

SAMPLE SITE SURVEY SCOPE OF WORK

C-1. PURPOSE. This scope of work is only a sample and should not be considered a final scope to be used for a specific project. The scope of work presented on the following pages is to be used as a guide by experienced surveyors in order to obtain data needed for design work. The scope must be tailored to meet the specific requirements of individual projects.

C-2. DATA COLLECTION. Aerial data collection may or may not be the most cost effective approach to data collection. Depending on the size of the range, a ground survey may be more feasible. This is one of the decisions that will have to be made on a project by project basis.

C-3. DATA FORMAT. A computerized data format is highly recommended on survey work. Most design firms and government agencies currently use CADD equipment for design. For line-of-site surveys to be analyzed on the Huntsville Center Range Analysis System, final survey data must be digitized into a 3D design file and furnished in Microstation format on compact disc (CD).

1.0 GENERAL. The [Corps of Engineers (COE) District] [architect-engineer] shall provide all engineering services required for providing a topographic (topo) survey of the proposed (range name and type) at (installation). The work includes establishing horizontal and vertical ground control, obtaining plane table/cross sections, aerial photography, digitizing map information, generation of the topo maps, and field verification.

2.0 SCOPE. The survey shall provide a topo map of the area(s) indicated on the enclosed drawing. (See figure C-1 for sample survey limits). The (range type) is approximately _____ acres. The survey shall be provided at a scale of 1:500 and show 1/2-meter contours, with each even contour identified. All of the topo maps shall be referenced to the North American Datum of 1983 (NAD83), if available, and to the North American Vertical Datum of 1988 (NAVD88), if available. These maps shall also be referenced to the 1,000-meter, Universal Transverse Mercator (UTM) coordinate system. The final survey data shall be digitized into a 3D design file and furnished in Microstation format on CD.

2.1 All surface features and underground utilities within the area to be surveyed shall be shown and identified on the maps. In addition, these features shall be located by sufficient distance ties and labeled on the sheets to permit accurate scaling and identification. The phrase "surface features and underground utilities" is intended to include, but is not necessarily limited to, the following existing features:

2.1.1 Power and communication lines, street light poles, guy wires, transformers and substations. Indicate the type and number of each power pole, the number of wires, and locate the intersection of all guy wires with natural ground.

2.1.2 Sanitary and industrial sewer manholes and all storm drainage structures, such as culverts, headwalls, inlets, cleanouts, and manholes. Always obtain an elevation at the

flow line at the bottom of all the pipes connected to a manhole or inlet (invert elevations). Clearly identify the size and type of each pipe. Obtain the pipe invert elevation up and downstream of all manholes and

