الفصل ٣

المعايير التصميمية: المدنية

CHAPTER 3:

DESIGN CRITERIA: CIVIL

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KINGDOM OF SAUDI ARABIA

Royal Commission for Jubail & Yanbu

المملكة العربية السعودية

الهيئة الملكية للجبيل وينبع

TABLE OF CONTENTS

3.01 SITE CONTROL

A. This chapter outlines the systems of site control which have been established for the Jubail and Yanbu Industrial Cities. The information given herein is for the purpose of giving an understanding of the grid system used to define land location, as well as systems for maintaining horizontal and vertical control.

B. Health, Safety and Welfare Considerations

1. All works undertaken in relation to this Specification shall be completed in full accordance with the respective health, safety and welfare requirements established by the following:

a) Kingdom of Saudi Arabia

1) Legislation, Regulation, Standards and Codes.

b) Royal Commission

1) Regulations, Standards, Contractual conditions, Health and Safety systems and guidance documentation.

c) Contractor

1) Health and Safety Standards and Systems as accepted by the Royal Commission.

2. In the absence of any or all of the above, best international industry practices, with reference to Health, Safety and Welfare, shall be employed and utilised throughout.

3.02 DEFINITIONS

A. **azimuth:** The direction of a line through a point with respect to the meridian through the point expressed as the clockwise angle from north. Except where the line is along a meridian or the equator, the azimuth of a straight line changes as the point moves along the line.

B. **cul-de-sac:** A dead-end tertiary road terminating in a paved turning circle.

C. **easting:** First measurement of a grid reference used to specify the location of a point on a rectangular coordinate system. The distance measured eastward from the origin of a rectangular coordinate system.

D. **latitude:** It is the angular position of a place north or south of the equator. Positive values in the Northern hemisphere, negative in the South (i.e., the South Pole has latitude = - 90°).

E. **longitude:** The angular location of a place on the Earth's surface measured east or west of the Prime meridian through Greenwich. Longitudes W are positive, E are negative.

F. **lot:** The smallest piece of land to be used for a specific purpose; i.e., the lot to be occupied by a house, an apartment house, a business establishment, a mosque, pump station, reserve tract, etc.

G. **lot line:** Any line bounding a lot as herein defined.

H. **monument:** A boundary or position marker.

I. **neighborhood center:** An area containing commercial and public facilities for a catchment area of approximately 10,000 to 15,000 people.

J. **northing:** Second measurement of a grid reference used to specify the location of a point on a rectangular coordinate system. The distance measured northward from the origin of a rectangular coordinate system.

K. **parcel:** A unit of land, or tract of land in a subdivision with specified location and boundaries, which is used or developed as a unit for a specific purpose.

L. **plant grid (PG):** A plane grid system established by the Royal Commission. All land and facilities shall be located based on the PG system or any authorized agency's system.

M. **reserve tracts:** Are lots (or blocks) for future use, which use is unknown or cannot be defined at the time of subdividing; i.e., land which may be needed at a future date – for example expansion of a park, school grounds, commercial development, etc.

N. **right-of-way:** Public land reserved for roads, sidewalks, pedestrian and bicycle paths, drainage and utility corridors, and pipelines.

O. **royal commission:** The legal entity created by Royal Decree No. M/75 dated 16/9/1395 A.H. to transform the two regions of Jubail and Yanbu into industrial areas.

P. **splay:** The expansion of street right-of-way required at intersections to permit compliance with intersection sight line criteria.

Q. **street:** A public right-of-way which includes a roadway and may also include sidewalks and landscaping, the principal function of which is to carry vehicular traffic and/or provide vehicular access to abutting property. The word "street" shall include "avenue," "cul-de-sac," "drive," "boulevards," "highway," "road," and "thoroughfare."

R. **subdivision:** A group of one or more blocks which lie within a geographically defined area, and where one or more of the blocks have been divided into lots, each lot to be used for a separate purpose.

S. **theodolite:** A precision instrument for measuring angles to vertical and horizontal planes. Consists, in its most basic form, of a telescope which can rotate horizontally and vertically allowing readings to be taken from a calibrated circle. The instrument has to be centered over a fixed (control) point.

T. **traverse:** Begins and ends at the same point (closed loop), or begins and ends at points whose relative positions have been determined by other surveys.

U. **triangulation:** Using a network of triangles to accurately plot positions.

V. **trilateration**: A basic geometric principle that allows to find a location using relative positions of three or more known locations. In this case, it makes use of signals transmitted by artificial celestial bodies - satellites. In two-dimensional space, at least three circles are needed to pinpoint the location. In three-dimensional space, at least four spheres are needed. Due to the fact that satellites transmit signals radially, the space the signal cover forms a sphere.

W. **true coordinate position:** The position of a point as determined by field survey originating from a known control survey marker of Royal Commission or any authorized agency, and performed to the precision and adjusted, as required for second order surveys.

X. **universal transverse mercator (UTM):** A grid system based upon the Transverse Mercator projection. The UTM grid extends North-South from 80°N to 80°S latitude and, starting at the 180° Meridian, is divided eastwards into 60, 6° zones with a half degree overlap with zone one beginning at 180° longitude. The UTM grid is used for topographic maps and georeferencing satellite images.

3.03 THE PLANT GRID SYSTEM

A. Jubail Industrial City

1. The entire site is covered by a Plant Grid (PG) which is a plane grid. This grid is laid out so that it is generally parallel or perpendicular to the blocks, lots and corridors within Existing Industrial Area. As a result of this orientation, Plant North is approximately N 43° W of True North.

2. The most southerly grid line of the PG is south of southeasterly corner of Jubail Industrial City, and this grid line has the coordinate designation of N 30,000. The grid lines proceed northerly in increasing increments of 1,000 m (1 km), with the most northerly grid line having the coordinate designate of N 64,000. Similarly, the most easterly grid line approximates the north end of the most easterly boundary line of Jubail Industrial City, said point lying east of the Open Sea Tanker Terminal, and with this grid line having the coordinate designation of E 84,000. The grid lines proceed westerly in decreasing increments of 1,000 m, with the most westerly grid line (which lies generally about 6 km west of Tapline Road) having the coordinate designation of E 40,000.

3. All land and facilities with Jubail Industrial City shall be located by coordinates based on the PG. No other coordinate system or any other system shall be used for any purpose whatsoever within the boundaries of this site, except as outlined in **Section 3.07** herein.

B. Yanbu Industrial City

1. The site is located at latitude 24° 00’ N, longitude 38° 10’ E.

2. The Yanbu Industrial City is situated on the Red Sea coast approximately 360 km northwest of Jeddah and near the town of Yanbu Al-Bahr. The City’s primary hydrocarbon-based industries are supplied with crude oil and natural gas by parallel pipelines from the east coast.

