meet the 0.5" (1,800 cu.ft/acre) standard	Sediment basins that meet the 1.0" (3,600 cu.ft/ac) standard, with permanent pools and/or dewatering control devices (e.g., skimmers)	Do # 2, but enhance performance with passive use of chemical additives to improve settling, filtration and surface outlets
Inspections	Monthly	Every 1 to 3 weeks	Inspections once every seven days and after each precipitation event > 1.0"
Level 4 ESC	Do Level 3 and employ active chemical treatment system (ATS) with fully automated pumps, controls, settling tanks, and sand filters that are specifically designed to achieve low numeric turbidity effluent concentrations for construction site discharge		

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

Functional Deficiency

- The four levels of ESC practice assume proper installation and maintenance of practices, as well as normal rainfall conditions that are within the design capacity of the practices. These assumptions are violated at some proportion of all construction sites, and at all sites during extreme storm events.

- Two levels of functional deficiency defined based on hydrologic considerations
  - *Moderate deficiency* occurs for rainfall events that exceed the designed sediment trapping capacity of ESC practices.
  - *Extreme functional deficiency* occurs for major storm events that exceed intensity or volume thresholds, and overwhelm the treatment capacity.

- The Panel developed method to compute the additional sediment load produced at functionally deficient sites, which is added to the estimated sediment load during normal conditions for appropriate level of ESC practice.

Summary of Bay States' Erosion & Sediment Control Programs

	Delaware	Maryland	New York	Pennsylvania	Virginia	West Virginia
First ESC regulations/ permits took effect	1991	1970	1993	1972	1973	1992
Most recent ESC Design Manual or Regulations	2013	2011 Manual effective 1/9/13	2005	Manual - 2012 Regulations – 2010	Manual--1992; Regulations--2012	2006 Manual
Area threshold for regulations	5,000 sf.	5,000 sf.	1 acre	5,000 sf	10,000 sf or 2,500 sf. in CBPA	1 acre
Sizing requirement for on-site retention	3,600 cf/acre or one inch	3,600 cf/acre or one inch	3,600 cf/acre or one inch	6,000 cf/acre (basin); 2,000 cf/acre (trap)	3,600 cf/acre or one inch	3,600 cf/ acre; half wet, half dry
Stabilization requirement *	14 days	7 days or less	7-14 days	within 4 days	7-14 days	7- 14 days
Regulatory inspection requirements	Weekly	Every other week	Weekly. more frequent at larger sites	Every 30 days	Every 2 weeks and within 48 hrs. of a runoff event	At least one visit for all sites ≥ 3 ac.
Self-inspection requirements	Weekly	Weekly and next day after a storm event	Daily	Weekly and after each storm event.	Daily to Bi-weekly, and after each storm event	Every 7 days and within 24 hrs after storm
Construction phasing	Phasing required to keep LoD < 20 acres	Required for projects with 20 + acres	Required on all projects.	Not required	Not required	Not required
* requirements may differ for temporary vs. final stabilization						

All Bay States and DC Operating at Level 2 ESC Practice

Review of the Science

- Construction Site Hydrology
- Sediment Discharge
- Turbidity Discharge
- Nutrient Dynamics

Construction Site Hydrology

- Four Methods to Define Runoff Coefficient for Construction Sites
  - One Monitored Site
  - Three Models
  - All Converged

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 RVs (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

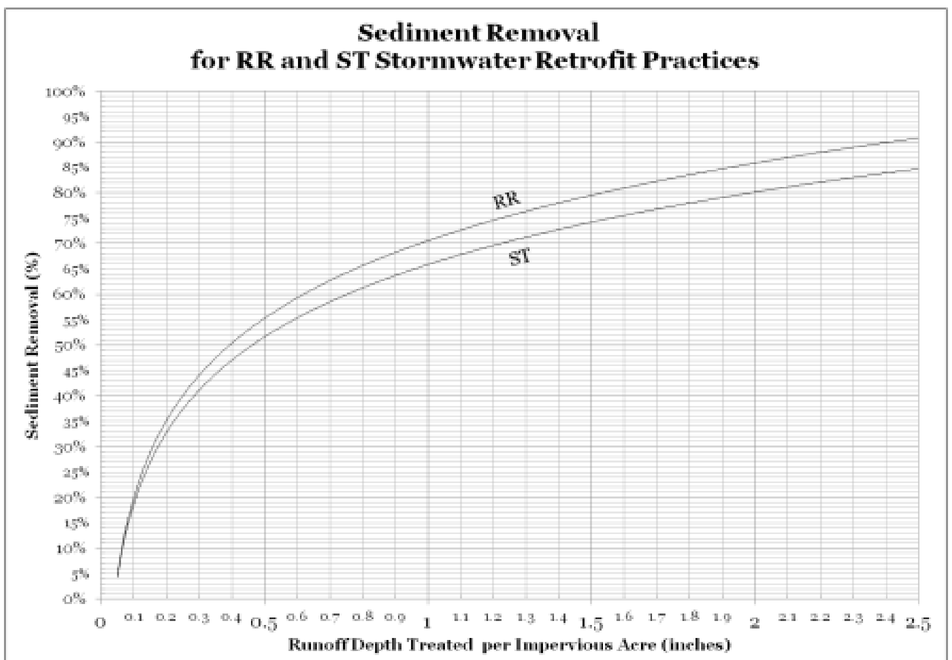
Table 16 Comparative Summary of ESC Scenarios (tons/ac/yr)				
ESC Scenario	Worst Case	Mid-point	Best Case	**Best Estimate**
Construction w/o ESC	22.3	8.6	5.1	**12.0**
Sites Operating at Level 1	2.5	1.8	1.1	**1.8**
Sites Operating at Level 2	1.6	1.0	0.7	**1.1**
Sites Operating at Level 3	1.05	0.57	0.31	**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 with 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

