THE TRINIDAD SEWERAGE PROJECT - A SECOND REPORT

By

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SYNOPSIS:

In 1963 Fojo and Bates (1) presented a paper dealing with the Sewerage Project at present under construction in Port of Spain and environs, San Fernando and Arima. Included in that paper was a short historical background and description of the project with pertinent data for sewers and operational features of the Pumping Stations and Sewage Treatment Works. Copies of that paper are no longer available and several enquiries for reprints have been made. The paper presented herewith summarizes the information given in the first paper and adds additional information, particularly on construction.

Historical Background and Existing Facilities - Port of Spain:

The first communal sewerage system in Trinidad of which we have records was constructed in Port of Spain in 1861; but the present Port of Spain system now in operation in a limited part of the city was started in 1899. At that time, a low-level sewer was laid along what is now Wrightson Road and sewer works established at Mucurapo, the site of the existing pumping station. The diameter of the sewer varies in size from 27 inches to 12 inches and at its deepest point is some 25 feet from ground level to invert. Extensions were made to the system from time to time but it was not until the period 1935-1937 that any additional major construction was carried out. At about this time, the High Level Sewer from 21 inches to 33 inches in diameter was constructed; this was intended to take sewage from Woodbrook and Belmont and from those areas between Queen's Park Savannah and Ariapita Avenue, Baden Powell Street, Tragarete Road and Oxford Street. In actual fact, Belmont had not yet been sewered at the start of the present project in 1962 and no major extension to the Port of Spain system was carried out from 1937 to that date.

The position in June 1962 when the new Project started was that the area bounded generally by the Maraval River on the West, the Dry or St. Ann's River on the East, Wrightson Road and South Quay on the South and the Queen's Park Savannah to the North, had already been provided with sewers. In addition, the sewers extended outside these boundaries to take in small areas and individual institutions, such as Federation and Ellerslie Parks, La Fantasie and St. Ann's Gardens, the Masson Hospital, the St. Ann's Hospital and the Girls' Industrial School.

Both the High Level as well as the low level sewers empty into the Pumping Station at Mucurapo. No treatment takes place here and the raw sewage is pumped into the Port of Spain harbour through two outfalls, one 16 inches in diameter and about 900 feet long built with the original scheme in 1899 and the other approximately 24 inches in diameter and built in the period 1934-1937. Float studies made in 1959 indicated that objects drifted back to shore even when placed 2,000 feet out to sea.

At present, the capacity of the low level sewer is insufficient to deal with the flow and in fact this line is surcharged for the greater part of its length.

San Fernando :

Owing to its almost impermeable clay soil, the town of San Fernando has been and is very much in need of a modern sewerage system. Reports recommending such facilities in 1937 and 1948 were without positive result. There do exist sewerage systems in two or three areas developed in San Fernando by the former Planning and Housing Commission. These systems cater for over 500 buildings out of a total of some 8,500 buildings in the town. The treatment in these systems is by septic tank and soakway. The nature of the soil is such that treatment by this method is not always effective and, as a result, the drains and open streams in San Fernando carry a fair proportion of inadequately treated sewage as part of their flow.

Other Areas :

As a result of the initiative of the late Mr. C. E. Newbold, a former Chief Engineer of the Planning and Housing Commission, who had previously been the Sanitation Engineer of the Public Works Department, most of the housing settlements constructed by the Commission in the nineteen forties were provided with communal sewers, the sewage from which was treated in septic tanks and soakaways or by trickling filters. Included in such settlements are the areas referred to in San Fernando at Mon Repos off the Naparima Mayaro Road and the Navet Housing Estate. The largest such settlement is at Morvant just east of Port of Spain and to the North of the

Eastern Main Road where a series of septic tanks deal with the sewage of almost 1,000 dwellings. In some cases, small trickling filters have been used but these have in some instances gone into disuse and recourse has often been had to the leaching properties of the soil for treatment.

In at least one instance, a communal system was constructed by an oil company at Point Fortin with half-a-dozen septic tanks at different locations to deal with the sewage from 200 houses built for its employees.

More recently in 1960, the National Housing Authority which is the successor of the former Planning and Housing Commission constructed at Diamondvale, Diego Martin, to the West of Port of Spain proper, a sewerage system for some 2,000 houses, 400 of which have already been built and occupied. For these 400 houses a temporary extended aeration treatment plant has been erected until the new project is completed, when the Diamondvale sewage will be collected by the new Diego Martin trunk.

There are in addition, individual systems at various isolated institutions where treatment is generally by septic tank followed by a small trickling filter and in one case, the University of the West Indies, St. Augustine, by a small extended aeration plant. In general however, the system for central Port of Spain collecting a flow of over 3,000,000 gals/day from some 40,000 persons was the only one of note in Trinidad and Tobago.

THE NEW PROJECT - GENERAL LOCATION PORT OF SPAIN:

Figures 1, 2 and 3 show the general layout of the trunks of the proposed systems for Port of Spain, San Fernando and Arima respectively, and the trunk capacity being provided.

The areas to be sewered are the new communities to the west of Port of Spain at Diego Martin, Bayshore, Cumana and Goodwood Park; those areas within the statutory limits of Port of Spain which are not yet sewered, Maraval, St. Ann's and Cascade to the north for about one mile beyond the City Limit in each case; and areas along the Eastern Main Road between 3 and 4 miles east of Port of Spain and including the major built-up areas in San Juan and Barataria. These areas together with the already sewered section of Port of Spain amount to 5,400 acres. Provision has however been made in the trunk sewers for flow from an area of over 12,000 acres in and around Port of Spain.

