1 Basic studies: Technical

1.1 System diagnosis.

1.1.1. Detailed diagnosis of the situation in the municipality.

The contractor must include within the products of the contract a diagnosis of the current conditions in the field of public health, the state of natural resources, and social welfare. The physical, economic and social conditions of the municipality and the area intended for the intervention should be described. In the same way, a diagnosis should be presented on the general state of the provision of public services, in relation to coverage, continuity, efficiency and quality.

1.1.2. Determining the affected population

The contractor must determine within the products of the contract the information regarding the population directly or indirectly affected, as well as the target population due to benefit from the implementation of the project, who will be the subject of the calculations necessary to define the population within the project design period. In order to establish a baseline, reliable information should be sought from official entities related to the topic.

Population demographics should be collected, especially the DANE population censuses and available censuses of sewage system subscribers, and other public services in the locality or in similar localities. Based on the above data, the parameters that determine population growth should be obtained.

1.1.3. Socio-cultural characteristics of the population and community participation.

The contractor must include within the products of the contract information about the social and cultural conditions of the target population, based on primary and/or secondary information. This information must contain at least specific characteristics, such as special conditions of the population, spatial distribution, stratification, population density and expected population growth, periods of the year that produce increases in the floating population, income levels and prevailing economic activities, as well as growth and trends in industrial and commercial development. In the same way, key aspects that determine decisions must be identified in the project's approach, related to customs, beliefs, and roots in the landscape and the natural resources, among others.

1.1.4. Quantification of demand and/or needs.

The contractor must establish within the products of the contract the methodology by which the current and future demands of the system are established, the above in accordance with the POT, the PGIRS and/or other municipal planning tools, with the aim of estimating the necessary capacity of the works to be built and the future expansions that each of the components will require.

In order to carry out the population and demand studies, the contractor should perform the analysis and confrontation of all the information available on estimates of population growth and water consumption in the study area, adjusted to the Territorial Land use Plan. Based on this information, a socio-economic development scheme will be defined to allow the future population to be established with its respective current and future stratification, as well as their probable spatial territorial location in each analysis period.

In addition, the following detailed activities must be carried out:

Information on existing urban developments, new and projected urban developments, subnormal developments and, in general, the different uses of soils present in these areas, must be collected, reviewed and represented in plans, and all this must be presented in accordance with the municipal regulations in force regarding land use.

A detailed assessment should be made of the occupied areas based on recent aerial photographs, plans and information from the IGAC and DANE, which should be supplemented and updated by field surveys.

The estimation of the current population and its spatial distribution will be carried out, and annual and five-year projections of the future population and their probable territorial distribution will be made. With this information the number of houses and homes in the study area should be projected.

1.1.5. Knowledge of existing infrastructure

1.1.5.1. Information collection and analysis

The contract must, on its own account and risk, collect and consult the existing information on the sewage service, and that which is relevant regarding the forms of sanitation used in the municipality, and that which is in the possession of the Territorial entity, the provider of public services, the Regional Autonomous Corporation, the Ministry of Housing, City and Territory – MVCT, the Agustín Codazzi Geographical Institute, Non-governmental organizations working, intervening or present in the project area, as well as additional information available in other local, departmental, regional and/or national entities, in order to be used as a reference for the creation of the project.

Information should be collected from existing studies, operation and maintenance logs, construction reports, flow rate records, corrosion information, geological, topographic and hydrologic information, etc. Once the information is analyzed, the preliminary inspection is defined.

Field-diagnosis activities including measurement of independent or simultaneous variables (depending on the type of infrastructure to be evaluated) should be incorporated and documented at different points of operation. This information should be verified with the operating information, and compared to what would be its "initial state" in order to evaluate the decrease in capacity.

In addition, the condition of the constructed networks must be documented in a geographic information system, technically called the register of network.

Critical areas that may require rehabilitation should be identified.

In addition, they should compile information on the population and conditions and/or ethnic characteristics thereof (if applicable), number of dwellings, type of dwellings, and ownership of the land on which the population is located (for example if they are located on land belonging to the population, on vacant lots, on collectively owned land, indigenous reservations, etc.), previous consultations, water infrastructure and existing sanitation, water quality provided for human consumption and discharged by the sanitation infrastructure, protected areas, ethnic minority territories, identification of required environmental procedures, morbidity and mortality and other relevant aspects associated with water supply for human consumption and basic sanitation; in order to make an analysis of the problems and identify viable technical and economic solutioin alternatives; and if the previous information does not exist or is insufficient for the Contractor, they must create it as part of the study of population and demand.

Based on documentary and office research along with the data obtained through field research and work, the contractor will give a description of the most important aspects that characterize the project area, from the following points of view:

Physical aspects: Geographical location, limits, communication routes, hydrology, climatology, soil types, topography, cartography, geology, building materials, road surfaces, urban layout, potential risk areas, etc.

Socioeconomic characteristics: Current population, stratification, NBI Index, population in severe poverty, land uses, social conditions, public health, educational aspects, civic organizations, income level, availability of human resources and materials in the region, etc.

The contractor must take into account for the creation of the project all the studies and designs for municipal and regional projects, that are directly and indirectly related to the Development Plans of the Municipality, Territorial Land Use Plan-POT, existing sewage designs, disaster prevention studies and risk areas, land registry studies, previous design studies.

In addition, they must search for and collect information about networks of other public services that are provided in the area, such as water, electricity, gas and telephone.

The contractor must be aware of the current regulations and plans of the Municipal, Departmental, Regional and National order that are related to this project.

Obtain and revise the property plans and urban plans of the study areas, as well as those of constructed and/or projected networks, to determine the corresponding drainage areas and the respective technical data.

Obtain existing studies and designs in other public service entities, official or private entities that benefit and/or may affect the designs of the sanitary and rainwater sewage networks at the target site for the contract.

Obtain the diagnosis of networks of other public services of electricity, natural gas, water, etc. that can generate interference with the sewage networks envisaged for design.

Assess whether the sectors envisaged for design are located in areas of high, medium or low threat or risk, defined by the environmental authority or the competent body; it should also be assessed whether the sectors intended for design are in the patrol areas and zones of environmental management and preservation of water bodies or forest reserve areas.

The contractor must evaluate in the field if there are sufficient work corridors to trace the alignments of the pipes, always trying to take these through zones of public space or public roads, and if there is no possibility of this they must diagnose the amount of properties or easements that must be acquired.

In addition to the foregoing, the contractor must carry out a detailed collection of information associated with:

a) Cartography

The available cartography will be obtained from secondary sources such as reports or studies of EOT, POT or the municipal development plan for the corresponding municipality, as well as the local territorial entities such as municipal secretaries.

In the same way they can consult entities such as IGAC, DANE, SIGOT, National Parks, Ministries, IDEAM, CAR's and/or competent environmental authorities and other public bodies who possess cartographic information of the area of possible intervention and its surroundings, including the catchment basins for water provision, and the areas to receive drainage from the area of possible intervention.

In the cartography collected at least the following should be located and identified:

- The location of the project, identifying the department, municipality, village.
- Approximate area for possible intervention
- Areas of environmental restriction extracted from EOT, POT or environmental and territorial management plans. It should be established if there is any overlap of the restricted areas with the area of possible intervention.

b) Demography

Available demographic information will be obtained from secondary sources such as reports or studies of EOT, POT or the municipal development plan for the corresponding municipality, as well as the local territorial entities such as the municipal secretaries, SISBEN, DANE, among others; so that they can establish the total population, that which is directly benefited, the structure of the population according to age groups, schooling, sex. Description of the population and their conformation by groups, social and ethnic status.

c) Spatial information

Based on the information available from secondary sources such as reports or studies of EOT, POT or the municipal development plan for the corresponding municipality, as well as local territorial entities such as municipal secretaries, the characterization will be carried out for:

- Public services provided in the possible intervention area of the project, such as: aqueduct, sewage system, solid waste management, electrical energy and telecommunications.

- Health services, housing, education provided in the possible intervention area of the project, in the municipality, and in the possible area of influence.

- Means of transport existing in the area of possible intervention and influence of the project, identifying all the means of transport present, and the state of the infrastructure, such as roads, ports, as well as of the vehicles that provide the service.

- Uses of natural resources and especially the water.

- Presence of ethnic communities, with the description of occupied territories, population, traditional productive activities carried out, technology and market. Social organization with collective regulations and traditional, local and legally recognized authorities.

d) Land registry

Based on the information available from secondary sources such as reports or studies of EOT, POT or the municipal development plan for the corresponding municipality, as well as local territorial entities such as municipal secretaries, information will be collected that characterizes at least the following basic property issues:

- Identification of the properties located in the project area.
- Description of the legal situation of the properties identified in the possible intervention area.
- General alphanumeric and cartographic informatiom regarding the size of the properties.

e) Climatology, Meteorology and Hydrology

Available climatological and meteorological information will be obtained from secondary sources such as reports or studies of EOT, POT or the municipal development plan for the corresponding municipality, as well as local territorial entities such as municipal secretaries.
Available climatic information should be collected and analyzed from the stations closest to the area of possible intervention, to enable the climatological characterization of the area if possible, and establish rainfall patterns.

- The availability of hydrological information for the creation of the project profile will be reviewed.

f) Social Management

The contractor will arrange with the audit, the municipality, the company providing public services, and Findeter, the different mechanisms for the private call, and the places where the different activities for the presentation of the project and/or educational activities will be carried out.

The contractor will design as educational support material, brochures and/or posters, which contain the topics to be worked on during the educational strategy, taking into account the technical specifications given by the audit. The contractor will present the respective reports requested by the audit, with their respective supports and/or evidences.

Given the importance of unifying criteria to interact with the community and municipal authorities, in common agreement with the audit, the contractor will prepare a social management plan in the municipality and its populated centers that basically should include a strategy to interact with the community, the educational strategy both for the management of the construction stage of the work, and for the current contract stage. Training should be included for the number of system operators necessary.

The Social Management Plan will be approved by the audit.

g) Environmental issues

The contractor must prepare all the necessary documentation so that Empresas Publicas in the municipality support the public service providers and/or municipal authorities and these apply to the Regional Autonomous Corporation of each of the municipalities, for the permits, concessions and authorizations required by law for the use and utilization of renewable natural resources or for carrying out activities that affect or may affect the environment, in order to comply with the environmental regulations in force.

h) Topography conditions

A review of existing studies will be carried out, with the objective of selecting the areas of intervention, so that they may be taken into account within the analysis of information that enables the establishment of the conditions of the general physical sites, and define potentially suitable areas for carrying out the project.

i) Diagnosis of the system in the area of influence of the project.

The comprehensive diagnosis should recognize and contain local information about the uses, customs and traditions regarding the basic forms of sanitation of the population, the existence of infrastructure and historical schemes in the provision of the service, and it should also include studies of capacity and payment availability of the population.

The diagnosis should refer to relevant secondary information such as available studies, Territorial Land Use Plan (POT), Municipal development plan, Basin regulation and management plan (if any), Protected area management plan (if it exists), statistics of morbidity and mortality, information from the education sector, results of the SISBEN, United Network, socioeconomic stratification, and other relevant information available in the municipality and other entities.

A diagnosis will be made of each and every one of the elements that compose the sewage system in the area of influence of the project. For this purpose, a technical identification and description of these components, their dimensions, their functioning, their condition, and their problems must be carried out. The whole diagnosis must be carried out taking into account the technical, economic, financial, institutional, social and environmental approaches.

The diagnosis and evaluation of the systems, mentioned above, and which are associated with the area of influence of the project, must be based on the identification, quantification and prioritization of the current problem, with the specific objective of prioritizing it in time and establishing the necessary solutions, pre-dimensioning and quantifying them for the immediate, short, medium and long term, understanding as long term the time corresponding to the design period of the project in accordance with the technical regulations in force.

Likewise, the diagnosis to be carried out should consider the effect of the discharge of wastewater along the roads of the municipality (where this occurs) with the risks that this implies in water quality and the health of the population, in such a way that the proposals are harmonized with environmental recovery projects.

In the area of influence of the project the contract must carry out a characterization and evaluation of the functioning and capacity of the sewage systems, based on records made by the service operator during the last year, and if necessary carry out inspections or tests in coordination with the operator and with the available infrastructure and equipment, identifying its basic characteristics, capacity, functionality and physical condition.

Where the following elements exist in the systems, the diagnosis thereof must include at least the following information:

- Catchment elements: Name (s), location, type (wastewater or rainwater), maximum and minimum volumes, hydraulic characterization, constituent elements of sewage networks.

- Visiting and inspection systems: type, location, characteristics, capacity, physical condition, operating conditions.

- Transport system of wastewater: location, if it is by gravity or by pumping, length, type and diameter of the pipes, capacity of transport in the case of box sewers, condition and antiquity. If it is by impulsion, indicate the characteristics of pumping stations such as: location, number of pumps, flow rate, physical condition, location, power, type, configuration, operating levels, suction-impulsion characteristics and features of main accessories, state of the electrical connection for the same or other.

- Wastewater Treatment Systems: location, type, treatment system, capacity, physical condition, discharge structure and quality of the same.

For diagnostic purposes, the contractor must present and determine the design parameters of the sewage systems (combined or separate). Include analysis of population and demand, selection of level of complexity, period and design flow rate for each component, and other guidelines and design parameters established in the current RAS; as well as the criteria related to the quality of the sources or receiving bodies of the discharges for the effluent of the wastewater treatment plants.

Based on the Master Plan Studies of the Sewage System, and the information investigated at the preliminary stage, the hydraulic diagnosis must be carried out, the quality of the discharges and impacts on the receiving bodies, and in general all aspects concerning the operation of collectors and interceptors and pumping systems. The contractor must carry out a review of the design flow rates envisaged in these studies.

Among other analyses, revise the adjustment of the theoretical flow rates versus the real ones in terms of wastewater generated by the domestic, commercial and industrial consumption (if that is the case), the presence of combined flow rates, either by presence of rainwater flow rates due to the effect of erroneous flow rates of the rainwater system, or because the system was defined from the outset as combined. Additionally, it must take into account the quality of the water in the reliefs provided at the receiving bodies, and its impacts on this water body downstream of the discharge, and compliance with the PSMV.

1.1.5.2. Systems Analysis

This Phase considers detailed research in problematic areas, conducting inspections to accurately determine faulty sections and types of damage.

With the diagnosis on the infrastructure, actions for rehabilitation, repositioning, optimization and/or enlargement must be considered.

To define infrastructure and equipment rehabilitation programs, the following criteria must be taken into account:

• Deterioration of infrastructure and equipment with age and use, for which infrastructure aging models should be implemented, in order to support decisions based on a system of asset management and risk management.

• Frequent causes of repair, determined by signals such as: customer complaints, leakage and/or damage to water systems, infiltration-exfiltration problems in sewage systems, recurrent failures in the wastewater collection vehicles, upwelling and/or leakage of leachates in landfills, alerts in monitoring systems, etc.

• Decision-making on expansion and capacity-building of systems leading to a proactive rehabilitation.

• The incidence of external factors that affect the rehabilitation strategy, for example through decisions made by a regulatory agent, or related ministries.

a) Hydraulic behavior of the existing drainage system

With the information obtained in the hydrological study, the contractor will have to carry out an evaluation of the urban drainage: rainwater, which runs through the municipality or populated center, including the identification and quantification of channels, interceptors and collectors to be valued within the studies of the contract.

For identifying the wastewater the information obtained in the diagnosis will be used, and that which is established by the regulations in force.

The contractor will review, evaluate and present an analysis of existing studies and projects, identifying collectors, interceptors and final sewage outlets constructed; describing and indicating in plans the quantities, lengths, capacities, hydraulic characteristics, structural components of the system and the basic characteristics of the currents, structures, sections, or receiving water bodies.

The contractor must identify the areas susceptible to flooding and evaluate the possible effects on the different structures of the system that could be affected by flooding, calculating the periods of return permitted by the system, required and indicated by the regulations, and the necessary protection measures must be established and designed to mitigate these impacts.

Studies and analysis for the collection and disposal system of wastewater and/or rainwater, which the contractor is required to carry out, must include:

- ✓ General description of the current system and operating conditions, structural state of the same and operation and maintenance costs of the system, reliability and vulnerability. All of the above taking into account also the projects that are in execution at the time of this contract.

- ✓ Integrality of the urban drainage.

- ✓ Determine whether there is a plan for ordering and managing the catchment area, the quality of the water must be determined from the effluent of the wastewater treatment plant or from existing discharge points, and a description of the systems of wastewater collection and the flow rates captured in each structure.

- ✓ The capacity, functioning status and operation of each component of the system must be determined, the types of existing sewage system, design flow rate and years of projection, installed capacity of the wastewater treatment plant; hydraulic characteristics of the networks of collection and transportation identifying matrix networks, and the coverage index of the sewage service, wastewater discharge points and environmental impacts.

b) Operational conditions.

The analysis and evaluation should be carried out of the current operating conditions of each of the components of the wastewater collection system in the intervention area such as: collectors, interceptors, inspection manholes, spillways, pumps, treatment systems and discharge structures to the water bodies.

It must be clearly defined if the system properly fulfils its normal operational function, analyzing the operation and status of each of its components.

The contractor will have to evaluate and present alternatives to rehabilitate, optimize and/or expand the operation of the existing infrastructure, and propose realistic actions that enable improvements of efficiency and productivity in the management and operation of the sewage services, calculating the potential of generating internal resource savings. The contractor must identify the actions necessary to increase operational efficiency, achievable goals, the necessary resources to achieve these goals, and indicators for control and monitoring of compliance.

The contractor must provide in the diagnosis, the respective conclusions of the state of each sewage component.

c) Sewage Register of networks in the area of influence of the project

At the development sites of the project where there is a sewage infrastructure that has an impact on the execution of the studies and designs, and of which there is no reliable register of networks, a register must be made of the sewage networks in those sections where required.

Sewage Systems (ALC) perform a technical function of environmental sanitation, especially when there is a domiciliary service of Drinking Water (AP). The contractor must identify, in the event of there being existing infrastructure, if in the sewage system the Sanitary Sewage (ALC-S) and Rainwater Sewage (ALC-P) exist as separate systems respectively; or if there is a mixed system.

These systems must be properly referenced for consultation and operational use. For this the corresponding registers of ALC networks are required in order to have a series of plans and datasheets to represent and operate adequately the set of existing works and facilities, for the collection, conduction, and final disposal of wastewater and/or rainwater.

An investigation of all the properties affected by the project must be carried out, basically defining fences or parameters of the properties, identifying the owner, state of the deeds, easements etc.

In cases where the creation of the register of ALC networks is required, the following stages and phases must be followed:

1. <u>Creation of the ALC register</u>

   a) <u>Drawing up the plans</u>

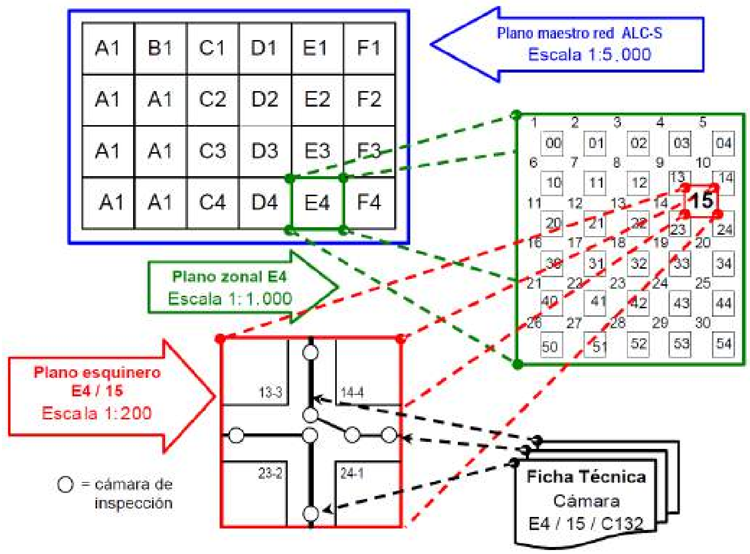
   - General Base
   - Corner units
   - Zonal
   - Master

2. <u>Maintenance of the ALC register:</u>

   a) Design of the procedure to update plans and technical datasheets
   b) Updating of plans and datasheets.

For the creation of the ALC register, it should be taken into account that the support works (structures) are visible on the surface, so it is not necessary to dig in order to locate and measure them (digging is required only for the sections of pipe between intersections), there is very little operational activity to do (although plenty of preventive maintenance).

For further guidance, the following figure presents the set of plans and datasheets that form the register of ALC networks.



The ALC register will have as a cartographic base a general base plan that must be new, with new copies of the same empty zonal plans, so that the division in zones and the codification of areas, intersections and corners will be identical to that of the distribution network.

The plans to be created for this register are the zonals 1:1.000, corners 1:200 and one master 1:5.000. The plans must represent sections of main, secondary and tertiary piping which, through other structures (manholes etc.), capture the wastewater from homes, and commercial and industrial uses, and lead them through the urbanized area to the point where they are treated.

