GUIDELINES AND BEST MANAGEMENT PRACTICES FOR SOIL STABILIZATION AND REVEGETATION IN THE GRANITE CREEK WATERSHED

FINAL REPORT

Prepared for the City and Borough of Sitka
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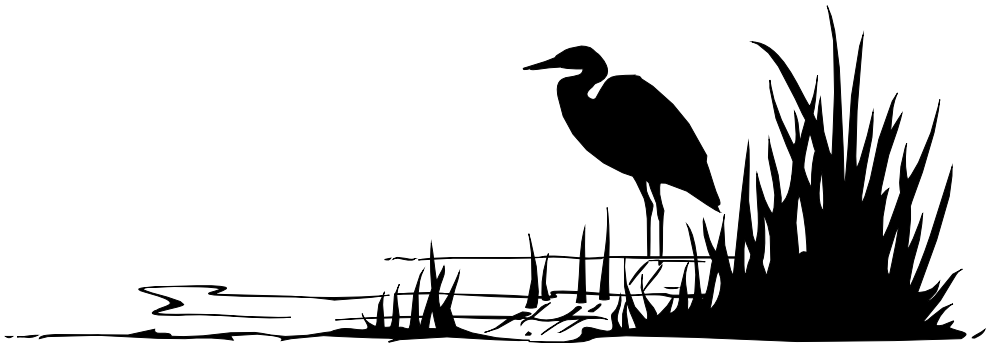
Redburn Environmental & Regulatory Services



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Guidelines and Best Management Practices for Soil Stabilization and Revegetation in the Granite Creek Watershed

Purpose, Scope and Background

Task 6 of the FY06 workplan for the Granite Creek Recovery Project calls for the City and Borough of Sitka (CBS) to "complete soil stabilization and revegetation guidelines for streamside buffers, roadside ditches, and steep slope erodible soils". The workplan acknowledges budget constraints by proposing guidelines and best management practices – or BMPs - in lieu of preparing a comprehensive guidebook or manual. The workplan description reads:

> *"This task addresses an action in the Granite Creek Recovery Action Plan that has yet to be completed – " a revegetation guidebook for streamside buffers". Rather than a formal guidebook, a series of soil stabilization and revegetation BMPs in the form of written guidance is proposed. The process will include review of DOT&PF contract specifications for reseeding highway construction projects and discussion with local plant specialists. DOT standards cover seeding seasons, seed mix, fertilizer and mulch application rates, use of Alaska seed mixes to avoid introducing non-indigenous species, soil preparation and measures of germination success. The guidelines will be useful not only for riparian buffer areas, but also along roadside drainage ditches in the watershed and for application to erodible-prone areas at the Golf Course lease. "*

Comment [SD1]: Double check to make sure seed mixes do not contain invasive species. DOT in this part of the state uses mixes with several non-native invasive species….

The Granite Creek watershed is the site of extensive development and soil disturbance, requiring a variety of BMPs to control runoff. Soil stabilization and revegetation are very effective erosion control techniques. Controlling erosion reduces sediment and turbidity in stormwater runoff and pollution of adjacent waterbodies. This is a focal point of ongoing recovery efforts at Granite Creek.

Soil stabilization, revegetation and streambank restoration guidelines exist in many forms. For purposes of this project, priority is given to techniques proven effective in Alaska. Soil stabilization, topsoil use, fertilizing, and seeding are major categories addressed. For streamside buffers at Granite Creek, allowing natural revegetation to proceed with alders and grasses has proven effective at stabilizing soils at low cost. Sophisticated streambank restoration techniques are not the focus of this project. "Low-tech" methods are emphasized. *Table 3* summarizes major riparian and streambank restoration techniques, timing considerations, and relative costs. Accepted restoration techniques and manuals used in Alaska are referenced at the end of the report for those readers seeking more information. Landscaping with trees and shrubs is also a lessor priority, as it requires a somewhat higher level of professional involvement and cost to ensure success.

The guidelines summarize the current specifications of the Alaska Department of Transportation and Public Facilities (ADOT&PF), CBS, Alaska Department of Natural Resources (ADNR) and Corps of Engineers and supplement them with recommendations from the International Erosion Control Association and local landscapers. The BMPs are presented in tabular form in Part II of the report to make

them easy to reference and apply to specific land or habitat types. Also included are the BMPs related to revegetation and streamback protection that are routinely carried out as part of the Granite Creek TMDL/waterbody recovery process. These guidelines and BMPs are found in the reports *Granite Creek Watershed Project Review Guidelines and Pollution Control Recommendations for Future Development (June 2005)* and the *Environmental Audit Checklist and Best Management Practices Inspection Form for Granite Creek Operations and Overburden Lease Sites (June 2005).* Lastly, municipal reclamation requirements for inactive leases in Granite Creek also involve revegetation and soil stabilization activities. These are summarized in *Table 4.*

The objective of this project is to achieve successful soil stabilization and revegetation in the Granite Creek watershed by providing simple, proven and cost-effective techniques. The principal users of the guidelines are the City and Borough of Sitka (the landowners) and lease operators in Granite Creek. Secondary users are professional contractors hired to assist with revegetation and soil stabilization.

The guidelines are a synthesis of BMPs and specifications from CBS, pertinent state and federal agencies, and private businesses and associations (e.g. the International Erosion Control Association) who are actively involved in soil stabilization and revegetation in Alaska. They acknowledge and adopt methods previously used in the Granite Creek watershed, particularly along roadside ditches. The experience of Alaskan plant specialists was also drawn upon to groundtruth the guidelines. *Adjustments in these techniques and timing are typically necessary, recognizing that successful soil stabilization and revegetation is both an art and a science.*

The following approach was followed in preparing this report:

1. Prepare outline of the guideline report and seek comments and revisions of scope.
2. Secure and review CBS and DOT soil stabilization, topsoil, and seeding/fertilizing specifications and erosion control guidelines.
3. Confirm scope and expectations with CBS staff
4. Call and interview knowledgeable ADOT&PF highway construction engineers, CBS Groundskeeper, CBS staff overseeing Granite Creek operations, and ADNR staff. Interview local plant specialists and Sitka Golf Association members on tips for success in hydroseeding, soil stabilization and use of overburden. Compare seed mixes, application rates, and relative successes.
5. Complete Web search for “soil stabilization” and reseeding guidance. Evaluate overburden use, jute mat use, lime/fertilizer and seed types for various soils and slopes.
6. Identify optional formats for presenting BMPs.
7. Draft the guideline report and tabulate BMPs
8. Provide estimated costs for common materials and revegetation practices

Summary and Analysis of Pertinent Municipal, State, Federal and Private Sector Soil Stabilization and Seeding Specifications and Guidelines for Possible Application to Granite Creek

Several government entities maintain specifications for seeding and soil stabilization in contract documents, standard operating procedures (SOPs), or in Nationwide or

Regional permit conditions. Those most germane to Granite Creek are summarized below.

1. Alaska Department of Transportation and Public Facilities (ADOT&PF) Highway Seeding, Soil Preparation and Construction Requirements

Standard contract specifications for state-funded highway projects address seeding and soil preparation under Section 618. Materials, soil preparation, seeding seasons, application, and plant establishment and maintenance are all specified in the contract language. The stated purpose is to "Establish a perennial stand of grass or other specified living vegetative cover, by seeding, in the areas indicated on the Plans. Maintain the cover for the term of the Contract".

Seed types are listed in Section 724**;** fertilizer in Section 725; Topsoil in Section 726.

Planting requirements for use of willow stakes, coirs or more sophisticated stabilization methods are not included in the DOT contract specifications (Van Sundberg, personal communication). These methods are found in a number of revegetation manuals published by the Alaska Department of Fish and Game (see references).

Soil preparation involves clearing the area to be seeding of stones greater than 4 inches in diameter and of all weeds, plant growth, sticks, stumps and other debris that could interfere with the seeding operation. Topsoil is to be applied where specified in Section 620/726. The surface is roughened slightly by dozer-tracking or other approved methods.