The System for Port of Spain includes an interception sewer from pumping station near the mouth of the Diego Martin River which runs along the coast to the west and collects sewage from trunks picking up flow from along valleys more or less perpendicular to the coast. The subsidiary trun

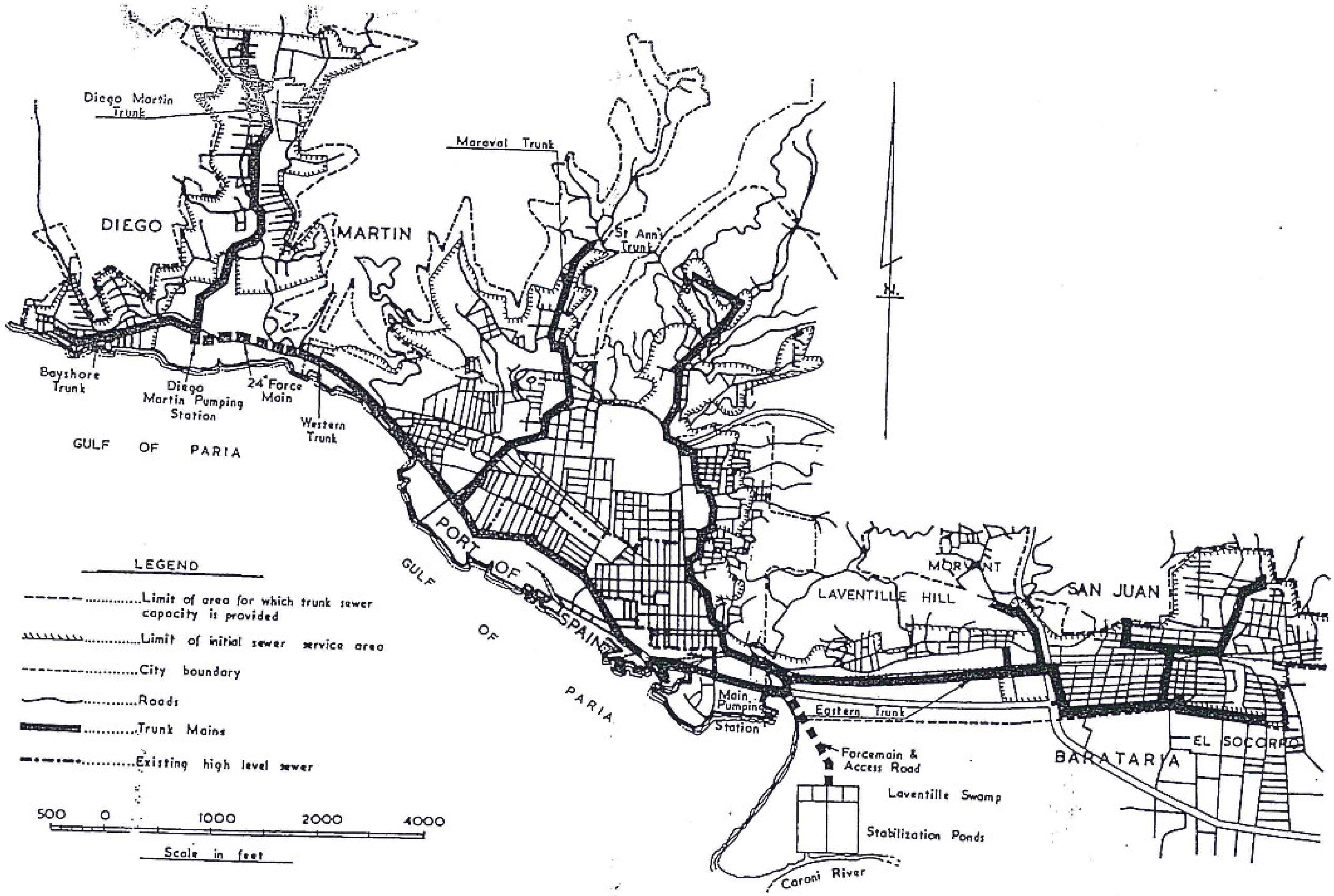


FIG. I. LAYOUT OF TRUNK MAINS — PORT OF SPAIN flowing into the main intercepting sewer (the Western Trunk) are the Diego Martin Trunk to the west, the Maraval Trunk and the St. Ann's Trunk generally along the course of the Maraval and St. Ann's Rivers. In addition, the Western Trunk will collect the flow from the existing high and low levels sewers which receive sewage from the existing sewered area. This Western Trunk empties into the Port of Spain Pumping Station immediately east of the city boundary off Beetham Highway. The maximum diameter of the Western Trunk is 72 ins. and its greatest depth almost 30 feet.

The other major intercepting sewer of the Port of Spain system will be the Eastern Trunk which roughly follows the plain at the foot of the Northern Range. This interceptor (maximum dia. 48 ins.) also empties its sewage into the Beetham Highway Pumping Station from whence, together with sewage from the west, it is pumped to the treatment works some three-quarters of a mile to the south on the banks of the Caroni, Trinidad's best known river.

The area proposed to be served includes 90,000 persons in Port of Spain proper plus 60,000 in its environs, and the Treatment Works is designed to accommodate sewage from 150,000 persons. However the trunks have a capacity sufficient to accommodate flow from a population of 480,000 persons.

San Fernando:

This town of some 36,000 people and some 37 miles by road from Port of Spain nestles around and at the foot of the Naparima Hill which on a clear day can be seen from the range to the north of Port of Spain. Two main trunks will receive the town sewage; they both start on the eastern boundary of the town and circle it in opposite directions to form an oval embrace meeting at the Treatment Works on the northern bank of the Cipero River near its mouth and in the south western corner of the town. The diameter of the largest main for San Fernando is 36 inches, but in certain sections, in order to avoid additional pumping stations, it is as deep as any in P.O.S.

While the Treasment Works are designed for a population of 50,000, the trunk sewers will be able to accommodate flow from 90,000 persons.

Arima:

Two trunks also serve Arima. These run from North to South generally along the course of two streams traversing the town, that is, the Mausica River and the Lavapiede Ravine. The maximum size of the trunk as it enters the Treatment Works is 27 ins. in diameter and will serve in the immediate future the present population of 11,000 people. Nevertheless, capacity has been allowed for in the trunk mains for 27,000 persons and the Treatment Plant designed for a population of 18,000.