The detailed information that must be contained in these plans is as follows:

Componente	Subcomponente	Detalles
configuración de red		• trazado de toda la red, malla por malla
tramos de tuberías		• diámetro • material • longitud de tramos • profundidad de solera (entre rasante y "fondo" interior del tubo) al inicio y al final de tramos • eventualmente profundidad de clave o corona (entre rasante y "techo" interior del tubo) al inicio y al final de tramos • pendiente de tramos
obras accesorias (estructuras)	• cámaras de inspección	• ubicación (referencias horizontales, cota) • diámetro • profundidad de solera (entre rasante y "fondo" interior de la cámara)
	• estructuras de conexión • sifones invertidos • estructuras disipadoras de energía (cámaras rompe-presión) • estaciones elevadoras (bombeo)	• diámetro • material • ubicación (referencias horizontales, cota) • profundidad de solera (entre rasante y "fondo" interior de la estructura)
rasantes		• cota • material • estado

Below are described the activities of the whole process of creating plans and datasheets for the register of ALC network:

- Collect primary background information where the expectation is to find information about the domiciliary connections of ALC, plans identifying the diameters of the sewage outlets (primary), main collectors or matrices (secondary), lengths of sections and slopes of the sections that connect to the manholes, surface elevations, key and sill of the inbound and outbound pipelines in each manhole.

  When analyzing the information found, there can be three alternative situations that can vary between the different service zones:

- That the data collected is sufficient and updated, so that the existing information is maintained, and it is only necessary to sort, redraw and enable it for the purposes of creating the register.

- That the plans found contain the required but outdated and/or incomplete information, in which case they should be updated by a verification survey.

- That the search did not provide any useful information; in this case, an initial survey of the ALC network should be carried out.

- The following assumes the need to proceed to a survey (verification or initial).

- Prepare "guide" zonal plans, based on the general base plan and on the empty zonal plans.

- Prepare blank and/or "guide" formats for corner plans and blank plans for technical datasheets of support works. It is suggested to apply the same basic design criteria.

- Initiate the route of the ALC network and the process of locating piping and structures in the field, following in principle the same routine as the one designed for the generation of corner plans for the distribution network.

- Fill out for each intersection: 1 corner plan format, and as many datasheet formats as the number of support works at the intersection.

- For sections between intersections, supplement information in the aforementioned piping datasheet.

- Organize the material surveyed in the field and compare it with the background information.

- Create the final corner plans, and parallel to this the definitive datasheets.

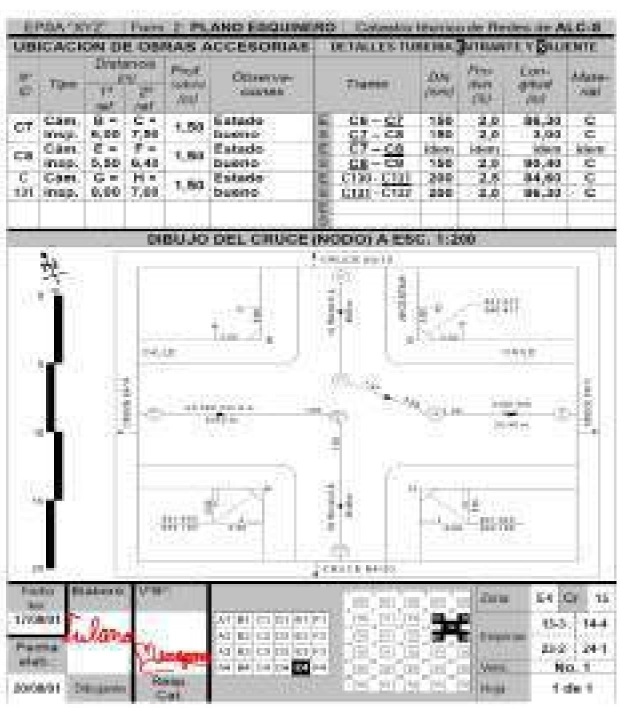
- Transfer all information to scale 1:1.000 and draw the definitive zonal plans.

- Transfer all information to scale 1:5,000 and draw the master plan of the ALC network.

- Approve the land registry documents and enable them for consultation and practical application in the corresponding file and as copies, in analogue form.

<u>Corner and zonal plans</u>

The following figure presents a corner plan format filled in with an example showing ALC-S pipelines belonging to two different networks:



As seen in the "details" part of the above figure, a section of pipe that enters and leaves a support work (structure), is identified by indicating the two structures which that section connects. It is a convention that the order of the two N º ID goes from left to right according to the flow rate direction.

For the creation of technical datasheets for ALC manholes it is advisable to have the network information previously as "guide" zonal plans, since the assignment in the office of a code to each manhole and the consequent identification of the pipeline sections to be studied, facilitates the later work in the field.

The preparation of the definitive zonal plans must be a result of the field inspection and of obtaining detailed information, and on these the existing networks of ALC-S are drawn and emphasized.

The updating of an ALC corner plan should be done periodically.

In the case of updating the corresponding zonal plan the same applies.

Technical datasheets for support works

Below is a technical datasheet format for a manhole.

It is worth commenting here on filling out some data in the manhole datasheet:

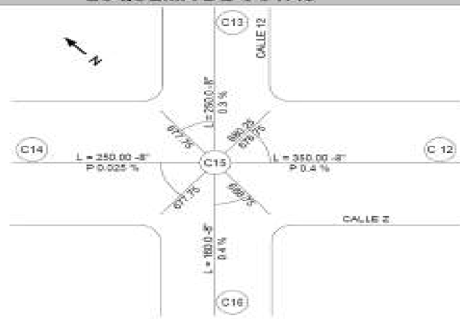
a) The manhole must be identified: by complementary Nº ID since there are few support works located at an intersection. If the manhole is located for some reason between two intersections in the middle of the block, the location of this manhole can also be indicated by the street between such and such a street.

EPSA "XYZ"	Form. 4: **FICHA TECNICA DE CAMARA DE INSPECCION**	Catastro técnico de Redes de **ALC-S**

UBICACIÓN DE LA CAMARA

Zona:	B3	Esquinas:	02-3	03-4	Dibujo del cruce (nodo): ver Form. 2
Cruce:	9		12-2	13-1	

ESQUEMA DE COTAS



CARACTERISTICAS DE LA CAMARA

Nº ID:	C15	Material:	C	Cota rasante (m):	680,25	Pavimento rasante:	Asfalto
DN (m):	2,00	Modelo:	Estándar	Prof. solera (m):	3,50		
Fecha ...	de construcción:		1987	de levantamto. catas.	18/08/01	de baja:	
Observaciones:							

CARACTERISTICAS DE TUBERIA ENTRANTE Y SALIENTE

	Tramo	*DN*	*Material*	*Long. (m)*	*Prof .sol. (m)*	*Estado al levantamiento catastral*
E	C14 – C15	200	C	250,00	2,50	Solera rota, posiblemente por ácidos
E	C13 – C15	200	C	250,00	2,50	
E	C16 – C15	200	C	350,00	1,50	
E						
S	C15 – C12	200	C	160,00	3,50	Solera rota, posiblemente por ácidos

Fecha lev.:	Fecha elab.:	Versión:	Hoja:	Elaboró:	VºBº:
18/08/01	21/08/01	No. 1	1 de 1	Fulano	Mengano

INTERVENCIONES DE CONTROL, OPERACION Y MANTENIMIENTO

Fecha	*Fun-ciona*	*Deficiencias halladas*	*Trabajo realizado*	*Observaciones (necesidad de repara-*	*Firma*

b) The information about the manhole model is optional. It depends on whether the company uses one or more manhole design types. If the company uses prefabricated manholes purchased on the market, it will make sense to fill out this box.

c) Diameters:

- The maximum inside diameter of the manhole body (i.e. not the entrance hole) is indicated in m.
- The DN of the pipeline sections analyzed is recorded in mm or inches; e.g. 200 mm or 8".

d) Surface elevation: indicates the level (absolute or relative elevation) in m that corresponds to the cover of the manhole, duly referenced to the BM (plate or physical element with defined elevation) of the IGAC. The level of the cover, put into place over the manhole, should be identical to the surface level of the road. However there may be cases where the surface is higher (e.g. asphalt) or lower (e.g. earth) than the level of the lid. As it is the function of a technical register to record also the abnormalities that can be a cause of risk to the networks, it is advisable that this height difference is highlighted in the "Remarks" in the part "characteristics of the manhole".

e) Sill Depths:

- The depth of the manhole sill is determined as the difference in m between the height of the cover in position, and that of the sill. This depth shall be equal to or greater than that of the inbound pipelines, and equal to that of the outbound pipelines.

- In the elevation scheme, the level (absolute or relative elevation in m) is indicated at which a pipe enters and exits the manhole respectively. The corresponding depth in m is indicated in the col. "Sill Depth" and results from the subtraction between the elevation of the manhole cover and the elevation of the sill of the pipe.

f) In order to facilitate the overview, it is advisable to note the slope in % of the inbound and outbound pipelines in the elevation scheme, not the "pipeline characteristics".

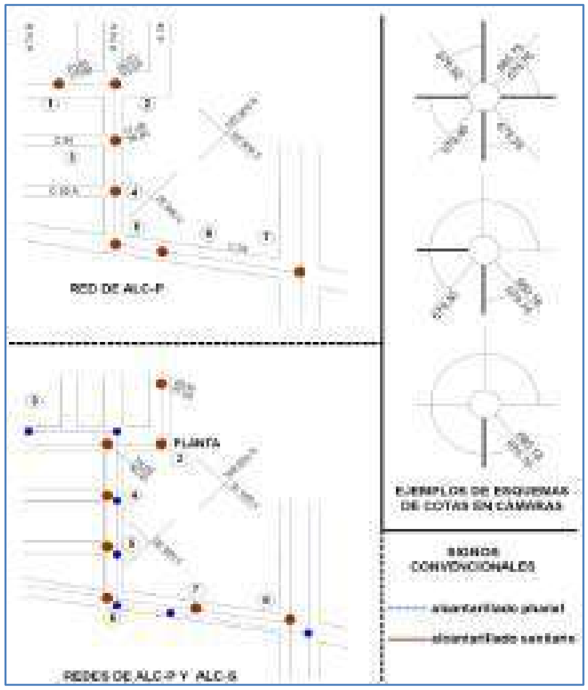
g) The manufacturing material is recorded for both the piping and the manhole itself, e.g. brick or baked clay, PVC, concrete (C) etc.

h) In the two parts for "characteristics" of the form there are reserved spaces to make "remarks" as to the physical "state" and functioning of the manhole respectively, and of the pipes at the time of the survey, eg: good, regular, bad. In addition any other important information will be highlighted.

i) The manhole's discharge date is a relative and optional. It is probable that a manhole, once built and entered into operation, may never be demolished or removed or replaced by another, but rather reconstructed repeatedly. The space for the discharge date may be more useful on the datasheet of another type of support work.

j) The format presented culminates with the operational part entitled "Control, operation and maintenance interventions"; the first of the interventions to be documented is the same land registry survey.

The following figure explains in more detail how the dimensions of an inspection manhole are indicated with the help of the elevation scheme, in three different manhole configuration cases, which appear on the right as three multi-axis circles, to signify that in a manhole there may be several inbound pipelines on all sides, and a single outbound one:



- The main axes at 0, 90, 180 and 270 º represent the inbound and outbound pipelines
- The intermediate axes at 45, 135, 225 and 315 º indicate the dimensions of the pipe which is first when turning in a clockwise direction.

So for example, in the above elevation scheme, at axis 45 º the fraction "680.75/679.78" is observed, where the numerator expresses the elevation of the surface or cover of the manhole (= 680.75 m), and the denominator the elevation of the sill (= 679.78 m) of the pipe located on the axis 90 º. This annotation method, the fractional form, is the most comfortable and common.

The same scheme shows a total of 4 pipelines with sill elevations 679.78 m (axis 90 º), 679.76 m (axis 180 º), 679.80 m (axis 270 º) and 675.62 m (axis 0 º). From the elevations it can be determined which is outbound from the manhole: it is the pipeline on the axis 0 º whose elevation is 675.62 m, inferior to the others which are therefore inbound.

The middle scheme displays a manhole with one inbound and one outbound pipeline; and the lower scheme represents a startup manhole that has an outbound pipeline only.

The figure shows in addition on the left how the indications of elevations would be seen in a plant drawing in a plan (in this example with both networks ALC-S and ALC-P).

The technical datasheets of support works of the ALC network are dependent on the inventory of the support works and their connected pipelines, so the datasheets require periodic updating; in each periodic updating campaign only those datasheets that warrant it will be reviewed and updated.

<u>The Master plan</u>

The ALC network must have its own master plan, also at a scale of 1:5,000, because the overview of the entire network is needed. With this function, the plan is an instrument for reference and location within the perimeter of the service area and the basis for the relationship with and between the zonal plans, and for these with the support work datasheets. It should be noted that this is due to the relatively low frequency of operations in a network of ALC.

The master plan can be used to preliminarily make note by hand of important changes in the situation of the ALC at the time they occur. From there, this information will be transferred to the zonal and corner plans, at the time of the annual updating of this register.

Personnel, equipment, and materials requirements

- **Base plans**

Provided by the company or some dependence of the municipality (Planning Office, Urban Development Institute). It must contain the current urban area of the municipality, preferably in datasheets of size 1.00 x 0.70 M. If the plan is not up-to-date, it should be updated. If it is not possible to obtain information from the provider or the municipality, a plan can be requested from the IGAC.

If no positive results are obtained from any of the above sources, the contractor must proceed to carry out their own survey of the municipal plan. It is advisable to include an urban topographic survey with level curves.

- **Topography Commission**

Georeferencing equipment with GPS, with commissions composed of a technician and assistants.

The auditor and/or supervisor of the contract shall define the most outstanding aspects, such as instrument types, degree of accuracy, system used, checks, linear, angular, and leveling errors.

The same applies for planimetric and altimetrical differences, and the moorings with B.M. or known points. All in accordance with the RAS 2017 regulations, and the type of detail of each system, and the information required for carrying out the hydraulic, structural, geotechnical, geological verifications, and others that enable the definition of the current state and capacity, and other information required for carrying out the register of networks.

Data both for distance and elevation will be obtained using high precision electronic equipment, counter-leveling in order to define the accuracy of the work done. In all the stakes of the changes of direction in the terrain, and also in the deltas, topography will be taken for fifteen meters on either side in order to obtain information of thirty meters of width along the line, determining the closed elevations for one (1) meter.

The shafts are directly related to the length of pipeline. The commissions will be composed of a technician and assistants according to the technical requirements for the fulfillment of the activity, equipped with the small tools, and the equipment for the georeferencing. This includes drilling equipment for breakage, excavation, filling, compaction and replacement of pavements for shafts, which will be carried out in accordance with the technical conditions presented in the project, and in the places determined by the auditor.

- **Pipeline detection equipment**

For this equipment there must be a system of buried pipelines and cables so that the electromagnetic fields emitted by these underground pipelines can be detected or traced from the surface. The procedure enables the surface directly above the pipeline to be marked, to avoid its destruction during excavation activities. Or, to safely dig and expose the pipe that needs repair or replacement. It is necessary to have a commission that permits the operation of the equipment required for the location of the piplines and cables.

- **Pipeline Inspection Manhole**

For the purpose of establishing the actual state of the sewage pipelines, the contractor must have inspection equipment with a camera and closed circuit color television, delivering a diagnosis in digital format.

In order to carry out this activity a televising team is required with the participation of a commission formed to collect the required georeferenced information.

- **Metal Detector**

In those cases where it is necessary to locate metal accessories such as access covers to inspection manholes, which are not at the level of the road surface, it is considered appropriate and suitable to use a metal detector as a supporting tool, and there must also be a commission composed of a technician and an assistant

Creation of the register of georeferenced users

The contract must create the register of georeferenced users, taking into account the guidelines published by the Ministry of Environment, Housing and Territorial Development (2000).

Georeferencing is a numerical description of a place that can be located on a map, i.e. mapped. The principles of georeferencing are precision, efficiency, reliability, accessibility, transparency, opportunity, and relevance. These principles enable the obtention of quality metadata and the methodology used to obtain the georeference of a locality, with exactitude, coherence and easy access to the information georeferenced by the users. Also, it will permit simple procedures for obtaining, analyzing and presenting reports and updates.

The creation of a register of georeferenced users will make it possible to create or to update a database of sewage system users, in order to register 100% of them, both active, feasible and potential, and likewise, to locate physically each property with its respective connections, and identify economic activity to characterize the services.

Updating the Subscribers register.

The contract must update the subscribers register, taking into account the guidelines published by the Ministry of Environment, Housing and Territorial Development (2000).

The creation or updating of a subscribers register, will make it possible to create or update a database of sewage system users, and to register 100% of them, both active, feasible and potential, and likewise, to physically locate each property with its respective connections, and identify economic activity to characterize the services. It will also register 100% of the technical information of domiciliary connections; and identify the availability and condition of all the micro meters and registration boxes.

Note: The topography Commission, pipeline detection equipment, pipeline inspection manholes and metal detector involve the costs and expenses both of the equipment and the staff.

<u>**Minimum products register of the sewage network in the area of influence of the project**</u>

As **Products** of the work will be the file of the register of networks that will include all the documents described above, namely:

- Original and two copies of the general base plan updated to scale 1:5,000
- Original and two copies of of the zonal plans 1:1.000
- Original and two copies of the set of corner plans 1:200
- Original and two copies of the set of technical datasheets
- Original and two copies of Master Plan of the ALC-S network.

The contractor must deliver to the beneficiary company of this contract a detailed report that includes the following components, among others:

-Deliver plant plan profile georeferenced from existing networks and main features with the identification of longitudes, diameters, materials and other hydraulic structures of the system, according to the land registry records of each one of the elements, and the characteristics established in the RAS or design manuals.

-Relate the planimetrical and altimetrical information based on the cartographic and topographic basis, and georeferenced to the current IGAC system, or by global positioning systems referencing with submetric precision, with coordinates certified by the IGAC.

-Deliver the urban georeferenced plan of the municipality containing the road network, rivers, streams, houses blocks, official urban nomenclature, and main sites where the register of the system elements is carried out.

-Topographic report which describes all the work done, and deliver the topographical, printed and magnetic portfolios, the calculations table of the coordinates and closures, and the description of the polygonals. Topographic portfolios or topographic information must be filled out according to the specifications given by the audit. IGAC coordinates certificate.

-The land registry report of the sewage system which must include the technical datasheets, photographic records of each of the components, IGAC certifications of the coordinates as well as the materialization diagrams of the points, and other records and documents.

All the information must be delivered in original plans, size 100 x 70, and two copies in bond paper size 100 x 70, and a notebook in bond paper quarter spread datasheet size, and in magnetic form, duly signed by the professionals who created it.

Asset Valuation: Asset valuation will be carried out according to the terms of the CRA 287 resolution of 2004 or the standard in force at the date of execution of the contract regulating the valuation of assets for companies providing domiciliary public services, the team required for this assessment must be composed of an economist, a health engineer, a civil engineer, a legal adviser and two engineering assistants and two accounting assistants.

Definition of the regulatory framework on which the appraisal is carried out, a decision that must be previously agreed with the auditor and/or supervisor of the contract.

The valuation should at least consider the following concepts:

· Nature of assets valued
· Valuation Basis, including type and value definition
· Date of assessment
· Identification of assets and their geographical location, and date and scope of inspection.
· Dates of inspections
· Regulatory framework applied (valuation methodology)
· Special assumptions and/or limitations
· Remaining useful lives of the assets, and if it is meaningful, the residual value of the asset.
· Name of the Appraiser and their professional qualifications

Qualification and legal information:

· Name of property owner
· Acquisition title
. The quality of the company's domiciliary public services.

Observations and recommendations:

The analyzed aspects and considerations for determining their valuation will be specified.
Once all the activities of the corresponding appraisals have been completed, the products to be delivered are as follows:

1.1.6. Information analysis.

Once the contractor has obtained the information in its entirety, they must classify, organize it, and create a summary document in such a way that it can be consulted in a simple and easy way.

Timely availability of the information will be guaranteed through an appropriate inventory, listings, records, files and formats defined based on the application of best practices for document management. Decisions taken with regard to the management of information will be standardized and managed by various means, depending on their nature.

A detailed analysis of all this information should be done for the purpose of verifying it with respect to the current reality. For example, the population projections that were implemented in the past will be verified to compare them with the population of today. Similarly, information on densifications, socioeconomic stratification, land use, trends, consumption, etc. will be obtained.

The compatibility and relevance of the municipality's Development Plan, the POT, as well as previous studies of the sewage system, environmental risk, flood plains and, in general, all related municipal, regional and national studies will be analyzed.

An assessment should be made of the urban and sanitary perimeter in order to determine the area to be covered by the project (considering also the rural suburban sectors, if that is the case); areas that are suitable for urban development will be identified on the basis of their topography, the quality of the soils, the possibility of receiving public services, the continuity of the urban network, spontaneous and directed urban growth trends.

On the other hand, it is necessary to validate in the field the information contained in the sewage system plans, regarding the designs previously developed to identify and quantify to what extent the projects that have been designed have actually been built.

Another important aspect is the cartography that will be used as a basis for the formulation and development of the project; based on it, the scope of the topographic surveys to be carried out will be defined very clearly, the methodology and technology to be used; all with due justification that should be supported in the information analysis.

All existing information will be collected and analyzed for the purpose of evaluating its relevance and the possibility of using it.

1.2. Feasibility studies

1.2.1. General Conditions.

The alternatives proposed by the contractor must be articulated with the plan or scheme for territorial land use, and with the environmental and sectoral plans such as: Basin regulation and management plan (Pomca), Sanitation and discharge management plan (PSMV), Integral Solid Waste Management Plan (PGIRS) in order to establish the implications that the system, or any of the components of the project, would have within the urban development or the basin, so that its execution aims at municipal and regional goals for the sector.