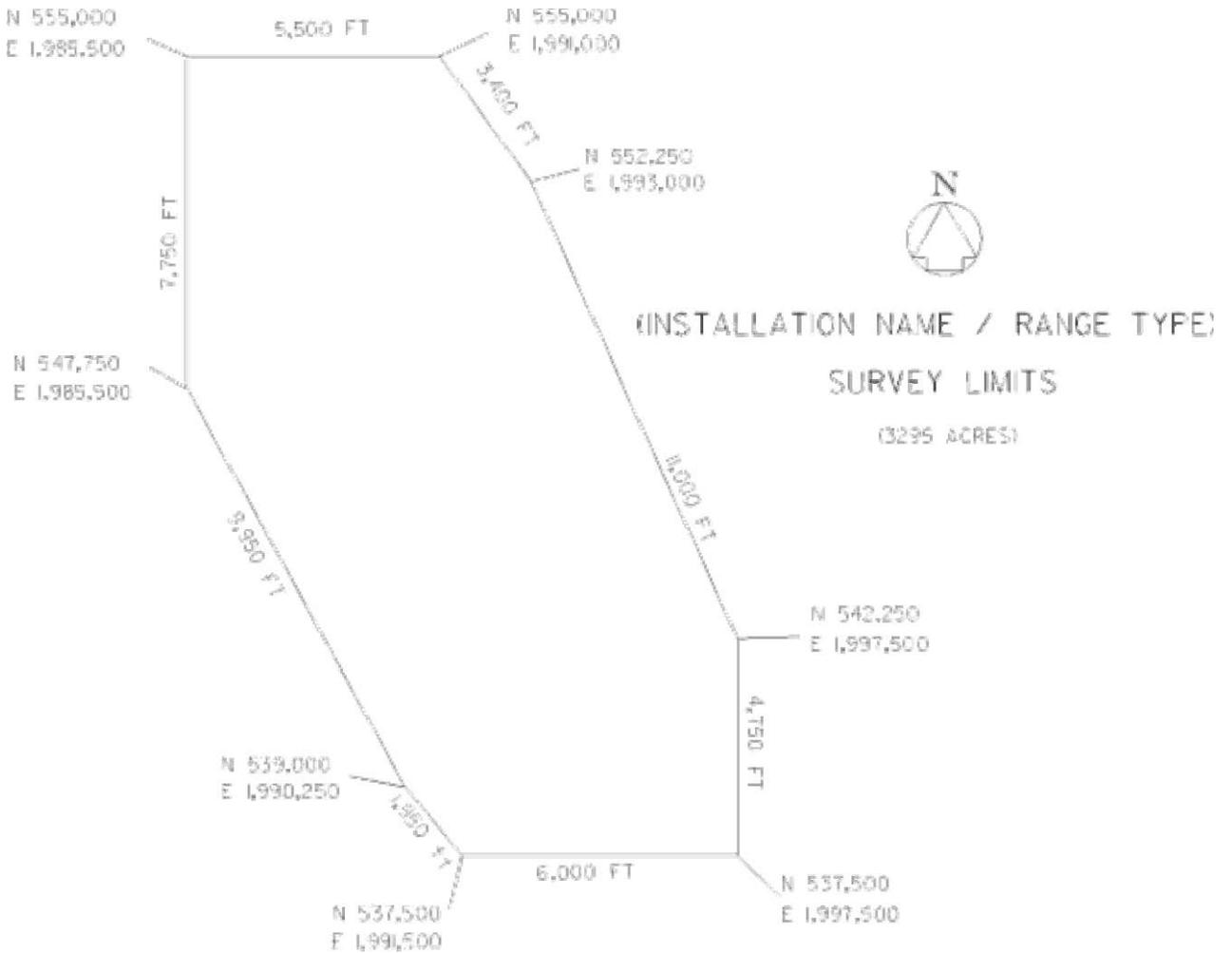


Figure C-1. Sample survey limits

inlets even if beyond the limits of the required topo. Provide sketches where needed for detail and clarity.

2.1.3 Water, gas, oil, fuel, and other ground pressure pipes. Locate all fire hydrants, hose bibs, valve boxes, pump stations, pipeline valves, etc., within the limits of the area to be surveyed. Include all information on the location and the size of each pressure pipe on the map inside the limits of the topo survey. Use sketched inserts where needed for detail and clarity.

2.1.4 Roads, road signs, drives, walks, and railroads. Railroads shall be identified by name and have the top of rail elevation on both rails at 100 meter intervals and all changes (breaks) in grade, show all switch locations. Sketch a typical section of the rails. All roads shall be identified by name and have elevations shown in the centerline and

each edge of the road at 25 meter intervals and at the centerline of each intersection. In addition, show the type of surfacing and the general condition of the road.

2.1.5 Fences (location, type, and height). Indicate type of wire and posts (pipe, wood, concrete, etc.), and provide coordinates at each corner to the closest 0.5 m.

2.1.6 Trees. Locate and show each tree line, and indicate the types and average diameter on the topo sheets. The diameter is measured one and a half meters above natural ground. Show and identify all trees that are individually isolated outside of the tree line.

2.1.7 Ditches, streams, canals, ponds, lakes, etc. Identify by name (if possible), show the elevation of the top of water to the closest 0.01 m, and show the direction of the flow (if possible).

2.1.8 Other visible surface features. Locate and show any storage tanks, radio antennas, monitoring wells, or other surface features visible and located within the area to be surveyed. Areas with active erosion shall be noted, and shown on the maps.

