CAMP DRESSER & McKEE
Inc.

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON, MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

Al Hanson
For your info
Bill K.

April 2, 1973

Mr. William Krasnow
Environmental Engineer
Digital Equipment Corporation
146 Main Street
Maynard, MA 01754

Well Testing
DEC - San German, Puerto Rico

Dear Mr. Krasnow:

As per your telephone request of last Friday (30 March), we have reviewed the pertinent data on the current well pumping test at San German. Our conclusion is summarized below.

It is our understanding that the current well pumping test at the DEC installation at San German was run for 6 hours on the test well originally installed by Chardon & Sons about a year ago. The measured discharge was approximately 220 gpm over a six hour period. The pump used was rated at 220 gpm at a 350' total head, and was installed at Elevation -350 during this test. The static ground water level of -20 was dropped to -220 during the test. The pump was then throttled back to produce 200 gpm and left to run, the thought being to return in 12 or 13 hours and measure the effect of this 200 gpm pumping rate on the groundwater levels. At 11:00 pm, the pump was not operating, and further examination led DEC to believe a short circuit in the motor caused the stoppage.

Our review of the above and our past report of January 1972, Report on Water Supply - DEC Corporation San German, Puerto Rico (a copy attached) indicate that very little confidence can be put into a test that ran for only 11 hours with 6 hours of close measurements.

The test well installed was basically a rock well (see above report) and for this type of installation, projections would have dubious value when based on so short a test.

We would recommend a test program, as stated in our report on the existing well. Pumping the well as outlined in the report continuously, for a minimum of 72 hours, should well define the potential of the existing groundwater. Further, as recommended in our report, the use of a stateside contractor to perform the work should be considered.

We appreciate your concern about this matter, as we realize the purchased water costs for San German are a major factor in developing the manufacturing facilities. However, we feel that the investment in a proper test will be well worth the cost, when measured against the possibility of developing a well installation of deficient quantity.

Very truly yours,

CAMP DRESSER & McKEE Inc.

David Laredo

David Laredo

File No. 493-4-RT

DL/gfi
encl.
cc: R. C. Marini

Puerto Rico

Correspondence

JUN 18 1973

CAMP DRESSER & McKEE

Inc.

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON, MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

ROBERT C. MARINI
SENIOR VICE PRESIDENT

CC file
H. Crume
G. Wood

June 15, 1973

Mr. William D. Krasnow
Environmental Engineer
Digital Equipment Corporation
Maynard, Massachusetts 01754

Digital Equipment Corporation
Process Water Treatment Plant
San German, Puerto Rico

Dear Mr. Krasnow:

As per our discussion of June 7, 1973, at your office, you indicated that Digital felt that CDM had been remiss in not providing a chemical precipitation waste treatment plant immediately at San German, based on the data provided by DEC at the time of design. We present the following points for your consideration.

The San German Process Water Treatment Plant was designed based on the flows and waste characteristics shown on Sheet WT-1 of the contract drawings for this project. This same table was shown in our report for this project submitted to DEC June 15, 1971. (See Table 2) The treatment plant unit operations design was based on the existing manufacturing processes at DEC's Maynard manufacturing facility. Analytical values of the metals concentrations were based on a sampling and testing program conducted at Maynard, and expected flows for the various process waters were ascertained by discussion with DEC personnel.

Based on the process water summary shown on Sheet WT-1 of the contract plan, we have prepared Attachment 1, which illustrates the maximum amount of copper expected per day is approximately 1.7 pounds.

All process water discharges total 101 gpm (see Sheet WT-1), all dumps average 393 gallons/day, and domestic wastes, HVAC and miscellaneous waters was assumed equal to an additional 25 gpm.

Based on a 16 hour day as per your recent direction, the maximum amount of wastewater discharged would be approximately 121,000 gallons per day (126 gpm x 960 min + 393).

Assuming continuous operation, the maximum copper concentration would then be approximately 1.7 mg/l ($1.732/121{,}000 \times 8.33 \times 10^{-6}$). We believe your previous calculations were the expected copper concentration at the effluent to end of the sedimentation facility.

In our opinion, as stated frequently during the design of this facility and others, (e.g. Ireland) the dilution afforded by other process and wastewaters not requiring treatment must be considered in determining if standards are to be met.

The copper concentrations shown above are the expected maximum values. Auspicious transfer of the ammonium persulfate dumps from the AP holding tank to the waste stream as outlined in the Operations Manual prepared for this project should reduce the overall maximum copper concentration discharged to approximately 1.30 mg/l.

The heavy metal ion concentrations in the effluent will be less or close to the allowable 2.0 ppm level established by the Acueductos (see PRASA Regulation No. 477) if the above procedure relating to the AP dump is adhered to. It should be emphasized that the copper concentrations shown in Attachment 1 were considered to be the maximum expected. The single most critical value would be the amount of copper in the AP holding tank. This could vary between 500 to 1600 mg/l. The amounts of copper in the rinse waters may also vary downward from those values shown. Therefore, we were confident that the copper concentrations could be kept at or below atl.0 mg/l level in the total plant effluent.

Our report also recognized that the high copper concentrations in the AP tank might not make it feasible to discharge into the treatment plant. Experimentation under actual conditions was recommended to determine if separate AP treatment was required.

The sedimentation facilities were designed with an overflow rate of approximately 1.2 gpm per square foot, 31 gpm of the total 101 gpm of continuous flow would discharge directly to the sanitary sewer, so that 70 gpm would be discharged to the sedimentation tank over 75 square feet of tube area. If 80 percent of the tube area is considered effective, the overflow rate would be (70/60 = 1.17 gpm per square foot.) This is about one-half the 2.0 gpm per square foot rate recommended by the tube manufacturers. It is our understanding that Mr. A. Rimer of our staff, during his plant startup work in San German, instructed the DEC plant personnel to install an appropriate influent baffling devide on the settling tank, prior to his leaving Puerto Rico.

With the expected low copper concentrations no provisions were made to remove copper by precipitation since it was not necessary to meet the authority standards. Further, since only small amounts of sludges were expected no continuous sludge removal devices were installed but provisions

were allowed to install them if necessary, in the future.

I believe this information answers the questions you raised at our June 7, 1973, meeting.

We believe that based on the data provided to us by DEC we would have been in error to recommend sedimentation by precipitation to meet the Acueducto standards of 2.0 ppm. Further, we do not consider that CDM is liable for any DEC expenses on establishing a chemical precipitation plant at San German because of the high copper concentration which resulted after the plant was put into operation.

If you require any further information on the matter, please contact me.

Very truly yours,

CAMP DRESSER & McKEE Inc.

Robert C. Marini
Senior Vice President

RCM/ltp

cc: Al Hanson

ATTACHMENT 1

DEC Process Water Treatment Plant
San German, Puerto Rico

DAILY DISCHARGES OF COPPER

Source	Flow Rate gpm or dump vol. per day (gal)	Cu concentrations mg/l	Total Cu[1] (lbs/day)
Board Strip - Rinse	10	.015	0.012
NaOH Tank	10	2.9	trace
Etcher - Standing Rinse after cupric chloride	9.6	2,500	0.200
First running rinse	10	4.6	0.368
NaOH Tank	24	30	0.006
Second running rinse	10	0.15	0.012
Gold Plate - Ammonium pers. tank	5.2	810	0.035
Rinse after AP tank	5	11	0.440
10% sulfuric acid tank	4.8	120	0.005
Rinse after 10% sulfuric	5	0.5	0.020
Immersion Tin - Ammonium Pers. Tank	40	1,600	0.534
- Rinse after AP Tank	5	2.5	0.100
	Total Pounds of Copper/Day =		1.732 lb
	Total in rinse =		0.952 lb/day
	Total in dumps =		0.780 lb/day

[1] Assumes 5 day week, 16 hours/day

Puerto Rico

cc: G. Wood
G. Beebe
correspondence

CAMP DRESSER & McKEE
Inc.

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON, MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

ROBERT C. MARINI
Senior Vice President

January 28, 1972

Mr. Allen Hanson
Digital Equipment Corporation
Maynard, Massachusetts 01754

Water Supply to Digital
Equipment Corporation
San German, Puerto Rico
CDM 493-4

Dear Mr. Hanson:

We enclose six copies of a report on the supply and treatment of water for industrial plant in San German, Puerto Rico.

Proposed development works and their estimated costs are summarized in the last two sections of the report. We believe that sufficient water of excellent quality may be obtained by the development of wells located within the land occupied by your plant and close to the plant within the alluvium-filled Rio Guanajibo valley. The development cost of these wells depends to a large extent on their individual yields which are unknown at present. However, with certain assumptions in this connection, the estimated cost of developing sufficient wells to yield between 0.68 and 0.80 mgd is $130,000.

The estimated construction cost of a plant to demineralize 25 per cent of the total supply (about 0.17 mgd) is $226,000 including associated works and storage but excluding housing the plant.

The estimated cost of a water storage tank of 0.5 mg, located at the plant is $95,000 and the cost of the pumping plant is $25,000. The total estimated cost of the entire development works is $476,000.

The estimated total annual operating cost of the wells in DEC property, the demineralization plant and the pumping plant is $29,000. After completion of construction, the wells in the Rio Guanajibo valley become the property of the Puerto Rico Aqueduct and Sewer Authority who will

meet operating costs. However, at the Authority's standard water charges the annual cost of an estimated 0.48 mgd from these wells would be $42,000. We believe that these charges are negotiable with the PRASA on the basis that since DEC are required to meet the entire construction costs of the wells, water charges should be reduced to cover operating costs only, which would not be more than $20,000 per year.

We estimate that, subject to negotiations and agreements with Puerto Rico Governmental Agencies, the whole of the recommended construction work could be completed in 12 to 18 months.

Please do not hesitate to contact us should you require further information.

Very truly yours,

CAMP DRESSER & McKEE Inc.

Robert C. Marini

PHW/jb

Enclosure

Peter Ware, CDM.

REPORT ON WATER SUPPLY TO

THE DIGITAL EQUIPMENT CORPORATION

SAN GERMAN, PUERTO RICO

January, 1972

CAMP DRESSER & McKEE Inc.
One Center Plaza
Boston, Massachusetts

CAMP DRESSER & McKEE
Inc.

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON, MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

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Very truly yours,

CAMP DRESSER & McKEE Inc.

Robert C. Marini

PHW/jb

Enclosure

LIST OF TABLES

TABLE OF CONTENTS

SUMMARY OF PREVIOUS RECOMMENDATIONS

In an interim report prepared in November, 1971 it was seen that the existing water supply facilities, operated by the Puerto Rico Aqueduct and Sewer Authority (PRASA) in San German, are not able to meet present maximum day demands. These facilities would be unable to contribute to DEC's predicted water demand of between 0.7 and 0.8 mgd and PRASA had no plans for the development of additional sources of water to meet the growing water needs of San German.

The interim report established that there were areas of good groundwater potential close to the Rio Guanajibo in San German and it was concluded that these resources should be developed either directly by DEC or by PRASA. It was also recommended that test wells should be constructed in DEC property with a view to providing some portion of DEC's future water requirements.

APPLICATION TO PRASA FOR WATER

On December 9, 1971 a formal request was made to PRASA for an increase in water supply to the DEC industrial plant in San German. The request mentioned the need for the development of new sources to meet DEC's water requirements of 680,000 gpd in addition to 90,000 gpd which PRASA are committed to supply at present.

On January 10, 1972 Mr. Victor Luis Lopez, Chief Engineering Technical Services Department, Puerto Rico Aqueduct and Sewer Authority verbally outlined the results of his investigation and proposals connected with the development of wells to provide the water required to meet DEC's future needs.

Mr. Lopez stated that PRASA were confident that sufficient water would be obtained from wells in San German to meet DEC's water needs. Mr. Lopez also recommended that DEC expand their operations in San German in preference to any other locality because: 1) There were no established water facilities in Puerto Rico capable of supplying this quantity of water without development of additional resources. 2) The Rio Guanajibo valley has good groundwater potential. 3) DEC are already established in San German and are located close to the groundwater area and close to the proposed wastewater treatment facilities now under construction.

Mr. Lopez stated that DEC could develop the wells and associated works or alternatively the work could be carried out by PRASA. The terms under which water would be made available to DEC (outlined to PRASA in our letter dated January 14) are as follows:

(a) Test wells would be constructed in the most geologically suitable area in San German, that is close to the existing septic tank. (Area A on the attached plan.)

(b) Subject to these wells proving a satisfactory yield then land would be acquired and two or three production wells

would be constructed and equipped with pumps, chlorinators and mains to deliver the water to the existing distribution system.

(c) The wells would be designed to meet the water needs of DEC.

(d) The whole of the cost of the wells and associated works would be borne by DEC.

(e) On completion of construction the wells would become the property of the Puerto Rico Aqueduct and Sewer Authority who would operate and maintain them.

(f) The Puerto Rico Aqueduct and Sewer Authority would charge for water at the standard rates.

The existing septic tank area will not be available for well construction until the new wastewater treatment facilities are completed in about six months' time. Because of this factor, and the possibility of serious contamination of groundwater in this area, we requested that PRASA consider alternate groundwater locations. The site shown as area B, on Fig. 1 was selected by the PRASA geologist as a relatively good potential groundwater area. It should be noted that these two areas are those recommended in our interim report as being suitable for development of wells.