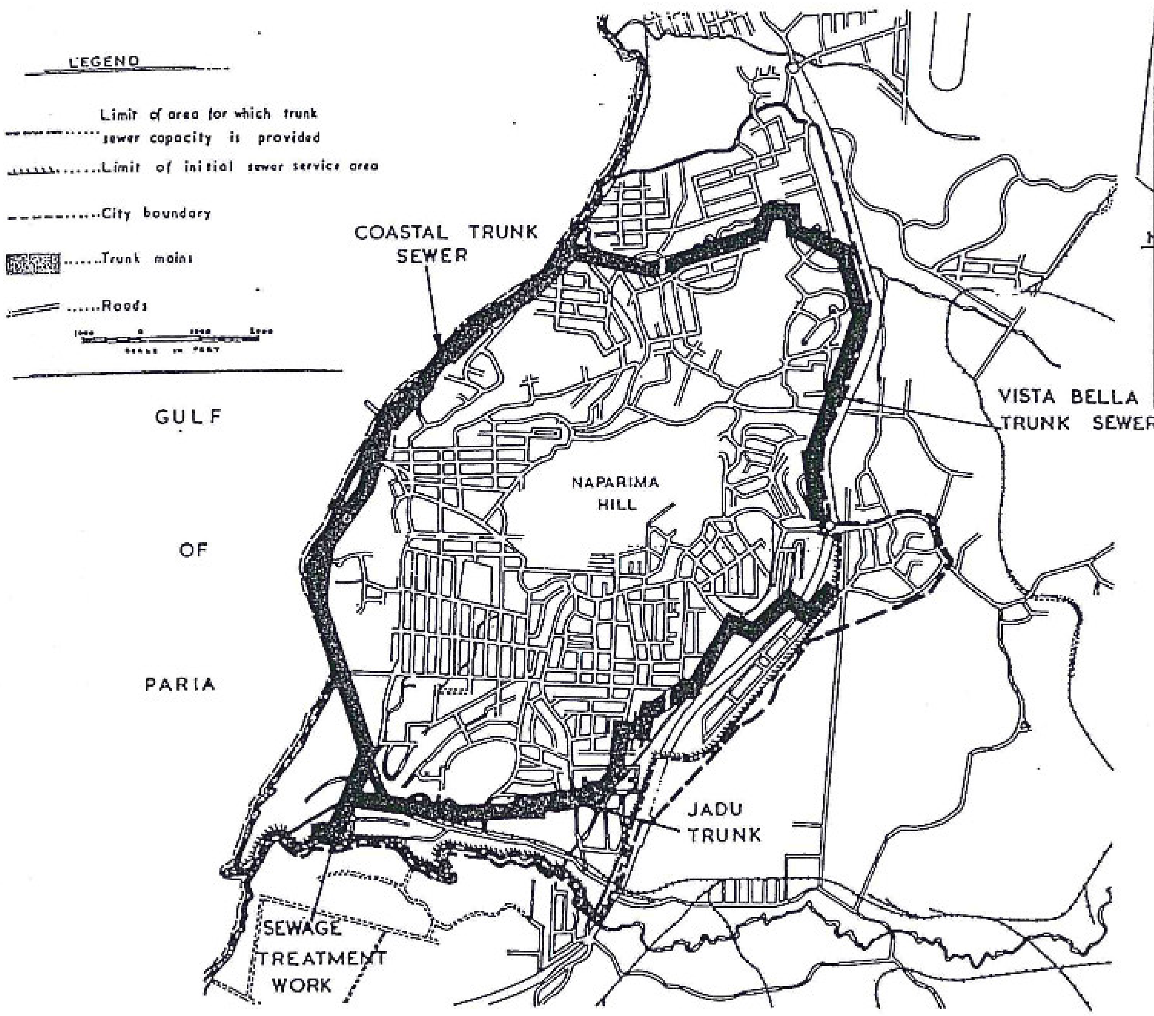


FIG. 2. LAYOUT OF TRUNK MAINS—SAN FERNANDO

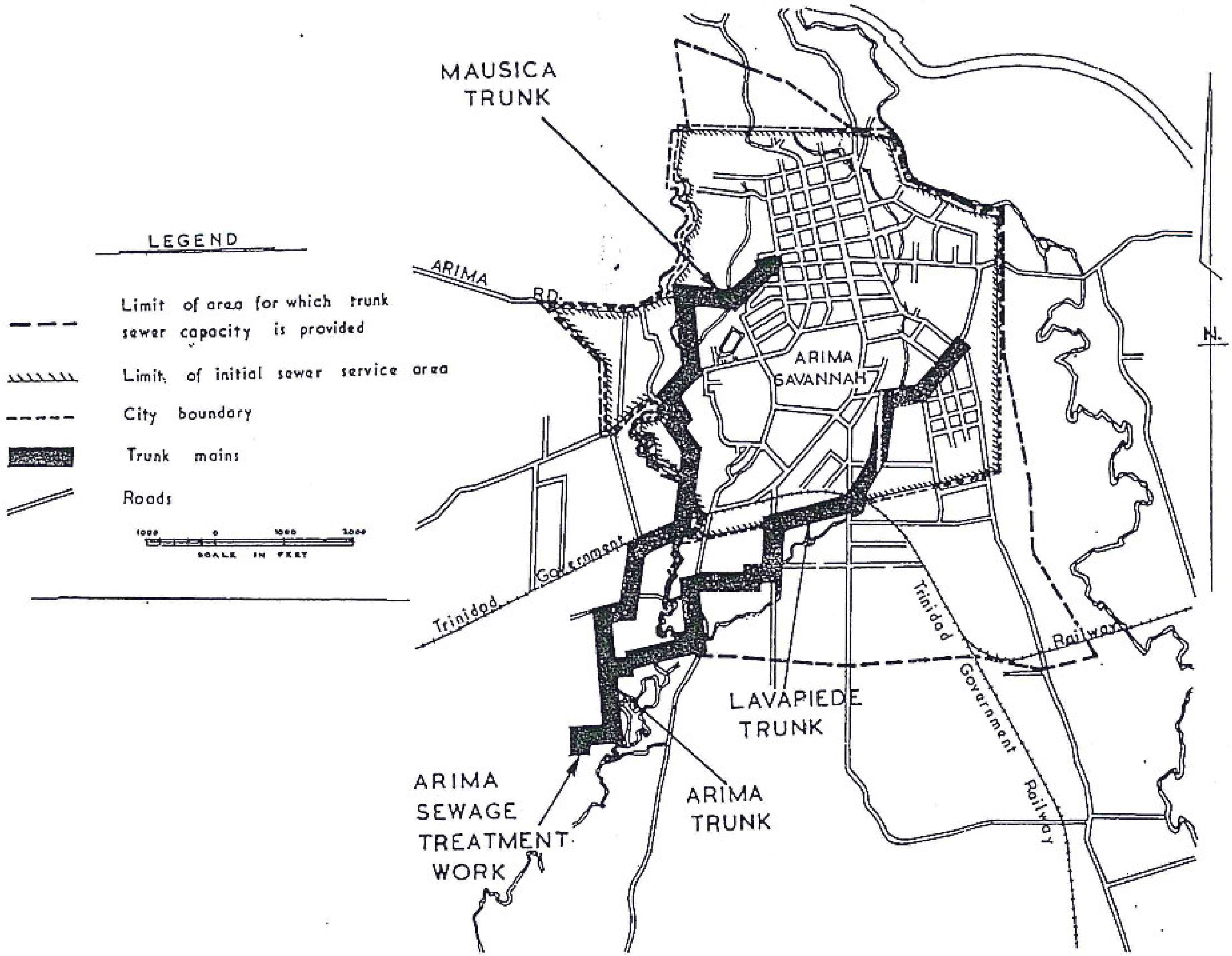


FIG. 3. LAYOUT OF TRUNK MAINS — ARIMA

GENERAL DESIGN ASPECTS

Studies made by the consultants of water consumption records in various areas and population densities resulted in the use of the following design factors:-

AVERAGE DOMESTIC SEWAGE FLOW

Port-of-Spain and adjacent areas........................ 75 g.p.c.d.
Eastern Main Road Communities...................... 60 g.p.c.d.
San Fernando and adjacent areas....................... 65 g.p.c.d.
Arima and adjacent areas................................. 60 g.p.c.d.

Allowances for industrial, commercial and infiltration flow were made on the basis of the consultants experience and examination of existing records. These are as follows :-

Industrial... 10,000 g.a.d.
Commercial... 5,000 g.a.d.
Infiltration... 2,000 g.a.d. for areas
already sewered and.................................. 500 g.a.d. for new areas

The ratio of maximum to average daily flow was estimated to be from, 4.5:1 for small flows of 0.1 m.g.d. and less, to 2:1 for average flows of 20 m.g.d.

POPULATION DENSITIES USED FOR DESIGN

(a) Port-of-Spain - East of St. Ann's River - From 180 persons per acre for areas of 40 acres or less to 80 persons/acre for a total of 1,000 acres.

(b) Port-of-Spain - West of St. Ann's River and San Fernando - from 80 persons/acre for areas of 49 acres or less to 55 persons per acre for a total of 2,000 acres.

(c) All areas adjacent to Port-of-Spain - From 70 persons/acre for areas of 40 acres or less to approximately 35 persons/acre for areas of 2,000 acres.

(d) Arima - From 40 persons/acre for areas of 40 acres or less to approximately 30 persons/acre for areas of 1,000 acres.

The relationship of population density to area is shown graphically on Figure 4 for the several districts in and around Port-of-Spain and for San Fernando and Arima.

TREATMENT PLANTS AND PUMPING STATIONS

PORT-OF-SPAIN

The Main Pumping Station off the Beetham Highway is a relatively large structure with foundations more than 40 feet below the ground surface and