Application rates for seed mixes and mulches are specified in the Special Provisions. Seed mixes are to be applied at a rate of 50 kg per hectare, or about 1.5 lbs seed mix per 100 sq. ft. Seeding and fertilizing shall be done during the local growing season. Fertilizer is applied at a rate of 400-450 lbs per acre.

Acceptable methods of application include hydraulic and dry methods. Hydraulic equipment must be sufficient to provide a nonfluctuating spray that will reach the extremities of the seeding area with the pump unit located on the roadbed. Dry methods must use approved mechanical spreaders for applying seed and fertilizer in dry form.

Following seeding, damaged areas must be regraded, reseeded and remulched as needed. Areas must be watered and maintained under final inspection and acceptance of work. Areas not showing evidence of satisfactory growth within 3 weeks of seeding must be reseeded.

Sections 724, 725 and 726 (see Appendix) include detailed specifications for acceptable seed mixes, fertilizer, and topsoil and limestone application rates.

2. City and Borough of Sitka Standard Construction Specifications for Seeding, Topsoil, Soil Stabilization and Landscaping

The CBS Public Works Department maintains Standard Construction Specifications for Seeding under Section 75.05 of the borough's manual. The specifications apply to both contractors hired by the city and CBS staff. Procedures cover the preparation of ground surfaces for the application and maintenance of seeded areas, fertilization, and lime

application, watering and mulching. All seeding shall be performed between May 1 and September 1. Seeding at other than these specified dates will only be allowed upon written approval of the Engineer. Seeding is not to be done during windy conditions or when climatic or ground conditions hinder placement or proper germination of seed mixes.

The Appendix contains details of CBS authorized seed mixes and application rates. Five types of seed mixes are authorized for use. Application rates vary from 5 to 8 lbs per 1000 sq ft; germination success of seed must be rated from 85 to 90%. Typical seed types include red fescue, annual ryegrass, Kentucky bluegrass, hard and boreal fescue and several clover species.

Fertilizer shall be of standard commercial type and labeled with the manufacturers guaranteed analysis of contents. No Cyanamid compounds or hydrated lime are permitted in mixed fertilizers.

Limestone must contain at least 85% calcium and magnesium carbonates. Mulch used shall be dried shredded peat moss, or cellulose wood or paper fiber such as “Astromulch”, “Silvafibre”, “Conweb”, or approved equal. Water used in all operations shall be of potable quality.

Application guidelines (Article 5.3) address soil preparation as well as hydraulic, dry and hand methods of application.

After grading has be completed in conformance with the project drawings, the area is cultivated to provide a firm seedbed. Cultivated areas are to be cleared of stone larger than 1 inch in diameter, all weeds, stumps, plant growth and debris that would interfere with successful seeding. Fertilizers shall be applied at a rate of 2 lbs actual Nitrogen per 1000 sq. ft. In the absence of soil tests, 16-16-16 fertilizer shall be applied at a rate of 7 lbs per 100 sq ft. Dry limestone shall be applied following fertilizer at a rate of 100 lbs per 1000 sq. feet and raked in prior to seeding.

Seed, fertilizer, limestone, mulch and water may be applied by either hydraulic, dry or hand methods depending on the circumstances. Hydraulic seeding consists of slurry of seed, fertilizer, dried peat moss/wood fiber, and water. Equipment must be capable of maintaining continuous agitation so that a homogeneous mixture can be sprayed through a nozzle. Pump pressure and hose length must be sufficient to extend from the roadbed. Hand application of seed mixes must be at twice the rate of dry methods, or roughly 10 lbs per 1000 sq. ft.

Mechanical spreaders, landscape seeder, fertilizer spreader and other approved equipment may be used to apply dry seed and fertilizer. Fertilizer is applied separately and incorporated into the soil to a depth of two inches. Seeded areas shall be compacted within 24 hours of seeding using a roller or cultipacker.

Hand broadcasting using portable, hand operated mechanical spreaders or “by hand” is acceptable provided that the application rate is twice that of the dry method and that the minimum of two passes is required over the area, at 90 degrees to one another to ensure uniform coverage.

Maintenance standards (Article 5.4) require the Contractor to protect seeded areas from damage and to apply fertilizer (16-16-16) at a rate of 7 lbs per 100 sq. ft. 45 days after seeding commenced.

Section 75.04 covers Topsoil, including allowable topsoil mixes, and limestone and fertilizer application rates to achieve a nutrient and pH balance in the topsoil. Section 75.03 covers Soil Stabilization, including use of jute meshes, glass fibers, blankets and nylon matting. Section 75.02 covers specifications for Landscaping with trees and shrubs. The Appendix includes all sections listed above. Pertinent BMPs for each section are listed in the Tables at the end of the report.

3. Sitka Golf Association Fairway and Slope Seeding and Fertilizing Methods

The non-profit Sitka Golf Association (SGA) is several years into constructing a nine-hole golf course in the Granite Creek watershed. Volunteer activities to date have included extensive fairway and slope preparation, numerous drainage improvements, road construction and active seeding and fertilizing of slopes and fairways.

Hydraulic methods are used at the site to apply the seed/fertilizer/lime mixture. The seed mix used consists of rye, creepy red and hard fescue, and sea breeze fescue (Roger Sudnikovitch, personal communication). This is identical to a Prince Rupert mix used successfully at several golf courses in British Columbia, which has a climate similar to Sitka's. *Table 5* details the techniques, cost, and maintenance issues for the Sea Mountain Golf Course lease site.

4. Corps of Engineers list of prohibited invasive grass species

The Corps of Engineers (COE) addresses revegetation and seeding in Regional Condition E under the 2002 reauthorized Nationwide Permits. These federal permit requirements are broader than just seeding, and also address planting shrubs and trees to stabilize and restore damaged areas. These conditions apply to local development activities in identified "waters of the U.S.", including wetlands.

Regional Condition E states that *"Areas disturbed during project construction must be revegetated as soon as possible, preferably in the same growing season as the disturbance. Erosion protection shall be provided and remain in place until the soil is permanently stabilized."*

" Revegetation techniques may vary with site conditions and include, but are not limited to the following:

> *Species to be used for seeding and planting should follow this order of preference: 1) species native to the site; 2) species native to the area; 3) species native to the state; and 4) non-native species. Only non-native species that are know not to reproduce in the project area may be used for revegetation. The following species are know to be highly invasive and may not be used under any circumstances for revegetation under the Nationwide Permits: Alopecurus arundinacea (meadow foxtail); A. pratensis (creeping foxtail), Lythrum salicaria (purple loosestrife), Melilotus alba (white sweet clover), M. officinalis (yellow sweet clover), Phalaris arundinacea (reed canary grass), Phleum pratense*

(timothy), and Polygonum suspidatum (Japanese knotweed, crimson beauty, Mexican bamboo and Japanese fleece flower), Lysimachia terristris (swamp looselife/yellow looselife) and Phragmites australis (common reed).

Restoration and revegetation of streambank habitat should utilize the most up-to-date bioengineering techniques and use of biodegradable materials when feasible and practicable (i.e. Streambank Revegetation and Protection: A Guide for Alaska (Muhlberg and Moore, 1998). Techniques may include, but are not limited to, brush layering, brush mattressing, live siltation, and use of jute matting and coir logs to stabilize soil and reestablish native vegetation."

Nationwide Permit General Conditions also include a provision for Soil Erosion and Sediment Controls, stating that "Appropriate soil erosion and sediment controls must be used and maintained in effective operating condition during construction, and all exposed soils and other fills, . . . must be permanently stabilized at the earliest practicable date. "

5. Alaska Department of Natural Resources performance standards

The ADNR typically includes performance specifications in permit stipulations related to soil stabilization and revegetation. Language emphasizes the need to minimize erosion and seed/fertilize erodible soils sufficient to ensure the permanent establishment of grasses or other rooted vegetation. ADNR defers to existing ADF&G and other agency manuals and techniques for the detailed approach used to complete revegetation so that it meets this performance standard. In essense, the end result to be accomplished is emphasized, but the specific means to achieve that end is flexible and the responsibility of the permittee or contractor consistent with accepted practices in the manuals.

