

ARTICLE 10

GEOTECHNICAL GUIDELINES

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ARTICLE 10

GEOTECHNICAL GUIDELINES

SECTION 10-100 GENERAL PROCEDURES

A geotechnical review is required for all developments. The extent of this review is directly related to the quality of the in-place materials as they relate to engineering applications. In an effort to standardize this review and to ensure all factors have been considered, the City of Manassas has herein formulated a systematic approach to soils and geotechnical issues (Refer to Soils Map).

The geotechnical study is to be prepared under the direction of, and sealed by, a registered professional engineer licensed in the Commonwealth of Virginia.

For problem soils (i.e., low bearing strength, highly plastic, etc.), the Director may request a review of the plans by the licensed soils engineer for comment and recommendations. The recommendations shall be forwarded to the Director and will be considered during the review and approval stages of proposed developments.

SECTION 10-200 DETAILED GEOTECHNICAL EVALUATION (TYPE II)

10-210 GUIDELINES FOR GEOTECHNICAL STUDIES

This section sets forth minimum requirements for geotechnical field investigations and reports. Should conditions peculiar to the site of the proposal manifest a need, additional requirements may be applied at the direction of the Director.

10-220 DETAILED GEOTECHNICAL INVESTIGATION

The scope and purpose of this study are comprehensive. Observations in the field should be spaced sufficiently close, so the site-specific recommendations can

be made with confidence. Laboratory data and precise field measurements, such as ground water levels and perched water table levels, should be provided to document findings and design parameters. Maps should be provided to illustrate major conclusions. The report should address all areas impacted by the proposed construction.

All final plans of subdivision or development plan submissions shall have a type II Soils Review as part of the submission if the following are being performed:

- A. Over 1000 L.F. of utilities
- B. Over 500 L.F. of new roadway construction
- C. Sites with over 5 acres of overlot grading
- D. Other sites that are suspect due to soil types as determined by the Director
- E. Any sites with cut or fills in the site work in excess of six (6) feet.

If a Type II soils review is not required, then a Type I soils review will be required; per the requirements of Section 2-550.7 for and Erosion Control Plan. The only additional item that will be required is a detailed narrative on soils types and their erodibility. Permeability will be required if stormwater infiltration trenches are recommended.

10-230 REQUIREMENTS

The Type II detailed geotechnical investigation must respond to the use proposed for the property reviewed. Laboratory data and precise field measurements shall be provided to document findings and design parameters. The report shall address all areas impacted by the proposed construction. It shall contain recommended designs, earthwork specifications, and recommendations for remedial action in problem areas. This review and report shall contain the following:

Background:

- A brief description of the terrain.
- A description of exploration and sampling methods.
- A description of laboratory test procedures and results.

Scope of project and objectives.

Narrative of standard terminology.

Report of field investigation. A report of the filed investigations shall contain the following:

- A. A map, drawn to 1:2400 scale (one inch equals two hundred (200) feet and others as desired, on a sheet measuring 24 inches by 36 inches shall be provided. Where the proposal covers more than one sheet, a compiled photo reduction, at 1:4800 scale (one inch equals four hundred (400) feet, of all maps shall be submitted in addition to the 1:2400 scale map. Other maps at larger scales may be used with prior approval of the Director. Maps shall show the following:
 - 1. The following details located to National Map Accuracy Standards:
 - a. Topography, with at least five (5') foot contour intervals.
 - b. Planimetric detail, including swamps, marshes, ponds, wooded areas, rock outcrops, buildings, roads, fence lines, utility structures.
 - c. Virginia Coordinate Grid system, with five hundred (500) foot intervals, location map, and north arrow.
 - 2. Location of all test holes, boring, backhoe pits, and/or seismic tests. Test holes/pits are to be numbered and located dimensionally and are to include surface elevations.
 - 3. Spatial distribution of soil and /or geologic materials.
- B. Cross sections of soil/geologic materials, showing stratigraphic relationships, including structure, and subsurface distribution.
- C. Narratives describing geology and hydrology.
 - 1. General report (structures and roads) -- for most development proposals, a general geologic report will be

sufficient. The exceptions are land developments proposed in mountain colluvium on slopes in excess of 15%. The report shall include, but shall not be limited to:

- a. Narrative of location, type, and hardness of bedrock encountered; presumable rippability.
 - b. Ground water conditions, including depth and location of water table.
2. Detailed report (all others as specified - a detailed section on geology and hydrology, evidenced by deep drill hole data, including rock cores, will be required when the proposed uses include large dams/impoundments, and land developments proposed in the limestone outcrop belt or in mountain colluvium with slopes greater than 15 %. The report shall include, but shall not be limited to:
- a. Type of rock materials present, including physical, chemical, and mineralogical properties, quality of rock and description of mapping units.
 - b. Macro- and micro-structure of rock or geologic material, including joints and fracture patterns; faults, if present; cleavage; foliation and bedding, if applicable.
 - c. Geologic cross sections of the tract.
 - d. Water movement in both soil and geological materials; method of recharge; dewatering effect of proposal; map showing ground water contours; transmissibility of rock; effect of regional fractures (linear fractures) on water movement; discussion of existing ground water supply; levels of water; and historic water availability; direction of ground water flow.
 - e. Environmental geology. Indication of susceptibility of the area to pollution from site-industry products, leachated,

or surface contamination (i.e., landfills, sewage disposal facilities, or limestone conglomerate outcrop belt). Description of the potential of the area to undergo catastrophic collapse, due to presence of slip plains and sinkholes, asbestos, content of rocks, and shock transfer.

- D. Narratives describing soils and surficial materials. In all other plan submittals, a detailed description of soils and surficial material illustrated on the map will be required and should include the following:
1. Description of physical properties for soils for each mapping unit or area of similar soil conditions or "strata", including thickness, consistency, compressibility, and shear strength of the various strata, content of fines, and characteristics (shrink-swell, plasticity, bearing capacity of materials, corrosion properties), and the apparent stability of sidewalls in cuts.
 2. Description of surface drainage, permeability, and presence of seasonal perched water tables.

10-230.1 RECOMMENDATIONS/CONCLUSIONS.

The following are areas which should be included in the recommendations and conclusion sections, as appropriate.

- A. Structures and roads.
1. Recommendations for feasible foundation types, including feasible foundation types and bearing, pressures, or capacities at all bearing locations and elevations.
 2. Other factors, such as alkali content, corrosiveness, underground springs, and maximum depth of fill areas.
 3. If soil conditions indicate, recommended pile type, capacity, tip elevations, etc.

4. Recommended bearing pressures of rock based on rock cores and pressure meter tests.
5. Evidence that rock strata are sound and not underlain with solution channels that would affect the allowable bearing loads, or recommendations that provide for correction of these conditions.
6. Recommendations on feasibility of slab on grade or supported ground floor construction.
7. Ground water elevations and recommendations for the temporary dewatering procedures during construction and the need of the design of permanent dewatering facilities after construction, including effects of seasonal variations.
8. Recommendations for removal of perched/seasonal water tables, including foundation drainage, underdrainage for roads and feasibility of below grade walls with finished living space.
9. Recommendations for typical pavement design, sidewalks, curb and gutter, travelways, typical design CBR values, and stabilization of subgrade.
10. Specifications for fill materials, including gradation ASTM, AASHTO, or VTM test method and percent of maximum theoretical density and optimum moisture, site preparation and material placement, qualifications of testing personnel and testing laboratory.
11. Recommendations for handling of shrink-swell clay, backfill, removal of stones, and what should be done when rock is encountered.
12. Comments of shoring for utility or other deep excavations.
13. A slope stability analysis must be prepared whenever final slopes steeper than two (2) to one (1) horizontal to vertical are being proposed or when site-specific conditions indicate potential slope stability problems.