ACCESS TO PRIVATE LANDS AND LAND ACQUISITION

It has not yet been possible to establish the ownership of land designated as areas A and B in Figure 1, however the Puerto Rico Industrial

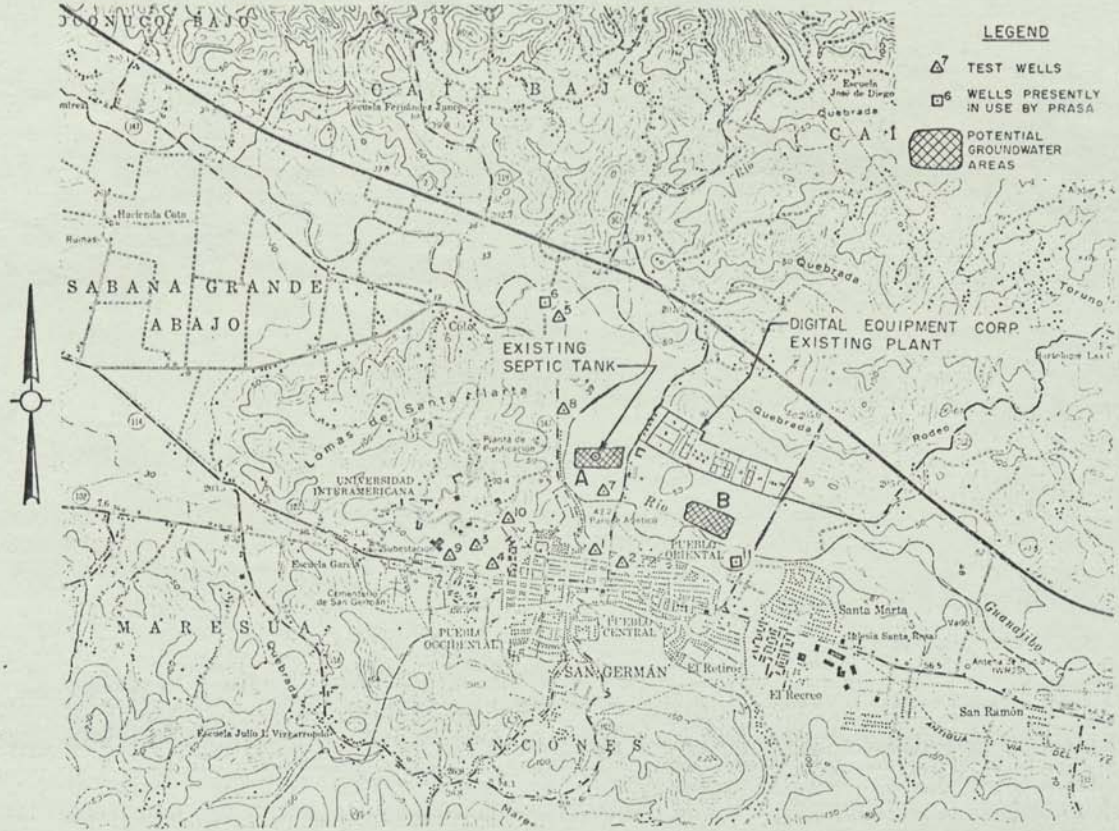


FIGURE I - GROUNDWATER SOURCES IN SAN GERMAN

Development Company (PRIDCO) have tentatively agreed to investigate this and to acquire land on behalf of DEC as necessary.

Under this arrangement it is understood that PRIDCO would obtain the agreement of land owners regarding the terms of acquisition. In the event of failure to agreed land values the matter would be settled by arbitration.

It is estimated that an area of 0.25 to 0.5 acres would be adequate for each well and land costs are therefore not expected to form a significant portion of the total cost of the works required. Land acquisition would apparently be unnecessary for the purpose of drilling test wells and would therefore not begin until completion of the test well program. PRASA estimate that land acquisition could be completed in one to two months unless arbitration is necessary.

Formal agreement to these proposals was requested from PRIDCO in our letter dated January 17, 1972.

CONSTRUCTION OF WELLS BY DEC OR BY THE PUERTO RICO AQUEDUCT AND SEWER AUTHORITY

Test wells and production wells may be constructed either by the Puerto Rico Aqueduct and Sewer Authority or by DEC. Production wells would become the property of PRASA on completion and either course of construction would not influence the access to private land for the purpose

of drilling test wells and would not change the land acquisitions procedure outlined above.

There are several advantages and disadvantages to either course of construction, as follows. The Puerto Rico Aqueduct and Sewer Authority would be bound by certain official administrative procedures and would be limited to employing local drilling contractors and to using locally available materials. The project would take its place in a program containing many other projects and would not necessarily be accorded a high priority.

These factors would almost certainly result in longer preparatory and construction periods and less efficient wells. The last factor could influence water quality and yield. The use of local facilities and materials may reduce construction costs.

Alternatively, the appointment by DEC of an independent expert contractor under the supervision of DEC's consultant would ensure completion of the work in a minimum period and with high priority. Such an agency would have greater flexibility in the use of plant and materials and would be able to provide continuous supervision to ensure optimum development and completion of the wells.

In either course the connection of wells to the distribution mains and the reinforcement of the distribution mains, to ensure adequate capacity between the well site and the DEC plant, would probably be more conveniently carried out by the Puerto Rico Aqueduct and Sewer Authority.

ESTIMATED CONSTRUCTION COSTS OF WELLS

NEAR RIO GUANAJIBO

An estimate of the number and depth of test wells required is based on information obtained from logs of existing wells in San German. This information is limited because comparatively few wells have been constructed and data for these wells is incomplete. The estimated number and depth of production wells is also based on this data and all cost estimates must therefore be regarded as preliminary and subject to revision on completion of the proposed test well program.

It has also been assumed that DEC would be required to meet the entire cost of the well program. It is considered that this is negotiable with the Puerto Rico Aqueduct and Sewer Authority, in the terms that the proposed wells and associated equipment constitute a revenue earning asset which, under the present terms, becomes the property of the Aqueduct and Sewer Authority who logically should therefore meet part of the construction cost.

The following cost estimates do not include: 1) Land acquisition or easements; 2) the cost of electric power transmission to the well sites. The estimates include an allowance for engineering.

TABLE 1

ESTIMATED COSTS OF WELLS NEAR RIO GUANAJIBO

Six, 6-in dia test wells to an average depth of 60 ft.	$17,000
Two, 16-in dia production wells	$45,000
Two submersible well pumps	$ 8,000
Pump installation, electrical controls and starters	$ 5,000
Pipelines, 2,000 ft, 8-in dia	$20,000
Hypochlorite feeders including installation	$ 5,000
TOTAL	$100,000

ESTIMATED ANNUAL COSTS OF WATER

In addition to a hundred percent contribution to the cost of constructing the wells, as outlined above, the Aqueduct and Sewer Authority propose to charge for water at normal rates as follows:

TABLE 2

PUERTO RICO AQUEDUCT AND SEWER AUTHORITY

Rate Schedule for Water and Sewer Service

Effective with the Consumption Cycle ending May 25th, 1970 and Effective with Billing starting on June 1st, 1970, and thereafter:

WATER SERVICE

Metered - Charge per Month		Per Cubic Meter Cents
For the first	10 cubic meters	13.1
For the next	90 " "	16.0
For the next	900 " "	12.5
For the next	9,000 " "	9.1
Over	10,000 " "	5.7

Assuming a water consumption of 800,000 gpd, and 21 working days per month the cost of water would be approximately $4,000 per month.

If the water consumption is 680,000 gpd, as recently suggested, then on similar assumptions the cost of water would be $3,500 per month.

It is estimated that the total cost of operating the wells would be about $1,700 per month including electric power, hypochlorite, maintenance and attendance.

If the wells and equipment are depreciated over an assumed full service life of ten years, the total monthly costs of operation and depreciation would be approximately $2,500 per month. The water revenue to the Aqueduct and Sewer Authority, estimated to be $3,500 to $4,000 per month, therefore appears to be excessive.

CONSTRUCTION OF WELLS WITHIN DEC PLANT BOUNDARY

The Interim Report contained details of the existing well located within the DEC plant boundary in San German. It was emphasized that the yield of wells in rock formations can only be determined by long term use. Attempts have been made to obtain meaningful data by test pumping this well. The company that drilled the well, Julio N. Chardon and Sons, Inc., were also engaged to carry out the test pumping. After a series of delays the well was test pumped but the pumping rate was limited by the equipment available. At a pumping rate of 75 gpm the water level stabilized at 39 ft below the static water level. From this result it has been estimated that the yield of this well could be as high as 200 gpm.

From the information available at present it is not possible to determine whether the whole of the water available in this area could be extracted by this existing well, or whether additional wells would yield more water without restrictions by interference between wells. This can only be determined by installing and test pumping a minimum of two additional wells.

An application for permission to drill two additional wells within the DEC plant boundary was submitted to the Environmental Quality Board, Puerto Rico on December 13, 1971. The construction of test wells should proceed as soon as the Board's agreement has been obtained.

It is assumed that water obtained from wells constructed and operated by DEC in property which is leased from the Puerto Rico Industrial Development Company would not be subject to the Aqueduct and Sewer Authority's water rates. Attempts to establish this assumption with PRIDCO have not yet yielded any information and inquiries in this connection are continuing.

There would clearly be a significant economic advantage if the above assumption is correct and if part of DEC's water requirements could be met from this source.

ESTIMATED COSTS OF WELLS IN DEC PROPERTY

Estimates contained in the Interim Report were based on the assumption that the work would be carried out by local drillers and that two wells would be completed. From additional information now available it is considered preferable to base the estimate on the assumption that U.S. based drillers would be employed and to provide for the completion of the existing well and two additional wells. Test pumping may prove that the completion of three wells would not be justified and costs would then be proportionately reduced.

The following cost estimates do not include the cost of power transmission to the well sites, however, it is possible that the 25 HP well pumps could be operated from the existing power supply to DEC and transmission line costs would therefore be relatively small.

TABLE 3

ESTIMATED COSTS OF WELLS IN DEC PROPERTY

Complete existing 6-in well, including a submersible well pump, pump installation and controls	$4,000
Drill two wells each 8-in dia to a depth 150 ft and 6-in dia to a depth of 400 ft, including test pumping	$15,000

TABLE 3

(Continued)

Furnish and install two submersible pumps including controls	$7,000
Pipelines, 600 ft, 6-in dia	$4,000
Total	$30,000

WATER QUALITY

Analysis of water from a well in San German which has been operated by the Aqueduct and Sewer Authority for several years is shown on the following page. The water from wells in the Rio Guanajibo area would probably be similar in quality to that from which this analysis was obtained.

This water is non-corrosive, moderately hard and contains a small amount of iron. It has no manganese, color or turbidity. It could be described as an excellent potable water requiring no treatment other than disinfection by chlorine. Treatment by ion exchange would not present any unusual difficulties, it would reduce the anions and cations to trace concentrations, that would meet the water quality required by DEC.

Wells in DEC property draw water from consolidated rock formations whereas wells in the Rio Guanajibo area are in alluvium. Both groundwaters would probably have similar characteristics with regard to color, turbidity and

Sample from		Collection		Type of Water		Analysis Requested
Town	San German	By	B. Morales	X	Deep well	By Div. de Produccion
Ward or St.		Date	7/21/71		Surface	Analyzed
Place	Urb. El Retiro	Time			Other	By Santiago - Ayala

Chemical Constituents	Expressed As			Limits U.S.P.H.S.*
Free Carbon Dioxide	CO_2	1.6	mg/l	
Dissolved Oxygen	O_2	-	mg/l	
Residual Chlorine	Cl_2	-	mg/l	
Calcium	Ca	11.2	mg/l	
Magnesium	Mg	26.3	mg/l	
Sodium and Potassium	Na	9.9	mg/l	
Total Iron	Fe	0.07	mg/l	0.3 mg/l
Dissolved Iron	Fe	0	mg/l	
Manganese	Mn	0	mg/l	0.05 mg/l
Oxides	R_2O_3	-	mg/l	
Silica	SiO_2	34.6	mg/l	
Total Alkalinity	$CaCO_3$	130	mg/l	
Ph. Alkalinity	$CaCO_3$	0	mg/l	
Carbonate	CO_3	0	mg/l	
Bicarbonate	HCO_3	159	mg/l	
Sulfate	SO_4	6.2	mg/l	250 mg/l
Chloride	Cl	15	mg/l	250 mg/l
Nitrate	NO_3	0.3	mg/l	45 mg/l
Nitrite	NO_2	0	mg/l	
Fluoride	F	0.45	mg/l	1.0 mg/l
Phosphate	PO_4	0	mg/l	
Sulfide	S	0	mg/l	
Total Dissolved Solids	Residue at 103°C	170	mg/l	500 mg/l
Loss on Ignition	at 600°C	45	mg/l	

Physical Characteristics

Turbidity	SiO_2 Stds	0	units	5 units
Color	Pt-Co Stds	0	units	15 units

Other Determinations

Total Hardness	136 mg/l	Noncarbonate hardness 6 mg/l
Conductivity	272 micromhos	
pH	8.15	
Saturation pH	8.15	
Saturation Index	0	

Bacteriological Examination

_____ M.P.N. Per 100 ml (Coliform Group)

*Maximum limits for drinking water established by the U.S.P.H.S. in 1962

Chemical Engineer

hardness but there could be slight variations in other constituents. Samples taken during tests of the existing well are at present being analysed in Puerto Rico.

WATER TREATMENT

From presently available data on groundwater quality in San German it is concluded that groundwater is suitable for general use without further treatment. For certain of DEC's processes, water of a higher quality is necessary. The standards required by DEC are that this water should be low in calcium, magnesium and hardness; silica should be less than 2 ppm and turbidity less than 5 units. It has been estimated by DEC that about 25 percent of the total quantity of the water used at the plant would be required to conform to this higher standard. Initially the total quantity required was estimated to be 800,000 gpd (about 560 gpm). It was subsequently suggested that this figure may be reduced to 680,000 gpd (about 475 gpm).

The standard of water quality required would be achieved by demineralization by ion exchange, using synthetic resins.

A suitable plant for this purpose would comprise two mixed bed deionizers having a combined capacity of 200,000 gpd when operating at 2.5 gpm/sq ft and each unit would treat 72,000 g between regeneration cycles.

The plant would be designed to operate automatically and would include

treated water storage to permit complete shut down without interruption of supply during regeneration. Pumps and storage for chemicals used during regeneration are included, in addition to pumps for influent and effluent water. No provision has been made for housing the plant and associated equipment or for the disposal of waste products.

A preliminary estimate of the cost of constructing and operating the plant based on costs in Puerto Rico are as follows.

TABLE 4

ESTIMATED COST OF DEIONIZATION PLANT

Construction Cost

Two mixed bed deionizers including automatic controls, shipping to site, installation in an existing building	$140,000
Storage tanks for chemicals and treated water	$13,000
Chemical pumps and treated water pumps	$8,000
Electrical, pipework and miscellaneous	$50,000
Total	$211,000

TABLE 4

(Continued)

Daily Operating Costs	
Chemical costs	$80
Replacement of resins	$15
Attendance, electrical power, maintenance	$15
Total operating costs	$110 per day

Assuming 21 working days per month, then monthly operating costs would be $2,310.

A number of variations of the treatment systems described above are practicable. Plants having lower operating costs but higher construction costs have been considered. A comparatively large operating expenditure is, of course, unavoidable because of the high quality water required and the relatively high dissolved solids content of the raw water.

One method given preliminary consideration was the use of a reverse osmosis roughing unit to be followed by a conventional deionization unit for removal of the remaining (about 10 percent) of the undesirable ions. The high initial cost of this equipment could perhaps be justified if the raw water contained organic compounds but since it is very satis-

factory in this respect more traditional treatment methods are economically preferable.

An alternative treatment arrangement would comprise separate cation and anion deionizers, designed as roughing units, a degasifier, and a mixed bed deionizer as a "polishing" unit.

Control and automation of the plant would be similar to that previously described, and again, no provision has been made for housing the plant or associated equipment.

The length of regeneration cycles for the roughing units would be twice that of the plant previously described and would be 2 mg for the polishing unit. The use of chemicals for regeneration would be considerably reduced as reflected in the operating costs summarized below.