The information available must be assessed and a plan of action adopted for the respective sector, in order to ensure for the medium-term future effectivenees in the collecting and processing of basic information, and the implementation of the appropriate network of measurements so as to guarantee its continuity in time.

1.2.2. Field surveys, property research.

The designer will perform detailed field surveys allowing them to visualize directly and unequivocally the situation of the area, the real possibilities of managing solutions to the problems formulated, the need of property acquisition, the requirements of special studies as well as the definition and scope of the topographic work to be carried out for the development of the project.

1.2.3. Characteristics of the receiving water bodies.

To carry out the design procedure for new sewage systems or expansions of existing systems, the designer must be aware of the Sanitation and Discharge management plan (PSMV) of the municipality, to be considered within the target of the design project. In addition, the design can take into account, if they exist, models and results of simulations on the quality of water in receiving bodies.

The receiving bodies of the discharges of wastewater must be identified, taking into account the quality objectives of each one of them, in accordance with the provisions of the Sanitation and discharge management plans (PSMV) approved by the Environmental Authority. In the same way, the respective balances must be established, identifying ways in which the project can affect them.

As a complement, the provisions of document CONPES 3177 of 2002, resolution 1443 of December 2004 and Decree 3100 of 2003 must be taken into account.

In the event that the design of a sewage project can affect the existing infrastructure in rivers, streams or other bodies of water, an assessment must be made in accordance with the guidelines established by the competent environmental authority, on the possible impact that new flow rates may have on this infrastructure, to establish preventive measures to avoid undermining or damaging them.

The contractor must include the characterization of the wastewater involved in the project (existing discharges), and physical, chemical and bacteriological analyses of them should be made according to the parameters established in the RAS and the regulations in force.

The laboratory where the samples will be analyzed must be certified by the IDEAM, for which they must attach the respective supports.

The calculation of the pollution load of domestic, commercial and industrial origin must be carried out for the total population of the urban and rural area. To do this, estimates should be made of the unit load based on the days of measurements of flow rate and concentrations of pollutants.

The results obtained in the characterization of the wastewater will be compared with table E. 2.6 of the RAS in force. Likewise, the calculation of the design flow rates of the different structures required must be carried out, according to what is stipulated in the RAS in force.

Likewise, the contractor shall analyse the historical data and water quality reports of the receiving bodies if required, as well as carrying out the relevant research, calculations, modeling and technical scenarios based on the official information available from the territorial entities, environmental and health authorities, and the providers; as well as in the respective sectorial planning tools, and in accordance with the environmental regulations issued on the subject.

The contractor must carry out an inspection of the environment in which the project will be developed. It must identify and characterize the environmental, biotic, abiotic and social components that will be affected by the realization of the works and their subsequent operation. Some of these components are described in the following table.

System	Component
Biotic	Flora
	Fauna
Abiotic	Water
	Air
	Soil
	Landscape
Social	Economic activities
	Public space
	Cultural Heritage
	Archaeological heritage
	Demographic component

In accordance with the foregoing, they should review, for example, the existing information on the quality of water sources, air quality, flora and fauna status, land uses, characteristics of neighboring communities and so on, depending on the interactions the activities have with the environment.

For the design of sewage systems, the designer must take into account the Sanitation and discharge management plan, PSMV, for the place where the project is to be executed. This is defined as "the set of programmes, projects and activities, with their respective schedules and investments necessary to advance in the sanitation and treatment of discharges, including the collection, transport, treatment and final disposition of the wastewater discharged into the public sewage system, both sanitary and rainwater, which must be articulated with the objectives and goals regarding quality and use, as defined by the competent environmental authority for the flow rate, section or water body." The above is according to the regulations in force from the Ministry of housing, city, and territory.

1.2.4. Instruments for the planning, regulation, and management of the hydrographic basins and aquifers

In the design of sewage systems, the provisions for the planning, regulation, and management of the hydrographic basins and aquifers should be taken into account. These instruments are:

1. Strategic plans in the Hydrographic Areas or Macro-Basins.
2. National Programme for monitoring water resources in hydrographic areas.
3. Plans for regulation and management of Hydrographic basins, in Hydrographic Subzones or their subsequent level.
4. Environmental management plans for Micro-Basins, in the basins that are inferior to the subsequent level of the Hydrographic Subzone.
5. Environmental management plans for Aquifers.

1.2.5. Geology, geomorphology, soils and geotechnics.

All infrastructure works require a geotechnical design to ensure its stability and functionality, as well as not affecting neighboring constructions and existing infrastructure. The geotechnical design should be based on the studies and research of soils described above.

The guidelines of geotechnical studies should be enforced in the establishment of slopes, water management, timbering, sheet piling, the identification of fault zones and geotechnical recommendations. In the same way the possibility should be studied for incorporating measures on maximum quantities of excavation according to the diameters of the pipes and slopes.

Target

Define the requirements for the presentation of the reports corresponding to geotechnical studies for the design of sewage systems to be contracted by FINDETER or subject to their approval.

Scope

This document includes the criteria and minimum aspects to be considered in geotechnical studies for hydraulic structures, specific, and special works, sewage networks and channels.

Definitions

Shaft

Excavation usually performed with hand tools (occasionally with mechanical equipment like a digger), of variable sections, about one meter and sides of half a meter, sufficient for the personnel to work both in the excavation itself and in taking samples and conducting field tests. Its depth depends on the purpose and needs, or the conditions of the soil found on the site.

Depending on the depth and type of soil to be excavated the shafts may or may not have timbering. In general for shafts greater than 2.5 m, a type of temporary support should be used.

Stratigraphy

It is the representation of the sequence in which the different strata or layers of the subsoil are found, with their physical and mechanical and eventually chemical properties (SPT, unconfined compression, etc.).

Direct type Exploration

Where there is direct access to the subsoil and the extraction of samples is feasible. It can be by shaft, trench or perforation (manual or mechanical).

Indirect Explorations. Geophysics.

Studies where indirect exploration techniques are used, by means of which electric waves or currents are generated, whose speed, propagation, or intensity is measured with sensor equipment; and when transmitted through the different layers of soil, they determine its physical and elastic properties. There are a variety of geophysical studies applicable to surface exploration of subsoil layers; the most common are seismic refraction and electrical resistivity.

Soil samples.

These are portions of soils taken from direct explorations of the subsoil (boreholes, shafts, trenches, etc.), of a specific and determined section, and then laboratory tests are carried out to identify and characterize their chemical, physical, mechanical and eventually bacteriological properties. These Samples can be classified as altered and not altered. The first term corresponds to those which, when taken, undergo alteration or disturbance in their different parameters, disintegrating the particles of their composition; whereas the unaltered samples are taken using molds that preserve their properties without suffering substantial alterations during the collection process.

Groundwater level

Depth at which water is found in the subsoil. Several levels may be found depending on the permeability and sequence of the strata.

Special Works

These are major works such as tunnels, reservoirs, dams, beacons, cofferdams, pumping stations, anchors and supports for which deformation controls, deep excavations, special constructive processes, unconventional working conditions etc. are specified.

Specific Works

Construction works such as houses, buildings, venues, etc., contemplated in accordance with the "NSR-10 Colombian standards for seism resistant design and construction" in force to date.

Soil profile

Graphic and descriptive representation of the information resulting from the exploration of the subsoil. The description and thickness of each detected strata, groundwater levels, the results of the field and laboratory tests and other relevant elements are recorded. The strata are described based on their material, color, odor, moisture, plasticity, consistency, mineral content and their degree of alteration, vegetation, etc.

Borehole

This is an exploratory hole in the subsoil, of a circular section, of variable diameter, which can be done with manual or mechanical tools. The latter can be by percussion (cohesive material) or rotation (granular soils, rocky masses).

Drilling with Manual Drill

Drilling method executed with a manual tool, and therefore there are inherent limitations in the hardness of the perforated material and/or depth achieved. This method only takes altered samples.

Hammer Drilling and washing

Direct exploration method of the subsoil, which is done with mechanical equipment by means of washing with water injection in conjunction with hammering. (SPT can be obtained). It is usually used in sands.

Rotation Drilling

Direct exploration method of the subsoil, which is done with mechanical equipment by rotation using elements such as drill bits and tricones or punchers; in addition, the hammer system can be applied and hammering and washing. It is usually used in coarse gravels, ridges or rock. Undisturbed samples of rocky masses can be obtained by recovering nuclei.

Anthropic Fillings

Earth, stone or artificial materials, deposited or accumulated by human action, presenting different combinations of fine fraction and coarse fraction. They may also involve construction waste, organic material, or organic silt. These may or may not be technically arranged.

Probing and drilling

Direct field exploration (standard penetration, cone penetration, torsional cut with vane, etc.) or indirect (Geoelectric probes or seismic refraction), carried out to establish some properties of the subsoil by means of measurement of the resistance of the subsoil to the action of the probe (penetration, torsion, propagation of electric current, seismic waves, etc.).

Boreholes for geotechnical exploration can be carried out manually (drills) or mechanically (by hammering and washing, or by rotation).

SPT

Standard penetration test.

Mixed soils

Combination of soils transported from different origins.

Section

For sewage networks this is defined as the sector between two connection structures. In all cases, a section cannot be greater than 150 m.

Trench

Surface excavation (< 3m) elongated with a width less than 1 m, carried out in the exploration of the subsoil in order to obtain detailed information of the most superficial layers at sites with rocky outcrops, on slopes, in ravines, escarpments, cuts made in roads, or in zones where there are cracks or geological discontinuities (faults). This type of exploration complements the superficial field studies and is intended to identify the soil profile and its characterization, by means of altered sampling and unaltered sampling using molds.

Trenches may have a temporary support system, especially in areas of soft soils, fillings or loose sands, as well as in areas with a high degree of soil saturation, or with the presence of major runoff waters that threaten the stability of the slopes.

USCS

The Unified Soil Classification System.

Regulation references

For the following regulation references apply the versions in force or regulations that modify, replace, or add to them.

AMERICAN SOCIETY FOR TESTING AND MATERIALS

-Standard Test Method for bearing capacity of soil for static load and spread footings. PhiladelphiaASTM. (ASTM D 1194)
Ministry of Economic Development (current Ministry of Environment, Housing and Territorial development)
-Resolution 1096 of 2000: by which the technical regulation for the sector of drinking water and basic sanitation is adopted-(RAS-2000). -Resolution 1096 of 2000: by which the technical regulation for the sector of drinking water and basic sanitation is adopted-(RAS-2000). Title G.

Colombian Seismic Engineering Association.

-Colombian standards for seism resistant design and construction. Bogotá: Als, 2010. (NSR-10).
Colombian Institute of Geology and Mining (INGEOMINAS) – Administrative Department of Environmental Management (DAGMA).

-Seismic microzoning study in Ibague, Santa Marta, Manizales.

Colombian Institute of Technical standards and certification.

-Test method for determining the liquid boundary, the plastic boundary and the plasticity index of the cohesive soils. Bogotá: ICONTEC. (NTC 4630)
-Soils. Test to determine moisture content. Bogotá: ICONTEC. (NTC 1495)
-Soils. Test to determine of resistance to unbound, undrained triaxial compression in cohesive soils. Bogotá: ICONTEC. (NTC 2041)
-Soils. Test method to determine the direct cutting of soils under consolidated and drained conditions. Bogotá: ICONTEC. (NTC 1917)
-Soils. Test to determine particle size by sieving. Bogotá: ICONTEC. (NTC 1522)
-Soils. Test method to determine the resistance to unconfined compression of cohesive soils. Bogotá: ICONTEC. (NTC 1527)
-Soils. Test method to determine the unidimensional consolidation properties of soils. Bogotá: ICONTEC. (NTC 1967)

National Institute of Roads Invias.

-General road construction specifications and test standards for road materials.

Requirements

This annex presents the minimum aspects to be considered in the geotechnical studies for hydraulic structures, specific and special works, sewage networks and channels, works that define the specific geotechnical scopes.

General Technical Requirements

Generalities

All the work and tests referred to in this annex must characterize the subsoil geotechnically and establish the dominant conditions in the project area, enabling the contractor to establish the most suitable excavation method, assess the stability of slopes, determine the most convenient type of containment structures in the trenches (type of timbering), to select the fillings and to determine the bearing capacities of the soils and their relation to the expansion pressure required. In addition, to install the foundation procedure for pipelines and structures that guarantees the stability of all the components of the project, and all the other requirements necessary to develope the designs. Finally, to provide the recommendations for the construction and operational stages of the works.

The water supply networks whose maximum excavation depth is less than 1.5m and the domiciliary sewage connections do not require geotechnical studies. The exploration and sampling for the specific works are governed by the "NSR-10 Colombian standards of seism resistant design and construction". (Exploration and sampling will only be carried out if recommended by the geotechnical study)

This annex raises some minimum requirements for special works, but FINDETER may define additional and/or specific requirements for any of its projects.

Location of the project

The geographical location of the project must be defined in all cases, georeferenced to the coordinates of the IGAC and by urban nomenclature, when it is available. The topography must be carried out in accordance with the criteria and guidelines established for the execution of topographic surveys

Field Explorations

Standards for field exploration

The test standards to be followed for the implementation of explorations, field tests and sampling are shown in Table 1.

Table 1. Standards for the execution of field explorations and tests

Name	Standard
Drilling with diamond drills for site research	"INVE-108"
Normal penetration and split tube sampling of the soil	"INVE-1 11"

Special care should be taken with the stability of the shaft walls and trenches, and if applicable, use a temporary support system. The water evacuation system must also be established and safety must be ensured in the excavation and its surrounding areas. In areas with the presence of saturated fine sands, special care should be taken in the pumping, since settlement phenomena can be induced in areas adjacent to the excavation.

During the drilling process, all the precautions should be taken to ensure that the holes are not clogged or obstructed by the implementation of some type of metal coating or the use of drilling muds. If any gap is clogged or obstructed for any reason during drilling, it must be cleaned or, if applicable, enlarged on account of the responsible of the investigation and to the satisfaction of FINDETER.

The upper ends of all probes and boreholes must be properly protected and referenced.
Once the drilling has been carried out, the samples taken and the groundwater level measured if there is one, the hole must be covered with the excavated material, installing a plug made with compacted soil at its top.

The contractor must guarantee during the execution of the explorations, the implementation and use of the elements of industrial safety and occupational health which are required for this type of work by the legal regulations in force, in this way protecting the integrity of those in charge of the work. Failure to comply with these regulations by the executor may result in the imposition of penalties.

Minimum number of field explorations

Any projected work must have sufficient boreholes both in number and depth to define the characteristics and properties of the subsoil on which, if so determined by the geotechnical engineer, geotechnical analyses may be carried out (settlements, bearing capacity, thrusts, stability of the excavation slopes and the bottom of the excavation, etc). In any case, the number of exploratory boreholes cannot be less than two. These can be of direct type, such as manual drilling or drilling with mechanical equipment.

The minimum exploration by work type is set out in Table 2. However, it should be noted that the final number of boreholes may be greater and must obey the need to have a good characterization in order to establish reliable conclusions and recommendations. On the other hand, the final depth of the exploration should be established based on the probable type of foundation, and the pressure bulb induced by it in the soil.

Table 2. Subsoil Exploration

Work	Minimum quantity [a]	Minimum depth [d]
Conventional structures	**NSR-10**	**NSR-10**
Hydraulic structures	**1 c/20m^2**	**NSR-10**
Matrix networks of Aqueduct	**1 c/200m[b]**	**1.5 times the Max. depth of**

		excavation
Secondary Networks of Aqueduct	**1 c/250m[b]**	**1.5 times the Max. depth of excavation**
Channels	**3 C/300m[c]**	**2.0 times the Max. depth of excavation**

*** For sewage systems, the indicated in chapter G must be applied. 2.3 (Soil investigations), paragraphs G. 2.3.2.3 and G. 2.3.2.4 and the contents of tables G. 2.1 and G. 2.2 of the RAS-2000 "technical regulations for the drinking water and basic sanitation sector."**

Notes:
[a] At least 2 direct-type probes
[b] or each morphological, lithological or structural change of relevance
[C] The probes should be distributed on both margins and the channel axis
[d] At least 1.5 m deep
The above mentioned depths serve as a guide, depending on the final depth of the exploration, the geological-geotechnical conditions of the area and the type of structure to be designed and constructed.

Field Explorations

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Drilling with diamond drills for site research	"INVE-108"
Normal penetration and split tube sampling of the soil	"INVE-1 11"

Special care should be taken with the stability of the shafts walls and trenches, and if applicable, use a temporary support system. The water evacuation system must also be established and safety must be ensured in the excavation and its surrounding areas. In areas with the presence of saturated fine sands, special care should be taken in the pumping, since settlement phenomena can be induced in areas adjacent to the excavation.

During the drilling process, all the precautions should be taken to ensure that the holes are not clogged or obstructed by the implementation of some type of metal coating or the use of drilling muds. If any gap is clogged or obstructed for any reason during drilling, it must be cleaned or, if applicable, enlarged on account of the responsible of the investigation and to the satisfaction of FINDETER.

The upper ends of all probes and boreholes must be properly protected and referenced.
Once the perforation has been carried out, the samples are taken and the groundwater level is measured if there is one, the hole must be covered with the excavated material, installing a plug made with compacted soil at its top.

The contractor must guarantee in the execution of the explorations, the implementation and use of the elements of industrial safety and occupational health which are required for this type of work by the legal regulations in force, in this way protecting the integrity of those in charge of the work. Failure to comply with these rules by the executor may result in the imposition of penalties.

Minimum number of field explorations

Any projected work must have sufficient boreholes in number and depth to define the characteristics and properties of the subsoil on which, if so determined by the engineer Geotecnista, geotechnical analyses may be carried out (settlements, bearing capacity, thrusts, stability of the slopes of the excavations and the bottom of the excavation, etc). In any case, the number of exploratory boreholes cannot be less than two. These can be of direct type, such as manual drilling or drilling with mechanical equipment.

The minimum exploration by work type is set out in table 2. However, it should be noted that the final number of boreholes may be greater and must obey the need to have a good characterization in order to establish reliable conclusions and recommendations. On the other hand, the final depth of the exploration should be established based on the type of probable foundation and the pressure bulb induced by it in the soil.

Table 2. Subsoil Exploration

Work	**Minimum quantity [a]**	**Minimum depth [d]**
Conventional structures	**NSR-10**	**NSR-10**
Hydraulic structures	**1 c/20m^2**	**NSR-10**
Matrix networks of the Aqueduct	**1 c/200m[b]**	**1.5 times the Max. depth of excavation**
Secondary Networks of Aqueduct	**1 c/250m[b]**	**1.5 times the Max. depth of excavation**
Channels	**3 C/300m[c]**	**2.0 times the Max. depth of excavation**

*** For sewage systems, the indicated in chapter G must be applied. 2.3 (Soil investigations), paragraphs G. 2.3.2.3 and G. 2.3.2.4 and the contents in tables G. 2.1 and G. 2.2 of the RAS-2000 "technical regulations for the drinking water and basic sanitation sector."**

Notes:
[a] At least 2 direct-type probes
[b] or each morphological, lithological or structural change of relevance
[C] The probes should be distributed on both margins and the channel axis
[d] At least 1.5 m deep

The above mentioned depths serve as a guide, depending on the final depth of the exploration, the geological-geotechnical conditions of the area and the type of structure to be designed and constructed.

Areal Projects

In areas of anthropic compressible fillings, the number of boreholes may be greater in order to zone and characterize them.

In the case of the evaluation of unstable or potentially unstable zones, the number of explorations to be carried out depends on the estimated size of the affected area, but not less than two (2) probes with mechanical equipment; the determination of whether it is by rotation or hammering, will depend on the characteristics of the different subsoil layers. The depth to which the explorations must be taken should be at least 5.0m below the fault plans estimated and recognized by the specialist.

Location and distribution of the exploration

The location and distribution of the probes will depend on the geomorphology of the site, the geological conditions of the sector, the type of soil prevailing in the area and the characteristics of the works and the sites of load application. Probes must coincide with special points of interest and must be spatially distributed in such a way as to cover the entire study area.

In the case of geotechnical studies for the design and construction of sewage networks and channels, the surveys must be aligned with the work and should not be laterally distanced from it more than 10 meters, so that the morphological accidents or similar conditions can suggest important changes in the subsoil.

For areal type projects, the explorations carried out must cover the whole of the foundation of the work, executing at least 3 deep explorations (boreholes) and two (2) superficial explorations (shafts, trenches).

In all cases, the location of the exploration must be clearly established based on its north and east coordinates (IGAC) and its dimension. If possible, it should be denominated with the urban nomenclature. Last of all each borehole or probe must have a surface elevation.