- B. Blasting
 - 1. Comments on potential effects that blasting vibrations will have on structures near the proposed facility.
 - 2. Recommendations for monitoring programs for blasting vibrations, including location and number of observation points and frequency of sampling.
- C. On-site sewage disposal (if applicable) -- Potential impacts on ground and surface water, loading rates and vegetative cover.
- D. Field logs.
 - 1. Ground water monitoring data.
 - 2. Seismic data for site.
 - 3. "N values" (standard penetration test results) and natural moisture content ("W") from split-spoon or Shelby tube samples.
 - 4. Rock core descriptions.
- E. Laboratory data -- Laboratory data shall be supplied as required to support recommendations and description narrative.

SECTION 10-300 STANDARD REFERENCES FOR SOILS AND GEOTECHNICAL STUDIES

Publications. The following will be considered standard reference manuals and publications:

Black, C.A. (ed.), 1965. Methods of Soil Analysis: Parts I and II, Agronomy Series, American society of Agronomy, Madison, Wisconsin.

American Society for Testing and Materials, 1980. Annual Book of ASTM Standards, Part 19; Soil and Rock; Building Stones (revised).

Soil Survey Staff, 1972. Soil Survey Laboratory Methods.

Virginia Department of Transportation, 1978. Virginia Test Manual.

Finn, D., and Cocacza, E., 1977. Procedures Manual for Ground Water Monitoring for Ground Water Monitoring at Solid Waste Disposal Facilities,

Environmental Protection Agency Manual No. SW611.

Conrad, E.T., et al., 1981. Solid Waste Landfill Design and Operation Practices, Environmental Protection Agency, Washington, D.C.

SECTION 10-400 STANDARD METHODS AND PROCEDURES FOR SOILS AND GEOTECHNICAL STUDIES

Classification and description of soils for geotechnical reports will be Unified Classification system of Soils for Engineering Purposes (ASTM D2487) and Visual Manual Identification Procedure (ASTM D2488).

The VTM Manual and ASTM manual should be consulted for approved procedures for the following:

- _ Atterberg limits (ASTM D4318, D424)
- _ Gradation
- _ CBR
- _ Density
- _ Consolidation tests (ASTM D2435)
- _ Hydraulic Conductivity tests (ASTM D2434, D5084)
- _ Rock Drilling (ASTM D2113)

The publication "Methods of Soils Analysis" provides acceptable procedures for the following:

- _ Hydraulic Conductivity tests
- _ Mineralogy
- _ Soil chemistry -- A1, CEC, Base Saturation
- _ Particle size analysis

- Moisture constraints
- Other procedures approved by the Director.

SECTION 10-500 IMPLEMENTATION OF RECOMMENDATIONS

10-510 GEOTECHNICAL REVIEW

The design engineer/architect shall provide the Director with a written statement from the geotechnical engineer stating that he has reviewed the plans, as submitted, and that the plans were prepared in accordance with the recommendations of the geotechnical report.

10-520 ARBITRATION

Where arbitration is necessary to resolve differences of opinion in geotechnical matters, the Director may refer the proposal to the Technical Review board for review and comment, or the Director may contract with an independent geotechnical engineer for review and comment. All costs for such independent review shall be borne by the applicant.

SECTION 10-600 GEOTECHNICAL REQUIREMENTS FOR INSTALLATION OF PUBLIC IMPROVEMENTS

10-610 TESTING AND LABORATORY SERVICES

The Developer shall employ and pay for the services of a geotechnical engineer to perform testing specifically indicated herein, and may at any other time elect to have materials and equipment tested for conformity with the standards set forth herein.

The contractor shall cooperate with the geotechnical engineer to facilitate the execution of his required services.

Employment of a geotechnical engineer shall in no way relieve the contractor's obligations to perform the work in accordance with standards and specifications.

Inspections, sampling and testing is required for, but not limited to earthwork, concrete, and paving materials.

The geotechnical engineer shall perform all laboratory work and on-site inspections and testing required by laws, ordinances, rules, regulations, orders or approvals of the Director.

10-610.1 LABORATORY DUTIES

Cooperation with the Director and contractor; provision of qualified personnel after due notice by the Director or contractor.

Performance of specified inspections, sampling, and testing of materials and methods of construction.

Compliance with specified standards for testing procedures.

Ascertained compliance of materials with requirements of the standards set forth herein.

Prompt notification of the owner and contractor of observed irregularities or deficiencies of work or products. If observed irregularities or deficiencies are not corrected then the Director shall be notified.

Obtaining and handling of samples at the project site or at the source of the product to be tested.

Prompt submission of two (2) copies of the written report of each test and inspection to the Director. Each report shall include:

- A. Date issued.
- B. Project title and number.
- C. Testing laboratory name, address, and telephone number.
- D. Name of field technician.
- E. Date and time of sampling testing or inspection.
- F. record of temperature and weather conditions.
- G. Identification of product and specification section.

- H. Location of sample or test on the project.
- I. Type of inspection or test.
- J. Results of tests and compliance with standards.
- K. Interpretation of test results, when requested by the Director.
- L. Signed seal of certification by professional engineer on each page.

Performance of additional test as required by the Director or the Owner.

10-610.2 LIMITATIONS OF AUTHORITY OF TESTING LABORATORY

The testing laboratory is not authorized to:

Release, revoke, alter or enlarge on requirements of standards as set forth herein.

Approve or accept any portion of the work.

Perform any duties of the contractor.

10-610.3 CONTRACTOR'S AND DEVELOPER'S RESPONSIBILITIES

Cooperation with the geotechnical engineer and provisions of access to work and to operations.

Materials and equipment used in the performance of work under the Article are subject to inspection and testing.

The Director may require the contractor to provide statements or certificates from the manufacturers and fabricators that the materials and equipment provided by them are manufactured or fabricated in full accordance with the standard specifications for quality and workmanship indicated herein.

All costs of this testing, required statements and certificates shall be a subsidiary obligation of the Owner/Developer, and no extra charge to the City shall be allowed for such testing and certification.

The contractor shall furnish incidental labor and facilities:

- _ To provide access to work to be tested.
- _ To facilitate inspections and tests.
- _ For storage and curing of test samples.

Notification of the geotechnical engineer and the Director sufficiently in advance of operations two (2) working days, to allow for laboratory assignment of personnel and scheduling of tests.

Meetings with the Director, Chief Inspector, and Geotechnical Engineer prior to the initiation of construction, to coordinate the construction and testing schedule for the project.

10-610.4 TESTING PROCEDURES

For all roadway work or work within the public right-of-way, test shall be in accordance with Virginia Testing Methods (VTM).

Outside of the public right-of-way, but within public utility easements, tests will be performed in accordance with applicable ASTM or AAHSTO standard methods, unless otherwise specified.