TABLE 5

ESTIMATED COST OF ALTERNATIVE DEIONIZATION PLANT

Construction Cost	
Cation and anion deionization "roughing" units and mixed bed "polishing" units including automatic controls and installation in an existing building.	$156,000
Storage tanks for chemicals and treated water	$12,000

TABLE 5

(Continued)

Pumps for chemicals and treated water	$8,000
Pipework, electrical and installation items	$50,000
	$226,000

Daily Operating Costs

Chemical costs	$20
Replacement of resins	$15
Attendance, electrical power and maintenance	$15
Total cost per day	$50

WATER STORAGE

The two purposes for which water storage tanks should be provided at the plant are for fire protection and to prevent an interruption in the normal operation of the plant in the event of failure of the public water supply.

It is understood that the storage capacity required for fire fighting has already been decided upon and that a tank is now under construction.

The capacity required to prevent serious interruption of the operation of the plant depends upon the proportion of water from the public supply, the facilities available to the Town for the repair of mains and equipment, and the reliability of the supply of electric power.

In recommending the size of the tank required it is therefore necessary to make a number of assumptions, as follows:

1. Assume that a quantity of 200,000 gallons of water per day is supplied from wells within DEC property and that standby electric power is available for operating these wells in the event of failure of the normal power supply.

2. Assume that electric power failure or water main failure effecting the Town's water supply, and the supply to the plant, would be repaired and the service returned within 24 hours.

The quantity of storage required to ensure that there would be no interruption in the plant operation under these conditions would be 490,000 gpd. A storage tank of this capacity could be constructed entirely above ground in the form of a steel standpipe; alternatively the tank could be of reinforced concrete construction, partially below ground, in which case the tank roof area (4,200 sq ft) could be utilized. The estimated cost of a steel tank is $95,000, compared with $120,000 for reinforced concrete. Both estimates include construction costs and an allowance for engineering.

The proposed 0.5 mg storage tank and the storage tank for fire fighting purposes, which is now under construction by DEC, would be supplied with water from the wells within the DEC plant boundary and from the Aqueduct and Sewer Authority's main supply to the plant.

Water used for domestic purposes within the DEC plant would be supplied directly from the Authority's main; all other water would be drawn from the proposed 0.5 mg storage tank.

For this purpose we recommend the installation of three electrically operated variable speed pumps, comprising two operating units and one standby unit. Two pumps operating in parallel would discharge a maximum flow of 0.7 mgd at 65 psi. Speed control, and discharge rate would be automatically varied by the pressure in the system. The pumps would be close coupled to 15 HP totally enclosed electric motors through hydraulic drives.

In view of the climatic conditions in Puerto Rico the pumps, motors and controls would not require elaborate protection. A pump house could conveniently comprise a concrete floor and roof structure.

The estimated cost of furnishing and installing pumping units, controls and pipework is $25,000. This estimate does not include electric power transmission line costs or standby electric power generators on the assumption that these are available as part of the present DEC facilities.

CONCLUSIONS AND RECOMMENDATIONS

Wells within DEC property would provide the most economical source of water. The yield from these wells can only be determined by the construction of test wells. A reliable estimate of yield will require several years pumping records.

Two test wells should be constructed within the DEC plant boundary as soon as permission to do so is received from the Puerto Rico Environmental Quality Board, to whom application was made on December 13, 1971.

It is clear that the yield from wells within DEC plant boundary will not be sufficient to meet DEC's estimated future water requirements and will need to be supplemented from wells in the higher yielding alluvial area near the Rio Guanajibo. The construction of test wells as a preliminary to the location of two or three production wells should proceed as soon as possible.

The terms under which the Puerto Rico Aqueduct and Sewer Authority will provide water from this source require that the total cost of constructing and equipping the wells be met by DEC and that the wells become the property of the Aqueduct and Sewer Authority, who will operate them. The Aqueduct and Sewer Authority will also charge for water at the standard rates. In this connection it is recommended that negotiations with DEC be opened with the aim of reducing water charges to a level commensurate with the Aqueduct and Sewer Authority's cost of supplying water from sources provided by DEC.

After reaching agreement with the Aqueduct and Sewer Authority on water charges, the construction of test wells and production wells should proceed. In the interests of reducing construction time to a minimum these wells may be constructed by DEC, through an experienced contractor under close supervision. Alternatively, if time is not a critical factor, the wells may be constructed by the Aqueduct and Sewer Authority.

The quality of groundwater in San German is relatively good, and treatment is not necessary unless the water is to be used for certain industrial processes requiring demineralization. A number of variations of a basic demineralization systems are possible. The system selected involves a relatively high initial cost but with a compensating reduction in operating costs. The plant would comprise separate cation and anion units designed as "roughing" units, a degasifier and a mixed bed deionizer as a "polishing" unit. The plant would be operated automatically with the exception of the final ion exchange unit which would have long runs between the regeneration process and would therefore be manually operated.

Water storage is recommended as a safeguard against interruption of supply in the event of a water main failure or an electric power failure. The capacity recommended is 0.5 mg assuming a total consumption of 0.68 mgd of which 0.2 mgd is obtained from wells within the DEC plant boundary.

A summary of the recommended construction items appears in the following table of estimates.

SUMMARY OF COSTS

The costs of constructing and operating the wells recommended will vary according to their yield and will also depend on the agreement reached with the Puerto Rico Aqueduct and Sewer Authority. The cost estimates are based on the following assumptions:

1. The total quantity of water required by DEC will be 475 gpm (0.68 mgd).

2. About 25 percent of this quantity will be demineralized.

3. Approximately 0.2 mgd will be obtained from wells located within the DEC plant boundary. The cost of constructing and operating these wells will be met by DEC, and there will be no additional water charges by the Aqueduct and Sewer Authority.

4. The remaining quantity of water, about 0.48 mgd will be obtained from two wells near Rio Guanajibo. The cost of constructing these wells, and the cost of providing associated pipelines and equipment, will be met by DEC; the Aqueduct and Sewer Authority will make standard charges for water.

The estimates do not include the cost of land required for wells near the Rio Guanajibo; the estimates do not include electrical transmission lines. An allowance for engineering has been included.

TABLE 6

SUMMARY OF ESTIMATED CONSTRUCTION COSTS

1. Wells and Associated Works		
Test wells in Rio Guanajibo area	$17,000	
Production wells in Rio Guanajibo area	$58,000	
Pipelines and chlorine feeders	$25,000	
Wells in DEC property	$26,000	
Pipelines	$4,000	$130,000
2. Demineralization by Ion Exchange		
Deionization units including installation	$156,000	
Chemical and treated water storage tanks and pumps	$20,000	
Pipework, electrical and miscellaneous	$50,000	$226,000
3. Water Storage and Pumping		
Steel storage tank, 0.5 mg capacity	$95,000	
Variable speed system pumps	$25,000	$120,000
Total Construction Costs		$476,000

TABLE 7

SUMMARY OF ESTIMATED ANNUAL OPERATING COSTS

AND WATER CHARGES

Costs of operating wells in DEC property at a rate of 200,000 gpd.	$8,000
Charges for water supplied by the Puerto Rico Aqueduct and Sewer Authority, (estimated 480,000 gpd).	$42,000
Costs of operating deionization plant, and system pumps	$21,000
Total Annual Operating Costs	$71,000

Puerto Rico

Correspondence
XR Water Supplies

CAMP DRESSER & McKEE
Inc.

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON, MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

November 22, 1971

Mr. Allan W. Hanson
Plant Engineer
Digital Equipment Corporation
146 Main Street
Maynard, Massachusetts

Digital Equipment Corporation
Water Supply Studies in
Puerto Rico
CDM 493-4

Dear Mr. Hanson:

We enclose four copies of an interim report on existing and potential water sources available to your existing and proposed industrial plants in Puerto Rico. This report was discussed with you and Mr. Peter Mackey on 12 November.

We wish to emphasize that this is an interim report and contains data collected during a very brief reconnaissance survey in Puerto Rico. However, we feel that the data are sufficiently accurate to enable us to make recommendations which will lead to satisfactory solutions to your water supply problems in Puerto Rico.

We shall contact you again regarding construction of an additional well in DEC property when test pumping figures are available from the existing well.

We hope to obtain further information regarding the Toa Vaca project; in the mean time, we suggest you consider making a formal application for water in the Penuelas - Tallaboa industrial area, subject of course to your acceptance of this location and land availability. Copies of a plan showing the proposed pipeline route to the industrial area are enclosed.

Mr. Allan W. Hanson
November 22, 1971

As explained in the report, we suggest that you make application to PRASA for additional water in San German, in the terms that you are considering possible expansion of your installation there. Simultaneously, judicious enquiries could be made regarding construction of wells in private lands in St. German.

We should be pleased to make these various applications on your behalf in the mean time we await your comments regarding our various recommendations.

Very truly yours,

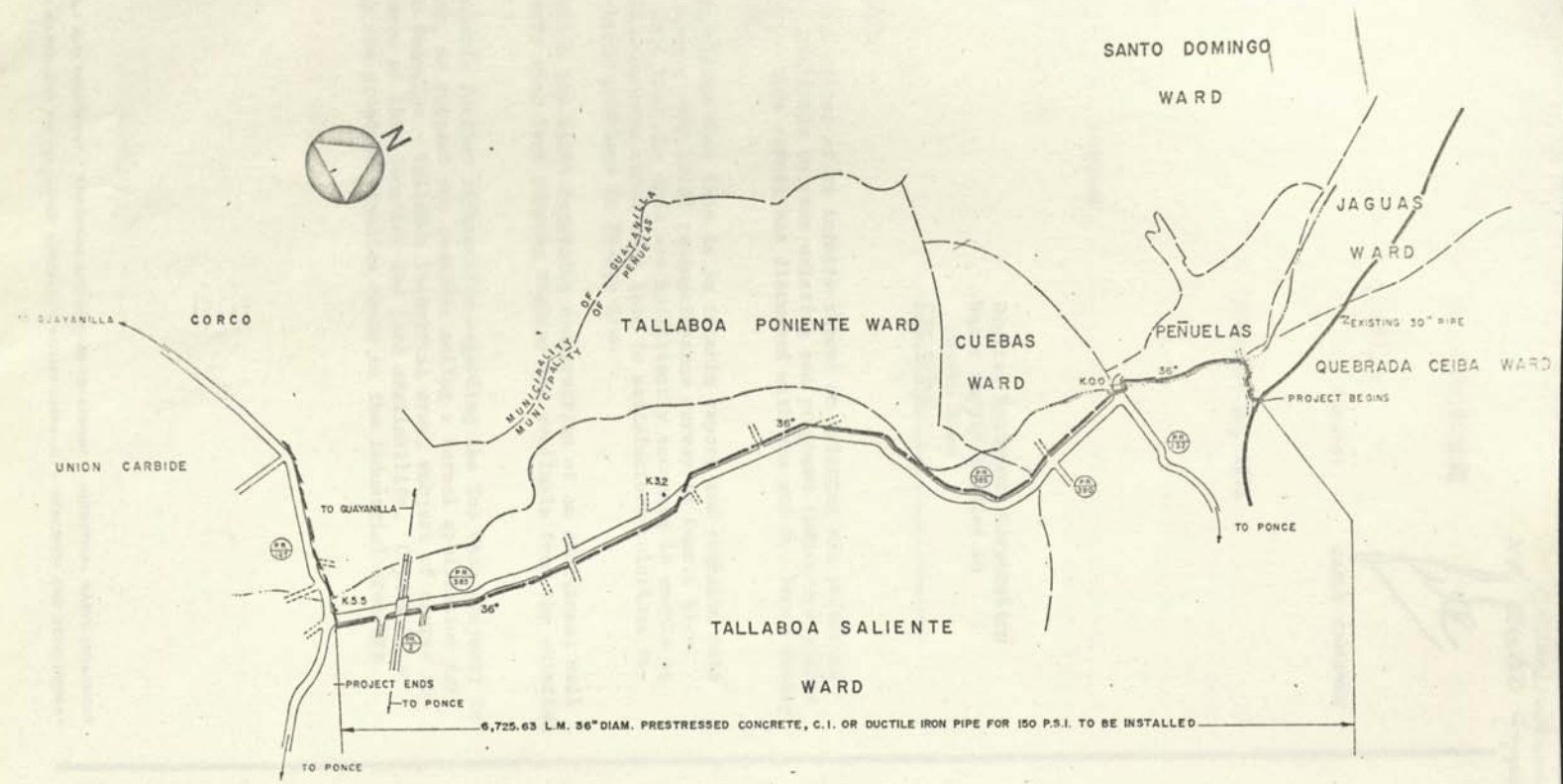
CAMP DRESSER & McKEE Inc.

Robert C. Marini

PHW/jb

Enclosures

cc : Mr. George Wood
Mr. Thomas MacDonald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TALLABOA PONIENTE WARD
CUEBAS
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EXISTING 30" PIPE
QUEBRADA CEIBA WARD
K0.0
36"
PROJECT BEGINS
UNION CARBIDE
TO GUAYANILLA
K3.2
36"
TO PONCE
K5.5
36"
TALLABOA SALIENTE
WARD
PROJECT ENDS
TO PONCE
6,725.63 L.M. 36" DIAM. PRESTRESSED CONCRETE, C.I. OR DUCTILE IRON PIPE FOR 150 P.S.I. TO BE INSTALLED
TO PONCE

Puerto Rico

Correspondence
XR Waste Treatment

CAMP DRESSER & McKEE
Inc.

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON, MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

ROBERT C. MARINI
Senior Vice President

cc Tom MacD.
Jo Beebe
R Carlson
Art.

August 27, 1971

Mr. Allen W. Hanson
Plant Engineer
Digital Equipment Corporation
146 Main Street
Maynard, Massachusetts 01754

Dear Mr. Hanson:

As requested by you at our meeting on August 20, 1971, we have studied the extent of engineering services required to prepare a report on water supply, wastewater disposal and drainage for proposed plants in Puerto Rico and Ireland. It is our opinion that the scope of the above-mentioned report should include, but not be limited to, the following:

A. WATER SUPPLY

1. Complete a detailed study of all pertinent maps and plans pertaining to possible sources of water. Investigate the possibility of developing sufficient groundwater on or near the Digital Equipment Corporation (DEC) plant sites, based on geological and visual surveys.

2. Assess the availability and reliability of municipal water on or near the plant sites. Investigate whether municipal water system needs reinforcing on the basis of the peak demands, estimated at 800,000 gpd from each proposed DEC plant.

3. Obtain water quality analyses of the potential sources so that the type of treatment for DEC plant use and needs may be established. It is understood that about 25 percent of plant water needs are to be treated for high standards, as stipulated by DEC.

4. Determine which source is most economical and reliable.

5. Present the conclusions and recommendations in a report contajning pertinent preliminary plans, estimates of construction costs and tentative operational and maintenance program.

B. WASTEWATER DISPOSAL

1. Determine from plans of proposed DEC plants whether the wastewater collection system external to the manufacturing facilities is hydraulically adequate and which could be separated and discharged without pretreatment. Assess the suitability and availability of sewer pipe material, locally.