C. All surveys shall use degrees for azimuth and angles, and meters for both vertical and horizontal measurement.

3.04 HORIZONTAL AND VERTICAL CONTROL

A. Horizontal

1. To establish and maintain horizontal control within Jubail and Yanbu Industrial Cities, four orders of horizontal control surveying have been mandated. These are:

a) Geodetic Surveys. (i.e.: The boundary of Jubail and Yanbu Industrial Cities).

b) Primary Surveys. (i.e.: The boundaries of Sections and Districts).

c) Secondary Surveys: (i.e.: Intersections of Street centerlines).

d) Tertiary Surveys. (i.e.: Lot lines, construction surveys, etc).

B. Vertical

1. To establish and maintain vertical control within Jubail and Yanbu Industrial Cities, three orders of vertical control surveying have been mandated. These are:

a) Precise Leveling. (i.e.: Any monument established by geodetic methods shall also be a bench mark with an elevation established by this order).

b) Primary Leveling. (i.e.: Monuments set at intersecting street centerlines shall also be bench marks with elevations established by this order).

c) Secondary Leveling. (i.e.: All other bench marks set shall have elevations established by this order).

C. With this system of orders of descending horizontal and vertical control, it is mandatory that each order of control shall be based on the next higher order of control, and never in reverse.

3.05 ACCURACY FOR ALL ORDERS OF SURVEYS

A. Monuments will be installed for each order of surveying, using the criteria as shown in **Section 3.17** and to the accuracy as described herein:

1. Horizontal Control Surveys

a) Geodetic Horizontal Control Surveys

1) Geodetic horizontal control surveys shall have an accuracy of 1 part in 100,000 parts.

b) Primary Horizontal Control Surveys

1) Primary horizontal control surveys shall have an accuracy of 1 part in 50,000 parts.

c) Secondary Horizontal Control Surveys

1) Secondary horizontal control surveys shall have an accuracy of 1 part in 25,000 parts.

d) Tertiary Horizontal Control Surveys

1) Tertiary horizontal control surveys shall have an accuracy of 1 part in 10,000 parts.

2. Vertical Control Surveys

a) Vertical surveying shall use the criteria as shown in **Section 3.17** and to the accuracy as described herein. All elevations shall be in meters, using the Royal Commission datum.

1) Precise Leveling

(a) Precise level runs shall be closed loop circuits beginning and ending at a precise bench mark. The maximum allowable differential in return runs on any single run shall not exceed, in meters, an amount determined by the equation:

Maximum Differential in Meters = 0.004 x Square Root (Distance in Kilometers)

2) Primary Leveling

(a) Primary level runs shall be closed loops beginning and ending at a precise bench mark. The error in any level loop shall not exceed, in meters, the amount as determined by the following equation:

Maximum Differential in Meters = 0.008 x Square Root (Distance in Kilometers)

3) Secondary Leveling

(a) Secondary level runs shall be closed loops beginning and ending at either a precise bench mark or a primary bench mark. The error in any loop shall not exceed, in meters, the amount as determined by the following equation:

Maximum Differential in Meters = 0.012 x Square Root (Distance in Kilometers)

3.06 USE FOR EACH ORDER OF SURVEY

A. Geodetic Order Surveying

1. Survey shall be used to locate all on-shore boundaries of Jubail and Yanbu Industrial Cities, as well as the boundaries of the following areas:

a) Community Area.

b) Existing Industrial Area.

c) Airport Area.

d) New Industrial Area.

2. Monuments shall be placed at all corners, angle points and at approximately 1000 m intervals on tangents along these boundaries. Every Geodetic monument shall have geographic coordinates, UTM coordinates with scale factor, and Plant Grid coordinates.

B. Primary Order Surveying

1. Survey shall be used within Community Area to locate the boundaries of Districts that are developed. The boundaries shall be established and monumented on each corner (on land only), angle point and also at approximately 1000 m intervals along the boundary. Each point established shall be identified in PG coordinates.

2. Within Community Area, Airport Area and New Industrial Area all section boundaries shall be established and monumented at each corner, and at approximately 1000 m intervals along the boundary lines (on land only), using primary order surveying. Each point established shall be identified in PG coordinates.

3. All monuments established by primary order surveying shall have elevations established using Precise Leveling accuracy.

C. Secondary Order Surveying

1. Survey shall be used for further subdivision of Sections and Districts. Within Community Area, all sector boundaries and street centerlines and intersections shall be established and monumented, as well as block boundaries, using secondary order surveying. All points so established shall have PG coordinates.

2. Secondary order surveying shall be used for further subdivision of Existing Industrial Area, Airport Area and New Industrial Area. For each of these Districts, each street centerline and centerline intersection shall be established and monumented. A minimum of 2 monuments shall be established within each primary industrial site. All other Districts, including Support and Secondary Industries, shall have each block monumented, with PG coordinates established for each point. Each point, so established, shall have an elevation established in accordance with Primary Leveling criteria.

D. Tertiary Order Surveying

1. Survey shall be used for the final subdivision of Blocks into lots, plots or parcels for final usage. This covers all lot or plot boundaries within Community Area which shall be established and monumented. Each point shall have coordinates in PG. All the Royal Commission facilities (i.e., pump stations, storage reservoirs, rest areas, O & M Centers, etc.) shall have their boundaries

established and monumented, and each point shall have PG coordinates.

E. Secondary Leveling

1. Leveling shall be used to establish elevations for monuments which have been set using Tertiary order surveying, or for temporary construction bench marks.

3.07 OFFSITE HORIZONTAL CONTROL

A. The PG is to be used onsite only, and consequently, all offsite work shall be tied into the Universal Transverse Mercator (UTM) Grid (i.e., the Jubail-Dammam Mainline Railroad, offsite Freeways, offsite environmental sampling station, etc.).

B. Interface Between PG and UTM

1. All offsite control shall be in UTM, and all onsite control shall be in PG. The only interface between these two shall be the intersections of offsite street, street and railroad centerlines within the boundary lines of Jubail and Yanbu Industrial Cities. These points shall have both PG and UTM coordinates established.

3.08 DOCUMENTATION

A. Horizontal and Vertical Survey Control

1. A system of horizontal and vertical survey control is only as good as the retrieved information. To achieve this purpose, information must be recorded and filed in such a manner that it is identifiable and retrievable. The information falls into three categories as follows:

a) Field data (notes, descriptions, etc.).

b) Computations (closures, balances, etc.).

c) Recovery (descriptions, maps, inventories, etc.).