- A. The optimum moisture content and the maximum density of each type of material used for structural fill and backfill shall be determined by the proper test method described in ASTM D698, ASTM D1557, AASHTO 99 or as specified by the Geotechnical Engineer.
- B. The field moisture content of materials being compacted shall be placed at +/- two percentage points of optimum as determined by "Determination of Moisture content of Soil in Place (ASTM D4959, ASTM D3017, AASHTO T-239)". The field density of compacted material shall be determined by "Test for Density of soil in Place by the Sand-Cone Method", (ASTM D1556, AASHTO T-191), or "Density of Soil in Place by Nuclear Methods" (ASTM D2922, AASHTO T-238).

10-610.5 MINIMUM REQUIREMENTS

Minimum Testing Requirements for Comprehensive Street Inspections.

All Testing must comply with current VDOT specifications and be submitted to the Department of Public Works within 2 weeks.

CBRs

One CBR every five hundred (500) linear feet of roadway and at every intersection with an existing state roadway. A minimum of two CBR's are required for roadways between two hundred (200) and five hundred (500) feet long. Roadways less than two hundred (200) feet in length shall have at least one CBR. Representative samples for CBR tests shall be taken from the top six (6) inches of the finished subgrade. Atterberg Limits shall be run on fine grained soils, in addition to the normal testing procedures. **The sampling must be witnessed by a city inspector.** All test results shall be submitted to the Director of Public Works with a revised pavement design if required.

Embankments

Density A minimum of one test per ten thousand (10,000) cubic yards of materials placed plus:
For each five hundred (500) to two thousand (2000) feet in length: one (1) density test, for each six (6) inch layer within the top five (5) feet. For fills less than five hundred (500) feet: one (1) density test for every four (4) - six (6) inch layer from bottom to the top of the fill.

Finished Subgrades

(Both Cut and Fill)

Density One test per two hundred fifty (250) linear feet per roadway (full width) with a minimum of two (2) per roadway. (Density requirement 100%)

Aggregate

Depth One test per 500 feet of material per paver application width per layer.

Density Density testing will be performed in accordance with the current VTM Manual and VDOT road and Bridge Specifications. The density required will be based upon the percentage retained on the #4 sieve. The percentage of #4 material should be checked on every test. Refer to VDOT specification 305.03.

Bituminous Concrete

Depth Tests are to be taken at intervals of not more than two hundred fifty (250) feet of roadway.

Density Roller patterns, test strips and all density testing will be performed in accordance with the current VTM Manual and VDOT road and Bridge Specifications.

Portland Cement Concrete Placed Within a Public Right of Way

Air Content One per truck, and when making compressive specimens.

Slump Two daily and when making compressive specimens. The use of non air entrained concrete within a public right of way will not be allowed. Concrete must be a minimum of a VDOT A-3 mix.

Compressive Strength

One set of two (2) cylinders (6" x 12") or one (1) set of three (3) cylinders (4" x 8") per two hundred and fifty (250) cubic yards, with a minimum of one (1) set per project. Any one (1) set to be made from the same truck.

Density tests - Backfills in trenches over utility lines

Sanitary Sewer; Storm sewer and Water Mains

One test per four hundred (400) feet of length or between manholes and per six to eight (6-8) feet of compacted backfill material. Manhole to manhole.

Density requirement 95%, +/- 2 percentage points of the optimum moisture.

Sanitary Sewer, Water Laterals, and Gas Laterals

One (1) test per ten (10) laterals. Show failing retests. Density requirement 95%.

Other Utilities (Telephone, gas, Television, etc.)

One (1) test per street crossing. Density requirement 95%, +/- 2 percentage points of the optimum moisture.

*All testing must be coordinated with the appropriate City of Manassas Inspector.

*All test results shall be submitted; including failures with corresponding retests to the City of Manassas Project Inspector within two weeks.

INSTRUCTIONS FOR COMPLETING CITY OF MANASSAS NUCLEAR DENSITY FOR SOIL & AGGREGATE

1. Print the name of the project as shown on the approved plans. Include Section # if applicable.
2. Print date that the tests were performed. mm-dd-yy
3. Print the name of the quarry if applicable: i.e. Luck Stone.
5. Indicate Gauge Model and Series: i.e. "Troloxler 3411B".
6. Indicate complete serial number: i.e. 407447.

FIELD TESTNUMBER: Begin with #1 for first test of the project. Number all subsequent tests with reference to the previous test performed. DO NOT begin with #1 on each day.

STREET: Print street name (include Dr. Ct. Rd. etc.)

STATION: Reference the STREET station shown on the SITE plan for all tests (include utilities). Do NOT reference tests as "40 ft from structure X". Use stations ONLY.

REFERENCE TO: Approximate the distance from the centerline CENTER LINE of the road including "left" or "right" side. If the test is located near the center, i.e. sanitary backfill, indicate "C/L". If the test is located at curb, indicate offset as shown on plan: i.e. twenty five (25ft) to RT (or LT).

ELEVATION: The elevation of the test location must be referenced using the PROFILE plan for the referenced road. These profiles are typically utility profiles.

Approximate the test location with respect to the station, backfilled utility or proposed

top of pavement (bold line). Elevations are located on the left and right sides of the profile detail.

Indicate subgrade (SG), subbase (SB), or depth below finished grade (FG) in parenthesis. Reference to nearest 0.5 feet: i.e. 340.5 (SG); 255.0 (SB) 123.5 (-10).

TYPE OF TEST: Indicate test type as shown in the following examples:

Sanitary MH 3-4	Curb/Gutter
Storm STR 1-2	San. Lat. Lot 13
Water Main BF	Road Fill

METHOD OF COMPACTION:

Compaction method should always identify two (2) items:

1. COMPACTION TYPE i.e. smooth-drum, sheepfoot, pneumatic tamper etc.
2. COMPACTION EFFORT i.e. (15 ton, 30 ton, etc. Make or model (CAT) is not as important, but you may include it. Ask a field representative for the compaction equipment specifications if you can not visually determine the information from the machine.

COMPACTED DEPTH OF LIFT: Using the field stakeout and visual observations, approximate the COMPACTED lift thickness at the test location in inches. You may indicate +/- x" if the lift varies i.e. 6" +/-2".

GAUGE DEPTH SETTING: Indicate BS, 2" 4" 6" 8" 10" 12"

- A. WET DENSITY PCF Direct gauge reading.
- B. DRY DENSITY PCF Direct gauge reading.
- C. PERCENT MOISTURE Direct gauge reading.
- D. MAXIMUM DRY WT. PCF UNCORRECTED value from 5 pt. or 1 pt. test. *Verify the material description for the Proctor test is representative of the field material tested.
- F. OPTIMUM MOISTURE UNCORRECTED value from 5 pt. or 1 pt. test.G.
CORRECTED MAT. DRY WT. Using VTM-1 nomograph based on the %+#4
CALCULATED FROM THAT FIELD TEST.

*The City of Manassas **will not** accept estimated #4 values or corrections based on a previous day's tests. If the % #4 appears to be a relatively consistent and uniform, you may do ONE #4 correction for a maximum of three (3) tests performed on a given day for the same material. Additional % #4 corrections must be performed with calculations shown if the material type changes; the % #4 varies significantly; or more than three (3) tests are performed on a given day. A ONE POINT SETUP must be taken to every project site where #4 material corrections are warranted. **Failure to comply with these procedures will violate City of Manassas requirements and may result in the City not accepting the test results.**

H. CORRECTED OPTIMUM MOISTURE Use the formula in VTM-1.

I. % DENSITY X 100 Indicate to 1.0%

J. % DENSITY REQUIRED Density required is specified on "City of Manassas Minimum Test Requirements for Comprehensive Street Inspection".