6. Alaska Department of Fish and Game

While statutory authority for protection of anadromous streams was transferred from the ADF&G to the ADNR in 2002, Fish and Game has historically prepared and maintained several streamside restoration and rehabilitation manuals.

The *Landowners Guide to Fish Habitat Conservation and Restoration Practices (2002)* focuses on riparian protection and restoration. The permitting process required for such projects and BMP tables covering various types of streamside development projects and methods are covered.

Recommended soil protection and erosion control principles particularly germane to Granite Creek include the following:

1. Keep or add natural vegetated buffers as "soil stabilizers" along streams.
2. Minimize vegetative clearing along banks and riparian setbacks along streams and tributaries to reduce erosion and sedimentation.
3. Stabilize and vegetate roadsides and drainage ditches with grasses and other methods to control erosion and sediment transport.
4. Use biodegradable materials in soil stabilization efforts.
5. Bank restoration is difficult and often expensive, requiring the expertise of a professional with experience and heavy equipment.
6. Avoid overuse of fertilizer in revegetating and reseeding.

The current streambank restoration "bible" used in Alaska by regulatory agencies is Streambank *Revegetation and Protection: A Guide for Alaska (Muhlberg and Moore, 1998),* with a revised edition in 2005 *(Walter, Hughes, and Moore, 2005)*. This excellent publication targets anadromous fish stream riparian areas. It includes sections on erosion control, plant care and preparation, revegetation and propogation, plant species selection lists, and a variety of revegetation techniques (willow bundles, live staking, brush mats, vegetated cribbing, and grass rolls) as well as protection techniques (coir logs, spruce revetments).

Riparian buffers and streambanks are one of five land types addressed in this report. While streambank restoration techniques are not the primary focus of this project – due to high costs and the level of sophistication requiring outside contractors – many of the BMPs and guidelines are useful for Granite Creek. *Table 3* at the end of the report itemizes recommended practices in this important habitat.

The reader is referred to the references above for a detailed treatment of the subject of streamside restoration.

7. Granite Creek TMDL and Watershed Recovery BMPs and Material Lease Site Reclamation Requirements

Considerable work has gone into implementing practices in the TMDL Action Plan to ensure protection of water quality. A number of BMPs are directly or indirectly linked to riparian protection, natural revegetation, reseeding and soil stabilization and erosion control. These are summarized in the Tables at the end of the report. Key reports drawn on include the *Granite Creek Watershed Project Review Guidelines and Pollution Control Recommendations for Future Development (June 2005)* and the *Environmental Audit Checklist and Best Management Practices Inspection Form for Granite Creek Operations and Overburden Lease Sites (June 2005).*

The original 1982 Granite Creek Reclamation Plan was updated in 2005. The report *An Updated Reclamation Plan for Granite Creek Material Lease Sites: A review and summary of current reclamation requirements, with recommended supplemental conditions (June 2005)* includes a number of revegetation and soil stabilization BMPs geared towards returning disturbed land to a stable and productive condition that will support a variety of future uses. Those reclamation BMPs and guidelines applicable to revegetation are listed in *Table 4.*

8. Environmental Protection Agency (EPA) Management Measures and Guidance for Revegetation of Disturbed Areas and Stormwater GP requirements

The EPA maintains a variety of recommended management measures (BMPs on its national website at http://www.epa.gov/owow/nps for the control of polluted runoff, soil stabilization and revegetation. Key recommendations are to revegetate disturbed areas promptly after disturbance, use seed mixes and treatments tailored for the region and area, and concentrate on erodible areas nearest waterbodies and most likely to affect water quality if left untreated. The EPA's general stormwater NPDES permit for

construction practices specifies that exposed, erodible soils be temporarily stabilized within two weeks of soil disturbance.

9. International Erosion Control Association and local landscaping businesses

The International Erosion Control Association has published several training manuals as part of its Professional Development Course series on how to control erosion and establish vegetation on steep slopes. A second manual is available covering biotechnical soil stabilization and erosion control for slopes and streambanks. The IECA has given several courses throughout Alaska, tailored towards the professional audience requiring "hands-on" training. The references include citations for the manuals.

The local knowledge of landscapers in Sitka and Juneau is particularly valuable and relevant to crafting revegetation guidelines and BMPs for Granite Creek. The seeding and planting experiences of these businesses was drawn upon to "ground truth" regulatory specifications. An example is the agency-prescribed timing window for seeding, typically limiting contractors to work during the period May 1 through September 1.

Comparative Analysis of Agency Specifications and Methods

Critical elements for seeding success include timing, high germination success, proper application rates, nutrient balance and maintenance. The CBS and ADOT&PF have very similar requirements for seeding, fertilizing, topsoil use and nutrient amendments. Specified seed mix varies somewhat, as does the minimum germination rate of mixes. In comparing the contract specifications and requirements of the agencies, the following differences show up.

DOT specifies a seasonal timing for application of seed between May 1 and September 15. The CBS specifies May 1 through September 1, with provision for extension with the written approval by the Public Works Engineer. The more restrictive September 1 date is used in the Tables, allowing for extensions that account for yearly and seasonal climate variations. DOT provides for temporary seeding beyond the limits of the normal seeding season provided that the application rate of the seeding mix is increased by 20%. The CBS has no similar specification. Lastly, DOT's seed application rate is significantly less than CBS specifications of 5-8 lbs per 1000 sq. ft.

The minimum seed germination success (sproutable seed %) for DOT varies from 67% to 78% depending on the grass species used. CBS specifies a germination success of 85% for all five of its approved seed mixes. Nutrient additions to topsoil are handled in different units between the two entities (lbs per acre vs. ppm) making it difficult to compare.

The only area of potential conflict exists with one of the approved CBS seed mixes (Schedule C under Section 75.05). This mix includes both Timothy grass and meadow foxtail. The Corps of Engineers prohibits both these species from use in revegetation under Nationwide Permit requirements due to their highly invasive nature.

It is recommended that the CBS not use the Schedule C seed formulation at Granite Creek to avoid a possible federal regulatory violation.

Alternatives to Seeding for Soil Stabilization and Erosion Control, including natural revegetation, bio- or photodegradable mats and overburden, and streambank bioengineering methods

Most of the previous sections centered on grass seeding as a technique for soil stabilization and revegetation. Effective soil stabilization and erosion control can be achieved in a variety of additional ways. Examples include plantings, using woven fiber mats to protect slopes and minimize erosion, reuse of vegetated mats of overburden to stabilize slopes, and a number of soil bioengineering techniques to stabilize streambanks. The Association of Soil Scientists and the Alaska Streambank Revegetation and Protection manuals (Muhlberg and Moore, 1998) encourages use of multiple techniques to meet the objective of soil stabilization. Those not involving seeding are briefly discussed below, with notes on applicability to Granite Creek. BMPs are also found in the Tables at the end of the report, keyed to specific land types and habitats.

1. Stripped overburden and vegetative mats (i.e. temporary cover with reusable materials over easily eroded soils)

Granite Creek has an ample supply of stripped overburden available from the gradual expansion of gravel pit operations and from highway projects and land clearing in the borough. The new waste overburden site above Granite Creek and the golf course lease area currently accept overburden for disposal.

Cut overburden (grass rolls or vegetative mats) has the ideal mix of soil, established native grasses, dormant seeds and nutrients that offer an ample source of stabilizing material for selected slopes, riparian buffers, and roadside ditches. The overburden reduces erosion and allows natural revegetation to “take”, further stabilizing the soil.

Tables 1, 3, 4 and 5 include recommended BMPs and situations that could use overburden for stabilizing soils, either alone or in combination with active seeding.