2. Study and confirm the volumes and characteristics of the various wastes supplied to us by DEC.

3. Review the potential discharge receiving systems that could accept DEC plant wastewater effluent. Determine the degree of pretreatment required to satisfy local municipal requirements.

4. Estimate the adequacy of the receiving system. Determine whether plant effluent need be pumped and estimate the effect of pretreated wastes, for example, on municipal sewage treatment plant.

5. Investigate special disposal methods for sludge and reclaimable components of the wastewater.

6. Present the conclusions and recommendations together with those in Item A-5 above, to include pertinent preliminary plans, cost estimates and operational program.

C. DRAINAGE

1. Review the site drainage plans of the proposed DEC plant(s) and comment on adequacy.

2. Surface runoff, roof drainage, uncontaminated cooling water may possibly be discharged into existing municipal drains, if available. Potential points of drainage disposal will be investigated.

3. Conclusions and recommendations, together with Items A-5 and B-6, above, will be presented in report form to include preliminary plans, pertinent costs and operational program.

The studies on water supply, wastewater disposal and drainage for each plant will be presented in an implementation report which shall be reproduced, bound and twenty copies presented to DEC.

To perform the work effectively, we anticipate a visit to each job site by one engineer for a period of 10 - 12 workdays.

We expect DEC to furnish us information relating to proposed plant units layout; topographical data; hydrogeological survey; subsurface data; generalized plant processes with the necessary water volumes and quality and resulting effluent volume and characteristics; and number of employees. Well test boring, sampling and analyses of groundwater may be necessary if that source appears potentially desirable.

We will make every effort to try and complete the report in three calendar months as required by DEC after the authorization to proceed. However, the actual time of completion will depend on the information supplied to us by DEC and the time which this information is available to us. Engineering services to develop one report for each plant site may cost about $16,000, depending upon the availability of data, computations and other technically required information. Billing for engineering services will be at salary cost plus 110 percent for staff members and $250 per day for Senior Vice Presidents, plus all reasonable out-of-pocket expenses. Estimated out-of-pocket expenses such as

transportation, living expenses, telephone calls and printing which will be billed at actual cost, is estimated at an additional $2,000 per plant site. Therefore, for two sites an estimate cost of $36,000 is indicated.

Billing for all engineering services listed will be submitted monthly to DEC.

In the event water sampling and analyses and/or well test borings or field surveys are necessary to supplement available information when done by others under our supervision these services will be billed at actual cost to CDM plus 15 percent or they may be paid directly by DEC.

This proposal is valid until December 1, 1971.

We welcome every opportunity to continue work with Digital Equipment Corporation and will continue to render the quality of service which, we trust, has proven satisfactory in the past.

Very truly yours,

CAMP DRESSER & McKEE Inc.

Robert C. Marini

Robert C. Marini
Senior Vice President

RCM:ef

Puerto Rico correspondence

CAMP DRESSER & McKEE
Inc.

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON, MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

August 9, 1971

Mr. Victor Garcia, Director
Victor M. Garcia Associates
Consulting Engineers
504 Munoz Rivera
Hato Rey, Puerto Rico 00918

Digital De Puerto Rico
License Application
CDM 493-3-GS

Dear Mr. Garcia:

It was a pleasure to talk with you and Manuel Fernandez last week on my visit to Puerto Rico and to discuss the necessary steps to be taken to obtain the special license necessary for us to officially complete the design for Digital De Puerto Rico in San German. I thought it might be beneficial for all concerned if we recapitulated that meeting.

It is our understanding that the Board of Examiners will be meeting during the second week in August, and if the special license is approved for Dr. R. H. Culver, it will be only necessary for Camp Dresser & McKee to seal the drawings with his stamp and send two (2) copies of the plant to the Aqueducto and two (2) sets of plans to the Puerto Rican Planning Board. After their approval, we should send six (6) copies and one (1) set of sepias to the Aqueducto for their final file. At the time of our discussion, Manuel indicated that he would inquire about the necessity of forwarding plans to the Environmental Quality Board. We would appreciate this information when it is available.

It was also our understanding that once the special license was granted and the plans were forwarded to the proper authorities, we could expect approval in fairly short order. Do you feel it would be to our advantage at this time to presume that the special license will be granted and take steps to expedite matters by physically walking the plans through the approval group? We have often found that by sitting down with the engineers who must review the plans and discussing the plans with them often speeds approval.

CAMP DRESSER & McKEE Inc.

At our meeting, I indicated that we would send Manuel the revised Sheet 2, entitled, "Collection System" and the revised Table 2 from our letter of July 12, 1971 to Mr. George Wood from R. H. Culver. These will be forwarded to you upon completion.

In our meeting with George Wood, Pete Gonzalez of Sam P. Wallace, Ray Carlson of Digital and you at the Mayaguez Hilton, it was agreed that Camp Dresser & McKee and your firm would proceed to obtain a special license and that at some point we could expect a per diem schedule from you for your work on this project. We recently received a letter from Mr. George Wood authorizing us to work with you in whatever way necessary to complete this project. He also requested that all of your billing come through our office. Would you, therefore be kind enough to forward your current per diem schedule for our files.

We will look forward to hearing from you when you have received word on the special license. If, in the meantime you should have any questions or comments on the above material, please feel free to contact the writer.

Very truly yours,

CAMP DRESSER & McKEE Inc.

Alan E. Rimer

AER/dlm

cc: Mr. George Wood, Digital

Puerto Rico Correspondence

CAMP DRESSER & McKEE Inc.

August 9, 1971

MEMORANDUM

TO: Digital Equipment Corporation File (493-3-GS)

FROM: Alan E. Rimer

SUBJECT: Meeting with Victor Garcia & Associates

On Thursday, July 29, 1971, the writer spent the morning with Victor Garcia & Associates in San Juan to discuss the Digital project and what steps were being taken to implement the procedures for obtaining a license for this project. One of the prime interest of meeting with Garcia during this week was to pull together any further information Camp Dresser & McKee might need regarding the application and to discuss Victor's phone conversation with Guzman a member of the Board of Registration.

The writer spoke with Victor Garcia for a short period of time. It was ascertained that Victor had not been able to get a hold of Guzman as anticipated, but that the application had been forwarded to the Board of Registration along with a check and a letter of recommendation from Victor Garcia & Associates. It is anticipated that by the middle of August the Board will rule on the application.

The writer spent a major portion of his time talking with Manuel Fernandez regarding the project. Manuel had several points; the two most important being: (1) if the pumps feeding strong acids, strong alkaline and ammonia persulfate solutions were run at full tilt with the chemical characteristics noted from the Maynard plant, the copper concentration in the effluent would be exceeded; (2) the waste lines on the "Collection System" drawing (Sheet 2 in our drawings and Table 2 in our letter report) did not coincide. I believe this was indicated to Garcia, but we indicated that a final drawing would be withcoming and that the discharges would be pretty much in line with that indicated in Table 2.

We discussed the sizing of the pumps. Manuel had made his calculations based on the results of the sampling we did in Maynard, which of course were estimates at best. He also went one step further and analyzed the pumping rates. He realized the necessity of bleeding back in most of the chemicals to the raw waste based on an average condition and that the system, as designed, would work properly on the average. The copper should not exceed the allowable limits except in rare cases when the pumps were running full speed and the copper content in the solution was high. [It is interesting to note that he had originally calculated the copper concentrations on the basis of the use of ferric chloride as an etchant. On this assumption the copper concentrations might be higher than that expected with cupric chloride because of the nature of the system.] In any case he was satisfied that arrangements had been made to treat the waste suitably.

MEMORANDUM
Digital File (San German) - 2
August 9, 1971

Once the special license has been granted, it will be necessary for CDM to submit two copies of the plans to the Puerto Rican Planning Board and to the Aqueducto. Upon acceptance of the plans, we will be required to submit six additional sets of the plans and 1 set of sepias for the Aqueducto's files. I asked them if there was anything further that we could do prior to the hearing meeting of the Board of Examiners. Apparently not, except that Garcia will continue to try to get in touch with Guzman. Based on Garcia's optimism, we should have no problem getting the project approved?

AER/dlm

cc: George Wood ✓
Bob Marini
Bob Culver

Correspondence

CAMP DRESSER & McKEE

Inc.

Puerto Rico

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON, MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

ROBERT C. MARINI
Senior Vice President

JUL 23 1971

July 23, 1971

Mr Ramon Guzman
Ramon M. Guzman and Associates
P.O. Box 1401
Hato Rey, Puerto Rico

Dear Mr. Guzman:

On Friday, July 23, 1971, the writer tried to contact you by telephone. Unfortunately, I could not reach you directly but left a message at your office. The following is a brief summary of the message that was relayed to one of the male personnel in your office.

As you undoubtedly remember, during the recent WPCF meeting in Puerto Rico, I mentioned to you that one of our clients might possibly be interested in retaining your concern to do some industrial hygiene work and other miscellaneous environmental engineering work at their new plant in San German.

Yesterday, July 22, 1971, the writer met with the various officials of Digital Equipment Corporation, and passed on your name and qualifications to them. The writer was informed that Mr. Al Hanson of Digital Equipment Corporation would be contacting you in the very near future for the purpose of discussing your providing services on their Puerto Rican operation.

I sincerely hope that this possible assignment will come your way.

Very truly yours,

CAMP DRESSER & McKEE Inc.

Robert C. Marini

bcc: Mr. Al Hanson
Digital Equipment Corp.

RCM:ef

cc: Ybarst, R Cushman, file

– Ray wrote letters to retain them...

Correspondence
PR Water Supplies
(Municipal)

digital

July 15, 1969

Mr. Andres Betances
Commonwealth of Puerto Rico
Economic Development Administration
607 Boylston Street
Boston, Massachusetts

Dear Sir:

Attached you will find a drawing of the domestic water system of the San German area.

Our insurance carrier, Factory Mutual, has investigated the water supply situation for our new plant in the San German Industrial Park, Digital Project No. 974-69. They have made a strong recommendation that the 12" line be connected to the 8" line, so that we might have two sources of supply for fire protection purposes. On the drawing, we have indicated this with a red pencil.

Would you please investigate to see if our drawing is accurate, and give me your recommendations as to whether or not this will be possible.

If you have any further questions, please contact Mr. Phil Wood, our manager in Puerto Rico, at 892-1231, or feel free to write or call me at any time.

Sincerely yours,

Allen W. Hanson
Plant Engineer

AWH/rtc

copies to
Phil Wood
Aqueduct Authority
Prudco-Western

DIGITAL EQUIPMENT CORPORATION, 146 MAIN STREET, MAYNARD, MASSACHUSETTS 01754
(617)897-5111 TWX: 710-347-0212 TELEX: 94-8457


PR 360
TO SABANA GRANDE
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F.L. = 92.50
18+80.00
23+30.00
28+70.00
+0100.00

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Arrow Co
Cutler Wood & Sorlien
Waltham
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Correspondence
XR Waste Treatment
XR Sanitary

Al Hanson
Digital Equip Corp.

WATER QUALITY CRITERIA AND USE CLASSIFICATIONS

FOR

COASTAL WATERS OF PUERTO RICO

Prepared by
Water Quality Standards Office
Federal Water Pollution Control Administration
Southeast Region
Atlanta, Georgia

COMMONWEALTH OF PUERTO RICO
DEPARTMENT OF HEALTH
SAN JUAN, PUERTO RICO

SANITARY REGULATION NO. 131

TO AMEND ARTICLES III, V AND VI OF SANITARY REGULATION NO. 127 APPROVED JUNE 30, 1967, AS AMENDED, ENTITLED "TO ESTABLISH CLASSIFICATIONS AND STANDARDS FOR THE COASTAL WATERS OF PUERTO RICO IN ACCORDANCE WITH ARTICLE 8 OF ACT NO. 142 APPROVED MAY 1, 1950 FOR THE WATER POLLUTION CONTROL, AS AMENDED AND OF ACT NO. 81 APPROVED MARCH 14, 1912, "AN ACT TO REORGANIZE THE SANITARY SERVICE" AS AMENDED.

Section I- Articles III, V, and VI of Sanitary Regulation No. 127 approved June 30, 1967, as amended, entitled "To Establish Classifications and Standards for the Coastal Waters of Puerto Rico in Accordance with Article 8 of Act No. 142 approved May 1, 1950, for the Water Pollution Control, as amended and of Act No. 81 approved March 14, 1912, "An Act to Reorganize the Sanitary Service" as amended, are amended to read as follow:

ARTICLE III- POLLUTION DISCHARGES

A- It is hereby prohibited to any person, to directly or indirectly throw, discharge, pour or dump and/or cause or allow to be thrown, discharged, poured or dumped into the coastal waters of Puerto Rico any kind of domestic or industrial wastes with less than conventional secondary treatment or control or its equivalent, or any other substances capable of polluting or creating a potential threat of pollution in such a way that coastal waters be rendered below the minimum standards of purity established in these Rules and Regulations.

B- Notwithstanding the foregoing prohibitions, the Secretary of Health may upon application to that effect, grant permission for drainage into the coastal waters when the discharged substances have been previously submitted to a proper degree of treatment. The degree of treatment will be as specified above in Part A, Article III, unless it can be demonstrated to the Secretary of Health, that a lesser degree of treatment or control with

approved ocean outfalls will not degradate the water quality. Since these are also Federal standards, these waste treatment requirements will be developed in cooperation with the Federal Water Pollution Control Administration.

C- Coastal waters whose existing quality is better than the established standards as of the date on which such standards become effective will be maintained at their existing high quality. These and other coastal waters of Puerto Rico will not be lowered in quality unless and until it has been affirmatively demonstrated to the water pollution control agency for Puerto Rico that such change is justifiable as a result of necessary economic or social development and will not interfere with or become injurious to any assigned uses made of, or presently possible in, such waters. This will require that any industrial, public or private project or development which would constitute a new source of pollution or an increased source of pollution to high quality waters will be required, as part of the initial project design, to provide the best practical degree of treatment available under existing technology, and, since these are also Federal standards, these waste treatment requirements will be developed in cooperation with the Federal Water Pollution Control Administration.

D- It is hereby prohibited to throw or deposit on the tidelands of the coastal waters, any object or substance capable of polluting them or of creating a potential threat of pollution in such a way that the coastal waters will be rendered below the minimum standards of purity established in these Rules and Regulations.

ARTICLE V - CLASSIFICATION AND STANDARDS OF QUALITY FOR THE COASTAL WATERS OF PUERTO RICO

A- The following classifications and standards shall be in force for the coastal waters of Puerto Rico at all times. In multiple use areas, criteria for the highest quality use will prevail.

1- Class SA

For the preservation of existing natural phenomena.

Quality Standards:

Existing natural conditions shall not be altered.

2- Class SB

Includes the coastal waters which are destined for or may be destined for the growth and fishing of shellfish for market purposes.

