

**Appendix B-3
Tier III Alternatives Analysis-Potential Research Variables for Study**

Potential Revegetation Test Variable	Test Variable Type (technical or CDOT process)	Description	Expected or Observed Result	CDOT Specification (Y/N)	Reference	Remarks	TerraLogic Scoring Average (5 best-1 worst)	CDOT comment	Ranking (1-5) 1 = your <i>highest</i> priority [Equal values = Variables lumped due to similarity, or equal priority level]									
									Banovich	Boyce	Klaetsch	Minges	Arbogast	Corwin	Mallonnee	Straub	Roeder	
								General Comments: Concern that scope of research topics too broad and do not consider what will work at CDOT Many variables similar to others, difficult to separate										
Certification or prequalification of CDOT Revegetation Contractors	Process	Create a prequalification or certification process for Revegetation Contractors. Try to filter out companies that cannot perform proper revegetation.	Increased success by experienced companies with proper revegetation equipment.	N		Qualified contractors would increase positive results and would create a sense of accountability to CDOT.	5.0	I think that #s P1, P2, and P8 could almost all go together and maybe be able to all be tested...? Focus type of equipment use, testing of equipment and enforcement of specs . The responsibility and accountability for revegetation needs to reside with the contractor.	3		6	6	1					3
Inspection of Material Application	Process	Ensures the proper application and rate of amendment, seed, mulch etc.	Increased effectiveness of existing specifications	Y		This is needed to make sure existing specifications are being enforced.	5.0	Develop test methods for inspectors and testers. P2 similar to P3 . Also related to P8	1	2	6							2
Additional training of CDOT staff or using an outside source for inspection	Process	Provide additional training to inspectors or project engineers on what they are looking for in proper revegetation.	If more people are properly inspecting the equipment, materials and methodology used on CDOT projects there would be in an increase in revegetation success.	N		Existing manuals could be utilized for training	5.0	Training should be done in cooperation with any accepted changes in process Existing practice is pocket guide. Combine with P2? Training needed for inspection in P2 also	1									2
Full Time Reclamation Specialist inspector during revegetation installation	Process	Assign a qualified representative to the project area during revegetation; provide direction to Contractor; daily oversight	Better revegetation results and less Contractor short cutting	N		Already done by CDOT but not sure if in specifications. How do we determine qualified individual? Should have education in plant and soil science.	5.0	See P3, provide swmp reviewer in design	4									
Seed Mix Design	Process	Make sure the seed mix is properly designed with proper species and balance. Use approximately 60 seeds per square foot (drill rate) as a general reference.	Increased success by targeting species that will thrive in post construction site conditions. Designing to achieve the proper seeds per square foot will eliminate die off from overcrowded seedlings.	N		A few recent CDOT mixes were evaluated and found to have very heavy seed mix rates some with rates as high as 600 seeds per square foot.	5.0	Researcher should conduct field surveys to verify what is growing	1	1				2				5
Inventory project site for native plants, shrubs and trees for replanting	Technical	Identify plant native species specific to project area. Use inventory to establish seed mixes.	Identify native, local plants that fit the region ecology and stabilize soils	N	16	Has shown success in Oil and Gas operations	5.0	Same as 8. T1, T2, T3, T4: assessment of initial site condition important	1	1			2					4
Obtain initial site/soil conditions	Technical	Evaluate soil types, chemistry, existing vegetation, solar exposure, slope, precipitation, and other limiting factors (deicing)	Provides more data to select the correct native seed species along with necessary soil augmentation elements	N	1, 6, 11		5.0	Conduct top soil tests at select sites. T1, T2, T3, T4: assessment of initial site condition important	2	3			2					4