Exploration depth

Any exploration must reach a sufficient depth to define the characteristics and properties of the subsoil from which geotechnical analyses can be carried out (settlements, bearing capacity, thrusts, stability of the slopes of the excavations and the bottom of the excavation, etc.). In any case, the depth of the explorations cannot be less than 1.5m. In addition, it may require up to 2 metres or a greater depth when deemed necessary.
The minimum exploration depth per project type is shown in table 2. In areas with rocky outcrops, field explorations can be carried out at lower depths, which must be fully justified and sufficient to determine the necessary parameters and carry out the analysis of the geotechnical study. However, a concept should be taken from a geological point of view because the presence of discontinuities in the rock could generate instabilities. The seismic refraction test is useful in the case of the presence of rock and can be used if direct exploration cannot be performed. In the same way, the indicated in the **paragraph G. 2.3.2.4 of RAS-2000** will be applied**.**

Field record

During explorations, the information resulting from it should be carefully recorded regarding the depth. The format to be used can be freely chosen by the executor of the project, however, at a minimum, the record must contain: basic project information (name, executor, date, etc.); basic exploration information (type of exploration, name, location by coordinates and dimension, equipment used, maximum depth reached, etc.); thickness and description of strata based on the "INVE-102"; type, name and length of samples, field test results, groundwater levels, presence of rock, need for coating, type of advance, special features such as color changes in recovered water, sites where drilling water was lost or regained, veins, cracks, residual soil, soft or fractured rock, fragments size, matrix, and any other characteristic that may contribute to the description of the borehole, field observations and conventions.

During the execution of the drilling, and on the completion of the field work, the position of the groundwater level must be measured (at the beginning and end of the day). Information should also be given on leaks and water losses during drilling, hanging levels, artesian water and the existence of gases or other fluids.

Field tests

Field tests should be performed according to the type of material found and may be complemented by laboratory tests. Any test must be carried out with the standards defined in the regulations in force in accordance with the following order of priorities:

-NTC Standards
-INV Standards
-ASTM Standards

In addition, all other tests deemed necessary to complement geotechnical analysis and those indicated by the **Audit** should be carried out.

The Penetrometer test will be accepted as complementary if the geotechnical engineer considers it viable, but it should not replace the unconfined compression test, or the direct cut (uu).

a) SPT and VST

As far as possible, the subsoil must be characterized by carrying out the standard penetration test (SPT) on granular soils at a maximum of every 2m, and the torsional cut with vane test on finely saturated soils normally consolidated under the groundwater level. In the first case, SPT ("INV E-111") must register the weight of the hammer used, the number of blows for every 6" or failing this, the amount of blows with respect to the penetration reached. As for the vane test ("INV E170"), it is recommended to obtain the plasticity index simultaneously to perform the respective correction.

The SPT values in sands must be corrected by depth and position of the groundwater level. The report must indicate the value for the field correction used.

b) Load Plate Test

The test must be carried out for the design of matrix networks for aqueduct and sewage systems, when the geotechnical engineer so defines it, or when the **Audit** deems it convenient. The test must be carried out in accordance with the instructions in the standard "ASTM D1194 standard test Method For Bearing Capacity Of Soil For Static Load and spread footings".

c) Permeability Tests

Lefranc type, with variable head for soils, and Lugeón type for rocky masses.

d) Other tests

In order to characterize soil or rock deposit thicknesses, resistivity or seismic refraction tests may be carried out. This information would be used as a complement to direct exploration. Unless **FINDETER** determines it, in no case will these tests replace direct exploration to establish the soil profile. Instead they will be used as a complement.

Sampling

a) Type

If soil consistency permits, unaltered samples should be obtained of the type Shelby, block, nucleus or other, for subsequent geomechanical characterization; if this is not the case, the in situ characterization must be carried out directly by means of the standard penetration test (SPT) or the torsional cut test with the vane, provided the latter is performed in saturated conditions. In special cases unaltered samples can be taken by molding these from manual excavations, forming cubes with dimensions that suit those of the laboratory where the test will take place. The samples should be protected with paraffin paper, aluminum foil, paraffin, and encapsulated in resistant wood-type protective material.

In addition, altered samples may be extracted and stored in bags for classification purposes or others. The regulations governing the collection of samples are quoted in table 3.

Table 3. Standards for sampling

Name	Test
Obtaining samples for test specimens using thin-wall tubes	**"INVE-105"**
Soil sampling by tube with inner ring liner	**"INVE-1 09"**
Soil sampling by hole with hollow stem	**"INVE-1 10"**
Normal penetration test and sampling with split tube of soils	**"INVE-1 11"**
Taking surface samples of unaltered soil	**"INVE-1 12"**

The number of samples for drilling tests must not be less than that obtained by dividing all the drilling meters by 3; samples should be taken for the purpose of characterizing the different strata.

b) Amount

Representative samples of soil or rock should be obtained and tested, at least those necessary to carry out the tests indicated in Table 4 with the minimum frequencies established.
The sampling for laboratory tests should cover all the surveys in order to obtain a range of geotechnical parameters of the different strata found, and in this way sectorize or take average values of them.

c) Conservation and Transportation

The extracted samples must be stored and transported according to their characteristics as indicated in the "INVE-1 03".
6.1.6 Laboratory tests

The necessary tests must be carried out to determine the average parameters of resistance, deformability, stiffness, permeability and density, of the strata of interest to the study, so that the designs in the total length present adequate margins of security. When the soil presents characteristics of expansion, collapsibility, or erosion, it should be characterized according to these specific topics.

The tests must be carried out in accordance with the regulations referred to in Table 4.

Table 4. Laboratory tests

Type of property	Test	Standard	Observations
Physical Properties and Index	Natural moisture Content	NTC 1495 Soil. Test to determine moisture content "	
	Granulometry	NTC 1522 Soils. Test to determine particle size by sieving	In fine soils, wash in sieve of 0075 mm (n ° 200); if the retained fraction is greater than 60%, the Granulometric analysis will be completed. In granular materials, the complete granulometric analysis will be carried out
	Consistency boundaries	NTC 4630 Test method for the determination of the liquid boundary, the plastic boundary, and the plasticity index for cohesive soils	Only for thin or fine-fraction soils
	Unit weight		Fine soils, samples taken with Shelby tube. Granular soils: density test in the field with sand cone.
Chemical Properties *	Ph	INV E-131: PH of soils.	Tests for concrete pipeline networks. Samples for these tests should be taken at maximum distances of 500m and at the projected depth of the horizontal axis of the

Type of property	Test	Standard	Observations
			pipeline.
	Organic matter	**INVE 121 Determination of organic content in soils through ignition loss "**	**It is specified for both organic and peat silts**
Resistance	**Unconfined compression**	**NTC 1527 Soils. Test method to determine unconfined compression resistance of cohesive soils**	**It is only specified for normally consolidated, saturated fine soils. The test should be carried out particularly in the foundation material**
	Direct cut	**NTC 1917 Soils. Test method for determining the direct cutting of soils under consolidated and drained conditions "**	**This test should be done when effective parameters are required in the analyses or when the conditions of the problem can be represented by the test or when the Audit so specifies.**
	Triaxial	**NTC 2041 Soils. Determination of resistance to non-consolidated, non-drained triaxial compression in cohesive soils**	**This test should be done when effective parameters are required in the analyses or when the conditions of the problem can be represented by the test or when the Audit so specifies.**
Deformability	**Consolidation**	**NTC 1967 Soils. Test method to determine the properties and unidimensional consolidation of soils**	**It is specific for saturated fine soils**
	Expansion	**INV-L 32. Determination of expansive soils**	**Tests should be carried out on samples obtained below the expected foundation level and above the groundwater level when the material is potentially expansive**

NOTES: * Determination of other chemical properties of the soil such as the content of sulphates, chlorides, acidity or alkalinity may be requested by the **Audit**. The methods of the California State Department of Transportation (1978) should be used for determining these parameters. Determination of acidity or total alkalinity. * Chemical analysis of soil samples should emphasize the content of salts.

The geotechnical engineer will be able to use another test if its implementation is necessary.
In order to obtain a profile of the representative subsoil, the samples must be physically characterized according to the visual classification resulting from the field activities ("INV-E102"), at least as specified in table 5.

Table 5. Minimum frequency of classification tests

Test	Natural humidity [b]			Consistency boundaries [b]			Unit weight or specific weight of solids [b]		
Type of soil [a] Work	A	B	C	A	B	C	A	B	C
Specific Works	C/1.5 m	C/1.5 m	C/1.5 m	C/2.5 m	C/2.5 m	-	C/3m	-	C/6m
Special Works	C/1.5 m	C/1.5 m	C/. 5m	C/2.0 M	C/2.0 M	-	C/2.5 m	-	C/5m
Hydraulic structures	C/1.5 m	C/1.5 m	C/1.5 m	C/2.5 m	C/2.5 m	-	C/3m	-	C/6m
Matrix networks and sewage system	C/1.5 m	C/. 5m	C/. 5m	C/2.5 m	C/2.5 m	-	C/3m	-	C/6m
Secondary networks	D/2m	C/2m	C/2m	C/3m	C/3m	-	C/3.5 m	-	C/8m
Channels	C/1.5 m	C/1.5 m	C/1.5 m	C/2.5 m	C/2.5 m	-	C/3m	-	C/6m

Test	Washing in Sieve 200			Sieved particle by size b		
Type of soil a Work	A	B	C	A	B	C
Specific Works	-	C/2.5 m	-	-	-	C/2.5 m
Special Works	-	C/2.0 M	-	-	-	C/2.5 m
Hydraulic structures	-	C/2.5 m	-	-	-	C/2.5 m
Matrix networks and sewage system	-	C/2.5 m	-	-	-	C/2.5 m
Secondary networks	-	C/3m	-	-	-	C/3m
Channels	-	C/2.5 m	-	-	-	C/2.5 m

Notes:

[a] Type of soil

[b] Minimum one drill test: Frequencies refer to meters drilled, c/2.5 m = every 2.5 meters

A: Fine

B: Mixed

C: Granular

In order to obtain a profile of the subsoil well characterized from the point of view resistance and compressibility in the design stage, the samples should be mechanically tested according to the visual classification resulting from the field activities ("INV-E1 02), at least as specified in Table 6.

Test b	Rpi			Qu			Cc		
Work	A	B	C	A	B	C	A	B	C
Specific Works	1/Sample	1/Sample see Note d	-	1 C/2.5M 1/strata	1/Strata See Note d	-	1c/100m2	-	-
Special Works	1/Sample	1/Sample see Note d	-	1 C/2.0M 1/strata	1/Strata See Note d	-	1 c/50m2	-	-
Hydraulic structures	1/Sample	1/Shows see Note d	-	1 C/2.5M 1/strata	1/Strata See Note d	-	See note g	-	-
Matrix networks	1/Sample	1/Sample see Note	-	1 C/3.0M	1/Strata See Note	-	1 c/300m from	-	-

Test [b]	Rpi			Qu			Cc		
and sewage system		d		1/strata 1 c/100 m from network See note I	d		Network See Note g		
Channels	1/Sample	1/Sample see Note d	-	1 C/3.5M 1/strata 1 c/150 m from network See note I	1/Strata See Note d	-	1 c/400m from Network See Note g	-	-

Test [b]	Exp [c]			Cd			S	PT or CPT	
Work	A	B	C	A	B	C	A	B	C
Specific Works	1 c/100m2	-	-	2 See note E	2 See note E	2 See note E	1 C/1.5M see Note J	1 c/1.5 m	1 c/1.5 m
Special Works	1 c/50m2	-	-	See notes E and F			1c0M see Note J	1c/1.0 M	1c/1.0 M
Hydraulic structures	1.0	-	-	1.0	1.0	-	1 d/1.5M see Note J	1d/1.5 m	1c/1.5 m
Matrix networks and sewage system	1/Geotechnical sector See note H	-	-	1/Every 300m	1/Every 300m	-	1 C/2.0M see Note J	1 c/2.0 M	1 c/2.0 M
Secondary networks	1/Geotechnical sector See note H	-	-	1.0	-	-	1 C/2.0M see Note J	1 c/2.0 M	1 c/2.0 M
Channels	1/Geotechnical sector See note H	-	-	1 c/300M 2/Geotechnical sector See note E			1 C/1.5M see Note J	1c/1 5m	1c/1 5m

Notes:

[a] Type of soil:
A: Fine
B: Mixed
C: Granular

[b] Test:
Rpi: Resistance to unaltered penetration
Qu: Unconfined Compression in saturated samples
Cc: Compressibility
Exp: Controlled expansion in consolidometer
CD: Direct cut in laboratory in partially saturated soils

SPT: Standard penetration test

[c] Only in the presence of potentially expansive soils
[d] If unaltered samples can be extracted
[e] In conditions of partially saturated soils depending on the conditions of the site. If the work is located on slopes with a slope > 30 º or if the geotechnical engineer considers it necessary. It is of equal or greater complexity than II according to table H. 3-3 of the NSR-10.
[f] The amount is established according to the opinion of the geotechnical engineer, or by special considerations, at least 2.
[g] if the soil is compressible LL > 70 e IP > 40.
[h] If the soil is potentially expansive LL > 50, NSPT > 25,% P200 > 7th, IP > 35.
[i] At the bearing level.
[j] In hard thin soils where it is not possible to extract unaltered samples.

* Frequencies refer to drilling meters except if something different is indicated.

Geotechnical parameters
The geotechnical engineer must pre-determine the geomechanical parameters with which the analyses and designs will be carried out, which must be obtained in order to program and execute the field tests and the respective sampling. In addition, all geotechnical parameters required to meet the standards must be determined (see Table 8).

In fine soils
• Cu: undrained resistance in normally consolidated saturated soils, for bearing capacity, bottom failure, critical depth, pressures for containment structures (undrained condition).

• Cc, Cr, Cv, e0 and T ': compressibility index, index of recompression, consolidation coefficient, initial vacuum ratio and preconsolidation effort, respectively, for primary consolidation settlements (compressible soils).

• Eu: undrained elasticity module for immediate settlements.

• E': reaction module of the subsurface (flexible pipes-deflection). It can be obtained from the unconfined compression test, at 50% of maximum effort.

• c': for analysis of load bearing capacity and analysis of slope stability, in partially saturated soils or CU or CD conditions. These values will be obtained from direct cut or triaxial laboratory tests.

In mixed and granular soils
• c for bearing capacity, stability and pressure of containment structures

• E and Gs for background survey

• E: elasticity module for immediate or elastic settlements.

• E': reaction module of the subsurface (flexible piping-deflection). It can be obtained from correlations with SPT or CPT and physical properties (granulometry and consistency boundaries)

The reaction modules of the filling surrounding the pipelines (flexible piping-deflection) can be estimated based on Table 7.

Table 7. Reaction modules of the filling surrounding the pipelines

Type of soil used for filling		Filling reaction module E ' [MPa]			
Description	Classification	Compaction degree (Proctor)			
Without compacting	Slightly compacted < 85%	Moderately Compacted 85% 95%		Strongly Compacted >95%	
Fine Soils (LL > 50%) Medium to High plasticity	CH MH CH-MH	Soils requiring specific studies and measures			
Fine Soils (LL < 50%) Zero-to-medium plasticity with gravels or sands < 25%	CL ML-CL LC-CH ML-MH	0.4	1.4	3	7

Type of soil used for filling		Filling reaction module E ' [MPa]			
Description	Classification	Compaction degree (Proctor)			
Fine Soils (LL < 50%) zero-to-medium plasticity with gravel or sands > 25%	CL ML-CL LC-CH ML-MH	0.7	3	7	14
Granular soils with fines > 12%	GM GC SM Sc				
Granular soils with or without fines < 12%	GW GP SW SP	1.4	7	14	20
Crushed Rock		7	20		

Analysis and geotechnical designs

In table 8, geotechnical analyses are displayed by projected work type, in the following paragraphs.

Table 8. Geotechnical analysis

Work Analysis type	Specific Works	Special Works	Hydraulic structures	Matrix networks and sewage systems	Secondary networks	Channels
Geotechnical Sectorization	No	No	No	Yes	Yes	Yes
Average Analysis profile	Yes	Yes	Yes	Yes	Yes	Yes
Bearing capacity	Yes	Yes	Note a	Note a	Note a	No
Settlements	Yes	Yes	Note a	Note a	Note a	No

Liquefaction	Note b	Note b	Note b	Note b	Note b	Note b
Expansiveness	Note c	Note c	Note c	Note c	Note c	Note c
Stability of excavations	Note d	Yes	Note d	Note e	Note e	Note ¿
Pressure diagrams	Yes	Note g	Yes	Note h	Note h	Yes
Slope stability	Note i	Yes	Note i	Note i	Note i	Note i
Foundation Design	Yes	Yes	Yes	Note j	Note j	No
Excavation design	Yes	Yes	Yes	Note k	Note k	Yes
Water Management Recommendations	Yes	Yes	Yes	Yes	Yes	Yes
Constructive recommendations	Yes	Yes	Yes	Yes	Yes	Yes

Notes:

[a] Only if the applied load is greater than 1.25 times the original effective efforts

[b] If the soil is potentially liquefiable, this is if N < 6, if the fines % is less than 20% and if it is fine sands below the groundwater level

[c] If the soil is potentially expansive, with natural moisture, to the plastic boundary

[d] If the digging depth is greater than 1.5m

[e] Background fault and critical depth should be analyzed

[F] Local fault analysis (slopes) and general or background fault analysis should be performed

[g] Soil structure interaction analysis and the derivative pressures diagrams should be presented

[h] The diagrams must be for scaffold and sheet piling type structures

[i] If the work is located in areas with slopes > 30 º or if the geotechnical engineer considers it necessary, or if it is of a complexity equal or greater than II according to table H. 3-3 of the NSR-10.

[j] Take into account the NS-035: requirements for the foundation of piplines for aqueduct and sewage networks

[k] Note the NS-072: Timbering and Sheet piling

Requests Assessment

A detailed description of the possible loads should be carried out and an assessment of each of the other requests to be submitted to the work under consideration, in accordance with the requirements of the project.

Geotechnical sectorization and average profile

The synthesis of field and laboratory work should constitute an average profile for analysis whose description and geomechanical parameters must be clearly defined, and additionally they must be represented geographically on a readable scale. If applicable, the profile must be set by sections and must be superimposed over the alignment of the pipelines. The profile must include the position of the groundwater level and the main geotechnical parameters established for each stratum (see Table 8). The information must be filled out in a geotechnical study summary format.

Bearing capacity and deformations

Bearing capacity and deformation analysis must be carried out, using the physical and mechanical parameters of the soil (resistance and compressibility) synthesized in the average profile. The potential total and differential settlements of the foundations should be calculated both long and short-term. In both cases, a comparison must be made with permissible values of pipe deflection or other structures or safety factors which must also be justified. The information must be filled out in a geotechnical study summary format (see table 8). The parameters should be derived from the results of conventional laboratory tests (classification tests, unconfined compression, direct cut, consolidation, expansion in edometer). Only in special cases will correlations be accepted to obtain these parameters.

Potential for liquefaction and densification

If applicable, the type of soil profile for seismic resistant analysis should be presented, with the parameters for the evaluation of the soil-structure interaction. The potential for liquefaction should be assessed in the presence of fine granular soils and if the structure is vulnerable, recommendations should be given to prevent it from collapsing or experiencing excessive deformation (see Table 8). The information must be filled out in a geotechnical study summary format.

Expansiveness

The potential for expansion should be assessed in the presence of hard thin soils (overconsolidated) partially saturated in their natural state, and the volumetric variation under different load conditions and initial moisture contents should be established (see Table 8).

Stability of excavations, hillsides and slopes

The stability of the walls of the excavations, the permanent and temporal, or hillside slopes must be evaluated, depending on the conditions of the work: with and without seism, with and without water influence, in the short and long term. If required, the systems of protection and/or temporary or permanent containment necessary to guarantee the stability of the works must be designed. The respective geotechnical models must be presented, showing the different fault plans evaluated, their safety factor analysis, the different layers of soils, their properties, etc. If the results are adverse in terms of stability, new calculations should be presented that include the implementation of protection, containment or mitigation works. The evaluation of the model should include an analysis without works and with works.

For the retaining walls and timbering the horizontal pressure diagram must be obtained according to the type of structure, taking into account lateral loads from soil, water, seism, external loads, etc. The design must meet the criteria established in the NSR-10, title H.

For all the slopes foreseen in the work, temporary and definitive, as a result of excavations or fillings, at a minimum the inclination and the height must be established in order to guarantee their stability, as well as verges and other relevant details. And also to establish the ability on the slopes to withstand overload on their crown.

For works that are projected on a half-slope, the incidence of the excavations and cuts in the general stability of the hillside must be verified by means of stability calculations.

The information must be filled out in a geotechnical study summary format.

Foundation type and depth

The type of foundation and its depth must be defined, described and justified. If it applies, the latter must be linked to the elevations and abscissas of the project.

Water management

An assessment should be made of the surface water and groundwater present in the project area and recommendations given on its management either temporarily (during construction) or definitively through the construction of ditches, trenches, sub-drainage systems, among others.

The management of groundwater must be conditioned to the stability of neighboring constructions, avoiding decreases in the groundwater level that can induce settlements in adjacent areas, either by consolidation or fine washing in the case of fine sands.

The information must be completed in a geotechnical study summary format.

Special subsoil conditions

In the event that special conditions are detected in the foundation soil, such as the presence of organic, expansive, collapsible, erodable soils, susceptible to liquefaction, or contraction, or any other state or property that affects the work, the location should be indicated, giving specific recommendations on the treatment that this soil should receive. (see Table 8).

If the case is such that the conditions of the subsoil are inadequate for the construction of the structure, the corresponding recommendations must be presented to request the change of site, or the structure type, or the material type, or any other that applies. In this regard, special care must be taken with the determination of the PH and the sulphate content of the soil, in order to limit the use of pipelines whose material may be affected by soil conditions.