B. Survey Control Information

1. All surveying control information shall be under the control of Chief Surveyor. He shall be responsible for receiving, cataloging, storing and dispersing all survey control information. He shall establish a system under the following guidelines:

a) Field Data

1) All field measurements shall be recorded in field note books in a format as determined by the Chief Surveyor.

2) Each book shall be numbered and each page shall be numbered.

3) Each day’s work shall be indexed in the front of the note book, each page shall be dated, and the survey party members with their duties shall be listed, along with a brief description of the

weather and the temperature.

4) Only field data relating to one order of control shall be in any book.

5) No erasures are to be made, and corrections are to be made by single line cross out only.

6) All field books are to be cataloged.

b) Computations

1) All computations shall be in a format determined by the Chief Surveyor. Standard computation sheets shall be used and the names of the computer and checker, and the date shall appear at the top of the sheet.

2) Sketches, as required, shall be included, and the purpose and process of the computation clearly stated.

3) Computations performed by electronic computer shall be in a format approved by the Chief Surveyor. Programs shall be outlined and proven. A brief narrative shall accompany the print-out sheets to identify the computations and give sufficient direction so that they may be easily followed and checked.

4) All computations shall be in numbered binders or folders which are cataloged.

c) Recovery

1) The Chief Surveyor shall cause maps to be prepared for each order of control. These maps shall have plotted and identified each control point, giving the coordinates and elevation of each control point. Each map shall clearly indicate the area covered and what order of control the map sheet covers. Control shall be identified on the Royal Commission Drawing, with an attached list of monuments, giving Northings, Eastings, and elevations. These monuments shall be considered Secondary Horizontal Control and Secondary Vertical Control, unless otherwise noted on the referenced drawing. The control shown on this drawing is being constantly updated and should always be checked for the latest revision before using Control date thereon.

2) A card catalog of each control point shall be established. Each control point shall have an identifying alphanumeric code relating to District-Section or District. Each card shall contain a description of the point and a sketch showing ties if applicable. All coordinates shall be shown as well as the appropriate elevations. The note book number, as well as computation folder number shall also be shown on the card, in addition to such other information as required by the Chief Surveyor.

3.09 SUBDIVISION

A. General

1. This Section covers only the plan subdivision of land into Blocks, and division of Blocks into Lots, and the plotting thereof. It does not cover such items as electric power distribution, domestic water supply, sanitary and storm sewers, or telephone services, these items being covered in other Sections herein or in other disciplinary Design Guidelines. Nor are such things as fire protection, landscaping, hardscaping, traffic safety devices, zoning, land use or topographical layout included in this Section.

B. Land Allocation

1. Jubail Industrial City

a) Areas

1) All land within Jubail Industrial City has been divided into 5 areas, which are as follows:

(a) Al-Batinah Island.

(b) Community Area.

(c) Existing Industrial Area.

(d) Airport Area.

(e) New Industrial Area.

b) Sections and Districts

1) Existing Industrial Area, Airport Area and New Industrial Area are subdivided into tracts called Sections. The total surface area within each area is so subdivided, and includes offshore areas, the Kharsaniya Ras Tanura (KRT) ARAMCO Right-of-Way and any other features which may fall within the boundaries of the area.

2) Community Area is subdivided into tracts called Districts, and here again the total surface area, including offshore and pristine desert areas, is so subdivided.

c) Sector

1) Each District in Existing Industrial Area has its entire area further subdivided into from 4 to 7 Sectors to designate manageable size tracts for development. Districts “J” through “L” have not been further subdivided, as no development is presently planned for these Districts.

C. Blocks

1. All land within a Section or Sector, which is not part of a utility corridor, right-of-way or shoreline, is subdivided into Blocks. Blocks consist of land bounded by at least one street; the other boundaries may be utility corridors, right-of-ways, shorelines or open lands. Within Community Area, Blocks shall be bounded by at least one major road (Collector, Sub-collector or Local Street); the other boundaries may be a major or minor road (Local Street or Residential Road), utility corridor, and right-of-way, shoreline, open land or other Blocks.

2. If the entire Block is to be occupied by one facility (or user), there will be no further subdivision of the Block. But where the Block is to be occupied by more than one user, the Block is to be divided into lots, which are defined as the smallest piece of land to be used for a specific purpose. Additionally, all lots shall have frontage on at least one street.

3. Where a Block is so divided, all the land within the Block boundary lines must be one of the two designations:

    a) Lots.

    b) Right-of-ways.

4. Right-of-ways differ from easements in that a right-of-way denotes ownership in fee simply by the agency or utility who occupies it, whereas the ownership of an easement remains with owner of the tract. The grantee of the easement has only the right of ingress and egress. An example of a right-of-way is a street right-of-way which runs from property line to property line. The owner of a right-of-way may fence his right-of-way or otherwise restrict access to it, and may exercise all the other rights of fee ownership (complete ownership without encumbrances). Saudi Law does not recognize easements.

5. Blocks and Lots, as well as Sections, Districts and Sectors shall be identified by Block and Lot numbers, Section and District letters, and Sector alphanumbers.

6. All design, layout and computations for subdivision work shall be to a degree of accuracy in accordance with **Section 3.05**.

D. Plotting of Subdivisions

1. Plots (map of subdivision) shall be prepared by the A/E for all subdivisions which the A/E has designed. Such plot shall conform to the drafting standards as outlined in Chapter 13, Drafting Guidelines, and shall include the following:

    a) All subdivision plots shall be on E Size mylar.

    b) All final drafting, including the line work, lettering, symbols, etc. shall conform to Chapter 13, Drafting Guidelines, referenced above.

    c) All plots shall be oriented to Plant North, and with Plant North being straight up on the drawing and depicted by a Plant North arrow.

    d) A scale of not less than 1:500 shall be used. Each sheet shall give both a graphic scale as well as a scale ratio.

    e) The Plant Grid System (PGS) shall be used as a basis of layout, and all even kilometer grids shall be shown on the drawing.

    f) All sheets shall contain a key map/key plan.

    g) All lengths of lot lines, street widths, curve data and lot areas shall be given on each drawing. Curve data shall include locations of point of curvature (P.C.), point of intersection (P.I.), point of tangency (P.T.), length of arc, radius and interior angle.

h) All Sectors, District corners, changes in direction of Sectors or District boundaries, block corners, intersections of street center lines and the P.C.'s and P.T.'s of all curves shall have PGS coordinates shown on the plot. Additionally, the PGS coordinates for each lot shall be calculated and provided to the Royal Commission, in tabular form, either on the plot or on a separate sheet.

i) All Primary and Secondary Control Monuments which lie within the subdivision shall also be shown, along with appropriate PGS coordinates.

j) A Legend of all symbols used in mapping shall be shown on each drawing.

k) The Standard International (SI) system of measurement shall be used in all designs, plans, specifications, calculations and drawings.