2. Jute mesh, straw and coir fiber mats, nylon mats, glass fiber mats and excelsior blankets

Biodegradable, woven matting is widely used in highway and other soil disturbing projects to stabilize slopes and minimize erosion. Recently, jute matting has received less use in favor of open weave geotextiles and straw and coir mats in photodegradable netting (David Lendrum and Shawn McLeod, personal communication). Excelsior blankets are recommended for slopes of 1.5:1. Matting can be used either in combination with topsoil, mulch, seeding and fertilizing, or solely as a tool to hold easily eroded soils in place until natural revegetation permanently stabilizes the slope.

Matting is the best single method for protecting the integrity of a mulched area but should not generally be applied alone where surface runoff is high. Jute mats act like straw mulch. Sediment reduction is typically 70 to 90 percent for up to 6 months, 40 to 60 percent for up to 2 years, and 10 to 30 percent beyond 2 years (Idaho Department of Environmental Quality, 2001). Matting can be applied to temporary construction sites, and to graded and bare areas receiving permanent revegetation treatment by seeding.

In addition to jute mesh mats, the CBS Contract specifications identify a number of other matting products approved for use. Nylon matting, excelsior (wood fiber) blankets, and glass fiber matting are listed in municipal specifications. Excelsior mats are made by bonding wood fibers to a plastic or paper net. The rolls are stapled to slopes to provide uniform cover to protect mulches and enhance seed germination. Excelsior mats are more difficult to install than straw and coir fiber mats or jute mats and are less predictable in controlling erosion. Wood excelsior mats have variable effectiveness in sediment reduction, ranging from 50 to 90 percent in 6 months, 20 to 60 percent over 2 years and 0 to 30 percent beyond 2 years (Idaho Dept. of Environmental Quality, 2001). Nylon mats or plastic netting are used primarily to hold straw and other materials in place, but provides no soil stabilization or erosion control.

Proper installation of each of these products is explained in the CBS specifications. Installation guidelines and diagrams are also included in the *Appendix.* Stapling or staking are commonly used to secure matting to the substrate. Design parameters for jute matting, wood fiber matting and plastic netting are found in the *Appendix.* Mats should be inspected at regular intervals and after storm events, with repairs made to restore coverage and full effectiveness of mats or netting.

Tables 1, 2 and 4 include recommended BMPs that use biodegradable matting for steep slope and roadside ditch stabilization and gravel lease operations.

3. Terracing, natural alder growth, brush layering, and willow bundles

Terracing banks to slow down stormwater runoff, shorten runoff distance, and reduce erosion is a common technique used by highway engineers. Terracing in combination with matting placed over eroded soils can be quite effective in stabilizing an area.

The active use of brush layering, coir logs, and willow bundles to stabilize and promote vegetative growth along streambanks is a rigorous practice typically requiring professionals with expertise. These techniques are commonly called streambank or soil bioengineering. *Table 3* (Riparian Buffers and Streambanks) itemizes BMPs and techniques adjacent to fish streams. These are relatively costly and often require use of heavy equipment and professional contractors.

Natural revegetation with alders and grasses has historically been the revegetation “tool of choice” for disturbed riparian/streamside areas in the Granite Creek watershed. Alder growth is robust in undisturbed, roped off riparian segments, has minimal cost, and achieves the objective of rapidly filling in and stabilizing soils and encouraging grass regrowth. Also, alders can be maintained quite easily with a brush mower. For these reasons, allowing natural revegetation to proceed in disturbed riparian areas is the CBS’ preferred approach over active bioengineering methods.

Site conditions to consider and “Lessons Learned” during years of streambank revegetation and protection by professionals are included as fact sheets in the *Appendix.*

The Permitting Process: Considerations in Revegetation Projects

The scope of these guidelines is limited to the Granite Creek watershed. The primary regulatory controls are the City and Borough of Sitka lease agreements and locally-approved SWPPPs covering each lease operator. However, if streambank protection is

to proceed in the anadromous tributaries or main stem of Granite Creek, a Corps of Engineers 404 permit, coastal consistency determination, Title 41 fish permit, and ADEC 401 water quality certification must be obtained prior to work. No permits are required for maintaining roadside ditches, steep slopes away from watercourses, or work already authorized under Corps of Engineers permits or EPA and DEC-approved SWPPPs (e.g. Golf Course construction, most bank stabilization and drainage improvements, existing waste overburden site expansion). New developments may require modified or new federal and state permit authorizations.

Prior to beginning soil stabilization in any new area, it is recommended that the CBS Environmental Department be notified and a site visit made to determine the potential need or applicability of any permits for work before it begins.

Relative Costs of Alternative Treatments and Doing it Right the First Time

The cost of a particular soil stabilization or revegetation practice is a major consideration is deciding which treatment – or combination of treatments – to select. For example, the cost of allowing alders and grasses to naturally revegetate encroached streamside buffers is minimal to zero. The initial placement of protective roping and stakes along with regular maintenance to ensure roping is not breached are the main costs. The cost of planting willow bundles along streambanks or placement of coir logs can be considerable. Additionally, rehabilitation work adjacent to fish streams requires permits and, typically, the hiring of professional contractors to complete the work.

The relative costs of each treatment are shown in the Tables using the dollar sign symbol. High costs are indicated as $$$, moderate as $$ and low costs as $. *Table 6* lists estimated costs for common materials and practices used in soil stabilization and revegetation as a tool in planning and budgeting overall costs of projects.

The costs of doing it right the first time are usually less than having to come back and reseed or fertilizer the following spring, replace jute matting, and oversee maintenance. Temporary stabilization measures will eventually need to be replaced by final, permanent control measures. The BMPs in *Tables 1 through 5* address this issue through identifying acceptable time periods for seeding, increasing the seed application rate if work is done outside normal seasons, scarifying the soil to ensure proper mixing of topsoil, use of amended topsoil and mulches in combination with seeding and fertilizing to achieve a proper nutrient balance and substrate for grass regrowth. Shortcuts usually don't work, requiring follow-up the following year. Repeat applications would add to the relative costs indicated in the Tables.

Linking Methods and BMPs to Stormwater Controls (SWPPPs) and ongoing maintenance operations

The soil stabilization and revegetation guidelines go hand-in-hand with erosion control practices mandated in approved Stormwater Pollution Prevention Plans (SWPPPs) for the Granite Creek watershed. They can be used as handouts to lease operators with existing SWPPPs to ensure continued erosion control and sediment reductions and also be provided to lessees proposing new construction projects in Granite Creek.

PART II

Recommended Guidelines and BMPs for Soil Stabilization and Revegetation at Granite Creek

Two tabular formats were considered for summarizing soil preparation/stabilization, topsoil and seeding/fertilizer information. One option was to organized the BMPs for all habitat types (steep slopes, roadside ditches, streamside areas) by each *major activity* (soil stabilization, topsoil, seeding, landscaping). The second – and selected – approach opted to organize BMPs and guidelines by the *habitat or land type being treated*. For example, steep slope areas are addressed in one table, with BMPs listed along with timing, relative cost and relative complexity of the technique. A second table addresses roadside ditches, a third riparian areas, a fourth active and inactive gravel lease sites, and a fifth the golf course lease. It was felt that organizing the BMPs by the *area* being considered, rather than by the method being used, made more practical sense and made it easier to use the guidelines.

Table 1: Steep banks and slopes

Table 2: Roadside ditches and stormwater conveyances

Table 3: Riparian buffers and streambanks

Table 4: Gravel lease operations: active and inactive

Table 5: Sea Mountain Golf Course lease site

Tracking Success and Conformance to Guidelines and BMPs

Tracking the success of any revegetation and soil stabilization effort requires regularly scheduled inspection and maintenance during and after completion of work. The CBS Public Works Department has the principal oversight responsibility for ensuring successful revegetation and soil stabilization practices on municipal leases in Granite Creek.