2.2 Established elevations. Spot elevations affecting the design of the facilities shall be provided, such as ground elevations, elevations on existing utilities, and on visible surface features within the area to be surveyed. Specifically, break points or changes in grades or terrain shall be provided, such as tops of hills, bottoms of ditches and gullies, high bank elevations, etc. Ground elevations shall be to the closest 0.01 m; all other elevations (paved roads, railroads, finished floors, utility lines, drainage structures, monitoring wells, etc.) shall be to the closest 0.001 m.

2.2.1 Manholes, inlets, and all drainage structures. Provide type, length, width, and top, bottom, and all pipe invert elevations to the closest 0.001 m. In addition, provide the elevations, dimensions, and the type of construction for all headwalls and wingwalls.

2.2.2 Curb and gutter: Provide top of the curb and gutter elevations along existing pavements to the closest 0.001 m. If necessary, provide a sketch to clearly show the type of curb or gutter.

2.2.3 Buildings and ramps. Provide and show the natural grade to each building line, including spot elevations at all building corners (to the closest 0.001 m for finished floors and paved areas, and to the closest 0.01 m for natural ground).

2.2.4 Ground elevations. Intermediate elevations shall be provided as necessary to show all breaks in grade or changes in terrain.

2.3 Control points. Wooden hubs shall be used for all basic control points. Five (5) new concrete monuments with horizontal and vertical control shall be established and set flush with the ground, be located within the topo limits of the range, be set 10 meters (10 m) from the edge of any existing road, and be a minimum of 300 meters apart. Witness posts shall be set within one meter of each monument. Horizontal control (1:10,000 and referenced to NAD83) and vertical control (1:5,000 and referenced to NAVD88) based on the metric system using the international survey foot (one inch = 25.4 millimeters (mm) and one foot = 3.2808399 feet) of "Third Order" or better shall be established for

each of the monuments. In addition, all of the monuments shall also be referenced to the 1,000 meter UTM, Zone 11. All of the control points recovered and/or established at the site shall be plotted at the appropriate coordinate point on the topo sheets and shall be identified by name or number, final adjusted coordinates, and final adjusted elevations. Each new monument shall have a 3 1/4 inch - 3 1/2 inch domed bronze, brass, or aluminum survey marker (cap) set in the top of the monument. The new monuments shall be numbered and stamped in sequence as follows: "MPMG-1-1995", "MPMG-2-1995", "MPMG-3-1995", etc. Each new monument shall also be stamped with the final adjusted elevation (to the closest one-hundredth of a foot) and "USAEDH, Huntsville". The dies used for stamping the survey markers shall be 1/8 inch - 3/16 inch in size. A tabulated list and a "Description Card" of all monuments established or used shall be submitted in accordance with Paragraph 8.2.3 of this scope. The Description Card shall show a sketch of each monument; its location relative to ROW lines, reference marks, buildings, roads, towers, etc.; a typed description telling how to locate the monument from a well recognized and known point; the monuments name or number; and, the final adjusted coordinates and elevations to the closest 0.01 foot and the closest one-thousandth of a meter (0.001 m) respectively. The description cards shall be five inches by eight inches (5" x 8") with one description per card, or two descriptions may be submitted on an eight and one-half inch by eleven inch (8 1/2" x 11") sheet of bond paper.

2.4 Field Notes. All field notes are to be clearly and precisely recorded in standard field books or in an electronic data recorder, and there are to be no erasures made in these books. All original field books and printouts are to be submitted to CEHNC in accordance with paragraph 8.2. of this SOW.

3.0 AERIAL PHOTOGRAPHY (if survey is obtained by aerial photography)
Compliance with accuracy requirements stated herein is required regardless of how the survey is obtained.

3.1 Type of Photography Required. Single lens vertical black and white panchromatic photography at scales of 1:4,800 or larger with characteristics suitable for analytical aerotriangulation and standard photogrammetric mapping. The average flight height above natural ground shall be consistent with the mapping accuracies required to provide a scale of restitution of 1:500.