REMARKS: Summarize test results performed as shown in following examples: i.e. "On site SM (see 1 pt. #3) backfill for sanitary. Tests passed." "Off site SM/ML (5pt.#7) for road fill. #11 is reset for #10 on 1-03-94."

TECHNICIAN: Print FULL name neatly.

CERT. NO.: Print four (4) digit VDOT, NICET, ACI and/or WACEL SOILS or Concrete Certification Number. Any technician testing materials in the City of Manassas must be certified.

OBSERVED BY: Request signature of City of Manassas inspector while on site if he or she was present during test performed. Otherwise, leave blank.

PROFESSIONAL

ENGINEER: Each sheet will be certified by a licensed professional engineer.

SECTION 10-700 EXCAVATION, TRENCHING AND BACKFILLING FOR UTILITIES

10-710 GENERAL CRITERIA

10-710.1 RELATED DOCUMENTS

Approved Constructions regulations
State Waterworks Regulations
State Sewerage regulations
Virginia Erosion and Sediment control handbook

10-710.2 DESCRIPTION OF WORK

Trenching and backfilling for utilities. Provision of suitable borrow for backfill material and disposal of spoil.

Prior to beginning excavations and embankment operations in any area, all temporary erosion and sediment control measures for the area shall be in place. Phasing of site work shall conform to the approved erosion and sediment control measures for the area shall be in place. Phasing of site work shall conform to the approved erosion and sediment control plan. *Refer to Article 4 of this Manual.*

10-710.3 QUALITY ASSURANCE

Codes and Standards. Performance of excavation work shall be in compliance with applicable requirements set forth herein.

Soil testing and Inspection Service. The developer shall provide an independent soil testing and inspection service (the "Geotechnical Engineer") for quality control testing during earthwork operations. The contractor shall coordinate and cooperate with the work of the Geotechnical Engineer.

The developer shall furnish a guarantee that backfilled areas will not suffer ponding or settlement for a period of one (1) year from the date of final acceptance. Fill materials and surfacing which settle shall be removed and replaced with suitable material at no cost to the City.

The contractor shall furnish a guarantee that all tests have been performed for all underground utilities.

10-710.4 SUBMITTALS

Tests Reports-excavating. The following reports shall be submitted to the Director from the Geotechnical Engineer, with a copy to contractor: Subgrade. One sieve analysis and one liquid limit and plasticity index determination for cohesive soils for each one thousand (1000) lineal feet or fraction thereof.

Field Density Tests

- A. Trench Subgrade.
 - 1. Trenches under Pavement. One (1) test per one hundred (100) lineal feet or fraction thereof, of trench for each pavement.
 - 2. Adjacent to Utility and Drainage Structures Abutting Pavements. One (1) test for each structure.
- B. Backfill Material
 - 1. Trenches Under Pavement. One (1) test for each lift for every one hundred (100) lineal feet or fraction thereof, of trench for each pavement. These tests shall be offset fifty (50) feet on each subsequent lift.
 - 2. Trenches in Overlot Areas. One test for every twenty four (24) inches or fraction thereof, for each five hundred (500) lineal feet or fraction thereof, of trench.
 - 3. Utility or Drainage Structures Which Abut a Pavement. One test for every twelve (12) inches of compacted thickness or fraction thereof, for each structure.
 - 4. Location of tests shall be the discretion of the Director.

10-710.5 SITE CONDITIONS

The developer's engineer shall examine the subsurface soil report and provide a preliminary analysis of the suitability of the site soils for backfill material.

The actual on-site testing during construction shall determine the suitability of materials and the acceptability of operations.

10-720 MATERIALS

Satisfactory soil materials for backfill shall be those materials classified in ASTM 2487 as GW, GP, GM, SW, SP, SM, SC or combinations thereof, properly worked by the contractor to obtain the specified compaction, while maintaining the moisture content as specified. Soil typed CL, ML, or combinations thereof, may be included as satisfactory material provided the liquid limit test result does not exceed 45 and plasticity does not exceed 20. The contractor should be aware of the possible construction difficulties and the very close moisture control required in the proper field placement and compaction of these latter materials, and of any micaceous materials on site.

Unsatisfactory materials for fill, embankment, and backfill shall be those materials in ASTM 2487, not meeting the requirements of the satisfactory materials as defined above.

Pipe bedding material shall consist of well-graded sand, gravel, crushed gravel, crushed stone or crushed slag composed of hard, tough and durable particles, and shall not contain more than 10% by weight of material passing a No. 200 mesh sieve, and no less than 95% by weight passing the one (1) inch sieve, with a maximum allowable aggregate size of 1.45 inches.

Backfill material shall be free of all organic material, trash, snow, ice, frozen soil or other objectionable materials. Soft, wet plastic soils which may be expansive and clay soils having a natural in-place moisture content in excess of 30%, maybe considered unsuitable for stockpiling and/or future use.

Select granular fill shall be sound, hard, durable crushed stone and shall conform to ASTM C33: Virginia Department of Transportation, Size No. 57.

Structural fill shall conform to the requirements set forth in Virginia Department of Transportation road and Bridge Specifications for Select Material, Types I, II, or III. Structural fill shall be used as fill and backfill as indicated on the drawings beneath appurtenant structures, and beneath paved areas, public or private. Sand shall conform to ASTM Standard C33, for concrete sand.

10-730 STRIPPING AND STOCKPILING OF TOPSOIL

Suitable topsoil encountered and/or in easement areas where pavement is to be placed shall be removed and stockpiled in locations designated or approved by the Director.

Topsoil shall be completely removed from an area prior to the beginning of regular excavation or embankment work and shall be kept from other excavated materials.

Topsoil stockpiles shall be temporarily seeded and provided with other temporary erosion and sediment control measures as required by the approved erosion and sediment control plan. Refer to Article 4 of this Manual.

10-740 BLASTING

All blasting operations shall be conducted in full compliance with all the laws of the State, all local ordinances, and with all possible care to avoid injury to persons and property. The rock shall be well-covered and sufficient warning shall be given to all persons in the vicinity of the work before blasting. Care shall be taken to avoid injury to all water pipes, gas pipes or other structures and to private property. The contractor, in addition to observing all municipal and other ordinances relating to the storage and handling of explosives, shall also conform to any further regulations which the Director shall deem necessary. If track drills are used for drilling rock, water must be provided with the drill to eliminate dust.

It is the contractor's responsibility to use methods of blasting and excavation which will result in undamaged, finished rock surfaces and which will prevent damage to any existing structures. A satisfactory rock surface shall be a stable, safe surface, free of loose rock, and any soft or yielding material. The blasting and excavation methods should be adjusted to achieve this objective.

Test blasting in the earliest stages of construction may be employed as the adjusting procedure. Based on the results of the test blasting, parameters such as maximum particle velocity, pounds of powder delay, maximum pounds of powder per cubic yard of rock, delay times and sequence, and hole spacing for blasting limits may be established. Production blasting should also be monitored by recording the same type of data.

The handling, transportations, storage and use of explosives shall conform to the requirements of governmental authorities having jurisdiction and shall follow all applicable provisions as adopted by the Institute of Makers of Explosives and OSHA, the use of explosives shall be limited to labor skilled in their use and all work shall be performed under the direct supervision of licensed blasters.