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

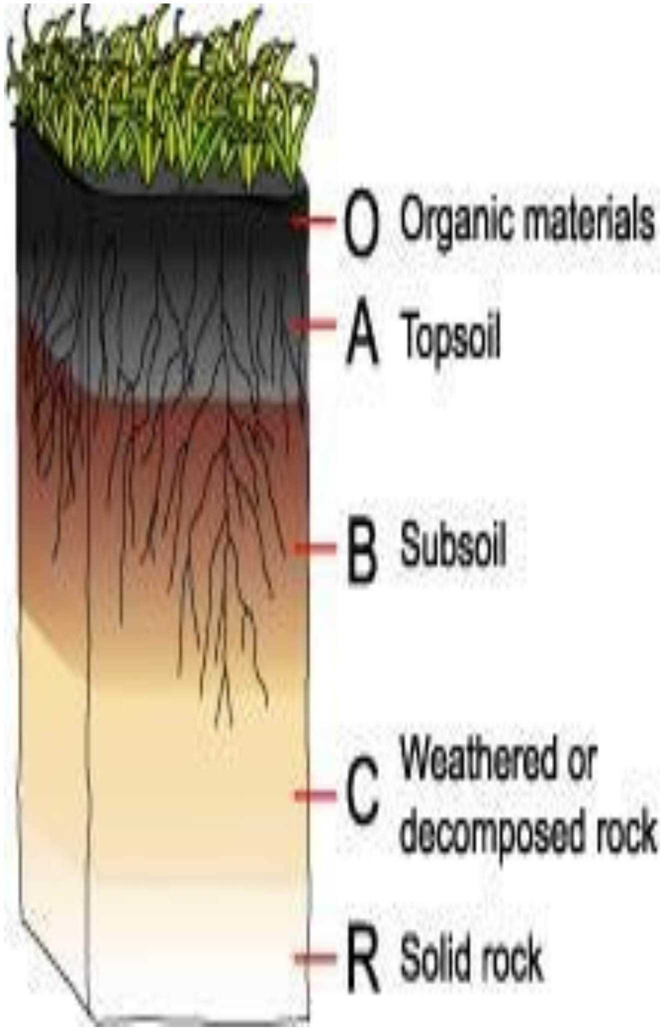
Five pathways for nutrient export from construction sites:

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 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% AB Horizon: 1.8%	O Horizon: 9.5% AB Horizon: 1.4%
Total Nitrogen (mg/kg)	O Horizon: **2,900** AB Horizon: **1,000**	O Horizon: **4,700** AB Horizon: **700**
Total Phosphorus (mg/kg)	O Horizon: **35** AB Horizon: **5**	O Horizon: **16** 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.						

Accountability Mechanisms

Inspections as Verification

- Each individual construction site is now subject to both self inspections by the contractor and regulatory inspections by the local or state ESC enforcement authority that occur multiple times during the construction year.
- Construction sites are subject to more on-site verification than any other urban or agricultural BMP used in the watershed.
- Current construction inspection protocols are more than sufficient to meet the CBP verification principles for crediting BMPs in the TMDL.
- Panel does not recommend any additional field verification protocols beyond those that are already in place in the Bay states.

State and Local ESC Reporting

- **State:** Two options for reporting annual construction acres (existing method or submit annual CGP acreage data)
- **State:** No geographic data, just which ESC Level is being used
- **Locals:** No reporting requirements, beyond existing permit mandates

Criteria to define when a jurisdiction crosses over the threshold to Level 3 ESC

- Passive chemical treatment is utilized within the construction site by adding PAM or other flocculants to:
  - Hydro-seeding mixes used for temporary stabilization
  - Fiber logs, socks, wattles or check dams installed in internal diversions, ditches, or channels
  - Sediment basins or traps
- Enhanced sediment basin design to include baffles, surface outlets, and/or skimmers
- ESC maintenance inspections at least once a week
- Enhanced measures for perimeter controls and natural resource buffers
- More stringent stabilization and construction phasing requirements than currently required

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

CBWM 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

Implementation of the ESC Panel Recommendations

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Presented to WTWG
February 6th, 2014

2 Principles to follow

- Honor the panel recommendations as the accumulation of the best science
- Ensure that we are modeling in a way that best measures real changes on the ground.

Summary Efficiency Reductions

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

Summary Efficiency Reductions

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

Summary Efficiency Reductions

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	25	0	40	0
Level 3		90	25	0	40	0

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

Summary Efficiency Reductions

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%)

Summary Efficiency Reductions

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%)

Summary Efficiency Reductions

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

Summary Target Loads

Sediment		Nitrogen		Phosphorus	
Phase 5.3.2	**Phase 6**	**Phase 5.3.2**	**Phase 6**	**Phase 5.3.2**	**Phase 6**
24.7	12	26.4	26.4	8.8	8.8

Note:
Actual loads may actually vary +/- 75% in individual river basin segments due to use of regional adjustment factors

Questions