3.2 Photographs and Film. Each negative of the photograph assignment shall be marked with the date of exposure, the approximate scale (1:XXXXX), the file number, the assigned roll number, the flight line number, and the exposure number. All such editing of numbered negatives shall be by mechanical lettering, with characters a minimum of 5 mm (0.2 inch) high, and shall be so placed as to appear within the image on the forward edge (in the line of the flight) of the positive prints, to read from the back edge, all in relative positions as follows. Example of data to appear on each photograph:

DATE XX-XXX-XX

SCALE 1:XXXX

FILE # MPMG, PEND

FILM ROLL # XXX

FLIGHT LINE # XXX

PHOTO # XXX (Photos in the mission to be consecutively numbered from first to last)

3.3 Paper Prints. All prints shall be made on resin coated (RC) paper stock approved by the Contracting Officer. They shall be sharp and clear, shall contain all highlight and shadow detail, and shall be evenly toned. They shall be permanently fixed; thoroughly washed; processed through flattening solution and dried without pressing, rolling, or excessive heating; and trimmed to the image area, approximately 229 mm by 229 mm (9" x 9"), with the imaged fiducial points retained on the print. Three copies of each paper print and all of the aerial photo negatives shall be delivered to the Huntsville Center in their proper flight line and exposure sequence.

3.4 Mylar Photo Index. Each sheet (minimum size of 508 mm by 610 mm (20" x 24")) of the Photo Index shall be one negative, entirely free of splicing and masking. Five reproducible (mylar) copies of each photo index are required. Each sheet shall have a True North and two Grid North Arrows, a Sheet Index , and a Title Block as per the following example:

U.S. ARMY ENGINEER AND SUPPORT CENTER, HUNTSVILLE

Project Name: _____

Date of Photography: _____

Scale of Photography: 1:XXXX

Scale of Index: 1:XXXX

Name of Contractor: _____

Sheet xx of xx

3.5 Quality of Materials. All materials, supplies or articles required for this work which are not covered by detailed specifications herein shall be standard products of reputable manufacturers and entirely suitable for the purpose. They shall be new and unused, unless otherwise specified, and will be subject to the approval of the Contracting Officer.

3.5.1 Aerial Film. Aerial film shall be of a quality that is equal or superior to Kodak Aerographic 2405 black and white film. Only fresh, fine-grained aerial film shall be used. The negatives shall be exposed and developed in such a manner that they shall be sharp and clear, and contain all highlight and shadow detail. They shall be free of any defects which, in the opinion of the Contracting Officer, render them unsuitable for their intended purpose.

3.5.2 Compilation Medium. Compilation materials shall be furnished by the Contractor of a quality that is equal or superior to Mylar or Cronoflex Stable Base Materials.

3.6 Performance Required. The company providing this work must be cognizant of the

difficulties involved and of the contingencies which may arise, and must ascertain that the personnel, plant, equipment, transportation facilities, and supply of materials are adequate at all times to ensure complete compliance with all provisions of this contract.

3.7 Personnel of Plane. The pilot must be well qualified, possessing a minimum of 250 hours of photographic map flying experience. The photographer shall possess a minimum of 250 hours of experience representing actual time spent in executing vertical aerial photography on photographic assignments. Oblique photography is not considered as qualifying experience. Equipment replacements shall not be made during the progress of this contract without the express consent of the Contracting Officer.

3.8 Airplane. The airplane to be used shall be entirely capable of stable performance at the necessary altitude and air speeds. It shall be equipped with all essential navigational and photographic instruments and accessories. These shall be maintained in operational condition during the period of service for this work and shall be subject to the approval of the Contracting Officer. No windows shall be interposed between the camera lens system and the terrain. The camera lens system shall not be in the direct path of any gases or oil from the aircraft engine(s).

3.9 Camera. All mapping photography shall be made with a single lens precision aerial mapping camera equipped with a "high-resolution, distortion-free" type lens, calibrated by the National Bureau of Standards or an agency making calibrations of equal accuracy, and approved by the Contracting Officer. The calibrated focal length of the lens (the focal length at which the values of lens distortion, irrespective of sign, are held to the minimum within 45 degrees of the optical axis) shall be 153 mm, plus or minus 3 mm. The camera shall function properly at the necessary altitude and under the expected climatic conditions, and shall expose a 229 mm (9 in.) square negative. The lens cone shall be so constructed that the lens, focal plane at calibrated focal length, fiducial markers and marginal data markers comprise an integral unit or are otherwise fixed in rigid orientation with one another. Dimensional changes brought about by variations of temperature or other conditions shall not be of such magnitude as would cause deviation from the calibrated focal length in excess of plus or minus 0.05 mm or would preclude determination of the principal point location to within plus or minus 0.003 mm.