3.10 HYDROLOGY AND DRAINAGE

A. General

1. Hydrologic and Hydraulic Engineering shall be required for the design of all surface (storm/run-off) and subsurface (ground water) drainage systems for Jubail and Yanbu Industrial Cities. Cognizant that many different Architect/Engineers will be contracted to design parts of the site drainage systems, the purpose of this Guideline is to limit the assumptions and to establish reasonable variations for those parameters needed for a complete drainage system design to assure compatible interfacing systems. This approach is expedient and considered valid for Jubail and Yanbu Industrial Cities because the topography, soil and climate is generally predictable for the entire site.

2. The areas to be drained are well defined physically, in that the finish grade elevation is relatively constant over the entire area, the soil classifications of the subsoil at various depths is relatively consistent and the depth of water below grade is relatively constant. In addition, climatologically, Jubail and Yanbu Industrial Cities are quite arid, as the occurrence of rain is not common.

a) The average annual rainfall at Jubail is 91 mm (21 year duration records), falling in short, and high intensity winter storms.

b) The average annual rainfall at Yanbu is 49 mm, but heavy rain has been known to occur in the area and cause flooding in low-lying areas.

B. Drainage Design Criteria

1. Rational Formula

a) All storm run-off designs and calculations shall be in accordance with the following criteria:

1) Run-off: The Rational Method

Formula: $Q = {}^{1}/_{360} * CIA$

Where:

Q = Run-off from a given area in cubic meter per second, m^3/sec.

C = Coefficient representing the ration of run-off to rainfall.

I = Intensity of rainfall, mm/hr.

A = Drainage area in hectares.

2) Time of Concentration (TC)

(a) The Time of Concentration (TC) consists of the inlet time plus the time of concentration of flow in the open channel or in the conduit from the most remote inlet to the point under consideration.

(b) The Time of Concentration (TC) shall be determined from **Table 3-A**, "Time of Concentration of Rainfall" for overland flow, or Scobey Charts for gutter flow times. Scobey Charts in reputable design handbooks, such as Seelyes, shall be used.

3) Rainfall Intensity (I)

(a) Rainfall intensity shall be as determined from **Table 3-B**, "Rainfall Intensity for Various Storm Durations and Return Periods for Jubail Industrial City," and **Table 3-B-1**, "Intensity-Duration-Frequency Curve of Rainfall for Yanbu Industrial City."

4) Run-Off Coefficient (C)

(a) Run-off factors shall be as determined from **Table 3-C**, "Run-off Factors." Composite factors shall be derived by direct ratio to areas being drained.

5) Drainage Area (A)

(a) The area to be drained shall be as measured on a topographic map, as determined from aerial photos or by a field survey.

3.11 HYDRAULIC DESIGNS

A. Hydraulics of channels, culverts and pipes shall be based on open channel flow, using Manning's Modified Formula; i.e., combined with Chezy Equation:

Formula: $Q = {}^{1}/_{N} * AR^{2/3}S^{1/2}$

Where:

Q = Discharge, m^3/sec.

A = Cross-sectional area of flow at right angle to direction of flow, m^2.

R = Hydraulic radius, m.

S = Slope or grade (gradient), m/m.

N = Coefficient of roughness, see **Table 3-D**.

1. Coefficient of Roughness

   a) As used in Manning's Formula, shall be as determined from **Table 3-D**, "Values for Coefficient, N, for Roughness of Channels."

2. Gradient and Wetted Perimeter

   a) The hydraulic gradients and wetted perimeter shall be controlled to avoid sedimentation and erosion. The minimum velocity at design flow shall be 0.60 m/s, and maximum velocity at design flow shall be 3 m/s.

3.12 DRAINAGE SYSTEMS

A. Primary System

1. Primary system shall be designed for a 50 year storm with provisions for storage run-off within a flood plain based on a 100 year storm and with the outfall completely tide locked. Channel to be lined and have zero freeboard for the 50 year storm flow, and maintain 0.30 freeboards for the minimum rough grading level at the edges of adjacent developed areas for the 100 year storm storage.

B. Secondary System

1. Secondary system shall be designed for a 25 year storm with zero freeboard. Intersections with primary systems shall be engineered using concrete protection.

C. Tertiary System

1. Tertiary system shall be designed for a 10 year storm, provided an emergency overflow outlet is available to prevent damage to any facility or structure. If no emergency overflow outlet is provided, the design period shall be determined on a cost benefit basis, but not to exceed a 25 year storm.

D. Auxiliary System

1. Swales and/or depressed areas, where flooding can be tolerated for short periods of time without adverse effect on any building, structure or facility such as parks, beaches, roadway medians, recreation facilities and open spaces, may be used. Architect/Engineers shall design capacity based on a 5 year storm; however, the capacity may be enlarged if used as temporary storage in conjunction with Primary System 100 year criteria.

3.13 DRAINAGE STRUCTURES

A. Culvert or Pipes

1. Closed culverts or pipes, which are circular, shall not be less than 300 mm in diameter. Any configuration other than circular shall have no dimension less than 300 mm.

B. Materials

1. Materials utilized within storm drainage systems shall be of quality which is resistant to both soil conditions and the liquid to be handled. Refer to Chapter 12, Corrosion Control.

3.14 STORM DRAINAGE CALCULATIONS

A. Calculations for storm drainage shall be submitted in the format shown in **Table 3-E**, "Storm Drainage Calculations."

3.15 SUBSURFACE DRAINAGE REQUIREMENTS

A. General

1. Subsurface drainage shall be provided for those areas where it becomes necessary to control perched water or ground water elevations (e.g., foundation walls, cut areas, landscape areas, etc.).

B. Design Requirements

1. Requirements for hydraulic designs shall be based on the following:

a) Soil permeability, as determined from the following percolation rates:

Material	mm/hr
Marl	0
Dense Sand (Compacted)	150
Loose Sand (Natural State)	300
Sabkhah	25

b) Area to be drained, as based on site evaluation and exploration.

c) Anticipated head.

d) Underdrain to be sized for open channel flow, using criteria defined in **Section 4.18** of Chapter 4, Roads.

e) No underdrain shall have a diameter of less than 100 mm for circular sections or any dimension of less than 200 mm for any other section.