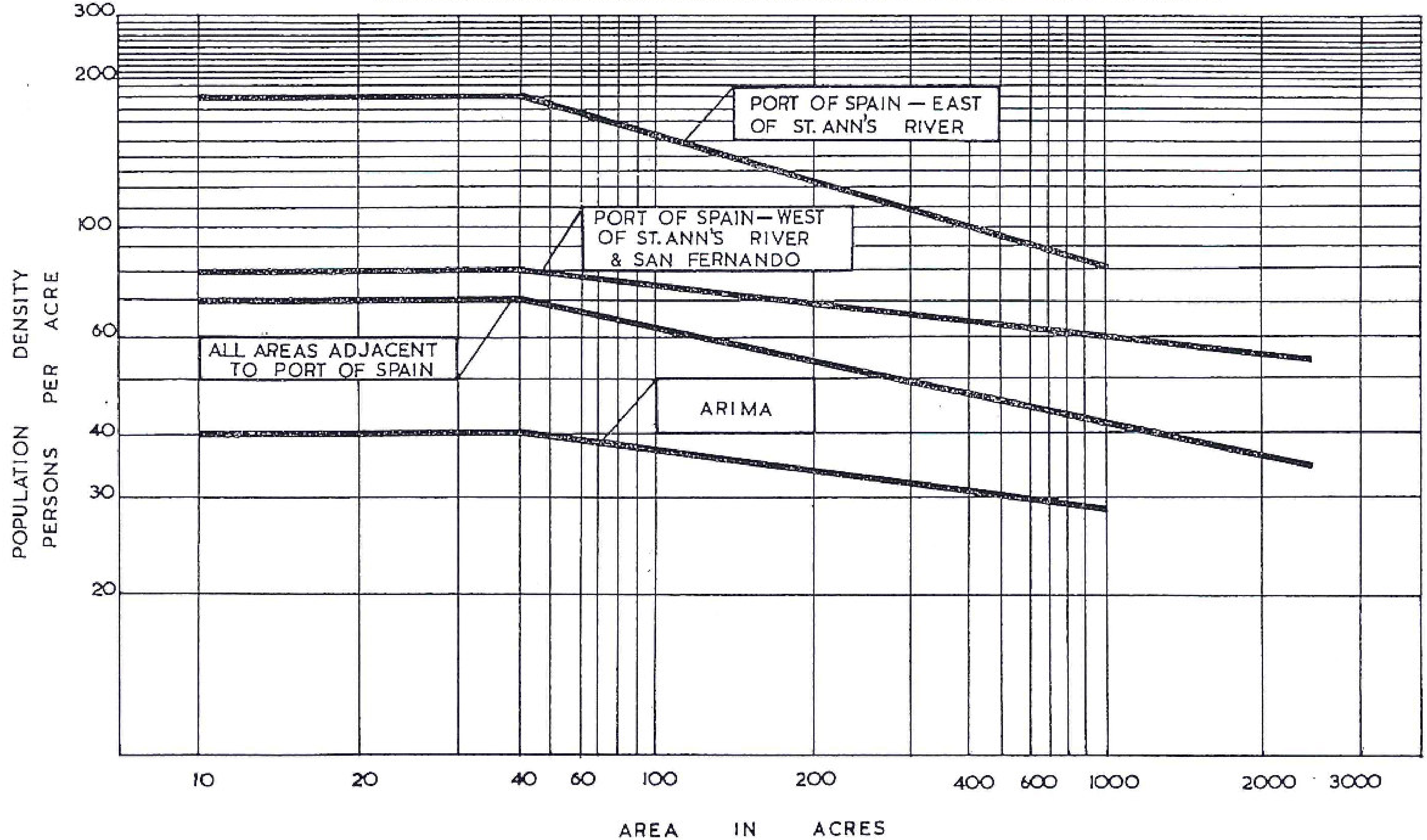


FIG.4. — POPULATION DENSITIES USED FOR DESIGN

a base slab 6.0 ft. thick. Borings disclosed firm materials at this level so that no foundation piles are required. Architecturally, the superstructure will be modern in design with a butterfly roof. Walls will be constructed from a combination of reinforced concrete, precast blocks and stucco.

All sewage flow will pass through comminutors which will shred coarse solids to small particles before the sewage enters the wet well. Bar-racks are provided for standby service. Pumps in a dry well will lift the sewage through a 4,000 feet long 48 in. diameter forcemain to the Stabilization Ponds. Because of the waterhammer problems which are inherent in such a system, cone valves and backflow relief piping are used.

The Stabilization Ponds are comprised of four 6.5 acre anaerobic lagoons and two 48 acre aerobic lagoons. The inside slopes of all units have been lined with precast concrete slabs, to preclude weed growth and bank erosion. A substantial removal of both suspended solids and organic impurities takes place in the anaerobic units as decomposition of settled solids simultaneously occurs in an atmosphere identical to that in ordinary septic tanks. The effluent from these lagoons will flow into the aerobic (or oxidation) lagoons where oxidation of practically all of the remaining organic matter will be accomplished. The phenomenon of photosynthesis promotes the growth of oxygen producing algae which release oxygen into the liquid, in sufficient quantities to result in efficiencies of BOD and coliform bacteria removals of the order of 98%.

A general plan and flow diagram of the system is shown on Figure 5. Basic data for the lagoons as well as for the Diego Martin and Main Pumping Stations are also listed below.

Pump selection for the Diego Martin and Main Pumping Stations considers conditions up to the year 2,000. The initial installations are designed for conditions expected to prevail in 1980.

For the Diego Martin Station three identical constant speed (870 rpm) vertical, non clog, pumps have been installed initially pumping into a 24 in. forcemain. Velocity in the forcemain with one pump operating will be approximately 2.7 ft. per sec. so that deposits are unlikely and detention time will not be excessive.

With two pumps operating the combined pumping capacity will be within approximately 10% of the estimated 1980 maximum wet weather flow of 8.0 M.G.D. Therefore one pump will serve as a spare until flows exceed 7.2 MGD. With all three pumps operating a flow of 8.6 MGD can be pumped,

The Main Pumping Station has four, three speed (585, 526, and 468 r.p.m) vertical, non clog pumps installed. With one of the 24 in. pumps out of service the maximum wet weather 1980 design flow of 40 MGD can be pumped.

BASIC DATA - PORT-OF-SPAIN

Main Pumping Station

Flow measurement, (Venturi type meter)...............48in.
Comminutors—No. initially installed...............2
Capacity. each...............20.0 MGD
Pumps–No. initially installed...............4
Size...............2-20 in—125 h.p.
2-24 in—200 h.p.

Capacity with 2-20 in. and 2-24. in. operating...............40 MGD
Standby generator, KW capacity...............350

Stabilisation Ponds

Design Population...............150,000
Average design Sewage flow...............15.0 MGD
Max. design wet weather flow...............40 MGD

Anaerobic Lagoons—number...............4
Dimensions, LxWxD...............540' x 520' x 3' – 4'
Total area, acres...............26
Organic loading, lb BOD/day...............25,500
Detention time at 15 M.G.D...............Approx. 1.5days
Estimated BOD removal...............70%