3.9.1 Platen. The focal plane surface of the platen shall be flat to within 0.013 mm and shall be truly normal to the optical axis of the lens. The camera shall be equipped with a means of holding the film motionless and flat against the platen at the instant of exposure.

3.9.2 Fiducial Marks. For mapping photography, the camera shall be equipped with a minimum of four (4) fiducial marks suitable for making precise measurements in analytical aerotriangulation process. The lens, focal plane, and fiducial marks must be permanently fixed in rigid orientation with each other.

3.9.3 Lens Distortion. As referred to the calibrated focal length, the radial distortion shall not exceed plus or minus 0.01 mm within a 42.5 degree half-field angle, and the tangential distortion shall not exceed 0.005 mm. Values of distortion at equal but opposite angular separations from the axis along the same diameter shall not differ from each other by more than 0.02 mm.

3.9.4 Lens Resolving Power. When installed in the camera, and with the appropriate filter mounted in place, the lens shall resolve at least 32 equally spaced lines to the millimeter in the center of the field; and, at least 14 equally spaced lines to the millimeter in any orientation extending to 45 degrees from its axis, all as could be determined by tests using Eastman Spectroscopic Type V-F Emulsion, or equivalent.

3.9.5 Filter. The appropriate minus-blue filter used in black and white photography shall be of such quality that no appreciable reduction in resolution will result. The surfaces of the filter shall be parallel to within 10 seconds of arc.

3.9.6 Shutter. The camera shall be equipped with a between-the-lens shutter of the variable speed type, whose efficiency shall be at least 75 percent at the fastest rated speed.

3.9.7 Substitute cameras may be used in taking special purpose aerial oblique photographs and photographs to be used in the preparation of mosaics, provided that prior written approval for the use of the special camera and lens is obtained from the Contracting Officer.

3.10 Flight Plan. Photographic flight height above the average ground elevation shall be such that the scale of the photographic film negatives will not have a variation of more than plus or minus five (5) percent of the desired photo scale. All strips shall be flown as straight as possible, and shall be void of crab, tilt, and altitude variations to the extent that they afford good stereoscopic coverage of the entire minimum area of the photographic assignment. Successive photographs along the line of flight shall overlap each other by approximately 60 percent, and parallel strips shall overlap each other by approximately 30 percent as indicated on the approved flight plan. Deviations of more than five (5) percent from these specified overlaps, except those excessive due to allowances made for abnormal relief displacements, shall be cause for rejection. A flight plan shall be prepared and submitted to the Contracting Officer's Representative for approval. The plan shall indicate the area to be mapped, the flight line locations, and the pretargeted panel positions needed to tie the individual frames of photography to the State Plane Grid System and the North American Vertical Datum.

3.11 Crabbing. Any series of two or more consecutive photographs crabbed in excess of five (5) degrees as measured from the mean flight path of the airplane, as indicated by the principal points of the consecutive photographs, shall be cause for rejection of the photographs in the flight.

3.12 Tilt. The average tilt for photographs shall not exceed one (1) degree and the maximum tilt shall not exceed three (3) degrees in a strip flight. Relative tilt between any two successive negatives exceeding five (5) degrees shall be cause for rejection.

3.13 Scale Requirements. The aerial photography shall be performed at a flight height above average ground so that the mapping can be provided at a scale of 1:500 and the contours can be stereoscopically obtained for 0.5 m intervals. Negatives having a departure from the specified scale by more than five (5) percent because of tilt or abrupt changes in the flying altitude shall be corrected.

3.14 Suitable Conditions. All photography shall be accomplished between the hours of 10:00 a.m. and 2:00 p.m., Standard Time Zone, when the atmosphere is sufficiently clear, and when no part of the terrain being photographed is obscured by clouds, cloud shadows, smoke, fog or snow, except with the permission of the Contracting Officer. Any day containing two or more consecutive hours of such suitable conditions, in any sizable portion of the area not yet photographed, will be considered a "Suitable Day" for aerial photography.

