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RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	6/28/99	Revised to become Chapter 3 of Facility Engineering Manual (FEM), superseding Civil Facilities Engineering Standards, Volume 3, Revision No. 8, 6/5/98.	Edward J. Hoth *FWO-UI*	Dennis McLain *FWO-FE*
1	8/16/04	Chapter divided into four sections based on UniFormat. Complete revision. FEM now ESM.	Edward J. Hoth *FWO-UI*	Gurinder Grewal *FWO-DO*
2	10/27/06	Administrative changes only. Organization and contract reference updates from LANS transition. IMP and ISD number changes based on new Conduct of Engineering IMP 341. Master Spec number/title updates. Other administrative changes.	Edward J. Hoth *MSS-UI*	Kirk Christensen, *CENG*

CONTACT THE CIVIL ENGINEERING STANDARDS POC

for upkeep, interpretation, and variance issues

Ch. 3, G10	**Civil POC/Committee**

G10 SITE PREPARATION

G1030 SITE EARTHWORK

1.0 SITE GRADING, EXCAVATION, AND DISPOSAL

A. Accomplish site grading in a manner which will cause the least disturbance to the natural terrain. Preserve and protect existing native vegetation and trees and shrubs on or adjacent to the construction site, which do not unreasonably interfere with construction operations. Scalp and stockpile the topsoil within the limits of disturbance for use in landscaping and re-vegetation operations upon completion of construction.

B. Establish grades such that site drainage is away from all structural foundations and open utility excavations. Good engineering practice requires at least a one-half (0.5) foot drop in 10 feet away from the structure. In general, surface drainage systems are preferred over closed-conduit systems. Divert roof runoff away from exterior door openings and walkways. During design, consider the effect of water and wind erosion upon the altered drainage patterns adjacent to new structures. Design must give consideration to winter shade conditions, i.e., north sides of structures, and heavy vegetation. Take reasonable precautions to preclude the continuation or acceleration of soil erosion at the project site.

C. Present elevations necessary for proper site grading on the grading plan. Attempt at achieving an earthwork balance during design. If an earthwork balance cannot reasonably be achieved due to existing site conditions, suitable sources of borrow material must be established prior to construction. Coordinate site selection for borrow pit operations with the LANL Project Leader.

D. Specify suitable materials and methods of placing and compacting backfill for buildings, parking areas, roads, loading areas, utility trenches, and the general site within the construction documents.

E. The grading design shall provide existing and new contours at an interval of 2 ft. and spot elevations shown for grade changes and structure elevations. Provide cross sections where practical and earthwork quantities are substantial. After construction is complete, including clean up, finish grading to the final contours as shown on the drawings shall conform to a tolerance of plus or minus 0.1 ft. Refer to LANL Master Specifications Section 31 2000, Earth Moving.

F. Convey excess material generated during site grading operations to the Los Alamos County sanitary landfill, or other designated locations. Coordinate through the LANL Project Leader.

G. Refer to LANL Master Specifications Section 01 5705, Temporary Controls and Compliance Requirements, for additional requirements on topics such as Erosion and Sediment Control, Storm Water Management, Site Stabilization, Spill Control and Response, Debris Control, Air Quality, Dust Suppression, Rodent Control, Environmental Restoration Sites, Hazardous Waste, and Traffic Control.

2.0 Earthwork

A. Natural soil shall not have a finished slope steeper than 2 horizontal to 1 vertical (2:1). Undisturbed volcanic tuff shall not have a finished slope steeper than 1 horizontal to 6 vertical (1:6).

B. Define subgrade preparation as the top 6 inches of site work under slabs and pavement. It shall be scarified, moistened to optimum conditions, and compacted to 95% of maximum density. Limit elevation tolerance to plus or minus 0.05 ft. per 10 ft. in any direction from specified grade and cross section. Finish slopes may exceed a 2:1 slope in special cases when designed by a registered professional geotechnical engineer.

3.0 Compaction

A. Density: Determine optimum density in accordance with ASTM D1557. Determine field control of density of in-place material in accordance with the Nuclear Method (ASTM D2922) or the relative density of cohesionless soils (ASTM D4253).

B. Moisture Content: Field control of moisture content shall be determined by the Nuclear Method (ASTM D3017) or the Laboratory Determination (ASTM D4253) for cohesionless material.

C. Compaction: Comply with Table G1030-1 requirements for approved material, moistened to optimum conditions, and placed in layers not to exceed 6 inches before compaction.