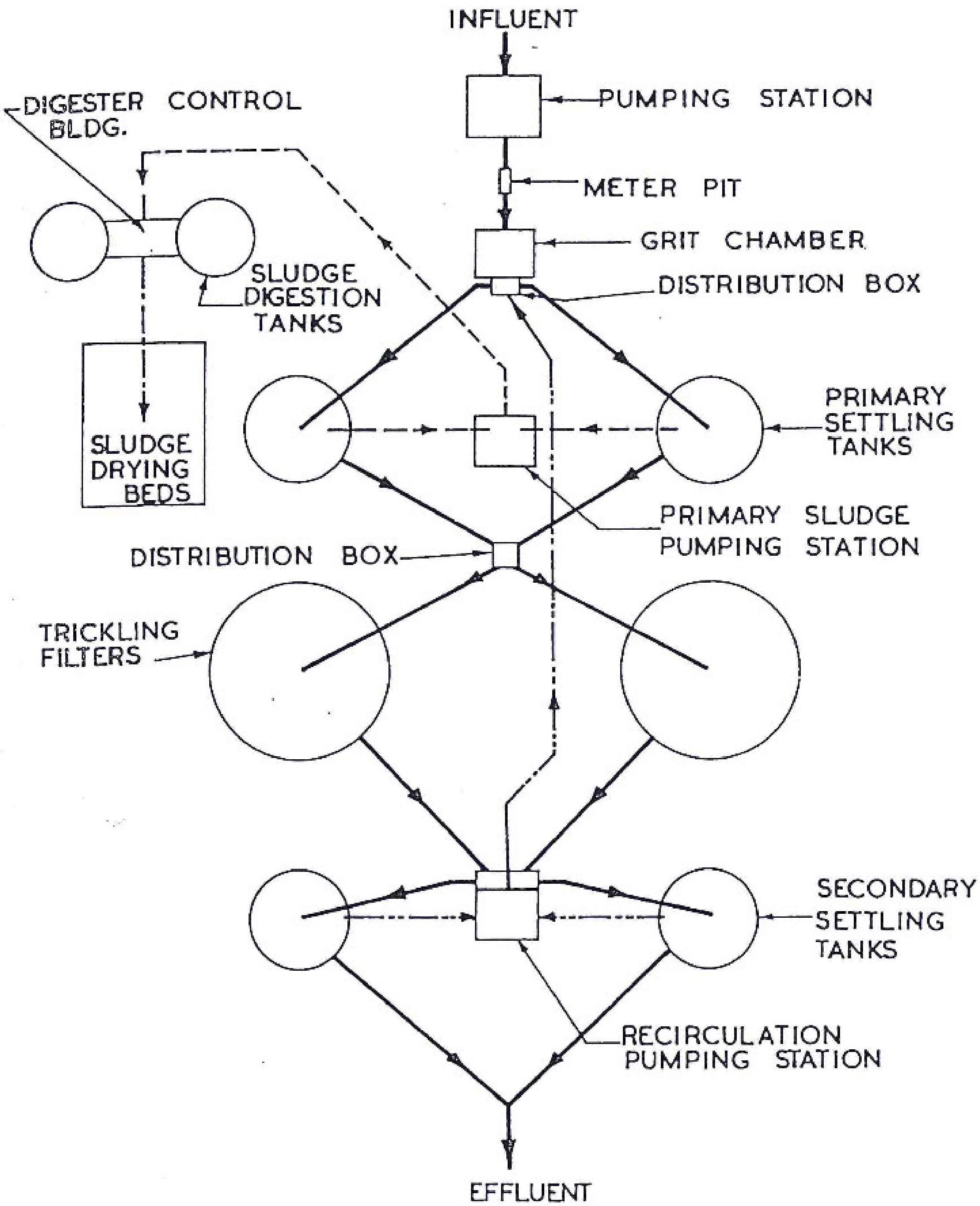
Aerobic Lagoons—number...............2
Dimensions, L x W x D...............1880'x 1120'x 3' to 4'
Total area, acres...............96
Organic loading, lb BOD/day...............7,600
Detention time at 15 M.G.D...............Approx· 5.0 days
Estimated BOD removal...............90%

Diego Martin Pumping Station

Flow measurement...............12 in. Parshall flume
Pumps—No. initially installed............... 3
Size ....12 in. - 40 h.p.
Capacity with 2 pumps operating............... 7.2 M.G.D.
Standby generator, KW capacity............... 100
Forcemain air injection system capacity............... 65 cfm

Note:–

B.O.D. Biochemical Oxygen Demand. The quantity of oxygen utilized in the biochemical oxidation of organic matter in a specified time at a specified temperature, in this instance 5 days and 20 C. This is a factor used for assessing the effectiveness of the treatment adopted.



LEGEND

- RECIRCULATED SLUDGE
- RAW SLUDGE
- DIGESTED SLUDGE
- SEWAGE

FIG. 5.—FLOW DIAGRAM SAN FERNANDO & ARIMA SEWAGE TREATMENT WORKS

SAN FERNANDO

The San Fernando treatment works is located on an 11 acre site at the Old Embarcadere, between the Cipero River and municipal refuse disposal grounds.

Basic data for the sewage treatment works are given below and a simple flow diagram of the plant is shown on figure 5.

A single sewage lift station, located within the treatment plant site will deliver all sewage flows to the plant units. The pumps are of the vertical multiple speed non clog type which will operate so that pumping rates closely match gravity flow rates. In this manner, maximum treatment efficiency is obtained since "shock" loads attributable to on-off single speed pump operation are all but eliminated. Three pumps will be installed initially, with provisions for a fourth 16 in. pump to be added when the need arises.

After passing through comminuting and flow measuring devices, sewage flows enter a double tank aerated gift chamber. By releasing compressed air along the bottom of one side of each tank, the contents are maintained in a swirling motion which removes heavy inorganic matter by centrifugal force. Accumulated grit will be removed by a bucket and hoist system and disposed of by burial.

Flow then passes to two circular primary settling tanks which will remove much of the solids not in solution. In all it is estimated that 50-60% of suspended solids and 30-35% of the BOD will be removed in these units. All the settled sludge will be pumped to the Digestion Tank for liquefaction and gasification by the anaerobic digestion process which reduces the raw material (sludge) to a practically inert wet ash.

Passing from the primary settling units all flows will be collected in a common chamber for distribution to the trickling filters where approximately 75% of the remaining suspended solids and BOD are removed.

The zoogleal mass growth (slime) on the stone surface making up the filter bed accomplishes this removal by a complicated process which includes the physical phenomenon of absorption. The sewage is distributed evenly over the filter stone by a constantly revolving mechanism with spraying nozzles. After passsing through the filter the flow is collected in a network of underdrains which convey the treated liquid into a single sump for further distribution and settling in two final clarifier, or settling tanks. The material collected in these last units is the sloughed slimes, sometimes called humus sludge, which is flushed from the filter. A Recirculation Pumping Station is provided to pump humus sludge and filter effluent to the primary tanks for recirculation to the Digestion Tanks. Resettled humus sludge is then removed with raw sludge to the Digestion Tanks while the final effluent goes directly from the secondary settling tanks into the Cipero River.