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Salvage topsoil	Technical	Salvage topsoil prior to construction	Provides native soils from project area	Y; 207.04	1, 2, 3, 4, 6, 7, 11, 16	Topsoil salvage has shown to increase reclamation results in the mining industry and is a BMP for most industries. Topsoil is a BMP and likely does not need further testing.	5.0	Do not allow import of topsoil. T1, T2, T3, T4: assessment of initial site condition important	2	4	1		2	1				4
Soil Testing and Analysis	Technical	Test soils for reclamation potential	Increased reclamation success on problematic soils	N		Done in agriculture all the time. Can not fix the problem if we do not understand the problem	5.0	Use soil maps to determine web survey of soil then test soil in field (T2). T1, T2, T3, T4: assessment of initial site condition important	1	3	2	6	2	3				4
Site specific amendment rates	Technical	Base reclamation plan on site specific conditions	Improved conditions for reclamation	N			5.0	Measure slopes on selected sites to compare reveg and slope	1	3		6						
Contract mechanisms to ensure proper revegetation installation and compliance to revegetation plan	Process	Develop Contractor language to force revegetation accountability and responsibility	Develop contract language that specifies Contractor expectation and measures of success	N	1		4.7	Provide incentive instead of force. The responsibility and accountability for revegetation needs to reside with the contractor.	3	5			3	1				1
On-Call Revegetation Maintenance Contractors	Process	Have prequalified and contracted revegetation contractors hired to be on call for touch up seeding and reveg maintenance items.	Take some pressure off of CDOT's maintenance crews and have qualified firms evaluating and maintaining challenging sites.	N		Andy Stecklein is utilizing a similar plan in his region	4.7	CDOT does this via SEP 14 contracts	1									
Correct equipment for job	Process	Spec equipment: Drill seeders, crimpers, deep rippers, cultivation, etc	Increase efficiency of contractors and ensure that proper equipment is being used	N			4.7	SeeP1. P2 related and similar to P8	2	5	6	6						
Develop a revegetation plan	Process	Revegetation objectives, description and map of each revegetation unit, desired outcomes, noxious weed management, laws and regulations, project background, analysis and limiting factors, mitigation measures, strategy methodology, key contracts and responsibilities, budget, schedule, monitoring approach, corrective actions based upon monitoring. Region specific plans developed for reference.	A management tool for the Project Manager as well as DOT landscape/environmental representatives; identifies expected outcomes and responsibilities at a minimum. Regional plans could be more cost effective solution than site-specific plans	N		1, 4, 6, 16 Andy Stecklein and Jennifer Gorek CDOT both mentioned a region specific reclamation plan.	4.7	This is the function of the regional specialist and or landscape architect unit. Each region should have a swmp preparer and veg specialist	1				4					
Project contains enough funding to stabilize soils and provide sustainable revegetation	Process	Ensures revegetation and water quality is being protected for several years after construction	Project manager and/or maintenance representatives need to know the real cost of revegetation to protect water quality and regulatory compliance	N	1	The only costs mentioned are Basis of Payments to Contractor and in 104.02 the Engineer can re-assess cost or time required.	4.7	Researcher: Interview maint in regions to determine what is needed	2									
Application of Amendments	Technical	If amendments are being applied make sure they are being applied in the most effective manner (topical or incorporated)	Increased effectiveness of costly amendments.	Y		Take advantage of amendments that are currently being used.	4.7	Researcher: test combinations of amendments and soil preparation: compost incorporated vs surface, spray on organics, mychorrizzle, organic fert vs inorganic fert, humates, timing of application	1	3	4							
Organic fertilizers	Technical	Are organic fertilizers working and at what rates are they effective? Are they all created equal?	There is a cost benefit to using amendments in some situations if applied properly.	Y		This would be a great test plot at a BMP or maintenance facility.	4.7	See T7	1		5							
Split Reveg Contract separate from general	Process	Temporary seeding through general on larger projects and final seeding completed by qualified revegetation contractor.	Qualified contractors performing revegetation work. Later permanent seeding.	N		KDOT Interview 7/3/13 It allows time for soil sampling of replaced soil but it also delays permanent seeding. General contractor to perform temp seeding.	4.3	I really like P11 and P12, don't know if they are test variables, but something to look at in future. Only works if 2+ yr schedules. Use temp mulch during construction, then seed perm	5			1						