TABLE G1030-1
Compaction Requirements

% of Maximum Density	Type of Material
95	Structural fill, embankment, backfill, subgrade and base course under building floor slab, concrete sidewalks, and paved areas.
90	General area grading, backfill, and embankments not under paved area.
85	Sand bedding for underground piping system, except under roadways where density shall be 95%.

D. Refer to LANL Master Specifications Section 31 2000, Earth Moving, for additional requirements.

4.0 NCB Compliance (NEPA, Cultural, and Biological Resources)

A. The purpose of the NEPA, Cultural Resources, and Biological Resources (NCB) process is to ensure that all new and modified programmatic and facility activities (1) consider environmental issues in planning, (2) comply with NCB legal requirements, and (3) incorporate measures necessary to mitigate the effects of activities on environmental resources, including Threatened & Endangered Species, Floodplains, Wetlands, Historic Buildings, and Archaeological sites.

B. The LANL Project Manager will complete the Project Review and Requirements Identification (PR-ID) Process as necessary prior to design. Completing the PR-ID process will ensure that the LANL Ecology and Air Quality Group or a trained NCB Reviewer screens all necessary projects and activities. Contact the Project Leader to obtain LANL Ecology and Air Quality Group NCB requirements identified through the PR-ID Process. Incorporate identified requirements into the project's design in order to avoid adverse effects to cultural and biological resources.

5.0 Environmental Restoration

A. For projects that disturb soil or cause runoff to cross a Potential Release Site (PRS), including Solid Waste Management Units (SWMUs), appropriate Best Management Practices (BMPs) shall be implemented. Specific storm water controls may also be required under regulatory agreements with the New Mexico Environment Department.

B. The LANL Project Manager will complete the Project Review and Requirements Identification (PR-ID) Process as necessary prior to design. Completing the PR-ID process will ensure that Environmental Restoration requirements are identified. Contact the LANL Project Leader to obtain Environmental Restoration requirements identified through the PR-ID Process. Incorporate identified requirements into the project's design.

C. Contact the Environmental Restoration Group at 665-6770 or the Solid Waste and Regulatory Compliance Group at 667-0666 for more information.

6.0 Storm Water Compliance

A. Storm Water Management Criteria

1. All projects, regardless of size, shall utilize appropriate BMPs to control the discharge or migration of pollutants, including sediment, from disturbed areas. These BMPs are required to maintain compliance with the New Mexico Water Quality Control Commission (WQCC) stream standards and, for sites disturbing 1 acre or more, Environmental Protection Agency (EPA) regulations.

2. Refer to Part 6.E for definition of BMPs, BMP requirements, and guidance on BMP selection. Additional information on BMP use is provided in LANL Master Specifications Sections 32 9219 Seeding; 01 5705 Temporary Controls and Compliance Requirements; and the Landscaping Section, G2050, of ESM Chapter 4, Architectural.

B. Sites Over One Acre

1. Projects where construction activities disturb 1 acre or more -- or where activities are part of a larger “common plan” of development that disturbs 1 acre or more -- are required to obtain a permit to discharge storm water from the site in accordance with the EPA’s National Pollutant Discharge Elimination System (NPDES) Storm Water Program. Submission of a Notice of Intent (NOI) to EPA is required to obtain Permit coverage.

2. Projects subject to NPDES Permit requirements must develop a Storm Water Pollution Prevention (SWPP) Plan prior to obtaining Permit coverage. An SWPP Plan identifies project activities, describes potential pollutant sources, and identifies the BMPs to minimize the potential for erosion and storm water contamination. Contact the LANL Water Quality Group at 665-0453 for more information on NPDES requirements.

3. LANL will provide a SWPP Plan for the project. Allow a minimum of one month for SWPP Plan preparation. A/E and contractor personnel shall provide assistance in SWPP Plan preparation through the following:

   a. Provide the Water Quality Group with the necessary design information in sufficient format and detail to complete the SWPP Plan.

   b. Prepare design drawings and specifications for required temporary and permanent BMPs that correspond with the SWPP Plan and NPDES Permit requirements. Project documents must specify the methods, materials, and procedures associated with the temporary and permanent stabilization of disturbed areas.

   c. Work with the LANL Water Quality Group to develop documentation that the specified BMPs prevent an increase in sediment yield and flow velocity from pre-construction, pre-development conditions.