Constructive recommendations

Recommendations related to land suitability or preparation, construction stages, ground movements, excavation systems and their containment, placing timbering, slope protection, quality control methods, filling type, required equipment, sectorization by type of materials to be excavated, protection of public service networks, etc. (see Table 8). The information must be completed in a geotechnical study summary format.

Presentation of the study and designs

The geotechnical study and design must be presented in printed form, legible and also in magnetic form. The report must contain at least the following information:

Scope

The objective must be defined, along with the activities contemplated, and the field where the geotechnical study will be applied.

It is necessary to identify the geotechnical aspects that must be studied and which basically relate to the stability of the work during the construction, the stability of the work in the medium and long term, and the stability in the short and long term of the existing structures close to the project.

Location

Information should be included regarding the location of the project, appending a general plan of the project location, referenced in the text, to the scale 1:2000, and which includes aspects such as coordinates, north, east, conventions, roads, sections for study or projected works, readable texts, etc.
In addition, a plan to the scale 1:20,000 must be presented showing the location of the project area indicated with a circle.

Description of the project

Both linear and specific works should be described, from a geometric, morphological and structural point of view, indicating depth of foundation and excavation. Particularly for linear works, the installation conditions, abscissas, length, width and depth of excavation, the project type, the type and material of the pipes, etc. should be described by sections and in the form of a table, indicating the structural requests for each one of them, such as loads and pressures or thrusts to withstand, both their own and those needed for operation.

It should also indicate all those structures located to the right of road that can affect the work, either by transmitting pressures or causing obstruction during construction.

Collecting Information

The information indicated in the paragraph regarding preliminary information, in the present annex, should be included. If no information is found, it should be left explicit.

Field Explorations

All the aspects reviewed for **Field Explorations** in this annex (quantity, location, depth, distribution, registration, and testing during field explorations, and sampling program-type and number) should be presented and justified here. Any modification must be duly justified.

A location map of the subsoil exploration points, referenced in the text, must be attached in a scale of 1:2000, which includes aspects such as coordinates, north, east, roads, readable texts, surveys, shafts, trenches, drills, conventions, etc. In the case of linear works, the sections of study or projected works, specific conventions for the different networks, etc. should be mentioned. If there are several subsoil exploration programs, or if reference is made to secondary information explorations, different conventions should be established.

All field records must be appended (boreholes, drills, geophysics, shafts, etc.), duly referenced in terms of coordinates, elevations and abscissas of the project, and in agreement with the exploration plan.

Additionally, and also consistent with the map and field records, the geotechnical characteristics must be filled out and presented in fileable formats.

Based on the boreholes, a plan should be created that includes a reconstruction of the subsoil in profile, showing the different layers with their respective description and classification according to the USCS system. This should also establish approximate thicknesses, the position of groundwater levels, and the results of field tests performed on each profile. This profile will be the basis of geotechnical analysis.

Laboratory tests

For this item at least all aspects related to (physical properties, index and mechanics - resistance and deformability) should be presented and justified. Any modification must be duly justified.

As an annex to the soil study, the reports or records of all the tests carried out must also be presented in a legible form, duly referenced in depth to the surveys.

In addition, and consistent with field records, technical formats should be filled out in order to enable the archiving of the geotechnical characteristics.

Geotechnical analysis

A text should be included with the criteria used for all aspects of the **Geotechnical analysis and designs** and a calculation record with the respective numerical analyses.

The requests assessment should be explicitly addressed in the text of the report.

Any geotechnical analysis should be based on soil characterization. The analysis model should also be established with its hypothesis and considerations, as well as its limitations. Last of all the calculations will be done, which must follow a rational and clear process. In the event that computer programs are used, the results must be validated with simplified manual calculations.

The settlement calculations should be carried out by establishing separately the analysis by consolidation and elastic deformation.

Bearing capacity, deformation calculation, and analysis of the stability of excavations, slopes and hillsides. The analyses can be carried out by any existing method, explaining the criteria used for this purpose. In the calculation record, graphs, abacuses, bibliographic references and everything that gives clarity to the study must be included. If it is the case that the foundations require complementary works, such as anchorages, walls, etc., the corresponding design must be presented accompanied by schemes and/or plans depending on the work.

Seismic analysis, liquefaction potential, and expansiveness analysis must be provided, according to the parameters of this paragraph.

Systems for the protection and/or containment of slopes: in the calculation records the diagrams of lateral pressures assumed for calculation, and the design of the structural elements must be presented. The text should set out the criteria, procedures, and recommendations.

Recommendations for water management should be established in accordance with what is indicated in the paragraph.

An analysis of the special conditions of the subsoil should be carried out in accordance with what is indicated in this paragraph.

Note: In the event that automatic information processing is used, a detailed description of the principles on which such processing is based should be given, as well as a description of the input and output data of the process and its units.

Conclusions and recommendations

All the conclusions and recommendations considered by the geotechnician to be relevant to the study should be presented.

The conclusions must contain different solution altalternatives from an economic and technical point of view, in the event that there is more than one. Finally, the recommendations should be given which favor the execution of the project from a technical and economic point of view.

Products to be delivered

- Introduction (objectives and scope of the study)
- Description of the curriculum.
- Geology of the area (brief description).
- Description of field work (boreholes, geophysical exploration, sampling, and laboratory tests.)
- Stratigraphy and groundwater level.
- Geotechnical characteristics of the soils found (classification, humidity, boundaries, contraction rates, expansion pressure and resistances of the soils found, determined by confined and unconfined compression tests, and in the cases where required, direct and triaxial cuts).
- Foundation design. (Support capacity analysis, recommended foundation type, pre-dimensioning of the foundation, foundation level, calculation of the consolidation or settlements of the structures to be built, soil parameters for the wall designs (if applicable).
- Seismic considerations.
- Results, conclusions and recommendations.
- Annexes (survey location plans, field work records, laboratory tests, records and report of recommended foundations, and printed and digital photographic file)
- Magnetic files duly ordered and referenced

Personnel requirements

The execution of geotechnical work must be performed by geotechnical engineers who will carry out the work under their own absolute responsibility, without delegating their functions to persons whose academic preparation and experience is inferior to theirs. Depending on the magnitude and complexity of the project, the audit will request the participation of geologists and/or structural engineers in the creation of the geotechnical study.

The fulfillment of this technical annex does not exempt the engineer from their responsibility for the concepts emitted, nor for the accomplishment of all the activities of the geotechnical study, in order to guarantee adequate knowledge of the soil, and to ensure the stability of the works of the whole project, as well as of the existing and projected neighboring works in the surroundings of the study area. This standard does not exempt the executor from the responsibility for conducting explorations, tests, analyses and/or designs which are considered by the engineer to be necessary for a particular case.

Bibliographical references

System of technical regulations for the aqueduct and sewage systems of Bogotá (SISTEC), 2006.
Design and construction standards for aqueduct and sewage systems of Empresas Municipales of Cali, 1999.
Geosynthetic Design Manual, Department of Engineering PAVCO, VII edition October 2006.
Aqueduct and sewage regulations of the Autonomous Regional Corporation for the defense of the plateau of Bucaramanga, 2006.
Aqueduct and sewage regulations of Aguas of Cartagena S.A. ESP, Aqueduct and Sewage Company of Cartagena, 2005.
Design standards for aqueduct and sewage systems of Empresas Publicas of Medellín (EPM), 2006

Field Explorations

Standards for field exploration

The test standards to be followed for the implementation of explorations, field tests and sampling are shown in table 1.

Table 1. Standards for the execution of field explorations and tests

Name	Standard
Drilling with diamond drills for site research	"INVE-108"
Normal penetration and split tube sampling of the soil	"INVE-1 11"

Special care should be taken with the stability of the shafts walls and trenches, and if applicable, use a temporary support system. The water evacuation system must also be established and safety must be ensured in the excavation and its surrounding areas. In areas with the presence of saturated fine sands, special care should be taken in the pumping, since settlement phenomena can be induced in areas adjacent to the excavation.

During the drilling process, all the precautions should be taken to ensure that the holes are not clogged or obstructed by the implementation of some type of metal coating or the use of drilling muds. If any gap is clogged or obstructed for any reason during drilling, it must be cleaned or, if applicable, enlarged on account of the responsible of the investigation and to the satisfaction of FINDETER.

The upper ends of all probes and boreholes must be properly protected and referenced.

Once the perforation has been carried out, the samples are taken and the groundwater level is measured if there is one, the hole must be covered with the excavated material, installing a plug made with compacted soil at its top.

The contractor must guarantee in the execution of the explorations, the implementation and use of the elements of industrial safety and occupational health which are required for this type of work by the legal regulations in force, in this way protecting the integrity of those in charge of the work. Failure to comply with these rules by the executor may result in the imposition of penalties.

Minimum number of field explorations

Any projected work must have sufficient boreholes in number and depth to define the characteristics and properties of the subsoil on which, if so determined by the engineer Geotecnista, geotechnical analyses may be carried out (settlements, bearing capacity, thrusts, stability of the slopes of the excavations and the bottom of the excavation, etc). In any case, the number of exploratory boreholes cannot be less than two. These can be of direct type, such as manual drilling or drilling with mechanical equipment.

The minimum exploration by work type is set out in table 2. However, it should be noted that the final number of boreholes may be greater and must obey the need to have a good characterization in order to establish reliable conclusions and recommendations. On the other hand, the final depth of the exploration should be established based on the type of probable foundation and the pressure bulb induced by it in the soil.

Table 2. Subsoil Exploration

Work	Minimum quantity [a]	Minimum depth [d]
Conventional structures	NSR-10	NSR-10
Hydraulic structures	1 c/20m^2	NSR-10
Matrix networks of the Aqueduct	1 c/200m[b]	1.5 times the Max. depth of excavation
Secondary Networks of Aqueduct	1 c/250m[b]	1.5 times the Max. depth of excavation
Channels	3 C/300m[c]	2.0 times the Max. depth of excavation

*** For sewage systems, the indicated in chapter G must be applied. 2.3 (Soil investigations), paragraphs G. 2.3.2.3 and G. 2.3.2.4 and the contents in tables G. 2.1 and G. 2.2 of the RAS-2000 "technical regulations for the drinking water and basic sanitation sector."**

Notes:
[a] At least 2 direct-type probes
[b] or each morphological, lithological or structural change of relevance
[C] The probes should be distributed on both margins and the channel axis
[d] At least 1.5 m deep

The above mentioned depths serve as a guide, depending on the final depth of the exploration, the geological-geotechnical conditions of the area and the type of structure to be designed and constructed.

Preliminary information

It should be consulted in the documentation office of the TERRITORIAL ENTITY, Municipal Planning, AUTONOMOUS CORPORATION, INGEOMINAS, IGAC, among others, regarding the existing information related to the project in terms of geology, geotechnics, and which is technically consider for the benefit of the project. The information resulting from the investigation of interferences, and the identification of restrictions and intersections during the construction of sewage systems should also be considered, as well as the elements involved in the geotechnical study environment, such as vegetation, land use and everything that is considered appropriate to acquire a global knowledge of the project.

Also collect and analyze information with interference on the project, such as neighboring constructions, pre-existing pipelines, problematic soils, unstable or potentially unstable zones, accessibility to the site, interferences, presence of embankments or channels, etc.

Geology and geomorphology

The Geological Survey will emphasize the identification and characterization of the geotechnical units present and their relationship with the project to be executed. Additionally it must include the identification and evaluation of the different threats of natural origin that could generate a risk for the project.

The geological and morphological characterization is necessary for those mountain or foothill sites where there are rocky masses, colluvial and alluvial deposits, debris flow rates, alluvial fans, and evidence of old mines, etc. In important works (collector channels, etc) photointerpretation becomes necessary in the vicinity of rivers, from which paleo-channels and the location of old water bodies will be identified, that may pose a threat to the stability of the projected work.
When the works require them, geological and geomorphological studies should be presented, which should include aspects such as photointerpretation, field recognition, and general information in order to establish in a general geological structural way, lithologies, geophysical explorations, geological sections, morphodynamic interpretation, geological and geomorphological maps, among others.

1.2.6. *Photogrammetric, and topographic studies, and field work.*

All the designs of the systems must be developed based on precise altimetric and planimetric topographical surveys, whose objective is to generate an exact reflection of the reality of the site where the works will be carried out, and for this they must be done with high precision equipment.

In order to facilitate its subsequent reconsideration during the construction phase, boundary markers should be used and pairs of high-precision geographic positioning systems (GPS), at least using dual frequency technology.

The geodetic mooring of the project must be ensured according to the provisions of the IGAC.

The magnetic files and topography plans shall be independent of the design plans, and should be part of the design records and documents, and conform to the provisions of title 3 of this Resolution on document management.

General considerations

- The surveys must contain at least the information that enables them to describe the plots precisely, in addition to all the characteristics and details that are relevant and that are within the area of influence of the project.
- Probe sites and geotechnical studies must be surveyed to locate them in the plans.

Presentation of the Works

The works of the collector systems, and the pumping station, must be geo-referenced in the geographic coordinates system, with geoid Magna Sirgas, Magna Datum Bogotá origin.

For the creation of plans and in order to differentiate and compare the data, the plan coordinate projection system Magna Sirgas Colombia Origin Magna Datum Bogotá should be used.

- The presentation of plans in analogue format (plotting) must be done at spread size (0.9 x 0.6 m), with the scale to be defined by the contractor. In any case the auditor will verify that the size of the scale used complies with the sufficient level of quality required for works or evaluation.
- A copy of calculations and adjustments to polygons must be submitted
- Copy of the portfolio of the topographic survey or copy of the raw data of the stations, in digital form.
- The presentation in digital format (Arcgis, CAD, PDF, reports, other files), must be done on a CD (compact disc), duly labelled. The format for the label must be filled out in full, for the box and for the CD. The format will be delivered by the audit of the contract.
- A folder containing all files delivered in an orderly manner (unified file) must be delivered.
- The contractor will carry out the necessary topographic work, making the respective planimetric and altimetric surveys moored to the IGAC coordinate system at the specified sites.
- The survey should be started from plates that are georeferenced and certified by the IGAC. The surveys can be carried out through conventional methods (Digital file format: theodolite or total station) whose actual minimum accuracy is 3 "(three seconds) or satellite (format Rinex: GPS).

Mooring plates and References

For the execution of these activities, the following requirements shall be taken into account:

- The points of support for the moorings of planimetric and altimetric works must be certified by the Geographical Institute Agustín Codazzi.
- It will have to be verified that the vertexes to which the topographic works are to be moored are not destroyed, deteriorated, or that they give some indication of having lost their original position.

- For planimetric surveys the transfer of the coordinates of the supports must be carried out by means of a check to two different supports or vertexes and with closure.
- For altimetric surveys these should be done by leveling and counterleveling in order to be able to determine the closing error.
- At least two (2) boundary markers shall be left (geodetic with their respective report and post-process) of concrete duly referenced for rapid localization (at least one marker must be located at a reference point of easy location and access and under custody such as schools, churches and/or communal halls). They must penetrate at least eighty centimeters into the ground and on the upper face will have embedded a metal plate of copper or bronze and giving the real coordinates and elevation, taking as reference the information of the IGAC and corresponding identification and the name of the contracting entity, guiding them to the magnetic north thus enabling the location of the structures. These markers should be included in a location plan.
- The contractor will be responsible for the reference points (P.R.) to remain in good condition and duly secured for the duration of the study until final approval.

Topography Equipment

Planimetric surveys can be performed by using total stations whose angular accuracy is less than or equal to 3 "(three seconds) or through the use of the GPS system. The survey must be carried out with the following minimum specifications:

- The equipment used must be in perfect condition, with calibration certificates valid for six (6) months; revisions should be carried out regularly to ensure proper operation, and if there is any indication that this is not the case, they should be tsken for maintenance.
- Canes must have a calibration certificate valid for six (6) months; ensure that the heights of the extenders are centered and calibrated.
- The prisms must be in good condition, without dents and without fractures in the crystals.
- The Porta Prisms may not be broken or fractured, and should not be tied to any type of adhesive tape, ropes or wires, and must fit perfectly into the cane and prism.
- Accessories such as tripods, poles, levelling bases, batteries, etc. must be in optimal operating condition.
- Altimetric surveys must be carried out using automatic or digital levels which must be in perfect condition and their calibration certificates valid for six (6) months. Revisions should be made regularly to ensure proper operation of the equipment and if there is any indication that this is not the case, they should be taken for maintenance.
- The viewers must be tight, the push-button locks must secure perfectly, the metric division may not have scratches, stains, or any deterioration that prevents or generates uncertainties in readings, and its calibration certificates valid for six (6) months.
- The tripods must be in perfect condition, the legs cannot have any type of play when they are tightened, the nails of the legs must be complete, they cannot be split or broken. The base of the tripod must be perfectly snug, its surface flat and smooth, the coupling screw cannot have bumps or dents and must be fixed at the base of the tripod.
- The contractor must carry out a detailed topographic survey of the areas where the collector systems and wastewater pumping station will be projected.

Planimetric Surveys

The surveys must contemplate at least the following specifications:

- All surveys must be carried out with closed polygons and their adjustment with a linear closing error equal to or greater than 1:25000.
- Length measurements should be taken with electronic measuring equipment. If you do not have this resource they should be taken directly with steel tapes that are in optimal condition.
- All angular measurements of the vertexes of the polygonal must be made in direct and reverse position, in order to eliminate the collimation error, these measurements must be registered in the records of the total station and written down in the field portfolio.
- If you are alternating a polygonal with taking details, then once the equipment is installed in the station, you should always first locate the next delta of the polygonal before starting the radiation and always the first detail of the radiation that is taken from that station must be the delta of the polygonal that was just located, so as to ensure the information of the polygonal.
- In the records of the total station, all the data of the deltas that compose the polygonal (North coordinate, east coordinate, horizontal distances, inclined, vertical, horizontal and vertical angles, azimuth) must be stored.
- All the deltas of the polygonals must be materialized with a stake in green areas and with points in hard areas guaranteeing that they are perfectly identified in the terrain, the stakes and/or the points must be marked in nearby stable places, like posts, fences, walls, bridges etc. with a vivid color that must also be exclusive to the topography works that are being performed. In the green areas you must clean the ground approximately 0.3 m around the vertex for easy location.
- As far as possible there should be no abrupt changes in the distances of the polygonal, to avoid geometric errors when adjusting it.
- The field portfolios must be filled out with all the data relevant to the work being performed.

Altimetric Surveys
The following considerations shall be attended for the execution of the work:

- Automatic or digital levels of precision must be used to carry out altimetric surveys.
- All leveling circuits must be closed with counterleveling and the latches must be less than one (1) millimeter per change.
- The visuals between changes should not exceed fifty (50) meters.
- The viewer holders must be in perfect condition, to guarantee the stability and the verticality of the viewer with the help of the circular bubble level, for as long as it is necessary, if it is the case that the leveling should provide geodetic precisions it will be necessary to use a base for the viewer.
- BMs must be generated for the construction of aqueduct and sewage systems, in such a way that they are not affected by the execution of the works. The BMs must be materialized with a marker in green areas and with a point with a fuse in hard areas.
- The BMs both in green areas and hard areas must be marked in nearby stable places, such as posts, fences, walls, bridges etc. with a vivid color so that they can be identified in the terrain. The color of paint used for the works of altimetry should be different from that uses in the planimetric works and different from those used in other activities being performed.

- Levelling should be done every ten (10) meters on the axes of the aqueduct or sewage project, for each abscissa reconsidered planimetrically. For the purposes of the creation of aqueduct and sewage registers, in the respective products, the detail to be surveyed shall be indicated.
- Interferences or intersections between projected sections and public service networks must be leveled.
- The field portfolios must be filled out with all the data relevant to the work being carried out in addition to:

  - ✓ Name of the surveyor.
  - ✓ Name of the auxiliaries.
  - ✓ Equipment used.
  - ✓ Date.
  - ✓ Activities area (address, village, property).

Guide for presenting reports or records of the topography works

Reports of topographic surveys carried out by conventional methods and global positioning systems (GPS) must contain at least the aspects indicated below.

- **Planimetry**
  - Work description
  - Objective of the survey.
  - Topography Commission with the members or participants of the Topography Commission (quantity, names, identification and professional license or professional registration as the case may be).
  - The mooring points used certified by the IGAC.
  - Number of localized deltas, used names and stipulated nomenclature.
  - Amount of details surveyed.
  - Methodology used to carr.y out the survey.
  - Determination scheme of the survey.
  - Description of the equipment used, annexing the calibration certificate valid for no less than six (6) months.

- **Calculations and adjustments**

  - The calculations and adjustments of the corresponding survey must be carried out and delivered according to the equipment used for the measurement.
  - The native files of each station must be delivered with the survey data, the files with the polygonal settings in which should appear:
    - Calculation and compensation of the angular closing error.
    - Azimuth calculation.
    - Calculation of the projections.
    - Calculation of the linear closing error.
    - Calculation of vertex coordinates.
    - Polygon calculations and adjustments must be delivered in an Excel file, with a copy in a file with a PDF extension.

- **Coordinate table**

The coordinates of the survey must be related according to the points identified in it, with their corresponding codification or nomenclature (related to the determination scheme in the field portfolios):

Punto: nomenclatura / código	ESTE	NORTE	COTA
PERÍMETRO			
ÁREA m^2			

- **Vertex certification**

The IGAC certificates of the vertexes used for moorings must be attached to the reports.