Quality Standards:

The coastal waters included in class SB shall not contain:

a. Floating solids, settleable solids, oils, and sludge deposits attributable to municipal, industrial or other waste discharges.

b. Any type of garbage, cinder, ash, oil, sludge or other refuse.

c. Sewage or similar effluents whose purification has not attained the necessary degree of purity to render the waters into which they are discharged capable to be utilized for the purposes for which they have been destined.

d. Dissolved oxygen in a concentration of less than five (5.0) milligrams per liter.

e. Toxic wastes or deleterious substances alone or in combination with other substances or wastes in sufficient amounts injurious to edible fish or their culture, or taste or propagation, or which in any way may adversely affect the flavor, color, odor or sanitary conditions of the water and otherwise none in sufficient amounts as to make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

f. Organisms of the coliform group when the median value in any series of samples representative of waters during a month exceeds seventy (70) per one hundred (100) milliliters.

g. A temperature more than $4^{o}F$ above ambient water temperature and in no case in excess of $93^{o}F$.

h. A pH factor less than six and eight tenths (6.8) or more than eight and five tenths (8.5).

3- Class SC

Includes the coastal waters which are destined for or may be destined for bathing.

Quality Standards:

The coastal waters included in class SC shall not contain:

a. Floating solids, settleable solids, oil, sludge deposits attributable to municipal, industrial or other waste discharges.

b. Any type of garbage, cinder, oil, sludge or other refuse.

c. Sewage or wastes effluents whose purification has not attained the necessary degree of purity to render the waters into which they are discharged capable of being utilized for the purposes for which they have been destined.

d. Dissolved oxygen in a concentration of less than five (5.0) milligrams per liter.

e. Toxic wastes or deleterious substances alone or in combination with other substances or wastes in sufficient amounts injurious to edible fish or their culture, taste or propagation, or which in any way may adversely affect the flavor, color, odor or sanitary conditions of the water and otherwise none in sufficient amounts as to make the waters unsafe or unsuitable for bathing or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

f. Organisms of coliform group in excess of one thousand (1,000) per one hundred (100) milliliters as a monthly median value. (Counts using the most probable number method (MPN) or the filter membrane method (MF) nor exceed this number in more than twenty (20) per cent of the samples examined during any month, or exceeds two thousand four hundred (2,400) per one hundred (100) milliliters (either most probable number (MPN) or membrane filter (MF) count on any day).

g. A temperature more than 4°F. above ambient water temperature and in no case in excess of 93°F.

h. A pH factor less than six and eight tenths (6.8) or more than eight and five tenths (8.5).

4- Class SD

Include the coastal waters which are destined or may be destined for the propagation of marine life.

Quality Standards:

The coastal waters included in class SD shall not contain:

a. Floating solids, settleable solids, oils, sludge deposits which are readily visible and attributable to municipal, industrial, or other wastes or which increase the amount of these constituents in receiving waters.

b. Any type of garbage, cinder, ash, oil, sludge or other refuse.

c. Sewage and effluents with other substances whose purification has not attained the necessary degree of purity to render the waters into which they are discharged capable of being utilized for the purpose for which they have been destined.

d. Dissolved oxygen in a concentration of less than four and a half (4.5) milligrams per liter.

e. Toxic wastes, oils, deleterious substances alone or in combination with other substances or wastes in sufficient amounts injurious to edible fish or their culture, taste or propagation, or which in any way may adversely affect the color, odor or sanitary condition of the waters, as well as any in sufficient quantities as to impair the waters for any other best usage as determined for the specific waters which are assigned for this class.

f. A pH factor less than six and eight tenths (6.8) or greater than eight and five tenths (8.5).

g. A temperature more than 4°F. above ambient water temperature and in no case in excess of 93°F.

h. Organisms of the total coliform group in excess of five thousand (5,000) per one hundred (100) milliliters as a monthly average, counts using the most probable number method (MPN).

5- Class SE

Includes the coastal waters which are destined for or may be destined for industrial usages.

Quality Standards:

The coastal waters included in class SE shall not contain:

a. Floating solids, settleable solids, oils, and sludge deposits which are readily visible and attributable to municipal, industrial or other wastes or which increase the amounts of these constituents in receiving waters or any other material or waste that would interfere with the esthetics of these waters.

b. Any type of garbage, cinder, ash, oil, sludge or other refuse.

c. Dissolved oxygen in a concentration of less than four and a half (4.5) milligrams per liter.

d. Toxic wastes, or deleterious substances alone or in combination with other substance or wastes in sufficient amount as to prevent the survival or propagation of fish life or impair the waters for any other best usage as determined for the specific waters which are assigned to this class.

e. A pH factor less than six and eight tenths (6.8) or more than eight and five tenths (8.5).

f. A temperature more than $4^{o}F$. above ambient water temperature and in no case in excess of $93^{o}F$.

B- These classifications were assigned since the coastal waters of Puerto Rico now fulfill or in the future must fulfill the requirements specified for said classifications.

C- The Secretary of Health of Puerto Rico is hereby empowered to modify the classifications and standards for the coastal waters when necessity and sanitary conditions so justify it. Such modifications shall

not include the establishment of new classifications and standards that may reduce the actual quality of the coastal waters as specified in this Regulation.

The foregoing power to modify the classifications and standards is limited and/or conditioned by the provisions of Section 10 of the Federal Water Pollution Control Act as amended, PL-84-660 of 1956.

D- The Secretary of Health of Puerto Rico shall hold public hearings before proceeding to make any change or alteration in the classifications and standards for the coastal waters of Puerto Rico.

E- Once public hearings have been held for the purpose of changing or modifying the classifications and standards for the coastal waters and after considering the arguments in such hearings, the Secretary of Health shall publish the new changes in two newspapers of general circulation in Puerto Rico.

F- The changes which are made in the future concerning the classifications and standards for the coastal waters shall constitute a part of this Regulation.

ARTICLE VI- CLASSIFICATIONS OF COASTAL WATERS ACCORDING TO QUALITY STANDARDS

A- Class SA

Phosphorescent Bays such as La Parguera in the South Coast and Mosquito Bay in Vieques.

B- Class SB

1- From Point Miquillo to Point Picua (Cove Comezon).

2- From Point Del Obispo to Point Ostiones not including the Phosphorescent Bay.

C- Class SC

1- From Fort El Morro to Point Miquillo.

2- From Point Picua to Point Candelero.

3- From Point Toro to Point Figuras.

4- From Point Arenas to Point Cabullon.

5- From Point Cuchara to Penon de Ponce.

6- From Point Vaquero to Point Meseta.

7- From Fronton de la Brea to Point del Obispo.

8- From Point Ostiones to Point Guanajibo.

9- From Point Algarrobo to Colon Park in Aguadilla Bay.

10- From Point Borinquen to Point Maracayo.

11- From Point Morrillos to Cabras Island.

12- Vieques and Culebras Island.

D- Class SD

1- From Point Figuras to Point Arenas.

2- From Point Cabullon to Point Cuchara not including Ponce Harbor. (See attached map.)

3- From Penon de Ponce at Puerto Rico Road #2, Km. 242.0 to Cove Parguera.

4- From Point Meseta to Fronton de la Brea (Guanica Bay).

5- From Point Guanajibo to Point Algarrobo not including Mayaguez Harbor. (See attached map.)

6- From Colon Park in Aguadilla to Point Borinquen.

7- From Point Maracayo to Point Morrillos (including Arecibo Harbor).

8- From Point Candelero to Point Icacos.

9- From Point Yeguas to Point Toro.

E- Class SE

1- San Juan Bay.

2- Ponce Harbor. (See attached map.)

3- Mayaguez Harbor. (See attached map.)

4- From Cove Parguera to Point Vaquero.

5- From Point Icacos to Point Yeguas (including Yabucoa Harbor).

SECTION II- EFFECTIVENESS

This Regulation shall come into effect immediately after being filed in the office of the Secretary of State according to Section II of the "Rules and Regulations Act of 1958", Act. No. 112 approved June 30, 1957, as amended.

REPORT ON WATER SUPPLY TO
THE DIGITAL EQUIPMENT CORPORATION
SAN GERMAN, PUERTO RICO

January, 1972

CAMP, DRESSER & McKEE
CONSULTING ENGINEERS BOSTON, MASSACHUSETTS

Puerto Rico

correspondence
XR Water Supply

REPORT ON WATER SUPPLY TO
THE DIGITAL EQUIPMENT CORPORATION
SAN GERMAN, PUERTO RICO

January, 1972

CAMP DRESSER & McKEE Inc.
One Center Plaza
Boston, Massachusetts

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Inc.

CONSULTING ENGINEERS

ONE CENTER PLAZA BOSTON. MASS. 02108 TEL. 617 742-5151 CABLE: CAMDRES

ROBERT C. MARINI
Senior Vice President

January 28, 1972

Mr. Allen Hanson
Digital Equipment Corporation
Maynard, Massachusetts 01754

Water Supply to Digital
Equipment Corporation
San German, Puerto Rico
CDM 493-4

Dear Mr. Hanson:

We enclose six copies of a report on the supply and treatment of water for industrial plant in San German, Puerto Rico.

Proposed development works and their estimated costs are summarized in the last two sections of the report. We believe that sufficient water of excellent quality may be obtained by the development of wells located within the land occupied by your plant and close to the plant within the alluvium-filled Rio Guanajibo valley. The development cost of these wells depends to a large extent on their individual yields which are unknown at present. However, with certain assumptions in this connection, the estimated cost of developing sufficient wells to yield between 0.68 and 0.80 mgd is $130,000.

The estimated construction cost of a plant to demineralize 25 per cent of the total supply (about 0.17 mgd) is $226,000 including associated works and storage but excluding housing the plant.

The estimated cost of a water storage tank of 0.5 mg, located at the plant is $95,000 and the cost of the pumping plant is $25,000. The total estimated cost of the entire development works is $476,000.

The estimated total annual operating cost of the wells in DEC property, the demineralization plant and the pumping plant is $29,000. After completion of construction, the wells in the Rio Guanajibo valley become the property of the Puerto Rico Aqueduct and Sewer Authority who will

meet operating costs. However, at the Authority's standard water charges the annual cost of an estimated 0.48 mgd from these wells would be $42,000. We believe that these charges are negotiable with the PRASA on the basis that since DEC are required to meet the entire construction costs of the wells, water charges should be reduced to cover operating costs only, which would not be more than $20,000 per year.

We estimate that, subject to negotiations and agreements with Puerto Rico Governmental Agencies, the whole of the recommended construction work could be completed in 12 to 18 months.

Please do not hesitate to contact us should you require further information.

Very truly yours,

CAMP DRESSER & McKEE Inc.

Robert C. Marini

PHW/jb

Enclosure

LIST OF TABLES

TABLE OF CONTENTS

SUMMARY OF PREVIOUS RECOMMENDATIONS

In an interim report prepared in November, 1971 it was seen that the existing water supply facilities, operated by the Puerto Rico Aqueduct and Sewer Authority (PRASA) in San German, are not able to meet present maximum day demands. These facilities would be unable to contribute to DEC's predicted water demand of between 0.7 and 0.8 mgd and PRASA had no plans for the development of additional sources of water to meet the growing water needs of San German.

The interim report established that there were areas of good groundwater potential close to the Rio Guanajibo in San German and it was concluded that these resources should be developed either directly by DEC or by PRASA. It was also recommended that test wells should be constructed in DEC property with a view to providing some portion of DEC's future water requirements.

APPLICATION TO PRASA FOR WATER

On December 9, 1971 a formal request was made to PRASA for an increase in water supply to the DEC industrial plant in San German. The request mentioned the need for the development of new sources to meet DEC's water requirements of 680,000 gpd in addition to 90,000 gpd which PRASA are committed to supply at present.

On January 10, 1972 Mr. Victor Luis Lopez, Chief Engineering Technical Services Department, Puerto Rico Aqueduct and Sewer Authority verbally outlined the results of his investigation and proposals connected with the development of wells to provide the water required to meet DEC's future needs.

Mr. Lopez stated that PRASA were confident that sufficient water would be obtained from wells in San German to meet DEC's water needs. Mr. Lopez also recommended that DEC expand their operations in San German in preference to any other locality because: 1) There were no established water facilities in Puerto Rico capable of supplying this quantity of water without development of additional resources. 2) The Rio Guanajibo valley has good groundwater potential. 3) DEC are already established in San German and are located close to the groundwater area and close to the proposed wastewater treatment facilities now under construction.

Mr. Lopez stated that DEC could develop the wells and associated works or alternatively the work could be carried out by PRASA. The terms under which water would be made available to DEC (outlined to PRASA in our letter dated January 14) are as follows:

(a) Test wells would be constructed in the most geologically suitable area in San German, that is close to the existing septic tank. (Area A on the attached plan.)

(b) Subject to these wells proving a satisfactory yield then land would be acquired and two or three production wells

would be constructed and equipped with pumps, chlorinators and mains to deliver the water to the existing distribution system.

(c) The wells would be designed to meet the water needs of DEC.

(d) The whole of the cost of the wells and associated works would be borne by DEC.

(e) On completion of construction the wells would become the property of the Puerto Rico Aqueduct and Sewer Authority who would operate and maintain them.

(f) The Puerto Rico Aqueduct and Sewer Authority would charge for water at the standard rates.

The existing septic tank area will not be available for well construction until the new wastewater treatment facilities are completed in about six months' time. Because of this factor, and the possibility of serious contamination of groundwater in this area, we requested that PRASA consider alternate groundwater locations. The site shown as area B, on Fig. 1 was selected by the PRASA geologist as a relatively good potential groundwater area. It should be noted that these two areas are those recommended in our interim report as being suitable for development of wells.

ACCESS TO PRIVATE LANDS AND LAND ACQUISITION

It has not yet been possible to establish the ownership of land designated as areas A and B in Figure 1, however the Puerto Rico Industrial

FIGURE I - GROUNDWATER SOURCES IN SAN GERMAN

Development Company (PRIDCO) have tentatively agreed to investigate this and to acquire land on behalf of DEC as necessary.

Under this arrangement it is understood that PRIDCO would obtain the agreement of land owners regarding the terms of acquisition. In the event of failure to agreed land values the matter would be settled by arbitration.

It is estimated that an area of 0.25 to 0.5 acres would be adequate for each well and land costs are therefore not expected to form a significant portion of the total cost of the works required. Land acquisition would apparently be unnecessary for the purpose of drilling test wells and would therefore not begin until completion of the test well program. PRASA estimate that land acquisition could be completed in one to two months unless arbitration is necessary.

Formal agreement to these proposals was requested from PRIDCO in our letter dated January 17, 1972.