3.15 Stereoscopic Coverage. The entire area of the project shall be stereoscopically covered within the usable portion of the field of the lens. This stipulation is a prime requisite of this scope of work (SOW). Nonattainment of acceptable stereoscopic coverage caused by the AE's failure to adhere to the specified flight design shall be corrected by reflights at his expense.

4.0 PHOTOGAMMETRIC MAPPING. Photogrammetric mapping shall be produced from photography meeting the specifications detailed in Paragraph 3.0. Enlargement from a negative scale to a compilation scale must be within the limits of the stereoplotter capability to produce mapping at a scale of 1:500.

4.1 Personnel. Operators of photogrammetric mapping equipment and digitizing graphics equipment shall be thoroughly trained and must have a minimum of six months production experience on the equipment they operate.

4.2 Control Extension. Aerotriangulation for control shall be accomplished by fully analytical methods. The positional accuracy (vector of both Northing and Easting coordinate errors) of pass points established by aerotriangulation shall meet either of the following minimum requirements:

4.2.1 A root-mean-square error in feet not greater than one part in 1,500 of the nominal negative scale as expressed in feet per inch.

4.2.2 Ninety (90) percent of the pass points in error in feet by not more than one part in 900 of the nominal negatives scale as expressed in feet per inch.

4.2.3 In either case, no point shall be in error by more than one part in 400 of the negative scale as expressed in feet per inch.

4.3 Stereo Compilation. Stereo compilation shall be accomplished using automated stereo plotting devices connected directly to the interactive graphics system. The stereo plotting device shall be capable of capturing the level of detail required from the aerial photography. The production of a pencil or scribe manuscript of the planimetric and cultural features and the contour data for direct digitization later will not be permitted. Stereo plotters and other mensuration instruments shall be well calibrated.

4.4 Photogrammetric Mapping Accuracy Requirements. All photogrammetric mapping shall meet the following horizontal and vertical accuracy requirements for a mapping scale of 1:500.

4.4.1 Contours. Ninety (90) percent of the elevations determined from the contours of the

topographic maps shall have an accuracy with respect to their true elevation of one-half of the contour interval or better, and the remaining ten percent of such elevations shall not be in error by more than one contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement of 0.635 mm. In densely wooded or heavy vegetated areas where the ground is obscured, elevations (shots) shall be obtained by cross sections or random shots taken by a survey crew at no more than 10 meter intervals and manually entered into the digitized data by the equipment operator.

4.4.2 Coordinate Grid Lines. State plane coordinate grid lines shall be plotted at each even 100 meter line, and shall not vary by more than 0.25 mm from the true grid value on each map. In addition, grid tic marks for the 1,000m UTM system shall be plotted and identified on the border of each sheet at 100 meter intervals and shall not vary by more than 0.25 mm from the true grid value on each map.

4.4.3 Horizontal Control. Each horizontal control point shall be plotted on the map within the coordinate grid in which it should lie to an accuracy of 0.25 mm of its true position as expressed by the coordinates computed for the point.

4.4.4 Planimetric Features. Ninety (90) percent of all planimetric features which are well defined on the photographs shall be plotted so that their position on the finished maps shall be accurate to within at least 0.635 mm of their true coordinate position, and none of the features shall be misplaced on the finished map by more than 1.27 mm from their true coordinate position.

4.4.5 Spot Elevations. Ninety (90) percent of all spot elevations placed on the maps shall have an accuracy of at least one-fourth (1/4) the contour interval, and the remaining 10 percent shall not be in error by more than one-half (1/2) the contour interval.

5.0 DIGITAL DATA.

5.1 General Design File Requirements.

5.1.1 An overall topographic design file shall be created and the topographic feature data shall be digitized into the Microstation 3D design file with each element (contours and spot elevations) at its correct elevation. An overall planimetric design file shall be created. The planimetric, surface and subsurface, feature data shall be digitized into the Microstation 3D design file at an elevation of zero. All characteristics such as file naming and relationships, level structure, colors, line styles, weights, etc. shall be in accordance with the latest version of the A/E/C CADD Standard.

5.1.2 Digital terrain model (dtm) files shall be created to model the topographic surface.

5.1.2.1 The dtm file shall be created using the elements of the topographic file. All spot elevations, contours, and breaklines necessary to create the dtm file shall be used. The dtm file shall be created so that it can be used in INROADS to recreate the contours at their exact locations.