- **Field portfolios**

The field portfolios must be clearly written and contain all the original data, schemes, and appropriate information, compiled in a book. The portfolios must be filled out with ink and not allowed to be erased, in the case of an error it must be crossed out and the correct measurement written. No freshly written out portfolios are accepted. The portfolios must be identified as follows:

- Name of the work or project.
- For whom the work or project is carried out.
- Number that identifies the polygonal.
- Vertexes used in the mooring.
- Location.
- Date and (Start time – end time).
- Name of the surveyor.
- Name of the auxiliaries.
- Equipment used. (Brand and serial).
- Activities area (address, village, property).

For surveys with total stations in the field portfolio, the following data must be recorded at a minimum:

PUNTO: NOMENCLATURA / CÓDIGO	DELTA VISADO: NOMENCLATURA / CÓDIGO	ALTURA INSTRUMENTAL	ALTURA PRISMA	NORTE	ESTE	COTA	DISTANCIA INCLINADA	ÁNGULO OBSERVADO	DETALLES

- **Altimetry**

Work description

- Objective of leveling.
- Topography Commission: the members or participants of the Topography Commission (quantity, names, identification and professional license or professional registration as the case may be).
- The mooring points used and certified by the IGAC.
- Number of points leveled.

- Amount of changes made and the length of leveling and counterleveling.
- Methodology used to carry out the leveling.
- Description of the equipment used, annexing the calibration certificate valid for no less than six (6) months.

Calculations and adjustments

Leveling calculations and adjustments must be made and delivered, these calculations and adjustments must be delivered on an Excel datasheet with a copy in a file with a PDF extension with the following information.

- Calculation of the elevations of the points taken in the levelling.
- Calculation of the counterleveling.
- Calculation of the length of the leveling circuit.
- Calculating the closing error
- Calculation of the adjusted leveling.

Vertex certification
The IGAC certificates of the vertexes used for moorings must be attached to the reports.

• **Field portfolios**

The field portfolios must be clearly written and contain all the original data, schemes, and appropriate information, compiled in a book. The portfolios must be filled out with ink and not allowed to be erased, in the case of an error it must be crossed out and the correct measurement written. No freshly written out portfolios are accepted. The portfolios must be identified as follows:

- Name of the work or project.
- For whom the work or project is carried out
- Number that identifies the leveling.
- Vertexes used in the mooring.
- Location.
- Date and (Start time – end time).
- Name of the surveyor.
- Name of the auxiliaries.
- Equipment used. (Brand and serial)
- Activities area (address, village, property).

For the leveling the portfolio must have at least the following data:

ABSCISA	VISTA (+)	ALTURA INSTRUMENTAL	VISTA (-)	VISTA (INT)	COTA	OBSERVACIONES

- **Determination of vertexes with GPS**

Work description

- Objective of positioning.

- Topography Commission: the members or participants of the Topography Commission (quantity, names, identification and professional license or professional registration as the case may be).
- The mooring vertexes used and certified by the IGAC.
- Number of vertexes positioned.
- Positioning time per vertex.
- Description of the equipment used and its accessories (brand and serial).

- **Calculations and adjustments**

GPS positioning calculations and adjustments must be delivered on an Excel datasheet with a copy in a file with a PDF extension; the calculations that must be presented are the following:

- Speed calculation.
- Calculation of geocentric coordinates.
- Calculation of geodetic coordinates.
- Calculation of the flat coordinates of Gauss and local cartesians.
- Determination plan in CAD formats (DXF, DGN or DWG) and ARC GIS (MDX).

- **Vertex certification**

The IGAC certificates of the vertexes used for moorings must be attached to the reports.

The sub-product will be the report in magnetic and physical form of topographic studies for defined projects. It must be endorsed with the signature and professional registration number of a surveyor or surveyor engineer with a professional license.

1.2.7. Bathymetry

The contractor should build the models and describe the factors that make up the study area by establishing the topographical conditions of the space and the terrain surrounding the section of Interest, together with the bathymetric measurements present on the axis of the receptor body at the time of the study. This is done with the intention of establishing the morphological, both superficial (length, width, shape, and those considered important within the study), and under the surface of the water (depth, thickness of the sediments, topography of the bottom, among others).

For this purpose, the technological tools to process information such as longitudinal profiles, cross sections, level curves, among others, should be at the service of the studies.

1.2.8. Characterization of wastewater

The contractor must include the characterization of the wastewater involved in the project (existing discharges), and physical, chemical and bacteriological analyses of these should be made according to the parameters established in the RAS and regulations in force.

The laboratory where the samples will be analyzed must be certified by the IDEAM, for which they must attach the respective supports.

The calculation of the pollution load of domestic, commercial and industrial origin must be carried out for the total population of the urban and rural area. To do this, estimates should be made of the unit load based on the days of measurements of flow rate and pollutant concentrations.

The results obtained in the characterization of the wastewaters will be compared with table E. 2.6 of the current RAS. Likewise, the calculation of the design flow rates for the different structures required, according to what is stipulated in the current RAS, must be carried out.

1.2.9. Sewage flow rate determination:

For calculating the flow rate of sanitary sewage parameters such as areas to be drained, coefficient of return to the sewage system, socioeconomic strata, water consumption, population density, capacity factor, infiltrations, erroneous connections, among others, must be identified, analyzed and defined. In addition, the contributions of commercial, industrial, and institutional type must be defined, to be adopted according to the user register.

Likewise, in rainwater and combined sewage systems (if applicable), for rainwater contributions, the following parameters are determined, among others: area to be drained, intensity-frequency-duration curves for the nearest pluviographic o pluviometric season, return period, concentration times, runoff coefficients, etc.

Additionally, the hydraulic parameters that foster the proper functioning of the sewage systems, defined in the RAS 2000, will be followed.

1.2.10. Vulnerability and Risk

The contractor must identify and characterize the threats present in the area, as well as identify the weaknesses of the infrastructure, determining the physical vulnerability of its components, of the financial capacities, such as suspension of payments, expenditure on systems repair, increase in production and distribution costs, and operations, observing the technical resources and prepared personnel, presented by the systems and services.

In considering the works to be carried out for the best provision of the water supply and management service, measures and works of protection must be included to ensure the sustainability of the systems regarding the environmental risks.

In the evaluation process it is important to consider and take advantage of the knowledge that the local population has about the environment. It should always be borne in mind that local risk management should involve the community itself and gather its knowledge of the main natural threats, the places at greatest risk and the magnitude with which these have occured, and combine all this with the available technological options so that the components are located in the lower-risk areas or the necessary preventive measures are included.

The contractor must identify, evaluate and quantify the risks associated with the proposed alternatives. For each type of risk the contractor should propose efficient mechanisms of allocation and mitigation. The responsibility of each risk must be assigned to the party that is best able to control it. The financial implications of the risks and mitigation mechanisms required must be quatified, so that the financial viability and the reliability of the proposed mechanisms can be established.

1.2.11. Hydraulic behavior of the existing drainage system

With the information obtained in the hydrological study, the contractor will have to carry out an evaluation of the urban drainage system: rainwater, which runs through the municipality or populated center, including the identification and quantification of channels, interceptors and collectors to be valued within the studies of the contract.
The identification of wastewaters will be established with the support of the information obtained in the diagnosis and by the regulations in force.

The contractor will review, evaluate and present an analysis of existing studies and projects, identifying collectors, interceptors and final sewage outlets constructed; describing and indicating in the plans the quantities, lengths, capacities, hydraulic and structural characteristics of the components of the system, and the basic characteristics of the flow rates, structures, sections, or receptor water bodies.

The contractor must identify the areas susceptible to flooding and evaluate the possible effects on the different structures of the system that could be affected by floods, calculating the periods of return allowed the system, required, and those indicated by the regulations, and the necessary protection measures must be established and designed to mitigate these impacts.

1.2.12. Sewage systems: Wastewater and Rainwater

Wastewater and rainwater collection and evacuation systems shall be evaluated and projected in accordance with section II, title D, domestic wastewater and rainwater collection and evacuation systems (RAS in force).
The following are some of the factors that should be considered in the study of rainwater collection and evacuation subsystems in urban and related areas:

- Maps with the identification of incidence areas and affectation zones.
- Plans with the location of structures in service, and those proposed.
- Analysis of solutions with open channels or closed pipes.
- Drain pipe materials and their condition.
- Identification of existing special hydraulic structures, their condition, operation, and conservation, and those required.

Availability of labor and building materials.

The availability of qualified and unqualified labor for the development of the project, and of technical personnel for operation and maintenance work, as well as the salaries in force in the locality, must be analysed. In the same way, the availability and capacity of local, regional and national production of materials and equipment required for the construction of works and supplies for operation and maintenance must be established, precisely defining the availability of quarries and their distance to the work sites, as well as the availability of sites. Depending on the type of engineering work that is expected to be carried out within the project, a greater depth and detail in the study of sources of stone materials and their specific environmental requirements will be necessary.

1.2.13. *Socioeconomic studies*

The socio-economic evaluation of projects should be carried out in order to measure the net contribution of projects to the well-being of the population. For aqueduct, sewage and/or sanitation projects, minimum socioeconomic studies such as cost-efficiency analysis and/or minimum cost analysis, and capacity expansion are required (see Social Management and Gender Equity Plan)

Environmental studies.

The environmental assessment should be carried out on the basis of the "General methodology for the presentation of environmental Studies" of the Ministry of Environment, Housing and Territorial Development (2010).

A methodology for identifying and evaluating impacts for situations with and without the project, based on cause effect matrices, which use qualitative and quantative indicators to assess environmental impacts and allow the evaluation to be presented in terms of relative values of environmental quality.

The contractor should incorporate the recommendations made by the Regional Autonomous Corporation regarding the works and actions formulated to mitigate the negative impacts generated by the project, in accordance with the obligations imposed in the environmental license, if any, or with the environmental management measures determined for the development of the project, both in its construction phase and in the operation of the system.

Environmental Impact Studies

The contractor will establish for each of the components of the project the positive and negative impacts generated by the execution of the project and its corresponding measures of prevention, mitigation or compensation with regard to the resources of water, air, fauna, flora and population, determining the degrees of affectation of each one, costs and priorities of which will be determined in the budget of the special paragraph.

The contractor will provide the necessary information for the procedure to the environmental authority responsible for the permissions required for the project; which may be: permission for water concession, occupation of watercourses, forestry use, permisssion for the extraction of material from quarries, permission for discharges, permissio for an environmental license, permission for the environmental diagnosis of alternatives, permission for atmospheric emissions and debris disposal in the study area.

The construction of the works proposed in the studies and designs will generate negative and positive impacts in their area of influence, which requires the structuring of an environmental management plan that contains measures designed to avoid, prevent, control and/or mitigate environmental impacts that affect biotic, abiotic, landscape and social components, and jeopardize the construction of the project. The environmental management plan for the execution of the intervention will be submitted to the audit which will approve it and monitor it.

Therefore, the contractor must recognise the regional and geographical context in which the works will be developed, which will enable him to define the programs that apply according to the scope of these and the conditions of his area of influence. This evaluation is intended to ensure sustainable development with its social and environmental environment, according to the applicable Colombian regulations.

Once the environmental management plan has been structured and approved, the contractor must turn it into a field manual, written in clear language that facilitates its application, to be taught to the operative staff, prior to and during the execution of the work, in such a way that ensures compliance. In this case, the contractor will be able to review the Handbook of Good Environmental practices published by the Ministry of Housing.

For the PMA, the contractor should carry out a different analysis of the effects and risks inherent to the work or activity and possible solutions, in addition to quantifying the mitigation and control measures for each of the alternatives.

The contractor must create the respective impact matrices and formulate the management plan with actions for the preservation, compensation, mitigation and control of the same, during the phases of the project, in the construction, operation and maintenance. It will analyse the effects of environmental impacts and control measures: soils, geology, water quality, hydrography, climate, fauna, flora, urban development and health. In the case of receiving bodies, the contractor must create a current and future basis, identifying the environmental conditions before and after the implementation of the works.

The contractor shall observe and apply laws and regulations concerning occupational health and Industrial safety, taking into account scenarios in order to take all necessary precautions aimed at avoiding and preventing in working areas and temporary installations, accidents or conditions derived from occupational diseases.

1.2.14. Permits, licenses, authorizations, *Property Acquisition Datasheets*

1.2.14.1. Analysis and management of property:

The required property studies should carried out, for the possible location sites of the infrastructure (collectors, treatment plants, etc.), for the process of acquiring the asset and/or recognition of easements.

The aforementioned components and their analyses must be compiled in a diagnostic report that identifies the conditions under which the designs will be made and how they could impact the future of the project in operation.

Similarly, a "socialization of the project" should be held with the community involved who may have some interest in the project, especially with the owners of the properties required for the project, or a community receiving an environmental impact from the project in the stages of design or subsequent construction and/or operation of the system, and in general any person or entity that wishes to have a say ragarding the project.

All designs must contemplate the detailed property aspect, which clearly establishes the necessities of acquisition of properties and easements to develope the construction of the works, and the administrative actions that the territorial entity or the environmental authority must carry out in order to ensure the timely availability of the land required for construction.

The designer must identify, in accordance with current regulations, the authorizations and permits required for the implementation of the project.

Properties, rights and Easements

Once the areas that will be occupied by the different components of the project are defined, the contractor will have to make an assessment of the property rights of these areas and establish the need to buy some of them and define their cost, or failing that to establish the actions for the legalization of the rights and easements that are necessary for the construction and operation of the project. The respective project plan must be attached, with an enclosed database identifying the properties intended for intervention, which must contain at least (if this information exists):

- Name of the property
- Land registry identification number
- Real Estate Registration number
- Georeferencing of each one of the properties to be intervened
- Owner's name and copy of the owner's citizenship or NIT card
- Village and/or neighborhood
- Simple copy of the public deed.
- Tradition and Freedom Certificate of the property with validity of two (2) months
- Property information contained in the registers.
- The contractor will present a topographical report of the affected properties that includes polygonal and the strip or plot used in the project, with field portfolios, polygonal diagrams, calculation memories, list of adjusted coordinates and photographic record of the materialized points, affected areas and free areas, and land registry and owner information to be obtained. The graphical output will be made in: two (2) printed copies in original and in magnetic form in a CD ROM with a file with a PDF extension.

Property Intervention Plan

For each property, this product will be delivered on appropriate scales, such as: 1:200, 1:500 or 1:1000, which will be approved by the audit. In addition, it will carry a table with the data of lengths of the boundaries and areas to be intervened according to topographic survey. The graphical output will be made in: two (2) printed copies in original and in magnetic form a CD ROM, in file format with PDF extension.

Property Datasheet

This product will be delivered with all the data surveyed according to the format provided by the auditor. The information will be delivered printed and in magnetic form, in two (2) copies, in Excel.

Legal report

- Relationship of properties to be intervened.
- Copy of the individual topographic register.
- Photographs of the venue.
- Copy of the owner's citizenship card.
- Tradition and Freedom Certificate.
- Simple copy of Public Deeds.
- Property information contained in the registers.
- Magnetic file of the photographs.

Based on the information obtained a diagnosis will be presented of the type of tenure and current legal status of the owners of the affected property to be intervened by the project, to make recommendations to the company regarding procedures with public entities.

If it is necessary for the Municipal Administration or the operator to acquire some land or bonded rights of easement, their cost must be included in the project's investment plan or budget.

In addition to the property study described, the contract must advance with the necessary steps to ensure that the acquisition of the properties and/or easement permits necessary for the development of each project is completed. This management includes:

- Approaches between the municipal authorities and the owners.
- Support to the municipality in obtaining the necessary documents for the fulfillment of the required formalities before the respective entities for the declaration of public utility of the required properties, negotiation, formalization and legalization of the purchase of the properties and/or the required easement permits

Product Analysis and Property Management

A study of titles and appraisals must be made for the acquisition of the necessary properties and/or easements, creating a property datasheet for each one; this information should be presented in a specific report and plans, which must be given to the municipal administration to proceed with the process of the procurement of the properties and/or easements, when required.

In addition to the study, the necessary steps must be taken to ensure that the acquisition of the properties and/or easement permits necessary for the development of each project is completed. This activity must be carried out in parallel with the creation of studies and definitive designs of the selected alternative in conjunction with the community, so that the acquisition of the properties and/or easements is ready at the time the project is delivered.

To be delivered regarding this product is a report of property management, which includes the aforementioned.

1.2.15. Other studies.

The contractor will carry out other studies such structural, hydraulic, electrical, mechanical, hydrological, fluvial, etc) and others that are deemed necessary for the development of the project in common agreement with the Audit of the project.

1.2.16. *Existing infrastructure of other services.*

The contractor must identify the main infrastructure works built and projected within the area of influence of the project, such as roads, bridges, canals, box-coulvert, electric power transmission lines, pipelines and any other important works. In the same way, the networks of other public services in the area, such as gas, telephone and electricity networks, and their respective service areas, with which interference could be generated, should be identified from secondary information sources, or field work.

1.2.17. *Availability of electric power.*

In cases where it is required the contractor must determine the availability and reliability of the supply of electricity in the area of influence of the project, as well as the characteristics of voltage, power and frequency of the service and the possibility of generating alternative energy solutions, in case of requiring works that require this service. Fees for the provision of these services must also be considered within the socioeconomic study.

1.2.18. *Access roads.*

An inventory must be made of the roads, paths, railways, as well as the routes by air, sea, river and lake providing access to the locality, establishing the distances to the closest urban areas. This will establish the accessibility for the required transport of materials and equipment for the execution of the works and their later maintenance.

1.3. Formulation, analysis, comparison, selection of viable alternative for the projects.

Project alternatives should be formulated to provide solutions to the problems, objectives and goals identified in the previous article, from a technical point of view, at the pre-dimensioning level. The analysis should take into account the risk management and environmental management, and review the financial, economic and social aspects which determine the viability of the respective project. As a result, at the least the pre-design document will be obtained with the respective plans and records.

1.3.1. Preliminary activities and analysis of alternatives

Based on the evaluation and diagnosis of existing sewage systems, the contractor must identify, raise and pre-dimension the solution alternatives for the identified problems and for each element that needs to be adapted, rehabilitated, optimized, and/or replaced, and the reasons and justifications for the inclusion of new elements. The contractor must therefore pre-dimension, evaluate, select and recommend to the contracting company, municipality and to the service provider the most convenient solution from the technical, economic, financial, social, environmental and institutional points of view.

The feasible alternatives proposed for each component should be to ensure the proper functioning of the sewage system and its components, incorporating its technical, institutional, financial, economic, social and environmental dimensions, in accordance with the current regulations of the Technical Regulations for Drinking Water and Basic Sanitation Sector – RAS

The cost of the initial investments and the recurrent costs of operation carried at net present value for each of the alternatives should be considered economically, in order to make the most favorable decision that generates the best sustainability of the service, taking into account that the operating costs are transferred to the users via fees.

Within the technological alternatives to be considered, the minimum cost solution must be taken into account that complies with the quality parameters demanded by the current regulations, both in initial investment and in operating costs. Likewise, it should consider the availability situation of the properties and easements required for the development of the project.

Each of the feasible alternatives proposed by the contractor must have a financial model that reflects the estimation of costs of investment, administration, operation and maintenance, and determine in an approximate way the fee and subsidy levels required, in order to conclude that the existing business scheme, or the new proposal and in general the alternative of providing the proposed services is feasible.

Each alternative should include the financial model of the scheme of provision, analysis and conclusions regarding the individual feasibility of each proposal, and the comparative analysis of the proposals, conclusions and recommendations.

In order to take advantage of the opportunities of scale economies in the different business processes, the contractor will be able to propose regional schemes as an alternative to guarantee the sustainability of the services.

Analyses should include minimum cost analysis and optimal selection of expansion capacity of all planned works.

The solution alternatives raised should be in accordance with the diagnostic phase in relation to the prioritization of the problem, for which the alternatives will be raised in response to the different stages, in terms of short, medium, and long term. For each of the alternatives raised, the corresponding hydraulic modeling should be developed.

A minimum of two to three alternatives should be raised for each analysis. Wastewater treatment systems must be fully justified in the adoption of technologies and/or proposed units.

For each alternative presented, the approximate investment costs and the opportunities in which they must be carried out must be included, as well as the costs of operation, maintenance and eventual replacement during the design horizon. Environmental costs should be included in all works designed whether for prevention, mitigation, correction, compensation, and/or handling of the negative effects generated.

For the selected alternative, the contractor will determine the first of the stages or the only one, if that is the case, in which the components of the system must be built, in such a way that the economic costs of the project are minimised, taking into account simultaneously financial, technical, environmental and institutional considerations.

The contractor must identify in relation to the infrastructure expansion plan (networks and modules of treatment systems, in aqueducts), short (5 years), medium (15 years) and long term (taken as the time corresponding to the design period of the project in accordance with the technical regulations in force), the opportune moment when the expansion of each system component and the installed capacity is required.

Based on the selected alternative, the relevant recommendations will be formulated and the general plan of the works and investments in the system will be proposed during the intended planning horizon, giving priority to the immediate investments oriented towards the rehabilitation of the systems and thus configuring the initial progress report, which will also indicate the required complementary actions, such as topographic surveys, additional special studies, among others, for the definitive design of the components resulting from the study.

Health risk analysis, investment costs, operating costs and hydraulic modeling should be included in the operation scenarios.

For purposes of the proposal of alternatives and designs, the contractor must initially take into account the basic cartography of the municipality, the condition of the networks, and condition and type of roads (pavement in hydraulic concrete, asphalted, affirmed, or dirt, etc.).