If rock below grade is shattered on account of holes having been drilled too deep, excessive charges of explosives used for any other reasons due to blasting by the contractor, and if, in the opinion of the engineer, said shattered rock is unfit for foundation, the shattered rock shall then be removed and the excavation refilled as required by the Director at no expense to the City.

10-740.1 RECORDS AND REPORTS

All blasting shall be field monitored using seismographic type equipment and shall be performed under the supervision of a licensed Virginia professional engineer or registered geologist.

Accurate records of each blast must be maintained showing location of the blast, depth and number of drill holes, kind and quantity of explosive used, ground velocity and displacement and other data required to complete the record.

A copy of the blast record must be submitted to the Director each day.

Before any blasting is carried out, the contractor shall submit to the Director a report, prepared by a professional engineer licensed to practice on the Commonwealth of Virginia, or a registered geologist, containing specific recommendations for blasting. The report shall include sketches showing blast locations and adjacent existing utilities, structures, etc., and shall cover amount of charge, firing times, ground velocities, energy rations, accelerations and displacements, and effects on adjacent structures. The report shall also outline the field monitoring program.

10-750 EXCAVATION

All excavation of every description, and of whatever substances encountered shall be performed to the depths indicated or as otherwise specified. Test pits must be hand dug to locate existing utilities. During excavation, materials found suitable for backfilling shall be piled in an orderly manner a sufficient distance from the banks of the trench to avoid overloading and to prevent slides or cave-ins. All excavated materials not required or unsuitable for backfill shall be removed from the work area.

Grading shall be done as may be necessary, to prevent surface water from flowing into trenches or other excavations, and any water accumulating therein shall be removed by pumping or by other approved methods. Sheet piling and shoring shall be done as may be necessary for other protection of the work and/or safety of personnel, as determined by the Director.

10-750.1 TRENCH EXCAVATION

The trench shall be excavated as recommended by the manufacturer of the pipe to be installed. Trench walls below the top of the pipe shall be sloped, or made vertical, as recommended in the manufacturer's installation manual. The trench width below the top of the pipe shall not exceed that recommended in the installation manual. Trench walls above the top of the

pipe shall be sloped as required for safety (refer to current OSHA regulations) and:

- A. Furnish, put in place, and maintain such sheeting and bracing as may be required to support the sides of excavations, to prevent any movement which could in any way diminish the width of the excavation below that necessary for proper construction, and to protect adjacent structures from undermining or other damage. If the Director is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at no expense to the City and compliance with such order shall not relieve or release the contractor from his responsibility for the sufficiency of such supports. Care shall be taken to prevent voids outside of the sheeting, but if voids are formed, they shall be immediately filled and rammed. Where solids cannot be properly compacted to fill a void, lean concrete shall be used as backfill, at no expense to the City. Sheeting and bracing requirements are further defined in OSHA Standards, Subpart P, Part 1926, of the Code of Federal Regulations.
- B. The contractor shall construct the sheeting outside the "neat" lines of the foundation unless indicated otherwise, to the extent he deems it desirable for his method of operation. Sheeting shall be plumb and securely braced and tied in position. Sheeting and bracing shall be adequate to withstand all pressures to which the structure or trench will be subjected. Any movement or bulging which may occur shall be corrected by the contractor at no expense to the city so as to provide the necessary clearances and dimensions.
- C. Where sheeting and bracing is required to support the sides of excavations for structures, the contractor shall engage a professional engineer, registered in the Commonwealth of Virginia, to design the sheeting and bracing. The sheeting and bracing installed shall be in conformity with the design, and certification of this shall be provided by the professional engineer.

- D. All sheeting and bracing shall be carefully removed in such a manner as not to endanger the construction or other structures, utilities or property. All voids left or caused by withdrawal of sheeting shall be immediately re-filled with sand by ramming with tools especially adapted to that purpose, or otherwise as may be directed by the City inspector.

Where no pipe manufacturer's installation manuals are available, design shall be performed by the developer's engineer and approved by the Director prior to installation of pipe. Design shall include using stronger pipe or special installation procedures. The cost of this design and the increased cost of pipe or installation procedures shall be at no expense to the City. If the contractor does not provide for dewatering or erosion and sediment control properly and the subgrade becomes unsuitable, then the contractor shall remove the unsuitable material and replace it with concrete, compacted structural fill or other approved material at no expense to the City, so that the condition of the subgrade meets with the approval of the engineer before any work is placed thereon.

Bedding. The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe. The pipe shall be bedded carefully in bedding material, accurately shaped and rounded to conform to the lowest one third (1/3) of the outside portion of the circular pipe for the entire length of pipe. When necessary, the bedding shall be tamped. Bell holes and depressions of joints shall be only of such length, depth, and width as required for properly making the particular type joint. Bedding in all cases shall conform to the pipe manufacturer's installation manual.

Removal of Unyielding Material. When unyielding material is encountered in the bottom sides of the trench, such material shall be removed four (4) inches below the required grade and replaced with satisfactory materials. Rock shall be removed to provide a minimum eight (8) inch clearance around the sides of the pipe being laid.

Removal of Unstable Material. Where unstable material is encountered in the bottom of the trench, such material shall be removed to the depth directed by the inspector and replaced to the proper grade with select granular material. When

removal of unstable material is required due to the fault or neglect of the contractor in his performance of the work, the resulting material shall be excavated and replaced by the contractor at no expense to the City.

Removal of Unsatisfactory Material. Unsatisfactory material encountered beyond the depths indicated shall be removed and replaced with satisfactory material as directed by the City Inspector. Determination of overdepth excavation elevations shall be done in concert with the Engineer.

10-750.2 EXCAVATION FOR APPURTENANCES

Excavation for manholes, catch basins, inlets, or similar structures shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations. Removal of unstable material shall be as specified above. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation.

Excavation to the final grade level shall not be made until just before the concrete or masonry is placed.

10-750.3 DEWATERING

The contractor shall note the subsurface water level recorded and dated when this level was recorded on the boring logs shown on the subsurface soil report. The water levels are only for the dates shown on the logs and it can be expected that the water table may fluctuate to some extent.

The contractor shall at all times during construction provide and maintain proper equipment and facilities to remove all water entering excavations, and shall keep such excavations dry so as to obtain a satisfactory undisturbed subgrade foundation condition until the fills, structures or pipes to be built thereon have been completed to such an extent that they will not be floated or otherwise damaged by allowing water levels to return to natural levels. The contractor shall engage a geotechnical engineer, registered in the Commonwealth of Virginia to design the

dewatering system. The contractor shall submit to the Director for review, the design of the dewatering system prior to commencing work.

The contractor shall furnish, install, maintain, operate and remove a temporary dewatering system consisting of trenches, sump pits, deep wells, well points or other methods as required to lower and control the groundwater level so that the structure may be constructed. The contractor shall, at no expense to the City, correct all damage resulting from inadequacy of the dewatering system or from flooding of the construction site from other causes.

The contractor shall maintain the water level below the excavated area for the various phases of the work continuously and shall make such provisions as may be necessary to avoid interruptions due to weather, labor strikes, power failures, or other delays. He shall provide and have ready for immediate use at all times, diesel or gasoline powered standby pumping units to serve the system in case of failure of the normal pumping units.

Piping or any form of uncontrolled seepage in the bottom or sides of the excavation shall be prevented at all times. If for any reason a dewatering system is found to be inadequate to meet the requirements set forth herein, the contractor shall at no expense to the City make such additions, changes, and/or replacements as necessary to provide a satisfactory dewatering system.