CONSTRUCTION OF WELLS BY DEC OR BY THE PUERTO RICO AQUEDUCT AND SEWER AUTHORITY

Test wells and production wells may be constructed either by the Puerto Rico Aqueduct and Sewer Authority or by DEC. Production wells would become the property of PRASA on completion and either course of construction would not influence the access to private land for the purpose

of drilling test wells and would not change the land acquisitions procedure outlined above.

There are several advantages and disadvantages to either course of construction, as follows. The Puerto Rico Aqueduct and Sewer Authority would be bound by certain official administrative procedures and would be limited to employing local drilling contractors and to using locally available materials. The project would take its place in a program containing many other projects and would not necessarily be accorded a high priority.

These factors would almost certainly result in longer preparatory and construction periods and less efficient wells. The last factor could influence water quality and yield. The use of local facilities and materials may reduce construction costs.

Alternatively, the appointment by DEC of an independent expert contractor under the supervision of DEC's consultant would ensure completion of the work in a minimum period and with high priority. Such an agency would have greater flexibility in the use of plant and materials and would be able to provide continuous supervision to ensure optimum development and completion of the wells.

In either course the connection of wells to the distribution mains and the reinforcement of the distribution mains, to ensure adequate capacity between the well site and the DEC plant, would probably be more conveniently carried out by the Puerto Rico Aqueduct and Sewer Authority.

ESTIMATED CONSTRUCTION COSTS OF WELLS

NEAR RIO GUANAJIBO

An estimate of the number and depth of test wells required is based on information obtained from logs of existing wells in San German. This information is limited because comparatively few wells have been constructed and data for these wells is incomplete. The estimated number and depth of production wells is also based on this data and all cost estimates must therefore be regarded as preliminary and subject to revision on completion of the proposed test well program.

It has also been assumed that DEC would be required to meet the entire cost of the well program. It is considered that this is negotiable with the Puerto Rico Aqueduct and Sewer Authority, in the terms that the proposed wells and associated equipment constitute a revenue earning asset which, under the present terms, becomes the property of the Aqueduct and Sewer Authority who logically should therefore meet part of the construction cost.

The following cost estimates do not include: 1) Land acquisition or easements; 2) the cost of electric power transmission to the well sites. The estimates include an allowance for engineering.

TABLE 1

ESTIMATED COSTS OF WELLS NEAR RIO GUANAJIBO

Six, 6-in dia test wells to an average depth of 60 ft.	$17,000
Two, 16-in dia production wells	$45,000
Two submersible well pumps	$ 8,000
Pump installation, electrical controls and starters	$ 5,000
Pipelines, 2,000 ft, 8-in dia	$20,000
Hypochlorite feeders including installation	$ 5,000
TOTAL	$100,000

ESTIMATED ANNUAL COSTS OF WATER

In addition to a hundred percent contribution to the cost of constructing the wells, as outlined above, the Aqueduct and Sewer Authority propose to charge for water at normal rates as follows:

TABLE 2

PUERTO RICO AQUEDUCT AND SEWER AUTHORITY

Rate Schedule for Water and Sewer Service

Effective with the Consumption Cycle ending May 25th, 1970 and Effective with Billing starting on June 1st, 1970, and thereafter:

WATER SERVICE

Metered - Charge per Month		Per Cubic Meter Cents
For the first	10 cubic meters	13.1
For the next	90 " "	16.0
For the next	900 " "	12.5
For the next	9,000 " "	9.1
Over	10,000 " "	5.7

Assuming a water consumption of 800,000 gpd, and 21 working days per month the cost of water would be approximately $4,000 per month.

If the water consumption is 680,000 gpd, as recently suggested, then on similar assumptions the cost of water would be $3,500 per month.

It is estimated that the total cost of operating the wells would be about $1,700 per month including electric power, hypochlorite, maintenance and attendance.

If the wells and equipment are depreciated over an assumed full service life of ten years, the total monthly costs of operation and depreciation would be approximately $2,500 per month. The water revenue to the Aqueduct and Sewer Authority, estimated to be $3,500 to $4,000 per month, therefore appears to be excessive.

CONSTRUCTION OF WELLS WITHIN DEC PLANT BOUNDARY

The Interim Report contained details of the existing well located within the DEC plant boundary in San German. It was emphasized that the yield of wells in rock formations can only be determined by long term use. Attempts have been made to obtain meaningful data by test pumping this well. The company that drilled the well, Julio N. Chardon and Sons, Inc., were also engaged to carry out the test pumping. After a series of delays the well was test pumped but the pumping rate was limited by the equipment available. At a pumping rate of 75 gpm the water level stabilized at 39 ft below the static water level. From this result it has been estimated that the yield of this well could be as high as 200 gpm.

From the information available at present it is not possible to determine whether the whole of the water available in this area could be extracted by this existing well, or whether additional wells would yield more water without restrictions by interference between wells. This can only be determined by installing and test pumping a minimum of two additional wells.

An application for permission to drill two additional wells within the DEC plant boundary was submitted to the Environmental Quality Board, Puerto Rico on December 13, 1971. The construction of test wells should proceed as soon as the Board's agreement has been obtained.

It is assumed that water obtained from wells constructed and operated by DEC in property which is leased from the Puerto Rico Industrial Development Company would not be subject to the Aqueduct and Sewer Authority's water rates. Attempts to establish this assumption with PRIDCO have not yet yielded any information and inquiries in this connection are continuing.

There would clearly be a significant economic advantage if the above assumption is correct and if part of DEC's water requirements could be met from this source.

ESTIMATED COSTS OF WELLS IN DEC PROPERTY

Estimates contained in the Interim Report were based on the assumption that the work would be carried out by local drillers and that two wells would be completed. From additional information now available it is considered preferable to base the estimate on the assumption that U.S. based drillers would be employed and to provide for the completion of the existing well and two additional wells. Test pumping may prove that the completion of three wells would not be justified and costs would then be proportionately reduced.

The following cost estimates do not include the cost of power transmission to the well sites, however, it is possible that the 25 HP well pumps could be operated from the existing power supply to DEC and transmission line costs would therefore be relatively small.

TABLE 3

ESTIMATED COSTS OF WELLS IN DEC PROPERTY

Complete existing 6-in well, including a submersible well pump, pump installation and controls	$4,000
Drill two wells each 8-in dia to a depth 150 ft and 6-in dia to a depth of 400 ft, including test pumping	$15,000

TABLE 3

(Continued)

Furnish and install two submersible pumps including controls	$7,000
Pipelines, 600 ft, 6-in dia	$4,000
Total	$30,000

WATER QUALITY

Analysis of water from a well in San German which has been operated by the Aqueduct and Sewer Authority for several years is shown on the following page. The water from wells in the Rio Guanajibo area would probably be similar in quality to that from which this analysis was obtained.

This water is non-corrosive, moderately hard and contains a small amount of iron. It has no manganese, color or turbidity. It could be described as an excellent potable water requiring no treatment other than disinfection by chlorine. Treatment by ion exchange would not present any unusual difficulties, it would reduce the anions and cations to trace concentrations, that would meet the water quality required by DEC.

Wells in DEC property draw water from consolidated rock formations whereas wells in the Rio Guanajibo area are in alluvium. Both groundwaters would probably have similar characteristics with regard to color, turbidity and

Sample from		Collection		Type of Water		Analysis Requested	
Town	San German	By	B. Morales	X	Deep well	By	Div. de Produccion
Ward or St.		Date	7/21/71		Surface	Analyzed	
Place	Urb. El Retiro	Time			Other	By	Santiago - Ayala

Chemical Constituents	Expressed As			Limits U.S.P.H.S.*
Free Carbon Dioxide	CO_2	1.6	mg/l	
Dissolved Oxygen	O_2	-	mg/l	
Residual Chlorine	Cl_2	-	mg/l	
Calcium	Ca	11.2	mg/l	
Magnesium	Mg	26.3	mg/l	
Sodium and Potassium	Na	9.9	mg/l	
Total Iron	Fe	0.07	mg/l	0.3 mg/l
Dissolved Iron	Fe	0	mg/l	
Manganese	Mn	0	mg/l	0.05 mg/l
Oxides	R_2O_3	-	mg/l	
Silica	SiO_2	34.6	mg/l	
Total Alkalinity	$CaCO_3$	130	mg/l	
Ph. Alkalinity	$CaCO_3$	0	mg/l	
Carbonate	CO_3	0	mg/l	
Bicarbonate	HCO_3	159	mg/l	
Sulfate	SO_4	6.2	mg/l	250 mg/l
Chloride	Cl	15	mg/l	250 mg/l
Nitrate	NO_3	0.3	mg/l	45 mg/l
Nitrite	NO_2	0	mg/l	
Fluoride	F	0.45	mg/l	1.0 mg/l
Phosphate	PO_4	0	mg/l	
Sulfide	S	0	mg/l	
Total Dissolved Solids	Residue at 103°C	170	mg/l	500 mg/l
Loss on Ignition	at 600°C	45	mg/l	

Physical Characteristics

Turbidity	SiO_2 Stds	0	units	5 units
Color	Pt-Co Stds	0	units	15 units

Other Determinations

Total Hardness	136 mg/l	Noncarbonate hardness 6 mg/l
Conductivity	272 micromhos	
pH	8.15	
Saturation pH	8.15	
Saturation Index	0	

Bacteriological Examination

_____ M.P.N. Per 100 ml (Coliform Group)

*Maximum limits for drinking water established by the U.S.P.H.S. in 1962

Chemical Engineer

hardness but there could be slight variations in other constituents. Samples taken during tests of the existing well are at present being analysed in Puerto Rico.

WATER TREATMENT

From presently available data on groundwater quality in San German it is concluded that groundwater is suitable for general use without further treatment. For certain of DEC's processes, water of a higher quality is necessary. The standards required by DEC are that this water should be low in calcium, magnesium and hardness; silica should be less than 2 ppm and turbidity less than 5 units. It has been estimated by DEC that about 25 percent of the total quantity of the water used at the plant would be required to conform to this higher standard. Initially the total quantity required was estimated to be 800,000 gpd (about 560 gpm). It was subsequently suggested that this figure may be reduced to 680,000 gpd (about 475 gpm).

The standard of water quality required would be achieved by demineralization by ion exchange, using synthetic resins.

A suitable plant for this purpose would comprise two mixed bed deionizers having a combined capacity of 200,000 gpd when operating at 2.5 gpm/sq ft and each unit would treat 72,000 g between regeneration cycles.

The plant would be designed to operate automatically and would include

treated water storage to permit complete shut down without interruption of supply during regeneration. Pumps and storage for chemicals used during regeneration are included, in addition to pumps for influent and effluent water. No provision has been made for housing the plant and associated equipment or for the disposal of waste products.

A preliminary estimate of the cost of constructing and operating the plant based on costs in Puerto Rico are as follows.

TABLE 4

ESTIMATED COST OF DEIONIZATION PLANT

Construction Cost	
Two mixed bed deionizers including automatic controls, shipping to site, installation in an existing building	$140,000
Storage tanks for chemicals and treated water	$13,000
Chemical pumps and treated water pumps	$8,000
Electrical, pipework and miscellaneous	$50,000
Total	$211,000

TABLE 4

(Continued)

Daily Operating Costs	
Chemical costs	$80
Replacement of resins	$15
Attendance, electrical power, maintenance	$15
Total operating costs	$110 per day

Assuming 21 working days per month, then monthly operating costs would be $2,310.

A number of variations of the treatment systems described above are practicable. Plants having lower operating costs but higher construction costs have been considered. A comparatively large operating expenditure is, of course, unavoidable because of the high quality water required and the relatively high dissolved solids content of the raw water.

One method given preliminary consideration was the use of a reverse osmosis roughing unit to be followed by a conventional deionization unit for removal of the remaining (about 10 percent) of the undesirable ions. The high initial cost of this equipment could perhaps be justified if the raw water contained organic compounds but since it is very satis-

factory in this respect more traditional treatment methods are economically preferable.

An alternative treatment arrangement would comprise separate cation and anion deionizers, designed as roughing units, a degasifier, and a mixed bed deionizer as a "polishing" unit.

Control and automation of the plant would be similar to that previously described, and again, no provision has been made for housing the plant or associated equipment.

The length of regeneration cycles for the roughing units would be twice that of the plant previously described and would be 2 mg for the polishing unit. The use of chemicals for regeneration would be considerably reduced as reflected in the operating costs summarized below.

TABLE 5

ESTIMATED COST OF ALTERNATIVE DEIONIZATION PLANT

Construction Cost	
Cation and anion deionization "roughing" units and mixed bed "polishing" units including automatic controls and installation in an existing building.	$156,000
Storage tanks for chemicals and treated water	$12,000

TABLE 5

(Continued)

Pumps for chemicals and treated water	$8,000
Pipework, electrical and installation items	$50,000
	$226,000

Daily Operating Costs

Chemical costs	$20
Replacement of resins	$15
Attendance, electrical power and maintenance	$15
Total cost per day	$50

WATER STORAGE

The two purposes for which water storage tanks should be provided at the plant are for fire protection and to prevent an interruption in the normal operation of the plant in the event of failure of the public water supply.

It is understood that the storage capacity required for fire fighting has already been decided upon and that a tank is now under construction.

The capacity required to prevent serious interruption of the operation of the plant depends upon the proportion of water from the public supply, the facilities available to the Town for the repair of mains and equipment, and the reliability of the supply of electric power.

In recommending the size of the tank required it is therefore necessary to make a number of assumptions, as follows:

1. Assume that a quantity of 200,000 gallons of water per day is supplied from wells within DEC property and that standby electric power is available for operating these wells in the event of failure of the normal power supply.

2. Assume that electric power failure or water main failure effecting the Town's water supply, and the supply to the plant, would be repaired and the service returned within 24 hours.

The quantity of storage required to ensure that there would be no interruption in the plant operation under these conditions would be 490,000 gpd. A storage tank of this capacity could be constructed entirely above ground in the form of a steel standpipe; alternatively the tank could be of reinforced concrete construction, partially below ground, in which case the tank roof area (4,200 sq ft) could be utilized. The estimated cost of a steel tank is $95,000, compared with $120,000 for reinforced concrete. Both estimates include construction costs and an allowance for engineering.

The proposed 0.5 mg storage tank and the storage tank for fire fighting purposes, which is now under construction by DEC, would be supplied with water from the wells within the DEC plant boundary and from the Aqueduct and Sewer Authority's main supply to the plant.

Water used for domestic purposes within the DEC plant would be supplied directly from the Authority's main; all other water would be drawn from the proposed 0.5 mg storage tank.

For this purpose we recommend the installation of three electrically operated variable speed pumps, comprising two operating units and one standby unit. Two pumps operating in parallel would discharge a maximum flow of 0.7 mgd at 65 psi. Speed control, and discharge rate would be automatically varied by the pressure in the system. The pumps would be close coupled to 15 HP totally enclosed electric motors through hydraulic drives.

In view of the climatic conditions in Puerto Rico the pumps, motors and controls would not require elaborate protection. A pump house could conveniently comprise a concrete floor and roof structure.