C. System Design

1. System design should be combined with practical considerations to assure satisfactory performance under actual field conditions, including the following:

a) Joints shall be constructed in such a manner by utilization of opening size, gaskets and/or filter media that the surrounding soil will not enter the underdrain itself.

b) The maximum length between cleanouts or access holes shall be 100 m.

c) All subsurface drains shall have a free-flowing positive outlet. Use of blind drains, French drains or any other configuration which does not have a positive conduit will not be permitted due to potential for sediment build up.

3.16 DESIGN FEATURES

A. Channels and Culverts

1. Channel and culvert materials of construction shall be selected to accommodate design capacity peak discharge, as determined by Design Criteria in **Sections 4.14** to **4.18** of Chapter 4, Roads, for minimum maintenance and to control erosion and/or silting. Details for the type of drainage structures proposed shall be selected from the Guideline Detail provided by the Royal Commission. Specifications for the materials used shall be in accordance with applicable Guideline Specification SECTION 02630 “Storm Drainage,” and related Sections specified therein. Also Refer to Chapter 12, Corrosion Control.

B. Buried Structures and Pipe

1. For buried structures and/or pipe required to support pavements, railroads, module path, etc., above it, the Architect/Engineer will be furnished with the design live load criteria. The selection of the type of buried conduit, depth of cover, bedding requirements, compaction, etc., shall be the responsibility of the Architect/Engineer. The following shall be considered during the design phase:

a) Procurement

1) Procurement shall be all in-Kingdom manufactured products.

b) Subsurface Exploration

1) Data shall be as prepared by the Architect/Engineer’s Soil Consultant.

c) Construction Restraints

1) Existing roads and/or engineered works, for example, may require use of a sleeved crossing. Where required, Architect/Engineer shall prepare design in accordance with Guideline SECTION 02585 “Underground Utility Pipe Sleeves.” Also refer to Chapter 12, Corrosion Control.

d) Construction Loads

1) Minimum design cover requirement is not always adequate during construction. When construction equipment, frequently heavier than traffic live loads for which the conduit has been designed, is to be driven over or close to the buried structure, it is the responsibility of the Contractor to provide additional cover required to avoid damage to the conduit.

C. Headwalls, Inlet-Structures and Manholes

1. The Architect/Engineer shall determine when these or similar structures are needed, based on the design criteria, structural integrity and/or hydraulic efficiency. Wherever possible, the Architect/Engineer shall utilize a type of structure shown in the Royal Commission Guideline Details. However, for items of hardware which will be, through normal wear and tear, replaced periodically by regular maintenance procedures, these Guidelines shall be used.

D. Channel Linings

1. Selections of cross-section for each channel shall be as required by Hydraulic design, and the material for the channel lining shall be determined from **Table 3-F**, “Channel Lining Materials for Drainage Culverts,” based on an economical evaluation.

E. Outfalls

1. Primary outfall conditions vary, depending upon whether the approach to the sea is in open channel or culvert construction and whether the discharge will take place at beach, revetment or wall situations. Culvert approaches are recommended where the outfall passes beneath, and/or discharges close to, paved roads or other coastal developments. Channel conditions may be maintained right to the outfall where the channel is routed through open undeveloped ground adjacent to the beach. The beach shall also be protected from erosion due to the heavy flow due to peak outflows. The outfall in the industrial areas shall also include provisions for closure to prevent intrusion of high tides. Type and method of operation shall be included in Architect/Engineer’s conceptual designs.

2. Secondary Outfall discharges will, in many circumstances, is similar but generally smaller than the primary discharges. The secondary outfall may, therefore, follow a similar arrangement to that of the primary outfall; but to avoid too many surface water discharges across the beaches, the secondary outfalls should be culverted across the beaches to discharge beyond the low water line; i.e., the Royal Commission Datum elevation 0.00.

3.17 STANDARDS OF ACCURACY

A. Scope

1. This Section prescribes the requirements for standards of accuracy for all horizontal and vertical control surveying which is done in Jubail and Yanbu Industrial Cities. All surveying must be done in accordance with the provisions of these Sections, as well as in accordance with the provisions of **Section 3.01**.

B. Horizontal Control

1. The Standards of accuracy for horizontal control are given for the three types of horizontal control surveying as follows:

   a) Triangulation: **Table 3-G**.

   b) Trilateration: **Table 3-H**.

   c) Traverse: **Table 3-I**.

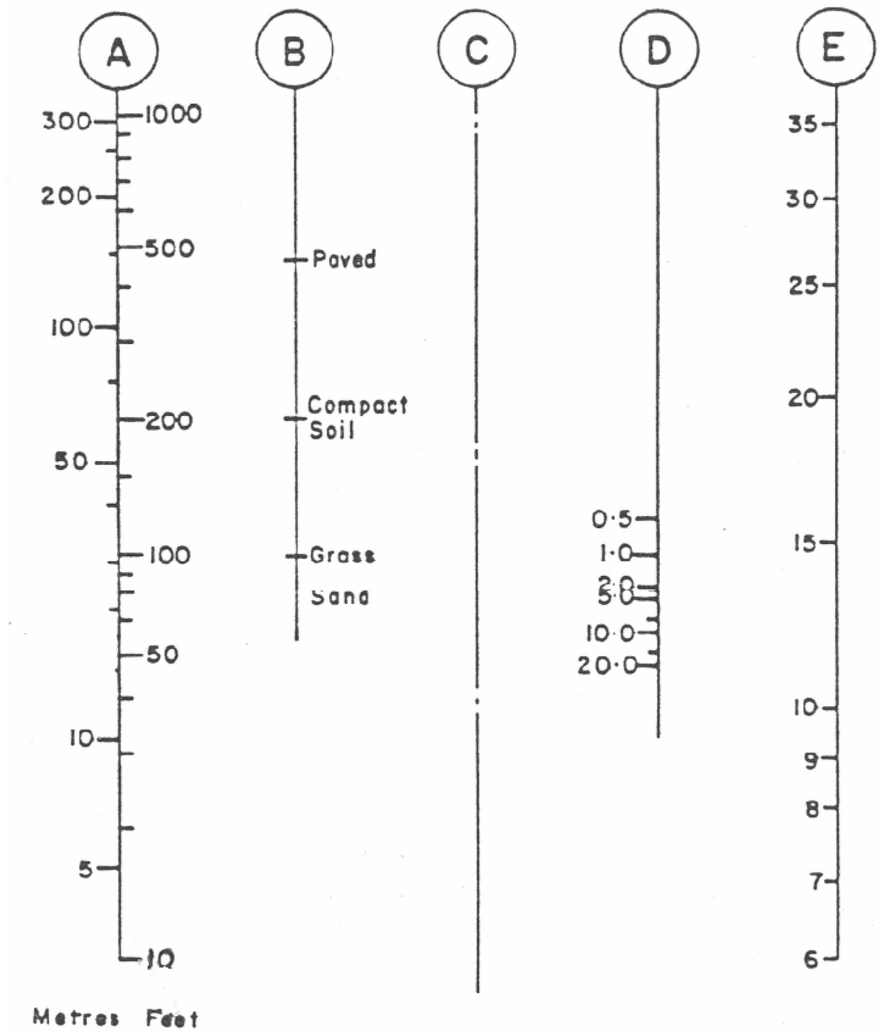
2. The notes that apply to these three types of horizontal control surveying are listed in "**Notes for Tables 3-G, 3-H and 3-I**" on pages 3-26 to 27.