It is particularly important for the CBS and operators to have a common understanding on what constitutes successful revegetation and soil stabilization. This can be accomplished by adopting specific performance standards or “measures of success” against which to evaluate various applications. This is a critical step for the reclamation of inactive gravel lease sites being prepared for future uses in the watershed.

Ten Key Points to Remember on Erosion Control, Soil Stabilization and Revegetation

1. Keep soil in place using a variety of erosion control practices. Controlling erosion is an essential element of successful revegetation.

2. Cost is often not the most important factor in ensuring success in soil stabilization.

3. Proper soil stabilization and revegetation efforts require regular follow-up maintenance and inspection to be successful.

4. Utilize natural vegetation and site features to enhance revegetation and the treatment of stormwater runoff.

5. Rainfall, soil erodibility, and slope degree are factors effecting erosion and the success of soil stabilization and revegetation. Long slopes should be shortened by creating contour benches or terraces.

6. Cover (matting, plants, hydroseed) applied to erodible areas reduces runoff velocities, rainfall impact, traps sediment, and promotes permanent revegetation.

7. Both structural BMPs and non-structural BMPs are essential components of successful erosion control and soil stabilization.

   Structural methods include: sediment or retention basins, check dams, catch basins, barriers such as hay bales, filter fences, gravel bags, berms.

   Non-structural methods include: roughing soil surfaces, using plants and grasses to limit erosion, mulches and soil binders, hydroseeding, and a variety of biodegradable matting products and blankets.

8. Hydroseeding is an efficient slope stabilizing technique in that seed, tackifiers, mulch, fertilizer and lime are all applied in one step. Apply tackifiers to slopes steeper than 3:1.

9. Time windows for seed application (typically May 1 through September 1) are guidelines for contractors and are not hard-and-fast limits. Seasonal and yearly variability in climate in Southeast Alaska allow for adjustments on either end of the window. Often, late application of grass seed with allow for partial germination and soil binding and will provide a “head start” on soil stabilization when supplemented with the following spring’s seed application.

10. Both art and science are factors leading to successful revegetation efforts. Local experience on what works is more important than following rigid prescriptions. Trial and error may be necessary to achieve optimal results.

Table 1: Steep Banks and Slopes (= slopes steeper than 3:1(horizontal: vertical dimension) [1]

Special considerations: Seeding steep slopes usually requires the use of tackifiers/binding agents along with mulch and fertilizers. Hydraulic application ensures better success. Post-seeded steep slopes should be protected with matting or other biodegradable material placed over topsoil to protect against erosion. Follow up inspection and maintenance is necessary.

CBS purchase of a hydraulic seeder is recommended, particularly for use on steep slopes and large open areas needing broad treatments to reduce and prevent erosion and sediment runoff. Seed, mulch and fertilizer plus tackifiers can be effectively applied all at once using hydraulic methods. Such a seeder could also be used on municipal lands throughout Sitka that might require erosion control measures. The alternative to purchasing is to lease equipment or contract with private firms for completing this work.

	BMPs/techniques	Timing	Cost ($$$)	Relative Complexity; Maintenance
Soil Stabilization and preparation	1. The surface should be smoothed and potholes and gullies filled before topsoil/mulch application. Remove stick and other materials that prevent contact of mulch and/or matting with the surface. 2. Soils should be thawed. 3. The soil surface should be moistened prior to applying topsoil, fertilizer and seed. 4. Mulch or biodegradable jute, straw or coir fiber or other matting should be applied within 24 hours after seeding. 5. Mulch should be applied at an average of 50 lbs/1000 sq. ft. 6. If hydraulic seeding methods are used, mulch should be mixed in with seed and fertilizer and applied in one application.	After the spring thaw. No work to proceed on frozen soils.	$$	Low.
Temporary cover with reusable materials	7. Use of glass fiber mats, nylon meshing, jute mesh or excelsior blankets are encouraged to stabilize easily eroded soils. These can be used in combination with topsoil and seeding or as standalone methods to minimize erosion. See CBS specifications under Section 75.03 (Soil stabilization).		$	Low
Topsoil/ Overburden	1. All slopes to be seeded shall be covered with topsoil prior to seeding. [2] Topsoil should be evenly spread to a minimum depth of 4 inches. Use of	May 1 through September 1	$$	Moderate. Heavy equipment use

[1] Steep slopes are defined here as steeper than a 3:1 ratio. For example, a 1:1 slope is steeper than a 2:1 slope; a 2:1 slope is steeper than a 3:1 slope. The BMPs and guidelines listed here also apply to gradual slopes unless specifically referenced to steep slope conditions. The CBS' maximum allowable standard for constructed cut and fill slopes is 2:1.

[2] In some cases, topsoil cannot be effectively applied to steeper slopes due to erosion problems. Matting can help stabilize slopes in such cases.

	stripped overburden may be preferred over topsoil brought to the site to achieve soil stabilization and revegetation. 2. Topsoil should be free of roots, clods, refuse, weeds, hard clay, tall grass, sticks and be free of petroleum or toxic materials. Applied topsoil shall not have more than 10% gravel by weight. 3. Don't apply topsoil on frozen ground or excessively wet ground. 4. Tracked vehicles shall be used to prepare/compact topsoil on slopes greater than 5%. 5. Applied topsoil shall be maintained and protected until subsequent seeding and/or landscaping is completed. 6. Soil amendment may be necessary. Test topsoil for nutrient makeup (nitrogen, phosphoric acid, potassium) and add nutrients to achieve a finished soil balance of 45-90 lbs per acre. Lime addition may be necessary for acidic soils to attain a pH of 6.0 to 7.0.			usually required.
Seeding Fertilizers	1. Use certified seed that meets or exceeds the percentages of sproutable seed/germination % found in CBS Construction Manual, Section 75.05. or ADOT Table 724-1 (see Appendix). Typically >85%. 2. Seed shall be applied between May 1 and September 1 at a rate of at least 5 lbs per 1,000 sq. ft. [3] 3. Seeding done outside the above period should increase the seed application rate by 20% to enhance germination success. 4. Seeding should not be done during windy conditions or when ground conditions hinder germination of seed mixes. 5. Tackifiers/binding agents should be used in all hydraulic seeding on steep slopes (3:1 or steeper) to ensure seed establishment and germination. 6. Hydraulic methods are preferred for use on steep slopes. The purchase or lease of a hydraulic seeder is recommended for use on steep slopes and larger open tracts of land needing treatment. 7. Protect steep slope treatments from erosion by using biodegradable matting or other biodegradable materials placed over topsoil. All matting should be maintained and any damaged areas rematted or reseeded as necessary. 1. Use standard commercial fertilizer with a guaranteed analysis and listing of % of each ingredient. Typically use mixes of 20-20-10 or adjust depending on	May 1 through September 1.[4]	$$	Low-Moderate level of complexity, particularly if hand seeding is used. More cost and complexity if using hydraulic seeding methods. Damaged matting should be replaced as necessary.

[3] From CBS specifications for seed mix application.

[4] Date-specific seeding windows are specified for CBS and DOT contractors to ensure timely completion of work. It is recognized that seeding outside the specified period is sometimes necessary and that variable annual weather conditions can often allow extensions without compromising germination success.

	results of soil analysis. Fertilizer should be worked into the topsoil. CBS specifications list deal finished concentrations of nutrients as: N (21-35 ppm), Phosphoric acid (10-20 ppm) and K (76-150 ppm). 2. Fertilizers shall not contain Cyanamid or hydrated lime. 3. Fertilizer should be reapplied between May 1 – June 1 the year following seeding at ½ the initial application rate.			
Natural revegetation and landscaping with shrubs or trees	1. Allow natural revegetation with alders to progress unimpeded along stream banks and buffers. Trim branches as necessary. 2. Planting of shrubs or trees may be necessary in addition to reseeding to create a stable steep slope. Consult the CBS Landscape Section 75.02 for a detailed list of plant materials, preparation of plants, mulching, watering, use of soil amendments, seasons for planting, staking, fertilizing and maintenance.	Year round. May 1 through September 1.[5]	$ (natural) $$-$$$ (landscape)	Relatively high labor needs for planting and for maintenance. Regular maintenance is important to success.