5.1.2.2 A file shall also be created showing the dtm boundaries, the dtm file name, and

coordinates of the area of coverage.

5.1.3 The individual sheet design files shall have the following salient features:

5.1.3.1 Each sheet border and sheet dependent element shall occupy a separate file and be referenced to the planimetric and topographic files.

5.1.3.2 Each sheet shall have a standard metric A-1 size drawing. Each sheet shall have a standard Corps of Engineers border, revision block, title block, complete index sheet layout, bar scale, legend, metric grid lines, a True North and two Grid North arrows, and be plotted at a horizontal scale of 1:500.

5.1.3.3 Each file shall be checked by viewing a top view to detect errors in element position. Each three dimensional file shall be checked by viewing a front and a side view to detect errors in element elevation.

5.1.3.4 The cell library used shall be attached.

5.2 Specific Design File Requirements.

5.2.1 The design file border sheet shall accommodate a scale of 1:500. Contours on the topo sheets shall appear at a 0.5 m vertical interval, and each even meter (2.0, 4.0, 6.0, etc.) contour elevation shall be darkened (heavied up) and labeled. Contour lines shall be continuous unbroken lines with the elevation shown at various intervals on each even meter contour line. All surface and subsurface features shall appear in the design file.

5.2.2 There shall not be any over plotting of spot elevations on the "Final" map sheets. The spot elevations assigned to Level 30 are to be plotted. Level 29 contains elevations of "Breakline" features required for generating the contours. Level 60 shall be utilized for concentrated spot elevations when required to define the topography, but shall not be plotted on the "Final" Map. All spot elevation and breaklines shall be used to create the ttn files.

5.2.3 In accordance with paragraph 8.0, the Government shall be provided with a copy of the design files on compact disks. The data to be submitted shall contain the final version of the design files, with corrections made. CD's shall be labeled, showing the project name, project number, date, company name, address and telephone number, and the number of files.

6.0 PROGRESS REPORTS.

6.1 A written progress report shall be submitted once every 2 weeks to COE [Division] [District]. The report shall include, as a minimum, a brief narrative of the work completed during the report period, an estimated percentage of the work completed to date, an estimate of the funds that have been expended to date, and any problems encountered that may or may not delay the completion of the project.

6.2 The progress report shall be submitted to _____, ATTN: _____ (Mr. _____), within three working days after the close of each reporting period.

7.0 DELIVERABLE ITEMS.

7.1 _____ shall deliver all the items and data listed below to the address listed below:

7.2 Items and data to be delivered to _____ are as follows:

7.2.1 Field Survey. The original copies of all field books, sketches, layout sheets, computation sheets, abstracts, and computer printouts. All of these items shall be suitably bound, and clearly marked and identified.

7.2.2 A tabulated list and design file of all monuments showing their adjusted coordinates and elevations (to the closest 0.01 ft and 0.001 m) established and/or used for this survey.

7.2.3 A "Report on Establishment of Survey Mark" (Description Card) on each permanent control monument established and/or used for the survey. In addition to the name or I.D. number of the monument, the cards should show the adjusted coordinates and the adjusted elevations (to the closest 0.01 ft and 0.001 m), a typed description for locating the monument, and a sketch showing how to locate the monument. These descriptions shall be submitted with one description being on a five inch by eight inch (5" x 8") card, or two descriptions may be submitted on an eight and one-half by eleven inch (8 1/2" x 11") sheet of bond paper as described in paragraph 2.3 of this SOW.

7.2.4 All unique items created and/or used to create the end product.

7.2.5 Drawings. All maps shall be plotted at a scale of 1:500 on standard metric A-1 size sheets, and shall be generated by the CADD system. One original copy of each final drawing shall be delivered.

7.2.6 CD's. Two copies of each compact disk specified herein shall be delivered.

7.2.7 Aerial Photographs. Three copies of each aerial photograph and five reproducible copies (mylar) of the aerial photo index and all of the aerial photographic negatives shall be delivered.

8.0 SCHEDULE. All work and services under this scope of work shall be completed and submitted on or before _____.