For the analysis of alternatives, if necessary, non-conventional energy systems for pumping should be raised, with the respective technical-financial justification. The above should be framed in climate change policy, with the implementation of self-sustaining and environmentally friendly systems.

The contract should submit a report of proposed alternatives for the project that comply with the required quality standards for approval by the audit. This report must contain at least:

i.) Feasibility analysis of the alternatives considered.
ii.) Description of the analysis for the formulation of each alternative (hydrological study, environmental analysis, pre-dimensioning of elements of the proposal, investment plan, property and permissions situation).

The contractor should clearly describe the analysis methodology used to prioritize the works. The solutions for the immediate, short and medium term will be established as priority works and the contractor must present them for the consideration of the audit when they are defined. Once accepted by the audit, they must be developed into detailed designs. The solutions for the long term will also be developed into detailed designs.

All existing information in the project area should be obtained by quoting the respective sources. In addition the description and diagnosis of the existing wastewater and rainwater collection and disposal system should be included.

Definition of the analysis period. The system planning period and the initial year of operation must be set.

Population estimation. In the case of sanitary systems, the population must be estimated throughout the system planning period. The estimated population in the project area should consider the density of saturation based on the POT – Territorial Land use Plan.

Delimitation of drainage area. The drainage areas contained in the project area must be demarcated.

Determination of the characteristics of the existing system, type of pipes, average slope, and final drainage point. The characteristics of the existing system, the wastewater or rainwater must be determined in terms of land-occupancy trends and territorial planning.

Generation of design alternatives for the collection and evacuation of wastewater or rainwater. It is necessary to evaluate each alternative from the point of view of environmental impact.

Use of existing components. The possibility of taking advantage of all or part of the existing collection and evacuation system should be established.

Discharge site analysis. Human settlements located downstream of possible discharge or disposal sites of wastewater from the locality should be identified, and the characteristics and self-purification capacity of the receiving water bodies must be analyzed (rivers, streams, wetlands) and the possible environmental effects of discharges with or without treatment, based on current legislation.

Pre-dimensioning of each of the components of the alternatives.

Preliminary cost estimate. Budgets of projects similar to those considered in the different alternatives should be compiled, citing the bibliographical sources that guarantee their validity. These budgets should consider construction, operation and maintenance costs. If this is the case, the construction stages of the project must be determined.

Selection of the best alternative. Based on technical, economic, financial, cultural and environmental considerations, the best alternative is to be selected in order to be designed, built, operated and maintained. The selected alternative must have an environmental license if required, or an environmental management plan.

In addition, the following aspects must be taken into account for the delivery of the product, as follows:

The contractor must propose the constructive method of the network (with open trenches or without trenches), and if the excavations are to be with open trenches the contractor must propose the shoring methods of the slopes, and/or works for the stabilization of slopes in the sectors that require it, as well as the methodology for fillings.

If the contractor proposes the use of renovation of sewage networks by the method without trenches, they must enclose a copy of the CCTV inspection videos, which guarantee the structural conditions of the network, this will not generate separate payment because they are part of the studies to be carried out by the contractor for a correct diagnosis of the proposed constructive system.

For other systems without trenches the contractor must take into account the applicable local and international technical standards, with the purpose of taking into consideration each of the technical aspects necessary for the construction of the works; they must also take into account the spaces for equipment installations, launching trenches, platforms, material collection points among others.

The contractor must create the technical specifications for each constructive system proposed, in accordance with the applicable regulations of the systems of renovation or rehabilitation without trenches, in order to have criteria for weighting and economic comparison of the works proposed.

The contractor shall deliver to the audit and/or supervision of the contract, the costs of the proposed renovations or rehabilitations, by the methods of open trench and without trench, as well as the valuation of impacts generated by the house construction method. Through concerted work sessions between contractor auditor and contracting party, the decision will be taken as to which system will be implemented for the contractor to create the detailed and definitive designs of the works to be executed.

1.3.2. Selection of alternatives.

The selection of the alternatives will be made taking into account that which, while solving the problem posed in the project horizon, corresponds to the one with the lowest cost in accordance with the criteria for the lowest present value of all the costs of investment and operation considered, and which complies with the availability of resources to finance the works.

For the selected alternative, the contractor will determine the first of the stages or the only one, if that is the case, in which the components of the system must be built, in such a way that the economic costs of the project are minimised, taking into account simultaneously the financial, technical, environmental and institutional considerations.

The contractor must identify in relation to the plan for infrastructure expansion (networks and treatment system modules in aqueducts), in the short, medium and long term, the opportune moment in which the expansion of each one of the components of the system and the capacity of the same is required.

Based on the selected alternative, the relevant recommendations will be formulated and the general plan of works and investments for the system will be proposed during the intended planning horizon, giving priority to the immediate investments oriented towards the rehabilitation of the systems and thus configuring the initial progress report, which will also indicate the required complementary actions, such as topographic surveys, additional special studies, among others, for the definitive design of the components resulting from the study.

A minimum cost analysis should be done, as set forth in the Title A of the current RAS.

For the selection of each alternative, the participation of the group of professionals hired by the contract is required, as this selection will be the definitive alternative to develop for the detailed engineering designs.

2. Detailed Design

The contractor must start from the technical studies (detailed designs) carried out in the feasibility stage and develop them in greater detail for the selected alternative.

2.1. Design criteria.

The design criteria applicable to each type of work must conform to that which is defined in the planning tools and planning stage and the design standards of the entity.

2.2. Definition and location of each project component to be designed.

In accordance with the analysis of the problem to be solved, and taking into account that which is defined in the planning tools and the basic engineering stage, as well as the specific characteristics of the area, the contractor will define the project components and their specific location within the study area.

The designer must take into account the information contained in the studies of basic engineering in order to identify possible interferences and/or limitations in the location of the project.

2.3. *Selection of alternatives.*

For the selection of technological design alternatives, a socioeconomic evaluation should be carried out resulting in the lowest economic cost, incorporating the initial investment, the costs of administration, operation, maintenance and replacement within the decision variables over a 25-year horizon.

Socio-Economic Assessment.

Current population, stratification, NBI index (unmet basic needs), population in severe poverty, soil uses, social conditions, public health, educational aspects, civic organizations, income level, public service fees, availability of human resources and materials in the region.

The design of any system in the basic sanitation sector must undergo a socioeconomic evaluation and be subject to a plan of construction, operation, maintenance and expansion of minimum cost, following the established in the current RAS.

The socio-economic evaluation of projects should be carried out in order to measure the net contribution of a social investment project or policy to the well-being of a community. That is to say, it will have the capacity to establish the goodness of the project or program for the national economy as a whole. In these terms, the value of any asset, factor or resource to be generated or used by the project should be valued according to its contribution to national welfare.

For basic sanitation projects the following types of socio-economic studies are permitted:

- Cost efficiency analysis.
- Minimum cost analysis of capacity expansions.

Socio-economic assessment studies should be carried out for medium, medium-high and high levels of complexity.

- Cost efficiency analysis.

A comparison of the costs of several feasible project alternatives will be carried out in order to select the one with the lowest present value of the investment, operation and maintenance costs. Cost-efficiency analysis should be based on the following assumptions:

-That the social discount rate established should be used
-That the benefits derived from the alternatives studied are the same
-That the benefits are greater than the costs in each alternative.

The analysis should select the project that presents the lowest net present value among the possible alternatives.

In order to carry out the studies, the guidelines of Annex B from this document should be used – "Guidelines for Socio-economic analysis".

- **Minimum cost analysis of capacity expansions.**

The years that are optimal for the execution of capacity expansions of a system should be fixed, taking into account the opposite effect that occurs between scale economies and the cost of capital opportunity.
The optimal capacity expansion period for a system must be defined based on the following criteria:

1. The balance between the period of expansion fixed by the scale economies which prefer a long period, looking for large-capacity components, and the period determined by the cost of capital opportunity that tends to be a short period with low-capacity components, seeking immediate investment of resources in other projects.

2. The expansion period must be chosen for the entire global system and not for each special component, in such a way as to minimize the impact caused by the specific extensions of each component, avoiding administrative over-expenditure.

3. The selected period can be adjusted at each expansion stage when there are demand studies carried out during two successive expansions showing changes in the demand functions, and in general, in the conditions under which the expansion period was initially formulated.

2.4. Topography

Planimetric-altimetric surveys will be carried out when it is necessary to complement what has already been done in the feasibility stage, regarding the sites where the structures for each of the components will be located.

The minimum specifications for these surveys shall be those required in the basic feasibility studies of this document.

2.5. Geometric design and interference analysis.

Based on the topography carried out and according to the requirements of the project the contractor will proceed to make the geometric design of the alignments, manholes and structures required by the project, locating them in the plant and in profile, and incorporating each and every one of the interferences that can be found at the time of executing the works. An intrinsic part of this is determining how to handle the visible and non-visible interference with other service networks. How this will be handled in relation to the construction must be resolved, detailed, authorized and budgeted. All the details of this design must be included in the plans and other documents of the design made.

2.6. Hydraulic design and Hydrology Studies.

The hydraulic design must include all the diagrams, calculations and modeling necessary for the definition of the works, specifying parameters such as diameters, flow rate, speeds, material specifications and other technical aspects that ensure proper system performance. The diagrams and calculations will constitute the calculation records that support the determinations of the designed elements.

2.6.1. Hydraulic designs with their respective calculation records.

The project to be submitted must contain the relevant designs and calculation records, for this reason the Contractor must generate the hydraulic designs of each of the components of the sewage system in order to take into account the guidelines established in the RAS regulations in force, and its modifications. Additionally, they must annex the results of the hydraulic calculations, where the input data, assumptions, resources, design flow rates, elevations, quality of discharges and impacts on the receiving water bodies, and pumping systems if applicable, among others, are all recorded. And the results obtained must be duly tabulated and consistent with the data represented in the design plans.

In the case of the sewage networks component, hydraulic modeling will preferably be carried out in a highly diffused program used for this type of modeling. All hydraulic modeling should be delivered with the information that was processed in the software for its magnetic and physical verification, and likewise for the hydraulic design the guidelines of the RAS regulations in force and its modifications will be taken into account.

The contractor developing the project will have to dimension and describe in detail the potency of the pumping stations, the diameters and lengths of both the impulsion line and the distribution line, this being the case if the sewage system operates through suction and impulsion systems.

The hydrosanitary designs of the local installations must be carried out; these contemplate drinking water supply to the huts, sanitary drainages, and rainwater drainages around the enclosure and the common areas.

2.6.1.1. Detailed design of sewage and rainwater drainage networks.

Design of the selected alternative. The alternative must be fully dimensioned and its construction costs fully quantified within a precise execution schedule of the works, including specific aspects of environmental and urban management required during its construction, such as property and easement studies, environmental licenses, environmental management plan, urban impact and technical specifications. The design must also obligatorily generate appropriate manuals, programs and procedures for operation and maintenance to ensure the effectiveness and sustainability of the system throughout its useful life and minimize negative environmental effects.

A. Written report, in physical and magnetic form with the information described above.
B. Technical datasheet of appraisal
C. Photographic report of each one of the assets
D. Documentation: that which was taken into account for the valuation.
E. Plans

2.6.2. Hydrological studies.

This activity consists in the search of hydrological information through the water points closest to the location of the project, in order to construct or validate the hydrologic model of the zone, clearly defining areas of overload, the calculation of the equations enabling the construction of the curves of intensity, duration and frequency, the analysis of the hydric balances considering the total precipitation, infiltration in the subsoil, potential and real evapotranspiration, surface runoff and maximum and minimum volumes of water in the receiving water bodies.

The estimation of the temporal distribution of rainfall (duration of rainfall) of the zone should be made to obtain the design flow rates, based on rainfall records, or hydroclimatological variables from stations located in the hydrological study area such as precipitation (maximum monthly average), evapotranspiration and evaporation (monthly average). All the information collected, analyzed and processed, should be taken as reference for the creation of the necessary studies for the sewage system.

The contractor must quantify, in each case, the maximum usable flow rates and minimum flow rates, among others, according to the information provided by the respective Regional Autonomous Corporation, which is the competent authority in the area of its jurisdiction to manage and administer the water resource, and/or other sources of information that they consider appropriate. They must also verify that there are respective environmental permits issued by the environmental corporation, such as: Sanitation and discharge management plan, duration curves of flow rates, general environmental and sanitary conditions of the source and the tributary basin, and analysis of the environmental impact on each of the receiving water bodies of wastewater and/or rainwater, and curves of intensity, frequency, duration (IFD), among other required information. In addition, at the least information of flow rates and rainfalls in the region should be analyzed, in order to determine in historical series the flow rates of the drainages and maximum and minimum levels.

The appropriate methodology should be established to determine the contribution of rainfall to the sewage systems of rainwater and combined waters, for the estimation of design flow rates. Analysis of the urban drainage network and the drainage capacity of the water bodies receiving the discharges.

A general analysis should be carried out regarding the drainages that cross the urban areas, estimating the quantities of runoff that drain into the sewage network and low areas (flood zones), and also include the appropriate recommendations based on the current regulations (Decree 3930 of 2010, Decree 4728 of 2010, resolution 1514 of 2012, resolution 631 of 2015 and others in force).

The contract should establish the appropriate methodology for determining the rainfall contributions to the rainwater sewage system, for the estimation of the design flow rates.

Records with historical data on existing rainfalls should be consulted at the Institute of Hydrology, Meteorology and Environmental studies of Colombia – IDEAM, which are managed in the pluviometric stations of the region.

The hydrological study report should include plans, descriptive and calculation records, curves of intensity duration, and the frequency of occurrence of storms on the hillsides. The following recommendations should be taken into account:

- Carry out hydrological studies, according to the records of the hydrometeorological stations existing in the project area for the last few years.
- Accurately determine the hydrographic basin based on plans with a scale of 1:10 000.
- Calculate the geomorphological parameters: area; main channel length; upper and lower elevation of the basin; upper and lower elevation of the main river; slope of the main channel and average slope of the river basin; straight line distance to the furthest point of the basin; basin perimeter; length to the centroid of the basin; and north and east coordinates, and elevation of every place of interest.
- Calculate the time of concentration of the basin using at least four methods, which should be chosen according to the morphometry of the basin, among the following: Temes, William, Kirpich, Johnstone and Cross, California Culverts Practice, Giandotti, S.C. S Ranser, Ventura-Heron, Brausby -William, or others duly supported.
- Identify rainfall stations that have influence on the study basin, and show their equation or a figure of the curve intensity – frequency – duration. The interval of the duration of the rain used should be indicated.
- Calculate effective rainfall and temporal distribution of rainfall. Rainfall should be calculated for return periods of 2.33, 5, 10, 25, 50 and 100 years. For the calculation of hydrological losses, the value of the CN curve number and the methodology for its choice must be clearly indicated.
- If it is a basin greater than 1 km^2, obtain the flooding design for return periods of 2.33, 5, 10, 25, 50 and 100 years, through four different methods, such as the following:

    1. Frequency analysis, if there are historical series of flow rates.
    2. Unitary Hydrograms: William – Hann, SCS (Soil Conservation Service), Snyder, Clark, geomorphoclimatic or other.
    3. Gradex method.
    4. Rational method.
    5. Tank Models.
    6. Regionalization of average characteristics and flooding rate.
    7. Other methods (justify with theory, data and calculation records).

- In the procedures of any methodology, the databases and calculation records must be delivered from the various analyses. The design flow rates chosen must be duly justified.
- Determine the location and/or relocation of the drainage works, as a result of the analysis of geological, geomorphological and hydraulic conditions. The location of major drainage works should be determined.
- Revise and complement the designs of the drainage works in accordance with the definitive designs.
- Evaluate the conditions of high and low tide, with the identification of flood dimensions, for the areas affected by the project.

Quality objectives for the receiving water bodies, and existing information on the supply and quality of the same.
With the analyses carried out the different hydrologic parameters will be obtained that have to serve for the quantification of the hydric resources available. And likewise for the inclusion of the analysis of temporal variability of the water quality and the analysis of supply risks. The drainage conditions of the basin, bearing capacity of existing sewage networks, and open artificial or natural drainage systems. Discharge quality and volume, and impact on the receiving bodies. Potential for flooding due to lack of evacuation capacity, or to the system of closed sewage channels and the receiving bodies.

2.7. Geology Soil Research and Geotechnics.

The tests required to complement those carried out in the feasibility stage will be carried out in order to identify the physical and mechanical characteristics, and chemical characteristics that identify the possible corrosive nature of the subsoil for metallic and non-metallic elements that will be located in the subsoil; geotechnical study to determine: bearing capacity, conditions of threat and vulnerability and the geotechnical stability of the soil and of the works that require it. Recommendations for the design and construction of foundation elements, containment structures, protection, and drainage; the geometry and safety factor of slopes. The need to undertake more detailed studies of geology, hydrogeology, and/or soils must be established, justifying the reasons for the recommendation, as well as the additional field research plan to be carried out during the design stage.

2.8. Structural Design.

The structures that make up the system must be designed to withstand the loads to which they will be subjected, in accordance with the provisions of the Colombian regulations for seismic resistant construction NSR-010, law 400 of 1997 and Decrees numbers 33 of 1998, 926 of 2010, 2525 of 2010, 92 of 2011 and 340 of 2012 or those that modify, add or replace them.

The design of the pipes must indicate the structural calculationa, the installation conditions, the loads applied, and the installation method of the same.

Definitions

Hydraulic structure

Any structure which is in direct contact with water; intended to treat it (either for purification or wastewater); for the improvement of the environment; or directly related to aqueduct and/or sewage systems.

Normative references

For the following regulation references the current version applies, or regulations that modify, replace or add to them.

American Concrete Institute.

-Code requirements for environmental engineering concrete structures and commentary. Detroit: ACI. (ACI 350/350R).

- Seismic Design Of Liquid-containing Concrete Structures and Commentary. Detroit: ACI. (ACI 350.3/350.3 R)

Colombian Association of Seismic Engineering.

-Colombian code of seismic design of bridges. Bogota: AIS, 1995. (CCDSP-95)

-Colombian standards for seism resistant design and construction. Bogota: AIS, 1998. (NSR-10)

CALI Municipal Companies – EMCALI EICE ESP

-Technical aspects for design and construction of subdrains. EMCALI EICE ESP (NDC-SE-GE-004)

-Concretes and mortars. EMCALI EICE ESP (NCO-PM-AA-004)

-Design criteria for anchors in aqueduct and sewage networks. EMCALI EICE ESP (NDI-SE-AA-017)

-General criteria for tank design. EMCALI EICE ESP (NDI-SE-AL-002)

-Joints and seals for joints in concrete structures. EMCALI EICE ESP (NCO-SE-AA-040)

-Requirements for the foundation of pipes in acueduct and sewage networks. EMCALI EICE ESPNDI-SE-AA-016)

-Requirements for design and construction of slope protection works. EMCALI EICE ESP (NDC-SE-GE-002)

-Requirements for the creation and presentation of geotechnical studies. EMCALI EICE ESP (NDC-SE-GE-001)

Requirements

Types of structures

1. Channels
2. Gutters and Waterways
3. BoxCulverts Cast on site
4. Network Interconnection Boxes
5. Boxes for accessories in aqueduct networks (valves, pitometers, manholes, suction pads, etc).
6. Dissipating structures
7. Special Inspection Manholes for sewage systems
8. Viaduct Structures

This type of structure comprises civil works, anchors, concrete supports for the installation of high-pass piping, base, docking, and concrete protection for networks, pipe anchorages and accessories.

Requirements for the design of hydraulic structures

The following standards must be applied for the design of hydraulic structures:
Colombian standards for seism resistant design and construction NSR-10, Law 400 of 1997 and its decrees 33 of 1998, 34 of 1999 and 2809 of 2000 and in particular the chapter C. 23-tanks and structures of environmental engineering of concrete. – Colombian Association of Seismic Engineering. Building Code Requirements for Structural Concrete Aci 318-14).

Also for hydraulic structures such as Culverts (from different sections), network interconnection boxes that on the basis of their location are subject to vehicular loads, the design standards to be applied will be the "CPC-14 Colombian standard of seismic design of bridges" and the American Association of State Officials of Highway and Transport AASHTO.

Materials

Concrete

The quality of the concrete for hydraulic structures must comply with the requirements of chapter C. 5 of the NSR-10.

The design resistance to the minimum compression for the concrete of hydraulic structures must be of F'c = 28 MPa (4000 psi) and the water-cement ratio must be at a maximum of 0.45. When the concrete is exposed to sulfates the minimum resistance must be F'c= 32 MPa (4500 psi) with a maximum water-cement ratio of 0.42 (see C .23-C. 4.5 "Colombian standards for seism resistant design and construction-NSR-10" and table 4.3.1 "Aci 350/350R Code Requirements For Environmental Engineering Concrete Structures and Commentary") or the corresponding update. Do not use calcium chloride additives in concretes exposed to sulfates.

Reinforcing steel

Reinforcing steel must comply with Chapter C. 3.5 of the Colombian standards for seism resistant design and construction-NSR-10.

Minimum thickness of walls and slabs

The definition of the minimum thickness is controlled by the minimum coatings required for reinforcement and by considerations of resistance and impermeability. No thicknesses less than 200 mm should be used; and the walls with free heights greater than 3.0 m must have a minimum thickness of 300 Mm. See C. 23-C. 14.6 Colombian standards for seism resistant design and construction-NSR-10.