The estimated cost of furnishing and installing pumping units, controls and pipework is $25,000. This estimate does not include electric power transmission line costs or standby electric power generators on the assumption that these are available as part of the present DEC facilities.

CONCLUSIONS AND RECOMMENDATIONS

Wells within DEC property would provide the most economical source of water. The yield from these wells can only be determined by the construction of test wells. A reliable estimate of yield will require several years pumping records.

Two test wells should be constructed within the DEC plant boundary as soon as permission to do so is received from the Puerto Rico Environmental Quality Board, to whom application was made on December 13, 1971.

It is clear that the yield from wells within DEC plant boundary will not be sufficient to meet DEC's estimated future water requirements and will need to be supplemented from wells in the higher yielding alluvial area near the Rio Guanajibo. The construction of test wells as a preliminary to the location of two or three production wells should proceed as soon as possible.

The terms under which the Puerto Rico Aqueduct and Sewer Authority will provide water from this source require that the total cost of constructing and equipping the wells be met by DEC and that the wells become the property of the Aqueduct and Sewer Authority, who will operate them. The Aqueduct and Sewer Authority will also charge for water at the standard rates. In this connection it is recommended that negotiations with DEC be opened with the aim of reducing water charges to a level commensurate with the Aqueduct and Sewer Authority's cost of supplying water from sources provided by DEC.

After reaching agreement with the Aqueduct and Sewer Authority on water charges, the construction of test wells and production wells should proceed. In the interests of reducing construction time to a minimum these wells may be constructed by DEC, through an experienced contractor under close supervision. Alternatively, if time is not a critical factor, the wells may be constructed by the Aqueduct and Sewer Authority.

The quality of groundwater in San German is relatively good, and treatment is not necessary unless the water is to be used for certain industrial processes requiring demineralization. A number of variations of a basic demineralization systems are possible. The system selected involves a relatively high initial cost but with a compensating reduction in operating costs. The plant would comprise separate cation and anion units designed as "roughing" units, a degasifier and a mixed bed deionizer as a "polishing" unit. The plant would be operated automatically with the exception of the final ion exchange unit which would have long runs between the regeneration process and would therefore be manually operated.

Water storage is recommended as a safeguard against interruption of supply in the event of a water main failure or an electric power failure. The capacity recommended is 0.5 mg assuming a total consumption of 0.68 mgd of which 0.2 mgd is obtained from wells within the DEC plant boundary.

A summary of the recommended construction items appears in the following table of estimates.

SUMMARY OF COSTS

The costs of constructing and operating the wells recommended will vary according to their yield and will also depend on the agreement reached with the Puerto Rico Aqueduct and Sewer Authority. The cost estimates are based on the following assumptions:

1. The total quantity of water required by DEC will be 475 gpm (0.68 mgd).

2. About 25 percent of this quantity will be demineralized.

3. Approximately 0.2 mgd will be obtained from wells located within the DEC plant boundary. The cost of constructing and operating these wells will be met by DEC, and there will be no additional water charges by the Aqueduct and Sewer Authority.

4. The remaining quantity of water, about 0.48 mgd will be obtained from two wells near Rio Guanajibo. The cost of constructing these wells, and the cost of providing associated pipelines and equipment, will be met by DEC; the Aqueduct and Sewer Authority will make standard charges for water.

The estimates do not include the cost of land required for wells near the Rio Guanajibo; the estimates do not include electrical transmission lines. An allowance for engineering has been included.

TABLE 6

SUMMARY OF ESTIMATED CONSTRUCTION COSTS

1. Wells and Associated Works		
Test wells in Rio Guanajibo area	$17,000	
Production wells in Rio Guanajibo area	$58,000	
Pipelines and chlorine feeders	$25,000	
Wells in DEC property	$26,000	
Pipelines	$4,000	$130,000
2. Demineralization by Ion Exchange		
Deionization units including installation	$156,000	
Chemical and treated water storage tanks and pumps	$20,000	
Pipework, electrical and miscellaneous	$50,000	$226,000
3. Water Storage and Pumping		
Steel storage tank, 0.5 mg capacity	$95,000	
Variable speed system pumps	$25,000	$120,000
Total Construction Costs		$476,000

TABLE 7

SUMMARY OF ESTIMATED ANNUAL OPERATING COSTS

AND WATER CHARGES

Costs of operating wells in DEC property at a rate of 200,000 gpd.	$8,000
Charges for water supplied by the Puerto Rico Aqueduct and Sewer Authority, (estimated 480,000 gpd).	$42,000
Costs of operating deionization plant, and system pumps	$21,000
Total Annual Operating Costs	$71,000

250 K - 70 - 75K.

500 K - 95K.

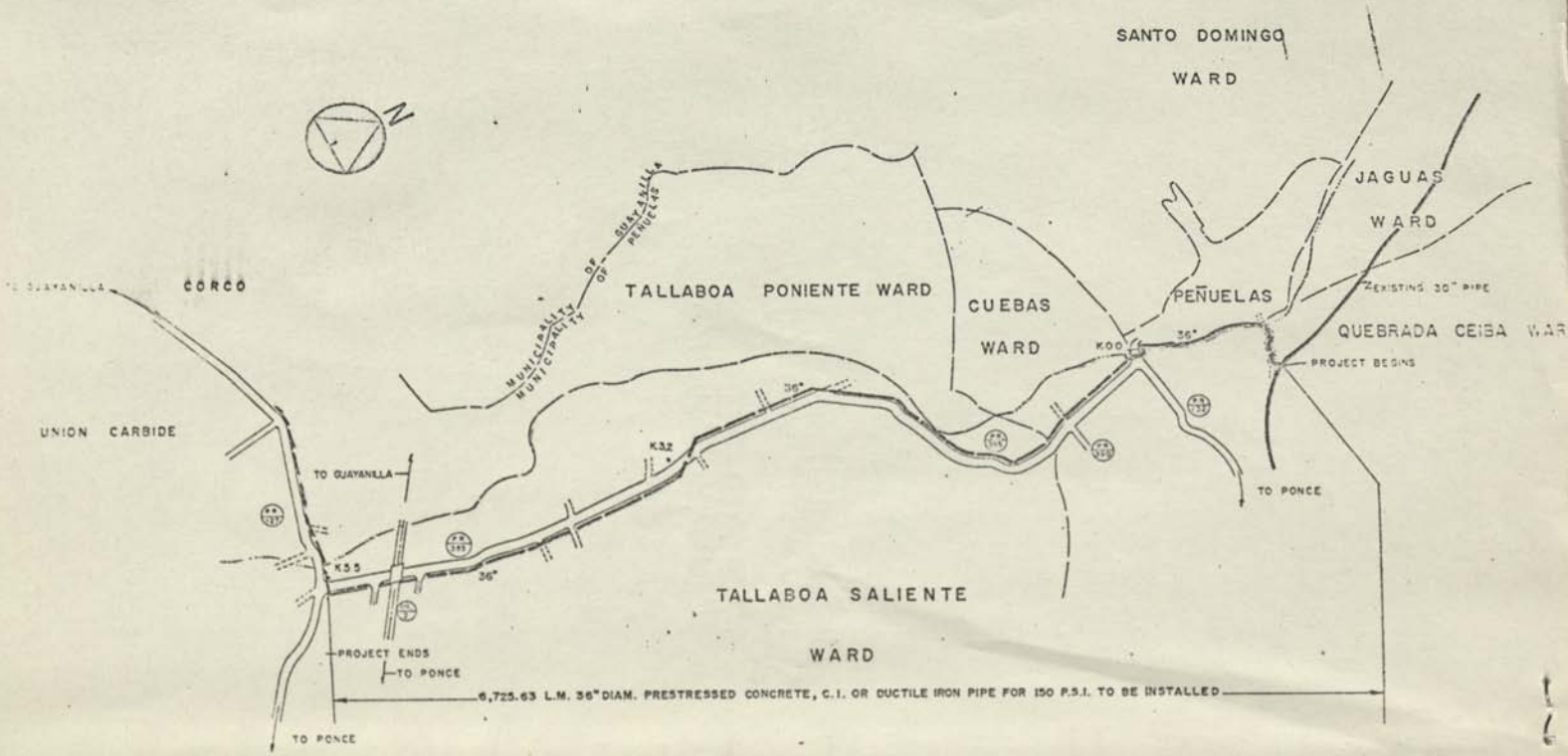
750 K - 150K.

Puerto Rico

Correspondence

J R Watters

Camp Dresser & McKee


SANTO DOMINGO
WARD
JAGUAS
WARD
N
MUNICIPALITY OF GUAYANILLA
MUNICIPALITY OF PEÑUELAS
TALLABOA PONIENTE WARD
CUEBAS
WARD
PEÑUELAS
EXISTING 30" PIPE
QUEBRADA CEIBA WARD
CORCO
UNION CARBIDE
TO GUAYANILLA
K00
36"
PROJECT BEGINS
K32
TO PONCE
K33
36"
TALLABOA SALIENTE
WARD
PROJECT ENDS
TO PONCE
6,725.63 L.M. 36" DIAM. PRESTRESSED CONCRETE, C.I. OR DUCTILE IRON PIPE FOR 150 P.S.I. TO BE INSTALLED
TO PONCE

Interim Report on

Water Resources Available to

The Digital Equipment Corporation

in Puerto Rico

November 1971

CAMP DRESSER & McKEE Inc.
ONE CENTER PLAZA
BOSTON, MASSACHUSETTS

TABLE OF CONTENTS

TABLE OF CONTENTS

(Continued)

TABLE OF CONTENTS
(Continued)

SUMMARY AND RECOMMENDATIONS

Scope

This is an interim report on data collected during a superficial, reconnaissance of the water resources in the San German area, Puerto Rico and a broader area of supply south of a line through Aguada, Maricao and Ponce. The survey was carried out from November 2 through November 5, 1971.

Quantity of Water Required

The report is based on the assumption that 800,000 gpd will be required at a plant to be developed by Digital Equipment Corporation (DEC) in one of the areas stated above. This quantity will be subject to review later and can probably be considerably reduced.

Quality of Water

The report quotes water quality data where they are available. No evaluation of water quality or treatment recommendations are included at this stage.

San German

The existing water supply facilities operated by the Puerto Rico Water and Sewer Authority (PRASA) in San German are not able to meet present water demands under certain conditions. Source "safe" yields are estimated to be:

Surface water about 0.8 mgd.

Groundwater about 0.5 mgd.

The total maximum day demand exceeds 1.8 mgd.

DEC's water demands in San German may be satisfied by one, or a combination of the following measures:

1) Fully develop the existing well in DEC property.
2) Drill an additional test well in DEC property.
3) Request PRASA to develop additional (groundwater) source(s) of supply in San German.
4) Nogotiate with land owners to permit construction of wells by DEC if (3) should fail.

Other Areas

An extension of supply is currently being constructed by PRASA between Mayaguez and Anasco. Water from this extension will be expensive and will probably not be available in large quantities because extensions of supply and treatment facilities are not planned at present.

The construction of the first stage of Toa Vaca project is nearing completion. This project could make available 9 mgd of raw water for industrial use in the Penuelas-Tallaboa area by late 1972 at reasonable cost.

There are other areas in which groundwater supplies could be developed, among these are the Guanajibo Valley, Sabana Grande and Cabo Rojo.

Recommendations

We recommend further investigation of the development of groundwater sources in DEC property although these sources may only provide a standby for larger groundwater supplies from other areas in San German.

Requests for additional water from PRASA and negotiations with private land owners to permit well drilling should proceed, as either course may lead to a means of increasing the supply to the San German plant.

If the Digital Equipment Corporation wishes to consider locating in the Ponce area, between Penuelas - Tallaboa, then a request for water from the Toa Vaca project should be submitted as soon as possible. On present information this project offers the best solution to the water supply problem.

All of the above recommendations should proceed simultaneously until the additional information obtained in this way indicates which water source or souces can best be developed.

SAN GERMAN EXISTING WATER SUPPLY SYSTEM

Location

San German is located at the eastern end of the Rio Guanajibo valley which extends in a southeasterly direction from the town of Mayaguez towards Sabana Grande. (Fig. 1)

Population and Consumption

The population of San German was 27,769 in the 1970 census. The average daily water demand is reported by the Puerto Rico Aqueduct and Sewer Authority (PRASA) to have been 1.57 mgd for the year July, 1970 through June, 1971. This is an increase of 16 percent over the previous year's figure of 1.41 mgd. The maximum monthly water demand occurred in May, the average daily demand for that month being 1.90 mgd. The minimum monthly demand occurred in September; the average demand for that month was 1.34 mgd.

Surface Water Sources

At present San German obtains water from two surface water sources, the Rio Hoconuco and the Rio Cain which are both tributaries of the Rio Guanajibo. Dams have been constructed across the upper reaches of these rivers from which water flows by gravity through 8-in diameter pipelines, over distances of 8 and 10 miles, to a water treatment plant at San German.

The dams on these rivers are apparently small and provide very little storage volume. The safe yields of the sources are therefore determined by the minimum stream flows. It is reported that during the dryer months of the year the combined yield of both sources is about 0.8 mgd. It is probable that the safe yield is considerably lower than this figure.

Treatment of Surface Water

The treatment plant is reported to be one of the oldest in use in Puerto Rico. Its capacity when originally constructed was 0.5 mgd. Two filters were subsequently added and the plant was then rated at 1 mgd. The plant comprises horizontal flow sedimentation tanks, rapid sand filters, chlorination and fluoridation facilities. It is reported that there are no record drawings of the plant and it is therefore difficult to estimate filtration and sedimentation rates of flow without extensive field work. The operator on duty when the plant was visited reported short filter runs and general problems associated with overloading the plant. Its "normal" operating rate, when the yield from the sources permits, is about 15. mgd. The maximum rate of which it has been operated is about 1.8 mgd. It is probable that the capacity of the filters at 2g/sq ft/min is 1.0 mgd. The plant appears to operate satisfactorily, when it is not heavily overloaded as indicated by the analysis of treated water. Unfortunately quality data of untreated water were not available.

Groundwater Sources

There are two wells used by PRASA in San German. These are wells numbered 6 and 11 (Fig. 2). Both wells are located in sands and gravels and are

very close to the Guanajibo River from which they obtain water. The logs of the wells were obtained from the USGS office in San Juan and are appended. These records show the yields of wells to be 340 gpm with 16 ft drawdown and 750 gpm with 24 ft drawdown. These figures do not agree with those of PRASA who quote the combined yield of the wells as 350 gpm It is possible that the figures quoted by PRASA are the present pumping rates. Yields may have decreased as a result of incorrect development, gravel packing or screening at the time of construction.

Treatment of Groundwater

Water from Well No. 11 is chlorinated although the chlorination equipment is very unreliable, and was unservicable when the installation was visited. Well No. 6 was not visited but similar treatment facilities are believed to exist.