[5] See description in Footnote 3 on seasonal and annual variability wit h respect to timing windows for landscaping.

Table 2: Roadside Ditches and Stormwater Channels

Special considerations: The successful seeding of roadside ditches and stormwater channels requires careful attention to season, soil surface preparation and selection of appropriate seed types. Reapplication of seed may often be necessary to establish a robust grass bed. Steep slopes in ditches may require use of tackifiers/binding agents along with mulch and fertilizers. Hydraulic application ensures better success. Post-seeded ditches and stormwater conveyances should ideally be protected with matting or other biodegradable material to protect against erosion. Truck traffic and equipment should be kept out of treated ditches to allow proper seed germination and establishment of grasses.

Currently, roadside ditch seeding and fertilizing at Granite Creek has been done by CBS staff using hand application methods. CBS purchase of a hydraulic seeder is recommended, particularly for use on steeper slopes and large open areas needing broad treatments to reduce and prevent erosion. The alternative to purchasing is to lease equipment for completing this work over a broad area.

BMPs/techniques		Timing	Cost ($$$)	Relative Complexity; Maintenance
Soil Stabilization and preparation	1. The ditch seeding surface should be scarified and smoothed and potholes and gullies filled before topsoil/mulch application 2. Treated ditch soils should be thawed before seeding. 3. The soil surface should be moistened prior to applying topsoil, fertilizer and seed. 4. If hydraulic seeding methods are used, mulch shall be mixed in with seed and fertilizer and applied in one application. Mulch should be applied at an average of 50 lbs/1000 sq. ft. 5. Check dam installation in roadside drainage ditches slows water down and, in combination with matting, reduces erosion and helps to ensure successful seed germination.	After the spring thaw. No work to proceed on frozen soils.	$	Low.
Temporary cover; reuse materials	6. Use of jute mesh or glass fiber mats, nylon meshing or excelsior blankets is encourage to stabilize easily eroded soils. These can be used in combination with topsoil and seeding or as standalone methods to minimize erosion.		$	Low
Topsoil	1. Ideally, a thin layer of topsoil (up to 4 inches) should be applied to the sloped areas of the ditches and stormwater channels. Biodegradable jute mesh, nylon matting, or excelsior blankets may be used to stabilize soils. Excelsior blankets used in ditches shall be applied in the direction of water flow. Biodegradable materials are preferred. Blankets and matting should be		$$	Moderate. Heavy equipment use is usually required for topsoil application.

	applied within 24 hours after seeding occurs. 2. Topsoil should be free of roots, clods, refuse, weeds, hard clay, tall grass, sticks and be free of petroleum or toxic materials. 3. Don't apply topsoil on frozen ground or excessively wet ground. 4. Topsoil application should be followed immediately by seeding and fertilizer application. If mulch or biodegradable jute matting is used, it should be applied within 24 hours after seeding**.** 5. Soil amendment may be necessary. Test topsoil for nutrient makeup (nitrogen, phosphoric acid, potassium) and add nutrients to achieve a finished soil balance of 45-90 lbs per acre. Lime addition may be necessary for acidic soils to attain a pH of 6.0 to 7.0.			
Seeding Fertilizers	1. Use certified seed that meets or exceeds the percentages of sproutable seed/germination % found in CBS Construction Manual, Section 75.05.or ADOT Table 724-1 (see Appendix). Typically >85%. 2. Seed shall be applied between May 1 and September 1. [6] Rates shall be at least 5 lbs seed per 1,000 sq ft. Hand application of seed should be at double the dry or hydraulic application rate. 3. Seeding done outside the above period should increase the seed application rate by 20% to enhance germination success. Reapplication may be needed. 4. Seeding should not be done during windy conditions or when ground conditions hinder germination of seed mixes. 5. Tackifiers/binding agents should be used in hydraulic seeding on ditches with steep slopes (slopes between 1:1 and 2:1) to ensure seed establishment and germination. 6. Protect ditch treatment from erosion by using photodegradable matting or other biodegradable materials placed over topsoil. 7. Use standard commercial fertilizer with a guaranteed analysis and listing of % of each ingredient. Typically use mixes of 20-20-10 or adjust depending on results of soil analysis. 8. Fertilizers shall not contain cyanamid or hydrated lime. 9. Fertilizer should be reapplied between May 1 – June 1 the year following seeding at ½ the initial application rate	May 1 through September 1. See footnote 3 for discussion on seasonal and annual climate variability, often allowing for modifications on either end of the time window.	$	Low level of complexity, particularly if hand seeding is used. Reapplication of seed and fertilizer is often necessary if hand-seeding techniques are use.
Landscaping with shrubs or trees	1. Not done in roadside ditches or stormwater conveyances as impeded water flow can result. Grassy swales are preferred in combination with check dams.	N/A		

[6] See footnote 3 under Table 1 on exceptions to seeding windows.

Table 3: Riparian Buffers and Streambanks

Special considerations: Streambank restoration and revegetation is often labor intensive and difficult, requiring the knowledge and expertise of a professional contractor. Heavy equipment is also often needed. "Soil bioengineering" is the common term for using live plants (cut and rooted vegetation) as the main structural component in stream landscaping projects.

For purposes of Granite Creek, priority is placed on the *protection* of existing riparian buffer areas and enhancing natural revegetation of damaged areas by alders and grasses. *It is more cost-effective to protect and maintain riparian habitat than to repair and restore damaged habitats.* Encroachment into protected riparian buffers is limited through roping/fencing, berming and municipal lease stipulations.

The published streambank revegetation and protection guidelines and BMPs of the Alaska Department of Fish and Game (initially published in 1998, with revisions in 2005) provide the most comprehensive approach to Alaska streambank protection methods. These methods are referenced here. The Appendix also includes fact sheets covering specific revegetation techniques and pitfalls to watch out for. Where seeding and fertilizer are applied on streambanks, the BMPs and guidelines for steep slopes listed in Table 1 should be followed. Over-fertilizing should be avoided.

The following is a summary of the ADF&G guidelines and BMPs germane to Granite Creek, with reference to the most common sreambank revegetation techniques. Hiring a professional contractor is recommended for carrying out these techniques.

	BMPs/techniques	**Timing**	**Cost ($$$)**	**Relative Complexity; Maintenance**
Protection of undisturbed vegetated buffers	1. Retain or add natural vegetated buffers along streams as a "soil stabilizer". 2. Minimize vegetative clearing along banks of streams or tributaries to reduce erosion and sedimentation. 3. Stabilize damaged riparian areas by allowing natural revegetation to proceed with alders and grasses. 4. Supplement natural revegetation of encroached areas with selective use of overburden and berming in critical stream segments. 5. Coir logs can be used to further protect stream banks and provide fish habitat. Provide stability until until vegetation is established.		$ $$ $$$	Low to nominal. Coir logs are expensive.
Grass rolls	1. Use where seeding is impractical due to fluctuating water levels. Good for erosion control. 2. Clumps of grass sods are placed together and held together with	May 1 through September 1.	$$	Moderate. Relatively inexpensive;