C. Vertical Control

1. The Standards of accuracy for vertical control surveying are given in **Table 3- J**, "Standards of Accuracy for Vertical Control."

3.18 TABLES

TABLE 3-A: TIME OF CONCENTRATION OF RAINFALL



Legend

(A) Overland flow - Metres/Feet

(B) Character of ground

(C) Pivot line

(D) Percent slope - Percent

(E) Time of concentration - Minutes

TABLE 3-B: RAINFALL INTENSITY FOR VARIOUS STORM DURATIONS AND RETURN PERIODS (JUBAIL INDUSTRIAL CITY)

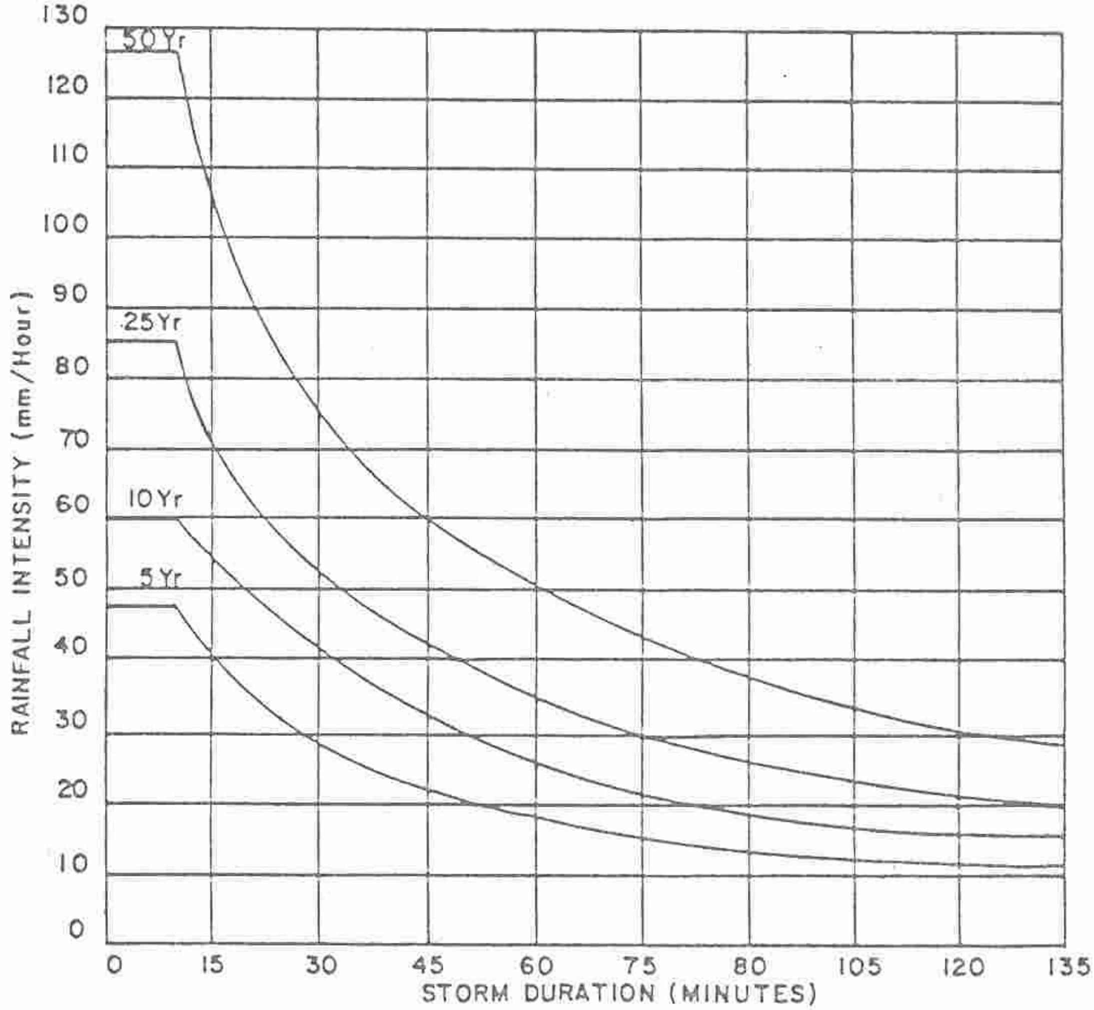


TABLE 3-B-1: INTENSITY-DURATION-FREQUENCY CURVE OF RAINFALL (YANBU INDUSTRIAL CITY)