Dewatering shall at all times be conducted in such a manner as to preserve the undisturbed bearing capacity of the subgrade soils at the proposed bottom of excavation. Well or sump installations shall be constructed with proper sand filters to prevent drawing of finer grained soil from the surrounding ground.

Water entering the excavation from surface runoff shall be collected in shallow ditches around the perimeter of the excavation drained to sumps, and pumped from the excavation to maintain a bottom free from standing water.

The contractor shall take all additional precautions to prevent uplift of any structure during construction. The contractor shall maintain the groundwater level at or below subgrade of the structure until the concrete substructure is up high enough

to prevent flooding of the structure, support is obtained at both bottom and top levels of walls and flotation is prevented.

Drainage water shall be disposed of through a desilting basin which will prevent the discharge of sediment into a creek or existing drains and to prevent flow or seepage back into the excavated area.

Flotation shall be prevented by the contractor by maintaining a positive and continuous operation of the dewatering system. The contractor shall be fully responsible and liable for all damages which may result from failure of this system.

Removal of dewatering equipment shall be accomplished after the system is no longer required; the material and equipment constituting the system, shall be removed by the contractor.

The contractor shall take all necessary precautions to preclude the accidental discharge of fuel, oil, etc. in order to prevent adverse effects on groundwater quality.

10-750.4 STEEL BOX INSTALLATION CRITERIA

The contractor shall meet the following criteria when the installation method includes the use of a steel box:

When installing rigid pipe, any portion of the box extending below mid-diameter of the pipe shall be raised above this point prior to moving the box ahead to install the next pipe. This is to prevent the separation of installed pipe joints due to movement of the box.

When installing flexible pipe (PVC, DI, etc.), the bottom of the box shall not extend below mid-diameter. This is to prevent loss of soil between the box and the pipe bedding which could result in excessive deflection of the installed pipe.

Where pipe is to be installed in fill of any type, fill shall be placed and compacted to the total depth required (rough grade elevation) and then re-excavated for pipe installation.

10-750.5 BORROW

Borrow shall consist of satisfactory material obtained off-site and required for the backfill of trenches or other portions of the utility installation. Sources of borrow material shall be approved by the Director.

10-760 BACKFILL

Backfill material shall consist of satisfactory material. Backfill shall be placed in layers not exceeding four (4) inches loose thickness for compaction by hand-operated machine compactors, and eight inches loose thickness for other than hand-operated machines, unless otherwise specified. Backfill shall be aerated or moistened as necessary to achieve an in-place moisture content within plus or minus 2% of optimum moisture. Each layer shall be compacted to 95% maximum density, unless otherwise specified.

Backfilling over pipes shall begin as soon as practicable after the pipe has been laid, jointed and inspected. All backfilling shall be completed expeditiously and as detailed on the plans.

- A. Trench Backfill. The trench shall be backfilled to finished grade prior to performing any required pressure tests. The joints and couplings may be left uncovered during the pressure test.
- B. Replacement of Unsatisfactory Material. Unsatisfactory material removed from the trench shall be replaced with satisfactory material placed in layers not exceeding eight (8) inches loose thickness and compacted to a minimum of 95% maximum density.
- C. Bedding and Initial Backfill. Bedding shall be of the type specified and a minimum of four (4) inches thick below the bottom of the pipe. Total bedding layer thickness shall be sufficient to bed the lower one-third of the pipe. Initial backfill material shall be placed in layers of a maximum of four (4) inches loose thickness, and compacted with approved tampers to a minimum of 95% maximum density to a height of at least one (1) foot above the utility pipe or conduit. The backfill shall be brought up evenly on both sides of pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of

the fill under the haunches of the pipe. Backfill material in this portion of the trench shall consist of satisfactory material at a moisture content within plus or minus two% of optimum moisture or as approved by the Geotechnical Engineer. It shall be free from stones larger than one (1) inch in any dimension.

D. Final Backfill. The remainder of the trench, except for special materials for roadways, shall be backfilled with satisfactory material. Backfill material shall be deposited and compacted as follows:

1. Pavement Restoration in public roadways shall be excavated, backfilled and reconstructed in accordance with the requirements of Section 9-500 of this Manual.
2. For trenches in pavement areas within the public right-of-way and areas such as, but not limited to, parking lots, common driveways, private parking courts and pipestem driveways, the following shall apply:
 - a. Soil shall be compacted to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture density relationship determined in accordance with ASTM D-698 AASHTO T-99, and not less than the following percentages of relative density determined in accordance with ASTM D-2049, for soils which do not exhibit a well-defined moisture-density relationship.
 - _ Pavements: Compact top twelve (12) inches of subgrade and each layer of backfill or fill material to 100% maximum density or 95% relative density.
 - _ Walkways, Slabs and Steps: Compact to six (6) inches of pipe subgrade and each layer of backfill or fill material to 95% maximum density or 90% relative density.

For soils classified as SP, SP-SM, SP-SC, ML, CL or any micaceous materials, or combination thereof, the contractor should always be aware of the close moisture control required to achieve the proper field placement and compaction of these soil types. Therefore, the contractor must properly moisten or aerate these soil types as required to obtain a placement moisture content which will result in an in-place moisture of +/- 1% of optimum or as allowed by the Geotechnical Engineer within the compacted lifts for each fill material.

Soil material that is too wet to permit compaction to specified density must be removed because it is too wet to permit compaction, may be stockpiled or spread and allowed to dry. Drying may be assisted by dicing, harrowing, or pulverizing until moisture content is reduced to a satisfactory value.

10-760.2 DRAINAGE AND DEWATERING

Drainage. Excavation, filling, and backfilling shall be performed such that the area of the site and the area immediately surrounding the site, and affecting operations at the site, will be continually and effectively drained. Perimeter and diversion ditches, together with dikes and grading, shall be provided and maintained as necessary to prevent surface water from flowing into any excavation. The contractor shall control any and all water entering the open-cut excavation and shall remove any surface and/or groundwater in the excavation by pumping from a sump or other approved method as necessary, or as required by the Director, to prevent water from accumulating in the excavation. Removal of water accumulating in the excavation shall be performed preferably from the lower end of the excavation, exercising care through the use of sandbags or other approved methods so as not to wash or otherwise remove fines from the surrounding soil.

Dewatering. Unless otherwise specifically authorized, all excavation, filling and backfilling shall be done "in the dry". No excavation which

will be influenced by groundwater and shall not be built to final grade until dewatering has been accomplished to the satisfaction of the Director. If dewatering is to be accomplished by means of pumping from a sump, french drain, ditch or trench, the contractor shall locate these systems outside the paving limits and provide suitable protection to ensure that fine-grained soils are not removed from the excavated area during the pumping operations. While the excavation is open and throughout the backfilling and filling operations, the groundwater level shall be continuously maintained to be the sufficient depth below the working level to obtain the specified compaction and soil moisture content in the subgrade, fills and backfills.

10-760.3 PAVEMENT SUBGRADE PREPARATION

Pavement Subgrades that are within the public right-of-way shall conform to current VDOT standards. Pavement Subgrades which underlie area, such as, but not limited to parking lots, common driveways, private parking courts and pipestem driveways shall meet the following requirements for the entire width and length of the area which forms a pavement or sidewalk subgrade.