	biodegradable fabric and twine. 3. Grass roll construction and placement instructions are found in the Appendix.			requiring little training or mechanized work. Reestablishes natural condition. Not recommended for high velocity environments.
Vegetative mat (overburden)	1. Provides large transplant mats that provide immediate vegetative cover after the mat is placed. Mats contain grasses and other native plant species that will take easily in the transplanted location. 2. Main expense is for labor and machinery for cutting and moving and installing the large mats. 3. Stripped overburden can be stored for several years without adverse effects on its use in revegetation. 4. Root/soil mass is cut into a block and transported to the storage or planting site. 5. Planting site and soil is prepared to accommodate the dimensions of the mat. The mat may need regular watering after planting.	May 1 through September 1. Annual climate variability allows for extensions.	$$	Moderate. An ample source of overburden exists in the Granite Creek watershed. May need watering after planting.
Bundles (fascines)	1. Bundles are a group of dormant branches (usually willows) bound together in a long log-like structure to provide plant cover. The bundle is used to encourage revegetation and stabilize slopes. 2. Collection, storage and hand planting information are found under http://www.sf.adfg.atate.ak.us/sarr/restoration/techniques/fascine.cfm 3. Bundles should be placed end-to-end and follow the contour of the slope.	May 1 through September 1. See caveats above.	$$	Moderate. Good in low velocity systems. Easy to construct and install. Provides terracing for seeds to settle. Requires lots of willow.
Brush layering	1. This is a revegetation technique used on slopes. Can be constructed of dormant branches that will root and grow and is often used in combination with other reveg and protection techniques to secure the toe of the slope. Root wads, live siltation, coir logs and spruce tree revetments are examples. 2. Preferred over just an erosion control mat without vegetation. 3. Traps native seeds and provides an environment for germination and growth. 4. Jute is used to anchor the mat to the bank. 5. Construction, installation and staking methods are found in the Appendix.	May 1 through September 1.	$$$	Moderate-high level of complexity. Labor intensive and may be technically challenging. Provides good erosion control and soil stability.

Landscaping with shrubs or trees	1. Allow natural revegetation with alders to progress unimpeded. 2. Planting of shrubs or trees may be necessary in addition to reseeding to create a stable steep slope. Consult the CBS Landscape Section 75.02 for a detailed list of plant materials, preparation of plants, mulching, watering, use of soil amendments, seasons for planting, staking, fertilizing and other maintenance activities.		$ (natural) $$$ for plantings.	Relatively high labor needs upfront and for regular maintenance. Maintenance activities are a key to successful landscaping

Table 4: Gravel Lease Operations: active and inactive [7]

Material extraction operations at Granite Creek are required to comply with conditions of municipal lease agreements signed with operators. The most important pollution erosion control requirement is the Stormwater Pollution Prevention Plan (SWPPP). These plans are required of each operator and include BMPs for protecting water quality. The erosion control-oriented SWPPPs are not intended to focus on revegetation but do address soil stabilization as a means of reducing erosion. Also, through limiting their encroachment into roped and stakes riparian buffers, operators allow natural revegetation to proceed along stream banks.

The CBS has taken the lead role in active revegetation work at municipal leases, including seeding roadside ditches. Lessees continue to focus on reducing stormwater runoff and sediment and turbidity from entering Granite Creek and its tributaries.

Inactive leases are subject to the terms and conditions of the Granite Creek Reclamation Plan. This 1982 Plan was amended in June 2005 to include additional requirements for reclamation. The Plan includes several revegetation and soil stabilization requirements with the objective of returning the affected land to a condition that safely supports future uses at the site.

The following includes a summary of municipal guidelines and BMPs germane to both protection of Granite Creek and the revegetation of damaged habitats. These BMPs are taken directly from the previously approved *Granite Creek Watershed Recovery Strategy,* the CBS environmental audit checklist for lease operations*,* and the *Granite Creek Pollution Control Recommendations for New Developments (2005).* Reclamation standards for revegetation are found in An *Updated Reclamation Plan for Granite Creek Material Lease Sites*, completed in June 2005.

	BMPs/techniques	**Timing**	**Cost ($$$)**	**Relative Complexity; Maintenance**
Active Leases				
Protection of undisturbed vegetated buffers	1. Retain or add natural vegetated buffers along streams as a "soil stabilizer". Established riparian buffers should be protected and maintained. 2. Minimize vegetative clearing along banks of streams or tributaries to reduce erosion and sedimentation. 3. Protect and stabilize riparian areas by roping/staking off sensitive areas to minimize encroachment and allow natural revegetation to proceed with alders	Year round	$	Low to nominal.

[7] While not addressed in this Table, waste overburden sites managed by the City and Borough of Sitka are subject to stabilization with a topsoil cap and revegetation when their useful life is over. The old waste overburden site at the golf course is an example.

	and grasses. 4. Stakes, ropes and berming installed along stream tributaries shall remain undisturbed. Roped areas shall be routinely inspected and repair as needed. 5. Construction equipment, aggregate stockpiles, vehicles or boats are not to be stored within 25 feet of Granite Creek or its North or South tributaries. Fuel and oil storage shall be a minimum of 50 feet away from stream banks. 6. Supplement natural revegetation of encroached areas with selective use of overburden and berming or other physical barriers in critical stream segments. 7. Retention of vegetated swales is encouraged to treat stormwater runoff (sediment and turbidity) from settling ponds prior to entering the stream. 8. CBS staff should routinely examine progress in revegetated ditches and steep banks and reapply seed or other treatments as necessary. 9. A revegetation "measure of success" (e.g. % cover, density, etc.) should be adopted as a threshold against which to evaluate the need for follow-up reseeding or other soil stabilization techniques.			.
Overburden use in soil stabilization	1. Reuse of stripped overburden and biodegradable fiber matting is encouraged to stabilize soils at gravel lease sites and riparian areas and to promote natural revegetation of sensitive areas along streams.	Year round	$	Readily available supply of overburden.
Road maintenance, drainage and erosion control	1. Check dams in roadside ditches should be regularly maintained by CBS. 2. Grassy swales should be established in roadside ditches through active seeding. Reseeding should occur, as necessary, to establish and maintain a sufficient grass density to slow water transport velocities and remove sediments. 3. Ditches and swales should not be disturbed by truck traffic or equipment and any damage repaired. 4. Soil stabilization, runoff, and vegetation of ditching for new lease road realignments should be factored in and completed during the year of road realignment. Drainage ditches should be seeded and fertilized to establish grasses. Collection ponds and/or swales should treat stormwater runoff. 5. Grass seed used in revegetation should meet CBS specifications for seed mix.	Ongoing. Seeding during May 1 through September 1.	$ $$	Low cost for maintenance. Engineering plans should specify stormwater collection and treatment
Inactive leases subject to the Updated Reclamation	Operators are subject to the conditions of the 1982 Granite Creek Reclamation Plan and CBS amendments adopted to the Plan in June 2005. Those specific conditions related to revegetation and soil stabilization are listed below. 1. Overburden in the disposal area should be used for the restoration of the site.		$$ - $$$	Moderate to high. Operators are required to file a Letter of Credit with CBS to adequately

Plan for Granite Creek Material Sites	2. Sites should be sloped and contoured to gentle grades suitable for the ultimate use of the site and stabilized with vegetation. 3. Work areas should be shaped and contoured to minimize ponding and erosion. 4. Revegetation is encouraged in all areas subject to erosion. 5. Natural vegetation is preferred. The CBS will provide specific recommendations on the type of revegetation desired for the planned use of the site. 6. Areas to be revegetated shall be covered with approximately 8-12 inches of high quality overburden material. The material should be placed after sloping and contouring is complete and should be compacted slightly to make it more resistant to erosion. Samples of the material should be collected and tested for nutrients and pH. Results should be submitted to the CBS.			cover the costs of reclamation. Agreement on acceptable end points of reclamation need to be negotiated as well as "measures of success" to objectively evaluate progress during reclamation.

Table 5: Sea Mountain Golf Course Lease Site

The non-profit Sitka Golf Association (SGA) has taken the lead role in active seeding and fertilizing work at the site, including fairway and slope preparation, drainage improvements, road construction, active seeding and fertilizing of roadside ditches, steep slopes and fairways, and the installation of several settling ponds. Through these efforts, the SGA has the most practical, "hands on" soil stabilization and revegetation experience of any lessee in the Granite Creek watershed. These collective efforts have been very successful in reducing stormwater runoff and sediment loads to Granite Creek, as verified by low turbidity levels in spot checks of settling pond effluent and connecting ditches draining to Granite Creek Road.