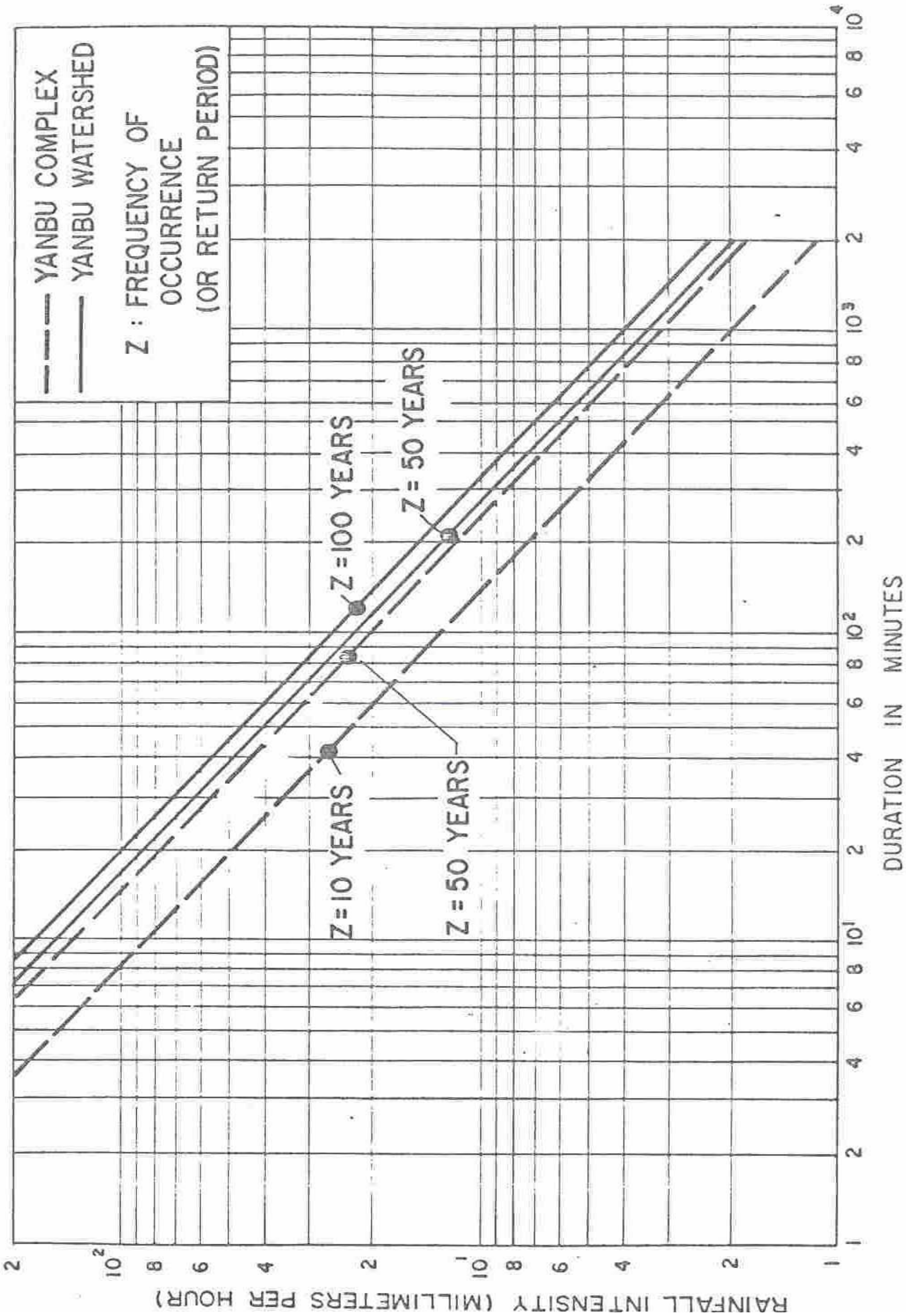


TABLE 3-C: RUN-OFF FACTORS

CLASSIFICATION OF DEVELOPED AREAS	STORM RETURN PERIOD	
	5 YEAR	100 YEAR
Residential Areas	0.60	0.65
District Centers	0.65	0.70
Flood Plains (Landscaped)	0.50	0.55
Flood Plains (Graded)	0.45	0.50
CLASSIFICATION OF PARTICULAR SURFACES		
Asphalt Pavement	0.85	0.95
Concrete Pavement	0.80	0.90
Impervious Soil (Marl)	0.60	0.65
Impervious Soil with gravel	0.50	0.55
Pervious Soil with gravel	0.35	0.40
Pervious Soil (Natural)	0.25	0.30
Pervious Soil with grass	0.20	0.20

TABLE 3-D: VALUES FOR COEFFICIENT, N, FOR ROUGHNESS OF CHANNELS

TYPE LINING	MANNING'S "N"
Concrete - Pipes	0.013
Concrete - Cast-in-place	0.015
Sulphur A/C Pavement	0.018
Rip Rap, Large-Hand Placed	0.030
Rip Rap, Small-Dumped	0.035
Earthen - Marl	0.040
Earthen - Grass Covered	0.050

TABLE 3-E: STORM DRAINAGE CALCULATIONS

Project________________					Area_________					Sheet_____of_____				
Structure		Contribute Area	ΣArea	Run-off Factor	Time of Concen-tration		Intensity mm/hr	Quantity	Gradient %	Section Size, m^2	Hydraulic Radius	Invert Elevation		Velocity, m/s
From	To				Δt	Σt						Inlet	Outlet	

TABLE 3-F: CHANNEL LINING MATERIALS FOR DRAINAGE CULVERTS

Acceptable Lining System	Sulphur Concrete (Plain)	Sides, Asphalt Concrete	Rip Rap Gravel or Grass Bottom	Marl and Covered Swales
Primary – Standing Water Permitted for Storage Purposes	Yes	No	No	No
Primary – No Standing Water Permitted	Yes	Yes	No	No
Secondary	Yes	Yes	Yes	No
Tertiary	Yes	Yes	Yes	Yes
Auxiliary	No	No	Yes	Yes

TABLE 3-G: STANDARDS OF ACCURACY FOR HORIZONTAL CONTROL – TRIANGULATION

ORDER	GEODETIC	PRIMARY	SECONDARY	TERTIARY
Strength of Figure [1]				
R_1 between bases				
Desirable limit	20	60	60	80
Maximum limit	25	80	120	130
Single Figure				
Desirable limit				
R_1	5	10	15	25
R_2	10	30	70	80
Maximum limit				
R_1	10	25	25	40
R_2	15	60	100	120
Base Measurement Standard Error [2]	1 part in 1,000,000	1 part in 900,000	1 part in 800,000	1 part in 500,000
Horizontal Directions [3]				
Instrument	0”.2	0”.2	0”.2 or 1”	1”
Number of positions	16	16	8 or 12	4
Rejection limit from mean	4”	4”	5” 5”	5
Triangle Closure				
Average not to exceed	1”	1”.2	2”	3”
Maximum seldom to exceed	3”	3”	5”	5”
Side Checks In side equation test, average correction to direction not to exceed	0”.3	0”.4	0”.6	0”.8
Astro Azimuths [4]				
Spacing-figure	6 – 8	6 – 10	8 – 10	10 -12
No. of observation/night	16	16	16	8
No. of nights	2	2	1	1
Standard error	0”.45	0”.45	0”.6	0”.8
Vertical Angle Observations [5]				
Number of and spread between observations	3 D/R – 10”	3 D/R – 10”	2 D/R – 10”	2 D/R – 10”
Number of figures between known elevations	4 - 6	6 - 8	8 - 10	10 - 15
Closure in length [6] [also position when applicable] after angle and side conditions have been satisfied, should not exceed	1 part in 100,000	1 part in 50,000	1 part in 25,000	1 part in 10,000

See **Notes for Tables 3-G, 3-H and 3-I** on pages 3-26 to 27.