C. 404/401 Permits

1. If project construction activities involve crossing, working in, or otherwise disturbing a watercourse, a Section 404 Dredge and Fill Permit from the U.S. Army Corps of Engineers and a New Mexico Environment Department Section 401 Water Quality Certification may be required. A watercourse is defined as “any river, creek, arroyo, canyon, draw, or wash, or any other channel having defined bed and banks with visible evidence of the occasional flow of water or high water mark.” If required, the Permit and Certification must be obtained prior to performing any work in a watercourse. Allow at least one to two months for 404/401 Permit Applications.

2. 404/401 Permits will require the implementation and specification of BMPs. The drawings shall clearly show the watercourse area and identify the required BMPs.

3. The Water Quality Group will file the 404/401 Permit Application and review the BMPs identified in design documents to ensure compliance with Permit requirements. All information required for the permit application shall be forwarded to the Water Quality & Group by the project coordinator for inclusion in the Permit Application. Contact the Water Quality Group at 665-0453 for more information.

D. New Mexico Environment Department Notices of Intent

1. Fertilizer, hydraulically applied mulches, Bonded Fiber Matrix, dust suppression additives, and other substances applied to the ground may require that a Notice of Intent (NOI) to Discharge be submitted to the New Mexico Environment Department (NMED). Contact the LANL Water Quality Group at 665-0453 for more information and to determine whether substances to be used are covered under an existing lab-wide NOI.

2. Substances applied to the ground shall not be applied in a watercourse.

E. Erosion and Sediment Control – BMP Guidance

1. Best Management Practices (BMPs) are measures used to prevent or mitigate pollution from any activity. They include processes, procedures, schedule of activities, prohibitions on practices, and other management practices to prevent or reduce water pollution. They include measures for stabilization, sediment and erosion control, and storm water management and can generally be broken down into two categories – structural and non-structural. Examples of non-structural BMPs include minimizing removal of established vegetation, good housekeeping, preventative maintenance, management of runoff, employee training, record keeping and reporting, visual inspections, and spill prevention and response. Some examples of structural BMPs are ground cover and vegetation, detention ponds, silt fence, Triangular Silt Dike™, earth berms, inlet protection, riprap, turf reinforcement mats, and construction entrances.

2. When soil is disturbed, implement a combination of erosion and sediment controls. Erosion controls stop erosion at the source. Sediment controls retain sediment that has eroded before the sediment leaves the site.

3. Permanent BMP Requirements

   a. Design permanent post-construction storm water management devices and sediment controls to be installed during the construction process to control pollutants in storm water discharges after construction operations have been completed. Such measures include but are not limited to permanent vegetation, storm water detention ponds, sediment basins, turf reinforcement mats, and rock check dams.

   b. A turnover process for acceptance of permanent BMPs must be documented by the responsible LANL FOD (acceptance form available from ENV-RCRA).

   c. *The labwide SWPPP is maintained by MSS Utilities & Infrastructure Group to the requirements set by ENV-RCRA.*

   d. Stabilize all unpaved areas and areas not covered by permanent structures or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles). Achieve stabilization by covering soil with measures including, but not limited to native perennial vegetation, asphalt, concrete, base course, or riprap. Avoid the use of impermeable surfaces when possible.

   e. Place velocity dissipation devices at discharge locations and along the length of any outfall channel to provide a non-erosive flow velocity from the structure to a water course so that natural physical and biological characteristics and functions are maintained and protected (e.g., no significant changes in the hydrological regime of the receiving water).

   f. For other areas of concentrated flow such as drainage ways, steep slopes, and compacted earth surfaces, provide appropriate energy dissipating devices. These include such controls as riprap, turf reinforcement mats, check dams, and waterbars.

   g. If permanent BMPs can be utilized during the construction phase to meet the objectives of temporary sediment and erosion controls, specify their installation in lieu of temporary controls.

4. Erosion Control

   a. Seeding and Mulching:

      - Revegetation using a native perennial seed mix is appropriate for areas with slopes less than 2 horizontal to 1 vertical (2:1). Perform seeding in conjunction with proper soil amendments and mulching. On slopes gentler than 3:1, straw mulch can be used. Straw mulch must be properly anchored in the soil to be effective. Slopes 3:1 to 2:1 and channels require hydraulic mulch, erosion control blankets, bonded fiber matrix (BFM), or turf reinforcement mats. These measures may also be used with gentler slopes if desired. Slopes steeper than 2:1 require engineered slope stabilization.
      - For flat areas and gentle slopes where vegetation is not desired, placement of riprap, turf reinforcement mat, gravel mulch, or other appropriate stabilizing material may be applied.
      - Refer to LANL Master Specifications Sections 32 9219 Seeding; 32 9223 Sodding; and 32 9300 Plants. Coordinate with the Landscaping Section, G2050, of ESM Chapter 4, Architectural for architectural suitability.