Operations at the lease site are required to comply with the Corps of Engineers permit and conditions of municipal lease agreements signed with operators. The most important pollution and erosion control requirement is the Stormwater Pollution Prevention Plan (SWPPP). These plans are required of each operator and include BMPs for protecting water quality.

	BMPs/techniques [8]	**Timing**	**Cost ($$$)**	**Relative Complexity; Maintenance issues**
Soil Stabilization and Preparation	1. Fairway surfaces are smoothed and rocks up to 22 inches are removed with a mechanical rock picker/harrow. 2. After rock removal, either topsoil or ash is applied to fairway surfaces, depending on availability, followed by hydraulic application of fertilizer, seed, lime and mulch. 3. Ash (in lieu of topsoil) is applied to steep slopes before hydraulic seeding.	May 1 through September 1	$	Low
Topsoil	1. Topsoil or ash is applied to fairways. Topsoil is not usually used on steep slopes as it does not hold well and is prone to erosion. Tackifiers are applied with mulch to improve adhesion. 2. Reapplication of topsoil, fertilizer and seed may be necessary on moderate slopes if newly-seeded areas are severely eroded by heavy rains. Areas should be checked routinely for erosion channels. 3. Riprap is used in lieu of overburden or topsoil/seed for soil stabilization in roadside drainage ditches. Commercial grass rolls are expensive and use of stripped overburden requires significant cutting and processing.	May 1 through September 1	$$	Low to nominal. .
Seeding and	1. Hydraulic methods are used to apply the seed/fertilizer/lime mixture. Fertilizer is reapplied to fairways after the first cutting and up to four times a	Generally May 1 through	$$$	The seed mix is identical to a Prince

[8] The following descriptions are techniques currently used on-site. In some cases, additional BMPs are proposed to augment existing practices.

Fertilizers	year. Fertilizer is reapplied to sloped areas twice per year. 2. Soils are acidic. A considerable amount of lime needs to be applied to balance the pH of soils. 3. The seed mix used on fairways consists of rye, creepy red and hard fescue, and sea breeze fescue (Roger Sudnikovitch, personal communication). 4. Tackifiers should be used with mulch in hydraulic applications to steep slopes.[9] A different seed mix is used for steep slopes than for fairways to encourage slower growth and less maintenance on steep slopes. Rye grass is used but different fescues are added. 5. Jute mats can be used on steep and moderate slopes provided close attention is given to properly anchoring mats and erosion potential is minimized. 6. Reuse of stripped overburden and jute or other fiber matting is encouraged to stabilize soils on moderate slopes. **7.** A revegetation "measure of success" (e.g. % cover, density, etc.) should be considered as a threshold against which to determine the need for follow-up reseeding or soil stabilization. Visual determinations are typically the norm.	September 1. Each year is variable, often allowing early and/or late application. On the other extreme, sometimes seeding is not possible after July due to heavy rains and soil erosion.	$$$ Fertilizer costs are particlarly high	Rupert mix used successfully at several golf courses in British Columbia, which has a climate similar to Sitka's. May 2005 cost estimates for fertilizer are $24/100 lb bag and lime at $5.25/50 lb bag. Mulch/tackifier mix is $12.50/50 lb bag. Prices have increased since 5/05.
Maintnance, drainage and erosion control	1. Subject to the conditions of the approved Stormwater Pollution Prevention Plan (SWPPP). Recommend considering amending the plan (as funds allow) to strengthen operational BMPs once the golf course is constructed. 2. Riprap is placed in roadside ditches to stabilize soils and slow down drainage. 3. The considerable drainage from upland areas should be routed with at least 8-inch piping and ditches and collected/treated in the lower areas before discharge. Drainage control is expected to be the largest maintenance issue (per Roger Sudnikovitch). Three new ditches are to be installed in the lower area of the course. 4. Periodic water quality monitoring should be done to comply with EPA SWPPP reporting requirements and the Granite Creek TMDL implementation plan. [10]	Ongoing.	$$ Drainage controls can be costly.	Moderate cost for maintenance.
Landscaping with shrubs and trees	1. Not typically done on the golf course. Existing trees are trimmed and thinned when required.	N/A	$	N/A

[9] Not all steep slopes are fertilized and seeded or otherwise stabilized due to insufficient funds.

[10] CBS and its contractor currently monitor turbidity and TSS at several permanent stations in the watershed. Effluents from settling ponds on the lease that drain to roadside ditches or other collection points that drain to Granite Creek can be routinely monitored for turbidity levels by the lessee.

Table 6: MATERIALS PRICE LIST: SOIL STABILATION AND REVEGETATION [11]

Item or Practice	Estimated Cost
1. Commercial light-duty hydroseeder unit (truck bed mount of 350 gallon or 600 gallon capacity or 1000 gallon/min unit –FMC Auger machine)	$ 2000-$3000 (small unit) $10,000 (1000 gal unit)
b. Contractor hydroseeding (soil prep, seed/fert/mulch/tackifier) $2000-$4000 per acre for permanent seeding)	$80 per 10,000 sq. ft unit;
2. Fertilizer (100 lb bag)	$24 - $30
3. Lime (40 lb bag)	$7.25
4. Mulch/tackifier mix for hydroseeder	$12.50 per 50 lb bag
5. Soil amendments (lime, fertilizer, iron, mulch, sand)	$30/ton (sand); $30/cyd mulch
6. Grass seed mix (bag of typical fescue mix)	$110/50lb bag (Alaskan Grass Seed); $150 to $200/50lb bag lot (Special Roadside mix)
7. Soil preparation (rock removal, rototilling)	Depends on site; high end in Sitka due to poor quality soil; estimate included under hydroseeding above)
8. Overburden/vegetative mats	$15 per sq. ft
9. Soil (pit run truckload)	$100
10. Topsoil (10 cyd truckload)	$150 for poor quality; $1000 for prime soil
11. Gravel/rock (per truckload)	$190 (D-1); $160 (2"minus); $100 (shot rock); $160 (rip rap)
12. Jute matting	$70 per 48" x 225 ft roll
13. Straw and coir fiber mats with photodegradable netting	$40 per 6 ft x 50 ft mat
14. Silt fencing (3 ft x 100 ft roll w/ stakes)	$30
15. Excelsior blankets (recommended for 1.5:1 slopes)	$70 (4 ft x180 ft)
16. Coir logs (20 foot length)	$125-165 per log
17. Poly jute (open weave geotextile)	$150 (6'3" x 432 ft roll)/$270 (12'6" x 432')
18. Willow bundles (fascines)	$.50/cutting; $25 per bundle of 50, 4 ft x 1" branches

[11] Prices quoted are estimates for early 2006 obtained from Sitkan and Juneau sources. Estimates do not included shipping costs. These estimates are intended for initial project preparation and to assist in choosing among alternatives. Cost ranges are provided to help account for variability. Minor tools such as rakes, shovel, pruners, twine, and other hand tools are not included in the price list. Sitka city staff and landscapers routinely have such tools available.

REFERENCES

Alaska Department of Natural Resources. Division of Agriculture, Plant Materials Center, Palmer, Alaska. 2005. Native plant directory and seed and plant standards.

Alaska Department of Transportation and Public Facilities. 2005. Contract Construction Requirements for Seeding, Soil Stabilization, Topsoil and Fertilizer. Sections 618 through 620, Sections 724 through 726.

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APPENDICES

1. ADF&G Sport Fish Division streambank revegetation and protection Fact Sheets

2. “Lessons Learned” in streambank restoration and protection

3. CBS contract specifications for seeding, fertilizer and soil prep

4. ADOT&PF contract specifications for seeding, soil prep and fertilizer use

5. Corps of Engineers Nationwide and Regional permit conditions for acceptable revegetation species (Regional Condition E)

6. Hydroseeder distributors, specifications and size options; choosing a unit

7. Matting BMPs and procedures. Idaho Dept. of Environmental Quality.