TABLE 3-H: STANDARDS OF ACCURACY FOR HORIZONTAL CONTROL – TRILATERATION

ORDER	GEODETIC	PRIMARY	SECONDARY	TERTIARY
Geometric Configuration Minimum angle contained within, not less than	25°	25°	20°	20°
Length of Measurement Standard error (2)	1 part in 1,000,000	1 part in 750,000	1 part in 450,000	1 part in 250,000
Vertical angle observations (5) Number of and spread between observations	3 D/R – 10”	3 D/R – 10”	2 D/R – 10”	2 D/R – 10”
Number of figures between known elevations	4 - 6	6 - 8	8 - 10	10 - 15
Astro Azimuths (4) Spacing-figures No. of observations/night No. of nights Standard error	6 – 8 16 2 0”.45	6 – 10 16 2 0”.45	8 – 10 16 1 0”.6	10 – 12 8 1 0”.8
Closure in position (6) after geometric conditions have been satisfied should not exceed	1 part in 100,000	1 part in 50,000	1 part in 25,000	1 part in 10,000

See **Notes for Tables 3-G, 3-H and 3-I** on pages 3-26 to 27.

TABLE 3-I: STANDARDS OF ACCURACY FOR HORIZONTAL CONTROL – TRAVERSE

ORDER	GEODETIC	PRIMARY	SECONDARY	TERTIARY
Horizontal Directions (3)				
Instrument	0”.2	0”.2 or 1”	0”.2 or 1”	1”
Number of observations	16	8 or 12	6 or 8	4
Rejection limit from mean	4”	4” 5”	4” 5”	5”
Length of measurements				
Standard error (2)	1 part in 600,000	1 part in 300,000	1 part in 120,000	1 part in 60,000
Reciprocal vertical angle Observations (5)				
Number of and spread between observations	3 D/R – 10”	3 D/R – 10”	2 D/R – 10”	2 D/R – 10”
Number of stations between known elevations	4 - 6	6 - 8	8 - 10	10 - 15
Astro Azimuths				
Number of courses between azimuth checks (7)	5 – 6	10 -12	15 – 20	20 - 25
No. of observations/night	16	16	12	8
No. of nights	2	2	1	1
Standard error	0”.45	0”.45	1”.5	3”.0
Azimuth closure at azimuth check point not to exceed (8)	1” per station or 2” √ N	1”.5 per station or 3” √ N	2” per station or 6” √ N	3” per station or 10” √ N
Position closure (6) (8) after azimuth adjustment	0.04 m √ K or 1 : 100,000	0.08 m √ K or 1 : 50,000	0.2 m √ K or 1 : 25,000	0.4 m √ K or 1 : 10,000

See **Notes for Tables 3-G, 3-H and 3-I** on pages 3-26 to 27.

NOTES FOR TABLES 3-G, 3-H AND 3-I

Note (1): The relative strength of figure can be evaluated quantitatively in terms of factor R based on the theory of probability; the lower the value R, the stronger the figure. The following brief statement gives the essential relations for computing R.

Let C = number of conditions to be satisfied in figure.

n = total number of lines in figure, including known line.

n_1 = number of lines observed in both directions, including known lines, if observed.

s = total number of stations.

s_1 = number of occupied stations.

D = number of directions observed (forward and/or back), excluding those along known lines.

$\delta A, \delta B$ = respective logarithmic differences of the sines, expressed in units of the sixth decimal place, corresponding to a change of 1 second in the “distance angles” A and B of a triangle. The distance angles are those opposite the known side and the side required.

$(\delta A^2 + \delta A\,\delta B + \delta B^2)$ = summation of values for the particular chain of triangles through which the computation is carried from the known line to the line required.

Then $C = (n_1 - s_1 + 1) + (n - 2s + 3)$

$$R = \frac{D - C}{D}(\delta A^2 + \delta A\,\delta B + \delta B^2)$$

Note (2): The standard error is to be estimated by:

$$\delta m \sqrt{V^2 / n(n-1)}$$

Where:

δm = is the standard error of the mean.

V = is a residual (that is, the difference between a measured length and the mean of all measured lengths of a line).

n = is the number of measurements.

The term “standard error” used herein is computed under the assumption that all errors are strictly random in nature.

Note (3): The figure for “Instrument” describes the theodolite recommended in terms of the smallest reading of the horizontal circle. A position is one measure, with the telescope both direct and reversed, of the horizontal direction from the initial station to each of the other stations.

Note (4): The standard error for astronomic azimuths is computed with all observations considered equal in weight (with 75% of the total number of observations required on a single night) after application of a 5-second rejection limit from the mean geodetic and primary observations.

Note (5): These elevations are intended to suffice for computations, adjustments, and broad mapping and control projects, not for vertical network elevations.

Note (6): Unless the survey is in the form of a loop closing on itself, the position closures would depend largely on the constraints or established control in the adjustment. The extent of constraints and the actual relationship of the surveys can be obtained through either a review of the computations, or a minimally constrained adjustment of all work involved. The proportional accuracy or closure (i.e. 1/100,000) can be obtained by computing the difference between the computed value and the fixed value, and dividing this quantity by the length of the loop connecting the two points.

Note (7): The number of azimuths for geodetic traverse are between Laplace azimuths. For other survey accuracies, the number of courses may be between Laplace azimuths and/or adjusted azimuths.

Note (8): The expression for closing errors in traverses is given in two forms. The expression containing the square root is designed for longer lines where higher proportional accuracy is required.

The formula that gives the smallest permissible closure should be used.

N is the number of stations for carrying azimuth.

K is the distance in kilometers.

TABLE 3-J: STANDARDS OF ACCURACY FOR VERTICAL CONTROL

ORDER	PRECISE	PRIMARY	SECONDARY
Instruments standards	Automatic or tilting levels with parallel plate micrometers; invar scale rods	Automatic or tilting levels with optical micrometers or three-wire levels; invar scale rods	Geodetic levels and rods
Field procedures	Double-run; forward and back-ward, each section	Double-run; forward and back-ward, each section	Double or single-run
Section Length	1 - 2 km	1 - 2 km	1 - 3 km for double-run
Maximum length of sight	50 m	60 m	90 m
Field Procedures			
Maximum difference in lengths			
Forward and backward sights per set up	2 m	5 m	10 m
Per section (cumulative)	4 m	10 m	10 m
Maximum length of line bet. connection	300 km	50 km	25 km double-run 10 km single-run
Maximum closures			
Section: forward and backward	3 mm √ K	6 mm √ K	10 mm √ K
Loop or line	4 mm √ K	8 mm √ K	12 mm √ K

Note K = distance in kilometers