   b. Soil Roughening—Roughen soil immediately prior to seeding to reduce runoff velocities and erosion. To increase infiltration, do not excessively compact soil.

   c. Turf Reinforcement Mats—Use Turf Reinforcement Mats (TRMs) in conjunction with seeding on steep slopes and in moderate to high flow channels where established vegetation alone would not withstand erosive forces. Choose the appropriate turf reinforcement mat for a channel based on the calculated shear stress and water velocities. These mats may be used in channels where shears are up to 11 lbs/ft^2 and velocities range up to 20 ft/sec.

   d. Magnesium Chloride—For use as dust or erosion control, specify a clear, thoroughly mixed solution that has a high concentration of magnesium chloride with no heavy metal contamination and no solid matter.

   e. Chemical Polymers—For use as dust control, erosion control, or water quality improvement, specify “water soluble” or “linear” or “non-crosslinked” polyacrylamides (PAMs), polyamines, or aluminum-chloride polymers. Contact the LANL Water Quality Group (665-0453) and the Ecology and Air Quality Group (665-8961) prior to polymer selection to ensure that the polymer meets all LANL ecological and water quality discharge and notification requirements.

   f. Newer Methods as Developed—Contact the LANL Water Quality Group for advisement and approval prior to use.

5. Sediment Control

   a. Straw Bale Structures—Straw bale structures are only suitable for sheet flow or small channels that have a flow of 1 ft^3/sec or less. The drainage area upslope of straw bale structures should be one acre or less, the slope length should be 100 feet or less, and the slope gradient for the swale 2H:1V or flatter. They must be embedded in soil a minimum of 4 inches and anchored together and to the ground with wooden stakes or rebar. Straw bales must be removed from the site after use.

   b. Straw Wattles—Use straw wattles to break up the slope length, which reduces flow velocities and prevents erosional rills. They shall not be used in channels. Wattles must be properly entrenched and staked in place. They can be left onsite to decompose.

   c. Silt Fence—If used as perimeter protection, place silt fence along a contour. Silt fence is not appropriate for use in channels. If used at the bottom of a slope, silt fence must be placed a minimum of six feet from the toe of a slope.

   d. Triangular Silt Dike™—Use Triangular Silt Dike ™ for perimeter protection (i.e., silt fence), check dams, inlet protection, or to form channels. They should be used in locations where the control may come in contact with construction equipment and vehicles and on surfaces that would limit or prevent proper trenching of silt fence. Triangular Silt Dike ™ may be used in channels and areas of concentrated flows.

   e. Inlet Protection—Do not specify silt fence for inlet protection if the inlet is subject to concentrated flows. Do not specify cinder blocks as a control for inlets adjacent to roadways. For inlets in or adjacent to roadways, walkways, buildings, or parking lots, do not design or specify controls that will cause excessive ponding or may cause flooding of adjacent structures if the control becomes plugged or damaged.

   f. Flocculants—For settling basins when flocculation is necessary to meet water quality objectives, use biodegradable, fish safe flocculants. Contact the LANL Water Quality and Ecology and Air Quality Groups prior to flocculant selection to ensure that all LANL ecological and water quality discharge and notification requirements are met.

   g. Temporary Sediment Basins/ Sediment Traps—A Professional Engineer (PE) or Certified Professional in Erosion and Sediment Control (CPESC) shall design temporary basins to capture runoff from at least a 2-year, 2-hour storm event. The basin should be designed to detain runoff for a sufficient period of time to allow a majority of the suspended sediment to settle.

   h. Construction Entrances—Design riprap construction entrances for sites where conditions may lead to offsite tracking of sediment. Use geotextile, as necessary, to improve stability of the pad foundation. Design construction entrances at a slope and/or grade that prevent runoff from carrying sediment off the site.

i. Permanent Sediment Basins and Detention Structures—A PE or CPESC shall design permanent sediment basins and detention structures to capture runoff from a least a 25-year, 2-hour storm event from the developed region (i.e., "C" value for impervious area) and release the water at a rate equal to the rate of runoff that would occur in an undeveloped region (i.e., "C" value for undeveloped land) from a 2-year, 2-hour storm event. All basins must fully discharge within 24 hours. Consider the settling characteristics of the site's soil in the design of the basin or pond. Incorporate an overflow spillway into basins and ponds to manage runoff from a storm event exceeding a 25-year event. . Discharge can be factored in if it significantly affects design volume. Submit designs and calculations to the LANL Water Quality Group for review prior to construction.