- A. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory material as directed. Low areas resulting from removal of unsatisfactory material shall be brought up to required grade with satisfactory materials, and the entire subgrade shall be shaped to line, grade and cross section and compacted as specified.
- B. Subgrades shall be prepared to achieve uniformity of soil conditions. In fill sections the least frost-susceptible soils shall be placed in the upper portion of the subgrade by temporarily stockpiling the better materials, cross-hauling and selective

grading. If the upper layers of fill contain frost-susceptible soils, the completed fill section shall be subjected to the subgrade preparation procedures required for cut sections. In cut sections, the subgrade shall be scarified and excavated to a prescribed depth and the excavated material shall be wind-rowed and bladed successively until thoroughly blended, relaid and compacted.

- C. In cut areas where the contractor is required to achieve compaction as called for above, the contractor will undercut material which is not compatible and replace with satisfactory material. Material will be deemed not compatible if the required compaction percentage cannot be attained by the use of twenty five (25) passes by the specified compaction equipment. To attain specified compaction, the contractor shall use tamping rollers, vibro-tampers, smooth rollers, sheeps-foot rollers or construction equipment as called for by the Director.
- D. In cut areas where potentially expansive plastic clay material is encountered, the contractor shall excavate potentially expansive plastic clay material to a depth of three (3) feet, or as directed by the Geotechnical Engineer, below the proposed subgrade and replace with satisfactory material.

10-770 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfilling relating to the specific utilities are as follows:

Water Supply. Trenches shall be a depth to provide a minimum cover of forty two (42) inches from the actual finished grade to the top of the pipe.

Electrical Distribution System. Electrical conduit or duct line shall have a minimum cover of twenty four (24) inches from the finished grade unless otherwise indicated. Special trenching requirements for direct-burial electrical cables may be

specified by the electrical utility company. A minimum of one (1) lane of traffic must be maintained at all times where a utility trench crosses an existing road, driveway or parking lot. Traffic control and flagmen must be provided to maintain orderly traffic flow.

Before commencing excavation in areas so designated on the plans, the contractor shall dig test pits as directed by the engineer to determine sizes and types of pipe and other underground utilities. Test pits shall be excavated sufficiently in advance of trench construction such that reasonable changes in line and grade can be made where the location of existing utilities and structures varies from that shown on the plans. The contractor shall adjust pipeline profile as required at connections to existing mains, subject to the approval of the Director. Sufficient trenching shall be excavated to ensure that no unforeseen obstructions exist before commencing pipe installation. Work resulting from failure to take such precautions shall be performed at no cost to the City.

Where subgrade or completed compacted areas are disturbed by subsequent construction operations, adverse weather or failure to maintain adequate drainage, the surface must be scarified, reshaped and compacted to required density prior to further construction at no expense to the city.

The contractor shall take measures for allaying dust. Measures shall be as described in the Virginia Erosion and Sediment Control Handbook.

The contractor shall be responsible for the stability of all embankments made under the contract until final acceptance of the work, and shall replace any portions which have become displaced due to carelessness or negligence on his part or due to damage resulting from natural causes.

10-780 EXCAVATION AND EARTHWORK FOR EMBANKMENT DAMS

10-780.1 EMBANKMENT DAMS

The following sections shall apply to all embankment dams utilized for stormwater management ponds (wet or dry) and permanent improvements constructed within the City of Manassas.

10-780.2 RELATED DOCUMENTS

- A. Approved Construction Drawings
- B. Virginia Department of Transportation
 - _ Standards for Road and Bridge Construction
 - _ Specifications for Road and Bridge Construction
 - _ Drainage Manual

10-780.3 QUALITY ASSURANCE

Codes and Standards. Excavation and earthwork shall be performed in compliance with applicable requirements.

Soil Testing and Inspection Service. The developer as set forth herein shall provide an independent soil testing and inspection service (the "Geotechnical Engineer" for quality control testing) during earthwork operations. The contractor shall coordinate and cooperate with the work of the Geotechnical Engineer.

The developer shall furnish a guarantee that embankment areas will not suffer settlement for a period of one (1) year from the date of final acceptance. Fill materials which settle shall be removed and replaced with suitable material at no cost to the City.

The contractor shall furnish a guarantee that all tests have been performed for underground utilities before backfilling to final grade.

10-780.4 SUBMITTALS

Test Reports-Excavating. The following reports shall be submitted directly to the Director from the Geotechnical engineer, with a copy to the contractor:

Subgrade. Results of tests include at least one (1) sieve analysis and one (1) liquid limit and plasticity index determination for suitable soils for each representative soil type sample and a minimum of two (2) tests.

Fill, and Backfill Material. One sieve analysis and one liquid limit and plasticity index determination for cohesive soils for each representative soil type sample and at least each two thousand five hundred (2500) cubic yards or fraction thereof.

Optimum Moisture and Maximum Density. One (1) moisture-density curve to determine the optimum moisture content and the maximum density values shall be provided for each representative soil type sample and at least each 2500 cubic yards or fraction thereof, for each type of embankment.

Field Density Tests:

- A. Cut-off Trench Subgrade. One test for every one hundred (100) lineal feet or fraction thereof, of trench.
- B. Fill Material
 - 1. Embankment. One (1) test for each lift per one hundred (100) lineal feet or fraction thereof, of embankment. Tests offset fifty (50) feet for each lift.
 - 2. Utility or Drainage Structures which abut a Pavement. One (1) test for every twelve (12) inches of compacted thickness or fraction thereof, for each structure.
- C. Location of tests shall be at the discretion of the Director.

10-780.5 SITE CONDITIONS

The developer's engineer shall examine the subsurface soil report and provide a preliminary analysis of the suitability of the site soils for embankment material. However, the actual on-site testing during construction shall determine the suitability of materials and the acceptability of operations.

10-780.6 SITE PREPARATION

Areas designated for borrow areas, embankment and structural works shall be cleared, grubbed and stripped of topsoil. All trees, vegetation and other objectionable material shall be removed. Channel banks and sharp breaks shall be sloped to no steeper than two (2) to one (1).

In order to facilitate clean-out and restoration, the area (measured at the top of the spillway pipe) will be cleared of all trees.

All cleared and grubbed material shall be disposed of outside and below the limits of the dam and reservoir as indicated on the approved plans. A sufficient quantity of topsoil shall be stockpiled in a suitable location for use on the embankment and other designated areas.

10-780.7 EARTH FILL

Material. The fill material shall be taken from approved borrow areas. It shall be clean mineral soil; free of roots, woody vegetation, oversized stones, rocks or other objectionable material.

Relatively porous materials such as sand or gravel (Unified Soil classes GW, GP, SW, & SP) shall not be placed in the embankment unless a core is provided on the interior of the embankment. Minimum core width shall be as recommended by the Geotechnical Engineer. The fill height along the full length of the embankment shall be increased at least 10% above the design elevation (including freeboard) unless otherwise recommended by the Geotechnical Engineer or as shown on the plans.

Placement. Areas on which fill is to be placed shall be scarified prior to placement of fill. Fill materials shall be placed in eight (8) inch maximum thickness (before compaction) layers which are to be continuous over the entire length of the fill. The most porous borrow material shall be placed in the downstream portions of the embankment.