Minimum reinforcement

Minimum reinforcement of elements subjected to bending, and by retraction and temperature
The minimum reinforcement to bending shall be defined in section C. 23 – c. 7.12 of the Colombian standards for seism resistant design and construction-NSR-10 and 10.5 of the "Aci 350/350R Code Requirements For Environmental Engineering Concrete Structures and Commentary", except for hydraulic structures subject to vehicular loads, for which the minimum

reinforcement to bending will be determined according to the" CPC-14 Colombian standard of seismic design of bridges "and the 8.17.1 section of the AASHTO.
The reinforcement details, their development and reinforcement splicing must be in accordance with chapters C7 and C12 of the Colombian standards for seism resistant design and construction-NSR-10, except for structures subject to vehicular loads, which will be governed by the "CPC-14 Colombian standard of seismic design of bridges".

Coatings
The minimum design coatings are defined in the paragraph C. 23 – c. 7.7 of the Colombian standards for seism resistant design and construction-NSR-10. and "7.7.1Aci 350/350R Code Requirements For Environmental Engineering Concrete Structures and Commentary"or its corresponding updates, if the elements are prefabricated in a plant certified under ISO 9000 scheme, the minimum coatings shall be those specified in the 7.7.2 paragraph of the" ACI 350/350R ", any other case is governed by the paragraph 7.7.1 of the "ACI 350/350R"., in addition to a. 1.4.2 – prefabricated systems, C. 7.7.2 "prefabricated elements built in Plant", Chapter C. 16 – "Prefabricated concrete".

Joints
For everything related to the joints in concrete structures, C. 20.1.4 "Impermeability" and C. 23 – c. 4.10 – "Joints" of the Colombian standards for seism resistant design and construction-NSR-10 should be consulted.

Load conditions
Load designs must be established by the structural designer and it is recommended to take into account the following minimums:
Dead loads
Dead loads must be assessed in accordance with Chapter B. 3 of the Colombian standards for seism resistant design and construction-NSR-10
Live loads
Live loads should be quantified taking into account at least what is specified in this paragraph **(XXX-Live loads)**, in the event that the designer uses different values, he must justify them and register them to the structural plans.
Other live loads specified by the Colombian standards for seism resistant design and construction-NSR-10 should be taken into account according to the use of the structure.
-For covers and plates of drains located on pavements, a live load of 1000 kg/m^2 must be used.
-For covers located on pavements, a live load of 1000 kg/m^2 should be used when the covers have an area of less than 1m^2, a minimum load of 1000 kg per element shall be taken.
-For structures subject to vehicular loads, the loads specified in the "CPC-14 Colombian bridge seismic design standard" must be used;
-The distribution of vehicular loads must be carried out in accordance with the criteria of the AASHTO standards and/or "CPC-14 Colombian standard of seismic design of bridges". For Box Culverts, the application and distribution of live loads must be carried out according to CPC-14 Colombian standard of seismic design of bridges.
-For structures close to the roads, a live load overload equivalent to a filling height of 0.70m should be taken.
-For loads of inspection manholes used in green areas, the live load must be 500 kg/m^2.

Impact Factor

For vehicular loads, the impact factors defined by the "CPC-14 Colombian standard of seismic design of bridges" and/or the American Association of State Officials for Roads and Transport AASHTO, should be considered.

Earth thrust

The parameters for calculating earth thrusts must be evaluated by the geatechnical engineer and must be presented in the geotechnical study according to the requirements of the Colombian standards for seism resistant design and construction-NSR-10 – Title H -"Geotechnical studies", and the technical annex in its Chapter "Requirements for the creation and presentation of geotechnical studies".

Seism

The evaluation of the seismic loads in hydraulic structures should be carried out, for which the recommendations contained in the report can be considered "Aci 350.3/350.3 R Seismic Design Of Liquid-containing Concrete Structures and Commentary", or other methods of recognised technical acceptance.

Certain cases require verifying seism for earth thrust by the numerical analysis method with specialized software with Sapetabs - Safe.

External stability

For hydraulic structures, external stability analysis must be carried out, which includes calculations of:

-Safety Factor for tipping, which must be greater than 1.5, according to ACI section 19.5

-Safety Factor for sliding, 1.5 according to ACI section 19.5

-Review that the bearing capacity of the terrain is not exceeded.

-Flotation

Safety factors for sliding and tipping shall be assessed for the structural systems to which their revision is applicable.

It is necessary to take into account the possible flotation of the structures either caused by the groundwater level or by water leakage from the structures themselves, for which the structure is considered empty and with all the possible dead loads that can counteract the phenomenon. A safety factor of 1.25 should be worked with in the case that systems can be provided to limit elevation and 1.50 otherwise, or as the designer envisages based on design hypothesis and dictated by the NSR 10 and/or CCP-14

In the verification of the load-bearing capacity, all live, dead and seismic loads must be considered. The effects of possible water flows should be taken into account. Stability should also be reviewed due to wind load effects.

Structural Design

This information presents the considerations for calculating loads on pipes that are part of a sewage system, and the design of their foundations. **The auditor** can approve calculation methodologies related to structures and foundations, for sewage pipes different to those presented here, as long as the designer presents the corresponding technical and economic justification.

External load types on a buried pipe

The types of load that a buried pipe must withstand are mainly the following:

1. Workloads
   − Pipe weight
   − Fluid weight
   − External dead load

2. Live loads
   − Live loads on roads
   − Live loads of railways and trains
   − Live loads of aircraft − live loads during a construction.

3. Impact Load: These loads are represented by a factor that increases live loads.

   The total external load of design per unit of pipe length (We) is given by the sum of the soil load (Wd), the external load concentrated (Wcsu) and the equivalent external load due to the weight of the liquid in the pipe (Ww), per unit of length in each case.

Calculating external loads

In general, the calculation of external loads and their effects on piping should be taken into account if the piping is considered flexible or rigid.

Flexible pipes

The following aspects must be considered for flexible piping:

1. Soil loads.
2. Cross section deflection.
3. Buckling of the pipe.

For each of these cases, the following considerations should be followed:

1. Soil loads: The external load must be calculated due to the weight of the soil.

2. Pipe deflections: The rigidity of the piping and the soil must develop sufficient field resistance so that the deflection of the pipe under the load does not exceed the maximum permissible deflection.

In manufacturers' catalogues, the empirical values of long-term deflection can be found for different installation conditions. But when this Information is not available, the approximate long-term deflection of flexible piping can be calculated using the Modified Iowa Formula, developed by Spangler and Watkins.

3. Buckling of the pipe: the buckling phenomenon can generate the collapse of the pipe due to the associated instability. The external pressure on the pipe must be less than or equal to the buckling pressure.

   a. External pressure, qext : For this, the worst condition should be used.

Rigid pipes

For a rigid pipe, it should be taken into account that the soil load is calculated considering the weight of the soil on the pipe, more or less the cutting force of friction with the adjacent soil walls. Additionally, the installation conditions of the piping must be taken into account, which may be:

1. Trench installation.
2. Installation on embankments with positive projection.
3. Installation on zero-projection embankments.
4. Installation on embankments with negative projection.
5. Installation on embankments with induced trench.
6. Installation in tunnel conditions.

Foundation types

In the installation of a trench pipe, some main parts are identified:
1. Foundation
2. Bed Support
3. Docking area
4. Initial filling
5. Final filling

The most important aspects that the designer should take into account are the following:

1. Quality of materials
2. Construction Specifications
3. Type of pipe (rigid or flexible)
4. Type of trench or filling
5. Pipe Material
6. Manufacturer's recommendations
7. Soil load capacity
8. Trench stability

Products to be delivered

Structural schemes

The calculation of the efforts in each of the constituent elements of the tank structure must be done for the limits of resistance and operation.

Maximum efforts must be determined in accordance with the most unfavorable main load hypothesis which, in the case of buried or semi-buried tank walls, must be the fundamental hypothesis of the full and empty tank.

Calculations Record

The designer must present the calculation record, which must be consistent with the structural design requirements ("Aci 350/350R Code Requirements For Environmental Engineering Concrete Structures and Commentary"), Colombian standards for seism resistant design and construction-NSR-10," CCDSP-95 Colombian code of seismic design of bridges ", and other standards quoted In conjunction with the hydraulic and/or sanitary project.

Information must be included from all the analyses performed, if computer programs were used the specific names and the version must be included; accompanied by a description of the program, the input data and the results obtained.

In general the calculations record should include:

-Description of the structure
-Structural Design
-Analysis Procedure
-Design Criteria
-Bases of the design, including the cases and hypothesis of loads made during this process.
-Standards used, with the year of issue.
-Description of the loads and procedures to evaluate them (live, dead, earth thrusts, operation, etc.) and the areas of the structure where they were used.
-Seismic loads including its evaluation procedure.
-Wind loads including its evaluation procedure.
-Information about the soil study and the design criteria for the foundation, including the soil's bearing capacity and the geotechnical parameters used in the evaluation of loads if applies.
-List of the types of structural materials, including their qualities, quantities used for each structural element according to the design, and their resistances: concrete, reinforcing steel, masonry, structural steel, wood, and the areas of the structure where they were used.
-Name and registration of the engineer who developed the design, name and registration of the engineer who reviewed the design, and name, registration and signature of the responsible for the calculations.
Localization diagrams of the structural elements.
-Analysis and design for vertical and lateral loads of the structural elements, including the foundation.
-Description of the constructive process proposed for the development of the work.
-Conclusions and recommendations

Structural plans

The plans must contain the location of the structural elements, their dimensions, reinforcements on an adequate scale, and sufficient details for correct construction. They can also refer to the dimensions indicated in the hydraulic and/or sanitary plans when appropriate. Elevations and cuts must be carried out with appropriate scale, quantity and scope to indicate interdependence and connections between the different elements. Special care should be taken to ensure that the details included and qualified as typical are applicable to the conditions of the project. In general the structural plans include the following, but they can vary according to the complexity of the project and the type of structural material used.

-General plant.
-General notes, including the specifications of the structural materials, the geotechnical parameters, the coatings, the live loads used.
-Foundation plans.
-Plans of the different structural plants.
-Plans to indicate the interdependence and connections between the structural elements, including the details of the types of different joints used in the design of the project.
-Based on the quantity of material for each structural element obtained during the design process, create a table of the total quantities used during the project execution, grouped by structural element, in order to establish the budget of the structures of the project.
-Main and secondary reinforcement plans for the structural elements (plates, walls, beams, columns, pads and piles). Each structural element must be drawn, with its dimensions, indication

of the armatures (mark, diameter and separation), using a clear and simple nomenclature; the different reinforcement rods must be cut next to each element with their respective mark, diameter, separation, partial lengths and total or cut length.
-Transversal, longitudinal, horizontal, partial, etc. cuts must be presented, which are necessary and clarifying.
-Every structural detail such as pipe passages, tank accesses etc., must be drawn with their own dimensions and armatures.
-Each different type of joint will carry its respective clear and detailed drawing.
-A general outline of the possible and recommended order for placing concrete must be made and it should contain the indications of the different types of joints which occur.
-In addition to the special explanatory notes, in each plan a series of general notes indicating the specifications of materials, coating, pressures, on the ground, and recommendations of the geotechnical study, etc. should be indicated.
-The work quantity table of the structure must be included with the plans, which will include the list of irons, which must indicate the brand, location, shape, diameter, length, quantity and weight of each of the different types of reinforcement, the volumes of concrete to be used, the lengths of the different types of joints used, and other quantities of materials that are part of the structure.

2.9. Design of complementary works.

The designs must include all the complementary works according to their speciality, which are necessary for the operation of the systems (electrical, mechanical, architectural, instrumentation and control, protection against risks from identified natural and socio-natural threats, among others).

Design criteria should be taken into account aimed at the use of appropriate electrical systems, instrumentation and control, for which the criteria set out in articles 237 and 238 of this resolution must also be taken into account.

In the event that the availability and reliability of the power supply is low, actions must be planned to:

• Have efficient and sustainable backup energy sources, among which the use of solar, wind, diesel or hybrid energies can be evaluated. The selection of the best alternative should consider operating costs during the lifetime of the supply system.

• Avoid damage to equipment (such as the use of frequency variators, surge suppressors, etc.).

2.10. Property Management

The contractor should complement the studies carried out at the feasibility stage. In the case of works which for their execution require the use of properties whose ownership, possession or tenancy does not correspond to the beneficiaries of the project, the information regarding the affected property must be prepared, which includes at least: the topographic location (Abscissas), the address of the site, the name and telephone number of the beneficiary, summary of free and affected areas.

This is necessary in order to obtain from the executing agency and/or the association of users, the respective authorisations, by signing the documents which grant the use of the necessary easements for the execution of the project, by means of the respective contract, elevated to public deed, and duly registered before the Registry Office for Public Instruments.

2.11. Definition of technical specifications for construction.

The design must specify the technical specifications of each of the elements of the project, including the details of materials, conditions, quantities and measures to be applied to the project. In addition, the design should include the constructive procedures recommended for the construction of the works.

The contractor will prepare the volume of technical specifications for construction, required for the quality control of the work and measurement and payment of the same, following the format established for this purpose, which must be previously determined with the Audit which is designated for that purpose.

These technical specifications contemplate the minimum technical quality of materials and general equipment to be used, labor and services necessary for the construction of the electric grids for the manholes.
For the creation of the technical specifications for the execution of the work, which is the product of this contract, the following recommendations must be taken into account:

- They must contemplate and establish the minimum technical quality of materials and equipment to be used, in addition to the labor and services necessary for the construction of the project.
- They must establish the essential characteristics of the product that will be acquired.
- They should avoid establishing an excess of specifications, and unnecessary characteristics which can result in too restrictive specifications that may impede free competition and increase the cost of the product.
- The specifications must be reasonable and contain the necessary precision, otherwise they could be expensive, and may limit competition.
- The text of the specifications should be clear, use common language, and avoid the use of terms susceptible to various interpretations.
- The use of abbreviations must be restricted to those which are of common use, and which won't generate misunderstandings.
- The execution of these specifications must be determined by the current updated versions of the following standards:
    - 1. Seismic resistance standard (NSR 2010).
    - 2. Technical construction standards (NTC).
    - 3. ICONTEC standards.

It is recommended to translate the technical specifications according to the following format, for each item of the work quantity form:

Item Description: *(as expressed in the work quantities form)*
General: *(Description of the constructive process, including type and quality of materials, tools and equipment to be used, qualities of the personnel to execute the activities, special conditions of transport to the interior of the work site. Location within the work, and special care the builder must have.)*
Associated regulations: *(Name the regulations of obligatory compliance that must be fulfilled in the execution of the activity, such as: NSR 2010, ICONTEC, NTC, Etc..)*
Unit of measure and payment method: *(Indicate the unit of measure, which must coincide with the one proposed in the work quantities form and in the analysis of unit prices, in addition to the manner in which this measurement will be carried out.)*

2.12. Determination of the budget and works schedule.

The design must include the estimated work budget for the works to be executed, specifying the work quantities and the respective unit price analyses. In addition, the design should include a proposed schedule of execution of the same.

It will also prepare the list of work quantities, unit prices of the project, and the supply of piping, including the respective analysis of AIU (administration, contingencies and utility) for the conformation of the work budget, according to the items of payment established within the technical specifications, duly grouped by components. The respective analysis of the AIU should be attached with the unit price analyses APUs for each of the items

The contractor project in order to determine the optimal sequence for making progress with the construction. A bar diagram will be made that indicates the duration of each activity, the interrelation between each one of them, and in a clear way the critical route of the project; preferably in Project.

An estimate must be made of the cost of the service required to audit the project, which will be part of the financial plan.

The tentative plan for the execution of the project will be formulated, involving the stages of recruitment and execution of the works of the different components of the project, identifying the critical route and defining the constructive sequence most suitable for the scheme proposed.

To advance satisfactorily with the execution of the project, it will recommend and dimension the technical and human resources that are necessary for the proper functioning of the required organizational scheme.

2.12.1. Work budget

For the creation of the work budgets, each and every one of the following conditions must be taken into account:

- An organized format should be presented containing:
    - Chapter number
    - Chapter Description
    - Item number
    - Item Description
    - Unit of Measure
    - Amount
    - Unit value
    - Total value (expressed in Colombian pesos, with maximum two (2) decimal figures) which is the product of multiplying the values of the work quantities and the unit value.
    - Direct Cost
    - A.I.U
    - Total Cost

- The description of the items should be be clear, concise, precise, in terms of: materials to be used, quality of work finishings, tools and/or special equipment to be used, internal carriage, and in general all the activities to be carried out in order to comply with the execution of the activities. With this the unit price analyses are carried out, from which the unit value for each item is derived.

- The unit of measure by which this activity will be paid should be represented.

- The unit value must be expressed in Colombian pesos, with a maximum of two (2) decimal digits, this value will be obtained from the unit price analyses.

- The total value must be expressed in Colombian pesos, with maximum two (2) decimal figures, this will be the product of multiplying the values of the work quantities and the unit value

- Direct cost will be the sum of the total values of each of the items.

- A.I.U. refers to the indirect costs of the work, administration, contingencies and utilities, expressed in percentage, with maximum two (2) decimal digits. When generating the

A.I.U. the taxes and fees applicable according to the municipality of execution of the project, must be taken into account.

- Total cost, this value will be the sum of the direct and indirect costs of the project.

2.12.2. Unit price analyses:

A mathematical model must provide a clear traceable justification of the value of each item on the work quantities form, for which a format must be used, enabling the breakdown of each of its components, equipment and tools, building materials, external and internal transport, labor and other parameters required for calculating the budget.

For purposes of calculating the AIU, administration, contingencies and utilities, a format must be used that can be filled out in an organized way with the different indirect costs of the project, including among others: administrative personnel, mobilization and facilities, general expenses and legal, legislative, and tax expenses, and in addition a percentage must be expressed for the contingencies, and a percentage for the utilities.

2.13. Other studies and designs.

The contractor must carry out all the studies and designs in detail, both sufficient and necessary, including all the technical components described and others that the project may require, thus enabling the execution and construction of the selected alternative.

Presentation of the project to the Ministry of Housing, City and Territory (MVCT)

The contractor must deliver to the contracting company all the necessary products so that the municipality can present to the Ministry of Housing, City and Territory the viability application of the project, and additionally they must accompany the municipality in the efforts and activities that are necessary, in order to obtain the viability of the project in accordance with what is set out in the resolution 1063 Of 2016, when it refers to: technically acceptable project.

In addition, the contractor must know all the requirements of one-stop window, since it is their responsibility to carry out all the studies and designs demanded by this, and they may be required by the auditor or the contracting party to carry out the adjustments and corrections in response to the doubts and concerns arising from the project, in such a way that they are introduced in a timely manner.

2.14. Results.

As a result of the design, a consolidated document shall be obtained containing each and every one of the documents produced in carrying out the steps described in the preceding article, including the design records, the detailed plans for construction, and the definitive design specifications which must conform to the provisions of Title 3 of this resolution on document management.

2.14.1. Presentation of plans and documents

The contractor will deliver the plans in magnetic and original physical form, and two (2) heliographic copies of the study, of 0.60m x 0.90m of the general plans, and a reduced plant version, and another in profile to a suitable scale in order to appreciate the entire project.

In the plans of the hydraulic works, the hydraulic profiles must be drawn, and in the lower part in separate spaces the abscissas, ground elevation, piezometric elevation, available pressure, etc.

The plans delivered as a product of this study must be signed by the contracting party, the designer, and the auditor; if the plans refer to the design of special systems they must also be signed by the specialist professional in the area.

The plans delivered must be constructive plans, be duly bound, at appropriate scales, and in the case of the structural plans they must include the list of irons.

In general, for the application of standards and technical specifications related to designs, plans, records, etc., that which is stated in the Drinking water and Sanitation regulations RAS and their updates will be taken into account.

The definitive design reports, including reports on the presentation of plans, calculation records, studies and definitive designs, and which should include the results, recommendations and conclusions of the development of the activities as described in the terms of reference, and other topics that the contractor has considered to be important and related to the studies, all this should be approved by the audit.

Final Report-This report should include the observations and corrections given by the study's audit and an executive summary document of the development of the studies and designs.

The contractor shall deliver the reports and products resulting from the contract with all its original annexes and two (2) copies, as well as in magnetic form (Cds) compatible with the software applications available in the municipality where the project will be executed.

In the documents of presentation of the results, the contractor will have to reference at the end of them, the bibliography used, citing the possible sources of consultation.

Original and two (2) copies of the topographic, general design, and detailed plans, all in paper size and appropriate scale, will be provided to enable an adequate reading of all the information consigned, representing the entire project. All records and plans must be delivered in physical and magnetic form. All design plans must have all the required elements clearly identified and drawn, detailing clear conventions to identify whether the elements exist or are proposed elements, which should be reflected in numbered tables, and quantity summaries. All plans must be duly signed by a professional accredited in the respective field, as well as by the audit/supervision of the work. The following plans for each project will be included, as appropriate, whether for water supply systems or for wastewater management, according to the selected technology:
-Topographic plans - Plans locating the projected systems in the plant. - Profiles of pipes and main pipelines - Plans of sectorization of the aqueduct systems. - Detailed plans of hydraulic structures, pumping stations and other elements that are projected for construction, including for each one

their location in the plant and constructive details. - Civil, hydraulic, structural, electrical, Mechanical, and Instrumentation Plans.