6. Slope Stabilization

a. Erosion Control Blankets—Use erosion control blankets in conjunction with seeding on areas with slopes between 3:1 and 2:1. If slopes inhibit blanket-soil contact, use Bonded Fiber Matrix or hydraulically applied mulch instead of erosion control blankets. Use erosion control blankets in channels with an expected velocity of less than 10 ft/ sec. Slopes steeper than 2:1 require engineered slope stabilization.

- 3:1 slopes or gentler—Use single netted, machine produced blankets using 100 percent straw or excelsior fibers sewn into a medium weight photo degradable bottom net. Minimum weight of blanket 0.5 lbs/ square yard, such as Greenfix America WS05, etc.

- 3:1 – 2:1 slopes—use double netted, machine produced blankets using 100 percent straw or excelsior fibers sewn into a medium weight photo degradable top net and a light weight photo degradable bottom net. Minimum weight of blanket 0.7 lbs/ square yard, such as Greenfix America WS072, etc.

- 2:1 slopes and steeper and/or 2 growing seasons of protection—use machine produced straw/ coir blend blankets using 70 percent straw /30 percent coir fibers sewn into a heavy weight photo degradable top net and a medium weight photo degradable bottom net. Minimum weight of blanket 0.7 lbs/square yard, such as Greenfix America CFS072R, etc.

b. Bonded Fiber Matrix—Use Bonded Fiber Matrix (BFM) in conjunction with seeding and engineered stabilization for erosion control and as mulch on steep, rough, and irregular slopes 2:1 or steeper. BFM may also be used on gentler slopes, if desired.

c. Hydraulic Mulches—Use hydraulic mulch in conjunction with seeding and in place of straw mulch. Hydraulic mulch may also be used as mulch on steep, rough, and irregular slopes 2:1 or steeper in conjunction with engineered stabilization.

7. Channel Velocity Control

   a. Riprap— Use riprap to dissipate energy and reduce velocity in channels subject to erosion and to prevent scour at hydraulic structure inlets and outlets.

      - Appropriately size riprap taking into account uniform flow depth, shear stress at maximum flow depth, permissible shear stress, and flow velocity. Identify permissible shear stress using published values or by calculating the value with the following equation: $\tau_p = 4.0\ D_{50}$, where D_{50} is in feet. Also ensure that stone size is adequate to withstand movement due to flow velocity (i.e., prevent rolling or migration).

      - Riprap thickness shall be 12 inches or equal to the diameter of the largest rock size in the gradation (approximately 1.5-3 times D_{50}), whichever is greater.

      - Place filter fabric beneath riprap applications. The fabric must be able to transmit water faster than the soil and be of sufficient size that the base material does not escape through the fabric.

      - Do not use round stone on channel side slopes steeper than 3:1. Do not use riprap on slopes steeper than 1.5:1.

      - Do not use flat slab-like stones.

   b. Gabions—Consider the use of wire enclosed riprap, gabion baskets, or gabion mattresses if adequate riprap size is not available, if slopes are to steep for standard riprap placement, or for locations of high flow velocity.

      - To prevent gabion mattresses from sliding down a slope, stabilize their base with a key trench. The trench depth shall be two times the mattress thickness and the trench width shall be three times the mattress thickness. Within a channel, tie the upstream and downstream ends of the mattress into the bank to prevent currents from unraveling the mattress.

      - The minimum rock size diameter for gabion baskets shall not be less than four inches.

      - The minimum rock size diameter for gabion mattresses shall not be less than three inches.

      - The minimum gabion mattress thickness shall be 1.5 times the largest rock size.

      - Place filter fabric beneath gabion applications. The fabric must be able to transmit water faster than the soil and be of sufficient size that the base material does not escape through the fabric.

   c. Culverts—In channel applications, place riprap or gabions flush with the invert of culverts. The break between a steep slope and a culvert entrance should equal 3-5 times the mean rock diameter of the mattress thickness.

d. Check Dams—Design the center of check dams (the spillway) at least 6 inches lower than the outer edges. Where applicable, extend abutments 18 inches into the channel bank. Maximum spacing between check dams shall provide that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

e. Other Methods—Contact Civil Standards POC and Water Quality Group for advisement and approval prior to use.