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Get Revegetation Contractor involved early on in the process.	Process	Get the Revegetation Contractor involved during pre-construction and lean on their knowledge of the area for value engineering or input to increase success.	Increased ownership in the project and an opportunity to increase success of the project.	N		More ownership to the project and allows the inspectors and engineers to set the stage for process and expectations.	4.3	Involve in statewide spec reviews, but not on project reviews unless cmgc.	4					1				
Early revegetation planning	Process	Early in the construction process and revegetation is not a afterthought	Revegetation is planned for well in advance	N	1		4.3	Reveg is determined in design and specs work well when followed. The responsibility and accountability for revegetation needs to reside with the contractor.	5					1				
Communication and cooperation among reclamation scientist with design engineers	Process	Reclamation Scientists and environmental representatives talk about revegetation with design engineers early in the process	Better planning and organization with will result in improved revegetation	Y; 208.03	1, 4	(6) CDOT landscape Arch. and (1) Engineer involved in Project Review	4.3	SWMP preparers and specialist incorporate guidance into process. The responsibility and accountability for revegetation needs to reside with the contractor.	5					1				
Reclamation planning at the front end of projects	Process	Use qualified reclamation scientists to evaluate the sites soils and vegetation prior to construction to establish a reclamation plan	Site specific reclamation plans will increase reveg success and in some cases save money on costly operations that are not needed (i.e.. compost)	N		This could be an outside resource or an internal process for CDOT.	4.3	The responsibility and accountability for revegetation needs to reside with the contractor.						1				
Species selection in seed mix	Material	Make sure plant species are site specific to increase likelihood of success.	Develop a methodology for observing and selecting proper seed mixes.	Y		Easy way to increase revegetation success	4.3	Variables, M1 through P16 are tied together, and may be most achievable way of reveg success		1				3				
Proper number of seeds per square feet	Material	Make sure the proper number of seeds are being added per square foot in order to increase success	Increases chances of seedling survival and needed coverage	Y		Easy way to increase revegetation success	4.3	Variables, M1 through P16 are tied together, and may be most achievable way of reveg success		1		6		3				
Use stockpiled soils	Technical	Mostly flat areas; stockpiled top soil to depth of 6 inches and tacked with heavy equipment; native seed mix from local reference site	Use stockpiled soils with organic matter to promote revegetation; reduce import costs and noxious weed introduction	Y	1	HOWEVER, no mention of OM in section 207 and Native Seeding only in non-irrigated areas in section 212.06	4.3	Variables, M1 through P16 are tied together, and may be most achievable way of reveg success			4			3				
Use of cover crops in off season seeding	Technical	Utilize cover crops to stabilize site and then interseed into stubble in following years	Annual covers will stabilize site and then provide mulch cover for establishing natives.	N			4.3	Variables, M1 through P16 are tied together, and may be most achievable way of reveg success		1				3				
Fertilization	Technical	Fertilizer rate studies	Increased weed competition, increased stand establishment, Weed management		5	Research is mixed	4.3	Variables, M1 through P16 are tied together, and may be most achievable way of reveg success						3				
Timing of Seeding	Process	Make sure proper seeding windows are being utilized.	Increased coverage due to taking advantage of natural precipitation	Y		Easy way to increase revegetation success	4.0	Variables, M1 through P16 are tied together, and may be most achievable way of reveg success		1				3				
Imprint seeding	Process	Modify seeding approach to increase soil moisture content	Increased seedling establishment	N	5, 15	Shown success in the Red desert of Wyoming	4.0				5							
Identify clear objectives with benchmarks	Process	Ensure there are objectives with performance metrics to manage revegetation	Ability to measure success or provide adaptive management for corrective actions	N	1	214.04 (a): Contractor, Eng., and CDOT Landscape Arch. conduct plant inspection. Also mention of replacing dead plants.	4.0											
Companion Crop seeding	Process	Determine if companion crops help or hinder seed establishment	Reduce expensive straw mulch and erosion	N	9, 12	Research is mixed	4.0											
Topographical planting along roadway	Technical	Change seed mix based on distance from road and soil moisture regime	Improve reclamation success due to better plant selection	N	17	increase cost and time. May speed reclamation and save	4.0											
Chemical Soil Amendments	Technical	Addition of soil amendments to alter soil chemistry	Increased reclamation success on degraded soil chemistry sites	N	5	Research shows improved reclamation results	4.0			3								
Compaction Relief	Process	How to measure compaction in the field? Standard pentrometers are dependant on sampling techniques	Increased reclamation success and decreased erosion	N		Pretty well documented	3.7			5		2		5				

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Compost berm to replace silt fencing onto rocky soils	Technical	Import in compost dirt material and stabilize to replace silt fencing	Prevent soil erosion and transport using a LID approach; difficult or impossible to trench in silt fencing in some areas	N	1		1.7											
Blown in place compost over rip-rap	Technical	Used for steep slopes; compost can be made up of recycled organics containing beneficial bacterial and mycorrhizal fungi, and binding agent; mixed with native seed, tackifier use	Promote short and long term stabilization especially on steep slopes	N	1	Use of compost was 5X more expensive than traditional hydro seeding (\$0.15/sf versus \$0.03/sf); may be cost effective on steep slopes within sensitive environments like river systems	1.7											
Rock mulch	Technical	On steep slopes, 4-6 inch diameter rocks spread over the entire slope; depth of rock was 12 inches; hydro seed mixture of woody shrubs; 30#/acre; annual grasses at 8#/acre; bonded fiber matrix sprayed to secure seeds. Perennial grasses suggested. Flush slope with water to fill voids with applied dirt/compost	Promote short and long term stabilization especially on steep slopes	N	1	May have initial aesthetic concerns	1.7											
PAM	Technical	Add PAM to other soil amendments to increase site stabilization	Help aggregate soil and stabilize site until vegetation can be established	N	18	Could be inexpensive soil stabilization technique	1.7											

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