Compaction. The movement of the hauling and spreading equipment over the fill shall be controlled so that the entire surface of each lift shall be traversed by not less than one (1) tread track of the equipment or compaction shall otherwise be achieved by a minimum of four (4) complete passes of a sheeps-foot, rubber tired or vibratory roller. Fill material shall contain sufficient moisture such that the required degree of compaction is obtained with the equipment use. Each layer of fill shall be compacted as necessary to obtain the minimum required density specified, and is to be tested for compliance by the Geotechnical Engineer.

Soil must be compacted to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture density relationship determined in accordance with ASTM D-698, and not less than the following percentages of relative density, determined in accordance with ASTM D-2049, for soils which will not exhibit a well-defined moisture to density relationship.

- A. The top twelve (12) inches of subgrade and each layer of backfill or fill material shall be compacted to 95% maximum density or relative density.

10-780.8 CUT-OFF TRENCH

Where specified, a cut-off trench shall be excavated along or parallel to the centerline of the embankment as shown on the plans. The bottom width of the trench shall be governed by the equipment used for excavation, with the minimum width being four (4) feet. The depth shall be at least four (4) feet or as shown on the plans. The side slopes of the trench shall be one to one or flatter.

The backfill material for the cutoff trench shall be "impervious" material and shall be compacted with equipment or rollers to assure maximum density and minimum permeability. The trench shall extend up both abutments to the riser crest elevation. The trench shall be dewatered during the backfilling and compacting operations.

10-780.9 BACKFILLING FOR OUTLET STRUCTURES AND OUTFALLS

Backfill material shall be of the type and quality conforming to that specified for the adjoining fill material. The fill shall be placed in horizontal layers not to exceed four (4) inches in thickness and compacted by hand tampers or other compaction equipment. The material must completely fill all spaces under and adjacent to the pipe. At no time during the backfilling operation shall any driven equipment be allowed to operate closer than four (4) feet, measured horizontally, to any part of the structure. Under no circumstances shall the contractor drive equipment over any part of a concrete structure or pipe unless there is a compacted fill of twenty four (24) inches of subgrade and each layer of backfill or fill material shall be compacted to 100% maximum density or 95% relative density.

10-790 MOISTURE CONTROL IN EMBANKMENT AND BACKFILL

Where the subgrade or layer of soil material must be moisture conditioned before compaction, water must be uniformly applied to the surface of the subgrade or layer soil material to prevent free water appearing on the surface during or subsequent to compaction operations.

For soils classified as SP, SP-SM, SP-SC, ML, CL or any micaceous materials, or combinations thereof, the contractor should be aware of the close moisture control required to achieve the proper field placement and compaction of these soil types. Therefore, the contractor shall be prepared to properly moisten or aerate these soil types as required to obtain a placement moisture content which will result in an in-place moisture of +/- 1% of optimum or as allowed by the Geotechnical Engineer within the compacted lifts of fills consisting of these soil types. All other satisfactory material shall have an in-place moisture content of +/- 2% of optimum within the compacted lifts for each fill material. However, in no case should a moisture content be allowed that would create pumping.

Soil material that is too wet to permit compaction to specified density must be removed and replaced, or scarified and air dried.

Satisfactory soil material that has been removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Drying may be assisted by dicing, harrowing or pulverizing until moisture content is reduced to a satisfactory value.

10-790.1 OUTLET STRUCTURES AND OUTFALLS

Base. The riser shall have a base attached with a watertight connection and shall have sufficient weight to prevent flotation of the riser. Two (2) approved bases for risers ten (10) feet or less in height are a concrete base, eighteen (18) inches thick, with the riser imbedded six (6) inches in the base and a 1/4-inch (minimum thickness) steel plate attached to the riser by a continuous weld around the circumference of the riser to form a watertight connection. The plate shall have at least two and one half (2.5) feet of tamped earth placed on it to prevent flotation. In either case, each side of the square base shall be twice the riser diameter. For risers greater than ten (10) feet high, computations shall be made to check flotation. The minimum factor of safety shall be 1.25 (Downward forces =1.25 x upward forces).

Anti-seep collars. Anti-seep collars or approved equal shall be installed any around the pipe conduit within the normal saturation zone to increase the seepage length at least ten percent when of the following conditions exist:

- A. The settled height of dam exceeds ten feet, or;
- B. The embankment material has a low silt-clay content (unified soil Classes SM or Gm) and the pipe diameter is ten inches or greater.

The phreatic line may be approximated with a line drawn downward on a 4:1 slope from the intersection of the normal pool (corresponding to the tip of the riser and the upstream face of the embankment). The seepage length is the length of the flow path of a particle of water along the conduit from the riser to the point of intersection between the approximate phreatic line and the invert of the pipe conduit. When anti-seep collars are used, the equation for revised seepage length is:

$$L_s + 2nV \geq 1.1 L_s \text{ or } n \geq \frac{.05L_s}{V}$$

V

Where: L_s = Saturated length is length, in feet, of pipe between the riser and the intersection of the phreatic line and the pipe invert.
 N = number of anti-seep collars.
 V = vertical projection of collar from pipe, in feet.

The anti-seep collar and its connection to the pipe shall be watertight. The maximum spacing, in feet, between collars shall be fourteen (14) times the minimum projection of the collar measured perpendicular to the pipe. The anti-seep collar shall be located below the phreatic line in the embankment and should be equally spaced. They shall not be located between collars to allow space for the hauling and compacting equipment.

Reinforced concrete Pipe Outfalls

- A. Materials - Reinforced concrete pipe shall have a rubber gasket joint and shall equal or exceed ASTM Specification C-361. Approved equivalents are AWWA Specification C-300, 301, and 302.
- B. Bedding - All reinforced concrete pipe conduits shall be laid in concrete bedding for their entire length. This bedding shall consist of high slump concrete placed under the pipe and up the sides of the pipe at least 10% of its diameter with a minimum thickness of three (3) inches.
- C. Laying pipe - Bell and spigot pipe shall be placed with the bell end upstream. Joints shall be made in accordance with recommendations of the manufacturer of the material. After the joints are sealed on the entire line, the bedding shall be placed so that all spaces under the pipe are filled. Care shall be exercised to prevent any deviation from the original line and grade of the pipe.
- D. Backfilling shall conform to structural backfill. Refer to Section 10-780.9 of this Article.
- E. Other details (anti-seep collars, valves, etc.) shall be as shown on the plans.

10-790.2 EMERGENCY SPILLWAY

The emergency spillway shall not be installed within a fill section of the embankment. Elevations, design width, entrance and exit channel slopes shall be constructed as shown on the approved construction plans.

10-790.3 STABILIZATION

All borrow areas shall be graded to provide proper drainage and left in a slightly condition. All exposed surfaces of the embankment, spillway, spoil and borrow areas, and berms shall be stabilized by seeding, liming, fertilizing and mulching (if required) in accordance with the vegetative treatment specifications.

10-790.4 EROSION AND SEDIMENT CONTROL

Construction operations will be performed in such a manner that erosion will be controlled and water and air pollution minimized. State and local laws concerning pollution abatement will be followed. Construction plans shall detail erosion and sediment control measures to be employed during the construction process.

10-790.5 RIPRAP

Riprap, if required for proper sediment and erosion control, shall be placed in conformance with the applicable requirements of Virginia Department of Transportation's Road and bridge Specifications and the Drainage Manual. Large stones shall be placed at the bottom of the slope. Spaces between stones shall be filled with spalls of suitable size to construct a solid, stable slope, free from large void and defects which might not protect the earth slopes against erosion.

A filter blanket shall be designed and approved as part of the riprap installation.

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