Hydraulic loading of the trickling filters with or without recirculation should not exceed about 25 mil. gals. per acre per day.

Digestion Tank supernatant and overflows will be returned to the plant influent. Digested sludge will be put on drying beds to remove most of its moisture so that it can be forked and hauled away for final disposal or fertilizing uses.

An Operations Building which will house office, laboratory, storage and other miscellaneous facilities has also been provided.

Space has been reserved on the site and provisions have been made for doubling plant capacity when and if required.

ARIMA

Like San Fernando, a highrate trickling filter type treatment plant was selected. The plant site is almost 9 acres in area and except for size and arrangement of structures will be similar to the San Fernando Plant.

BASIC DATA FOR SEWAGE TREATMENT WORKS

SAN FERNANDO AND ARIMA

	San Fernando	Arima
Designed Population	50,000	18,000
Average design sewage flow	4.5 MGD	1.5 MGD
Max. design sewage flow	12.5 MGD	4.2 MGD
Pumping Station		
Flow measurement, Venturi-type meter	24 in.	16 in
Comminutors - No. installed	2	2
Capacity each	6.2 MGD	2.0 MGD
Pumps - No. initially installed	3	3
Size	2-12 in-40 h. p. 1-16 in-100 h. p.	8 in-20 h.p.
Capacity with one pump out of service	12.5 MGD	4.2 MGD
Standby generator, KW capacity	200	100
Aerated Grit Chambers - number	2	2
Dimensions, L x W x D ft.	24 x 12 x 8	15 x 10 x 6
Air supply, cfm/ft of length	5	5
Primary Settling Tanks - number	2	2
Dimensions Dia x D ft.	75 x 9	44 x 8
High-Rate Tricking Filters - number	2	2
Dimensions Dia x D ft	115 x 5	70 x 5
Final Settling Tanks - number	2	2
Dimensions - Dia x D ft.	65 x 9	38 x 9
Sludge Digestion Tanks, number	2	2
Dimensions - Dia x D ft.	65 x 22	45 x 22
Cone depth, ft.	8	5.5
Sludge Drying Beds - number	8	8
Dimensions L x W ft.	90 x 55	45 x 40
Estimated BOD Removal	85	85

MATERIALS OF CONSTRUCTION

Conventional reinforced concrete construction was used for all pumping stations, treatment works and sewerage system structures except in San Fernando where it was found that the soil was sufficiently corrosive to necessitate the use of sulphate resistant cement.

Epoxy coated steel and asphalt coated cast iron are used in relatively minor quanties in the project where pipe lines cross through or over drains, streams, and rivers. Interior process piping in the treatment plants and pumping stations are of cast iron. Forcemains are reinforced concrete, cast iron or steel. For instance, the 24" diameter forcemain from the Diego Martin Pumping Station is reinforced concrete, while the 48" diameter forcemain from the Main Pumping Station to the sewage lagoons in the Laventille swamp is steel, exposed above ground for its entire length.

Sewers in the project are non-reinforced concrete for 6", 8" and 10" diameter pipes (80% of all footage) and reinforced concrete for larger sizes. The consultants have been aware of the considerations necessary in using concrete sewers especially in a warm climate. This question was thoroughly investigated during the report and design stages of the project and the conclusion drawn that concrete sewers made with ASTM Type II or Ordinary Portland Cement and without special coatings or lines would be suitable and long lasting. In practice, sulphate resistant cement similar to ASTM Type V is being used in the construction of all sewer pipes and manholes as well as for buried structures at the San Fernando Treatment Works.

Examination of existing sewerage structures revealed no unusual corrosion. Even existing steel sewers inspected at manholes gave no evidence of unexpected corrosion conditions.

Sewage flows into the existing Mucurapo Pumping Station are not above normal in B.O.D. strength and not septic. Local water supplies are not high in sulphates.

All sewage flows to the treatment plants are expected to arrive within 24 hours in a non-septic condition. This means that some dissolved oxygen should be available and the production of Hydrogen Sulphide not yet started when sewage arrives at the treatment plants.

Concrete pipe is at present the only sewer pipe made in the country and the basic materials are all obtainable here.

Precautions taken in the design to control abnormal corrosion conditions should they arise from completely unforeseen circumstances include:—

(1) Limitation of minimum slope of sewers 24" and larger (which carry the oldest sewage) to 0.0008 ft/ft. At this slope the velocity of a 72" diameter pipe flowing half full would be 4ft. per second and should preclude solids accumulation.

(2) A compressed air injection system for the Diego Martin Pumping Station forcemain to "freshen" sewage from the districts furthest from the Port-of-Spain Treatment Works.

(3) Submerged gravity sewer inlets into trunks to minimize turbulence.

(4) A submerged outlet for the Diego Martin forcemain.

COST AND FINANCE

The total cost of the work to be carried out by the contractor was in March 1962 estimated to be TT $7,815,000.00 plus US $16,221,000.00 not including fees or cost of lands. The Trinidad and Tobago currency is being provided from the revenues of the Government of Trinidad and Tobago and :he United States currency will include:—

(i) A loan of U.S. $6,000,000 at 6% provided in equal shares by two private banks;

(ii) A line of credit amounting to U.S. $9,000,000 from the Export-Import Bank of Washington at 5¾% per annum;

(iii) A loan of $1,221,000 U.S. from Lock Joint American (Trinidad) Ltd. nd its affiliates at 6% per annum.

The work being done comprises:-

(i) Construction of Trunk Mains, Laterals, Manholes and House-connections up to the house property boundary in the areas shown on relevant maps of Arima, San Fernando and Port-of-Spain and environs and the reinstatement of road surfaces and other structures disturbed by the work;

(ii) Construction of Treatment Plants at Port-of-Spain, San Fernando and Arima and of a Pumping Station at Diego Martin.

Approximate quantities are as follows:-

6" diameter pipe	300,000'
8" diameter pipe	694,000'
10" diameter pipe	60,000'
12" to 72" diameter pipe	226,000'
Total	1,280,000 = 243 miles
No. of Manholes	5,100

ONSTRUCTION

The official starting date of the contract was 6th April, 1962, but conuction work on sewers started in Port-of-Spain on the 12th June, 1962 and San Fernando in August 1962. Although work in Arima did not start until bruary 1963, the system there is substantially complete. Work on the Treatnt Plants started in each case around October 1962 and on the Diego Martin mping Station in November 1962.

At the end of June 1965 sewers were approximately 90% complete and itment works 99%. Overall job progress was almost 93%. The final 10% of allation of sewers includes largely the laying of several thousand feet of the diameter intercepting sewer, the Western Trunk along Wrightson Road Beetham Highway. As a result, increase in percentage progress is not expected to be as rapid as in previous years and the contractors' latest estimated date of completion is December 1965.

The majority of the trenching was carried out without shoring and by open cut. However, in a few cases during the course of the contract pipe has been "jacked" under railways and narrow road intersections where deep cut was necessary, which might have endangered adjacent buildings.

The contractor originally anticipated installing the 66" Trunk Sewer on Wrightson Road by the open trench method. In fact, a considerable footage of pipe was installed along this road without the use of any supports to the sides of the trench. However, at Colville Street, the location of the Trinidad and Tobago Electricity Commissions' Power Station, the proximity of a 33,000 volt underground cable, and the presence of other utilities led the Contractor to believe that the most feasible method would be underground construction. Another factor influencing this type of construction was the contractors' fear that any extensive open trench work could result in damage claims from adjacent property owners.

Taking these factors into account, the contractor engaged a soils Engineering firm to make a detailed study (including borings) of sub-surface conditions. The contractor reported that some thirty borings were made to a depth of 5' below invert level or 25' below the surface of Wrigthson Road, and was advised by his consultant that the proposed underground construction method was feasible.

The technique chosen by the contractor was that of jacking the pipe into position for a distance of some 4,400 ft.

The jacking procedure begins with the establishment of a series of pits of sufficient size to accommodate the jacks, guide rails and at least two pipes. These pits must be properly sheeted and braced and considerable emphasis is given to the building of a solid base to support the jacks as well as proper provisions to receive the reactive thrust against the sheeting as the jacking pressure is applied to the pipe.

Pit location is governed to some extent by avoidance of underground utilities and drains, however, the principal criterion is the distance that the jacks can be expected to successfully push the pipe. On Wrightson Road, 150 feet is considered to be the nominal distance in view of the capacity of the jacks and soil conditions.

The actual installation of the pipe is done by excavating to the full diameter of pipe and always slightly ahead of the pipe. As the excavation proceeds the pipe is pushed ahead by the jacks in the jacking pit. Once the excavation and jacking are started the work must be continued on a 24 hour day basis, since any prolonged stoppage will result in the pipe being "frozen" in place to a point that the jacks cannot reinitiate forward movement.

Bentonite or barytes is used as a lubricant to reduce skin friction of the pipe and actual experience has shown that the use of Betonite will increase effective jacking distances by as much as 50%.

Forward progress has averaged 1.3 feet per hour with the relatively good soil conditions now encountered. However, as the work nears the St. Vincent Street roundabout, average progress is expected to fall off considerably due to less suitable soil and obstructions.

Four 200 ton jacks are used to provide a maximum of 800 tons of thrust. With this capacity a distance of 150 feet can be reached.

At the present rate of progress the installation work on Wrightson Road should be completed by November 1965 if no major difficulties are encountered.

It may be of interest to record the labour and equipment involved in a project of this magnitude. During the last three years, that is from June 1962 when the first pipe was laid, the Contractor and his subcontractors have maintained an average employment rate of 1075 men per working day of whom over 1,000 were recruited locally. Peak employment was experienced in March and April 1963 when over 1,600 persons were on the employment roll. It was during this period that the Contractor installed an average of 4,700′ of sewer every working day for one month.

The Contractor has supplied the following list of equipment with his approximate costs for these items:—

		Quantity	Cost
(a)	Crawler Cranes, Truck Cranes, Loaders, Dozers, Motor Patrols, Side Booms, Trenching Machines. Blowers, Generators, Light Plants, Crusher, etc.	74	$2,211,000
(b)	Compressors	15	117,000
(c)	Pumps	105	113,000
(d)	Transportation Vehicles	85	376,000
(e)	Concrete Mixers	8	34,000
(f)	Air Tools, drills, tampers, paving breakers, etc.	51	21,000
(g)	Shop equipment including grease trucks		93,000
(h)	Office and Engineering Equipment		52,000
(i)	Pipe Plant and Equipment		1,126,000
	Cost of Investment in Equipment and plant		TT $4,143,000
(j)	In addition to the above equipment the cost of rented equipment to June 1, 1965 was		TT $1,933,216
(k)	In order to maintain the above noted equipment, the warehouse stock of parts and materials has a value of		TT$ 450,000

Although the latest estimated date of completion is December 1965, it appears almost certain that all three treatment plants will be in operation by the end of September 1965. A connection is at present being made from the existing Port-of-Spain System at the junction of Abercomby Street and Independence Square north to the new 66" diameter trunk on Beetham Highway; when this has been done the Port-of-Spain Treatment Works can start operations. In Arima, plans for the start of construction of domestic connection to individual houses are almost complete. In San Fernando, as explained earlier, there already exist three minor systems the flow from which will be turned into the newly laid pipes.

Finally, the Water and Sewerage Act which will lay down the basis for a Water and Sewerage Authority has been presented to Parliament and will serve as the legal instrument whereby the new system, soon to come into operation, will be regulated and controlled.

REFERENCES:

1. R. K. BATES and F. R. FOJO - "Trinidad Sewerage Project" The Journal of the Association of Professional Engineers of Trinidad and Tobago. Vol. 3 No. 2, 1963 pp 13 to 29.

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