Water from both wells is pumped directly into the distribution system. The system has distribution storage of 0.725 mg, that is about half of the average day supply, and considerably less than would normally be provided.

Digital Equipment Corporation's

Existing Well

In September, 1971 a 6-in diameter well was drilled to a depth of 405 ft in the northwest corner of Digital Equipment Corporation's property at San German. The well was drilled by Julio N. Chardon and Sons Inc. Extracts from the record of the drilling are as follows:

Type of rig:	rotary
Depth of well:	405 ft
Depth/dia/type of casing:	80 ft/6-in/plain
Depth of chief aquifer:	370 to 375 ft
Depth of other aquifer:	145 ft estimated yield 35 gpm
Yield, using air lift:	150 gpm
Drawdown:	100 ft after 6 hrs pumping of 150 gpm
Quality of water:	clear; no sample taken; temp 70°F.
Well log:	0 to 5 ft topsoil; 5 to 40 ft decomposed blue/brown rock 40 to 405 ft hard blue rock.

Arrangements have been made to test pump the well as soon as possible, in an attempt to obtain more information regarding its yield.

It should be emphasized that the yield of wells in rock formations can only be reliably determined by long term use, as explained in a later section.

POTENTIAL WATER SOURCES IN SAN GERMAN

Sources Available to PRASA

General

It is clear from examination of the existing water supply system in San German that PRASA must develop additional sources of water in the very near future if severe water shortages are to be avoided. There is no shortage of water sources in the San German area, in fact there is a choice of solutions to the short term water supply problem. In the long term it may be necessary to go to a more remote watershed to obtain the larger quantities of water which will be required if the population shows a significant increase.

Rio Guanajibo

It is probable that long term flow records are available for this river but these have not been sought in the limited time allocated for this interim study. The eight years dry weather discharge measurements contained in the USGS[1] report appended will suffice to indicate the availability of water from this river. Dry weather discharge measurements on the Guanajibo River at San German are as follows:

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1 Reconnaissance of the Water Resources of the Central Guanajibo Valley, Cabo Rojo, Puerto Rico by Robert B. Anders, U.S. Geological Survey.

Discharge in mgd

Feb., 1959	Mar., 1960	Feb., 1961	Feb., 1962	Mar., 1963	Mar., 1964
5.6	6.8	9.6	6.9	3.8	4.3

Feb., 1965	Apr., 1966
2.4	3.6

At the time of the year that these flow measurements were taken, rainfall and river flow are generally at or near their yearly lows. The flows do not necessarily represent the minimum flows but they indicate that 1 mgd, or perhaps more, could be abstracted directly from the Rio Guanajibo.

Lajas

A water treatment plant having a capacity of 1 mgd was recently constructed at Lajas, a small town located about 3 miles to the southwest of San German. It is understood from PRASA that this plant could be extended to supply additional water to San German.

The capacity of the surface water source at present in use at Lajas was not determined during these preliminary investigations but presumably, extension of the source and yield is practicable.

Groundwater

San German is not located in the most promising groundwater area in the Guanajibo valley, however the sands and gravels in the immediate vicinity

of the river provide a reasonably good aquifer. It is reported[2] that the aquifer is about 40 ft deep in some places and that large quantities of groundwater are held in transient storage.

Obtaining this water from wells depends on many factors, of which two primary ones are aquifer characteristics and well completion practices, as illustrated by the few well records obtained during this preliminary investigation.

It is clear that a suitable aquifer exists in the alluvium at some point along the center of the narrow valley. From present data it seems probable that a series of wells suitably located and carefully and correctly developed would produce at least 1 mgd and probably very much more. Specific capacities of existing wells in the narrow valley at San German are about 25 gpm/ft. Increased groundwater withdrawals may temporarily lower groundwater levels during periods of low rainfall but these would be quickly restored by recharge from surface sources during higher rainfall period.

Sources Available for Development by DEC

General

It is assumed that direct abstraction of water from the Rio Guanajibo by DEC is impracticable because of its relatively high cost and difficulties

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2 Reconnaissance of the Water Resources of the Central Guanajibo Valley, Cabo Rojo, Puerto Rico by Robert B. Anders, U.S. Geological Survey.

of operation, among other factors. The only remaining sources are wells either within DEC property or nearby.

Wells in DEC Property

It is not presently possible to establish estimates of potential yield from wells located in the underlying consolidated rock formations of the DEC Area because of lack of data. There is no information regarding the location and extent of the recharge area, the extent of the aquifer(s), the degree and distribution of joints from which water is drawn and a number of other factors. A reliable estimate of yield will therefore not be possible until the wells have been in use for several years. To illustrate this point, it is possible that the wells could draw water from storage which has accumulated over a long period of time at very low recharge rates. Ultimately the yield must equal the average rate of recharge. Although such an extreme is unlikely it is possible and must be considered.

Considerably more information on groundwater potential within DEC property will be available when present investigations connected with the existing well have been completed.

Wells Adjacent to DEC Property

The groundwater potential has been reviewed in the light of the following:

(i) Discussion with Mr. Chardon on wells drilled in San German.

(ii) Discussion with Mr. Robert B. Anders, USGS, San Juan.

(iii) Examination of logs of wells (Fig. 2) in the San German area.

From the above information it is concluded that wells in the alluvium, close to the Rio Guanajibo would be expected to yield about 400 gpm. Such wells could be drilled close to the river and at locations (a) southeast of DEC property as suggested by Geological Services of Puerto Rico, Inc. in their letter of May, 15 (appended to this report), and (b) west of DEC property, between Route 119 and the river. Comments under the previous section headed "Groundwater" apply to these locations.

Water Quality

Surface Water

The development of a new surface water source is unlikely. An analysis of the water supplied by PRASA is appended. It should be noted that because the supply is made up of varying proportions of treated surface water and groundwater there will be considerable variations in water quality.

Groundwater

Analyses of groundwater from PRASA wells and from DEC wells are not yet available but the following extract from a U.S. Geological Survey report is a general guide to the quality of groundwater which may be expected in the Rio Guanajibo valley.

		Minimum	Maximum
Dissolved solids	Milligrams/liter	250	425
Hardness, calcium and magnesium	"	178	380
Chloride, Cl	"	17	64
Sulfate, SO_4	"	9.9	22
Silica, SiO_2	"	26	48
pH		7.3	8.1

Additional data are now being obtained.

RECOMMENDED DEVELOPMENT PROGRAM IN SAN GERMAN

General

It is clear from the foregoing data that PRASA is unable to meet any increase in demand from their existing water sources in San German. It is also clear that some quantity of water probably in excess of 1 mgd is available from the Rio Guanajibo, and that additional groundwater could be obtained from wells in the alluvium near to the Rio Guanajibo. Wells in the rock formation in DEC property are an unknown quantity but they could prove to be a reliable source of supply.

There are therefore three means by which the supply to DEC in San German could be supplemented:

1) By requesting PRASA to make additional water available.
2) By obtaining permission from PRASA to develop wells in either private or State land near the Rio Guanajibo.
3) By developing additional wells in DEC property.

These alternatives are discussed below.

Additional Water from PRASA

Several of the PRASA officials have expressed the opinion that a formal letter to PRASA requesting an additional water supply to the DEC Plant at San German would permit them to investigate the means by which this demand might be met. A reply to such an inquiry could be expected within two two to three weeks provided certain formalities were followed.

It is also apparent that funds for an extension of water supply facilities in San German to enable DEC's request to be met are not available, and PRASA would probably expect financial assistance from DEC and/or from the Puerto Rico Industrial Development Company (PRIDCO). A request to both authorities would therefore seem necessary. Officials of PRASA emphasized the advantage in having such a request delivered personally by a representative of DEC who would then discuss the requirements with the officials concerned and who may be asked to attend subsequent meetings on the subject. Information accompanying the request, in addition to the quantity of water required, should include the number of people to be employed, the total estimated investment, the type of project and proposed provisions for the disposal of wastes.

No precise information could be obtained regarding the type of assistance which could be expected from PRIDCO or the time which might be involved.

Construction of Wells by DEC

Regulations

As alternative to the above DEC could undertake the construction of wells in private or State land.

According to present regulations there are no restrictions on the construction of wells in privately owned property. This regulation will change in January, 1972 when it will be necessary to obtain permission from three agencies before drilling wells. These agencies are: the Environmental Quality Board, the Public Service Commission, the Depart-

ment of Public Works and PRASA. Well drilling in DEC property or in other privately owned property with a suitably negotiated agreement with the owner, could therefore proceed immediately.

The construction of wells in State land would require approval of the same three agencies.

Well Construction

There are three relatively large well drilling companies in Puerto Rico:

1) Julio N. Chardon and Sons, Inc.
2) Vivas Drilling Company
3) International Pollution Control

Geraghty and Miller, Groundwater Consultants, New York also have experience in the area and their advice in evaluating water potential may be of value if well drilling is to proceed.

Of the three local drilling companies, International Pollution Control are considered to be the most reliable. They operate percussion rigs only and do not have rotary equipment. Both of the other companies operate rotary and percussion equipment.

When employing local companies it is essential to prepare comprehensive contracts. Information from reliable sources suggests that for wells in unconsolidated formations where careful and correct well completion procedures are important, it is preferable to employ U.S.based drilling companies.

Screens are not available on the island. The usual practice is to use slotted casing having random slot sizes cut by a welding torch, this is not recommended. It is not possible to obtain all sizes of gravel for gravel packing wells and Garaghty and Millar have imported gravel for this purpose in the past, which is of course expensive. Wells in rock, similar to that on DEC property in San German, do not normally require gravel packing and may or may not require screens.

Recommended Program

It would clearly be advantageous for DEC to develop a water supply to which they have exclusive rights, provided this does not require DEC's involvement in operation and maintenance procedures remote from their plant. This could best be achieved by DEC developing wells within their own property, supplemented by water from wells developed and operated by PRASA to which DEC has exclusive rights or at least prior rights.

These factors, and the data or water resources previously discussed, suggest the following program of investigation and development. It is suggested that items 1 through 4 proceed simultaneously and as soon as possible.

1) Proceed with investigation of the existing DEC well to determine yield, water quality and type of aquifer.
2) Proceed with the construction of an additional well in DEC property following the foregoing recommendations regarding construction and testing procedures. Advise the Governmental agencies of the intention to drive a test well.

3) Immediately submit a request to PRASA and PRIDCO for additional water, in the terms outlined above.

4) Approach land owners in areas of good groundwater potential with a view to obtaining an agreement to (a) drive test wells and (b) construct and operate production wells, pipelines and associated equipment.

Estimated Costs

General

Estimates for wells to be completed in consolidated rock in DEC property are based on rates charged by Puerto Rico well drilling contractors. Estimates for wells completed in unconsolidated sands and gravels are calsulated from estimated rates charged by U.S. based drilling contractors. Estimates include an allowance for engineering and contingencies.

Cost of Wells in DEC Property

1) Drilling and test pumping one additional 6-in diameter test well in DEC property.	$ 7,000
2) Completion of two DEC wells including provision and installation of pumps, pipelines and miscellaneous equipment. Excluding power supply, water storage, water treatment.	$12,000
Total Cost of Wells in DEC Property	$19,000

Cost of Wells in Government or Private Land

Assume six 6-in diameter test wells, to an average depth of 60 ft, and two 16 inch diameter production wells. Include 1,000 ft pipelines and pumps.

Exclude power supply, water storage and treatment. Exclude easements or land purchase.

Test wells		$16,000
Production wells.		$45,000
Pumps including installation		$ 7,000
Pipelines		$20,000
	Total	$88,000

OTHER POTENTIAL WATER SUPPLY AREAS

General

The water supply systems of most of the larger towns within the designated area (south of a line through Aquadilla, Maricao and Ponce) were superficially examined. These towns and relevant water supply data are as follows:

Town/City	Design Capacity (mgd)	Dist. Res. Capacity (mg)	Source	Treat-ment	Average Day Demand (mgd)	Population (1970 Census)
Aguadilla	8.0	1.35	S	(1)	5.4	51,332
Aguada	*	0.10	S	(1)	---	25,166
Moca	*	---	S	(1)	---	
Rincon	0.94	0.34	W	(2)	0.29	9,350
Anasco	0.5	0.10	W	(1)	0.61	19,296
Mayaguez	13.0	2.90	S	(1)	12.06	86,267
Cabo Rojo	2.3	0.42	W	(2)	1.50	10,803
Hormigueros	0.4	0.16	W	(2)	0.55	28.569
San German	1.47	0.73	S & W	(1)	1.47	27,769
Sabana Grande	0.7	0.26	S	(1)	0.72	16,301
Yauco	1.6	0.54	S	(1)	1.32	35,090
Guayanilla	0.79	0.17	W	(2)	0.85	18,074
Guanica	0.58	0.10	W	(2)	0.67	14,433
Penuelas	0.5	0.52	S	(1)	0.67	14,910
Ponce	14.0	5.17	S	(1)	11.30	156,498
Lajas	1.0	0.57	S	(1)	---	---

See Footnote on following page.

* Supplied from Aguadilla

(1) Sedimentation, Filtration, Chlorination and Fluoridation.

(2) Chlorination & Fluoridation.

S Surface Water.

W Well Water.

With the possible exception of Rincon it can be seen that the present water supply facilities are barely adequate to meet water demands. It should be noted that the water demands quoted in the above table are average day figures; maximum day demands, which the facilities are required to supply, are about 1.5 to 2.0 times the figure shown.

The full commitment of existing water supply facilities was generally confirmed by inquiries with PRASA officials who also stated that there were only two planned developments of water supply facilities, the Mayaguez/Anasco supply and the TOA VACA project.

The Mayaguez-Anesco Supply:

Proposed Improvements by PRASA

Anasco is at present supplied entirely from wells. Additional wells designed to provide for Anasco's increasing demand were found to be high in chlorides. PRASA therefore decided to meet Anasco's increasing water demand by conveying water from Mayaguez. It was planned that a suitable sized pipeline between Mayaguez and Anesco would also enable water to be supplied to industry in the Anesco area.

The proposed construction of a regional sewage treatment plant near Mayaguez was considered a further attraction for industry.

The pipeline from Mayaguez to Anasco in now under construction and is expected to be completed within one year.

Quantity of Water Available For Industry

It is not planned to expand water supply and treatment facilities, in order to meet water demands from industry and Anasco. There are two existing water treatment plants in Mayaguez, the "old" plant, capacity 3 mgd and Miradero plant, capacity 10 mgd, which draws water from the Rio Anasco. During 1970/71 this plant operated at its full capacity calculated at filtration rates of 2g/sq ft/min.

PRASA considers that the plant output can be increased by raising operating rates, to make available the water required for Anasco plus 1 mgd for industry.

No commitments to supply water to industry have been made by PRASA, although it is reported that one established industrial company will require water to replace their own failing well supply.

Some optimism was expressed by PRASA officials regarding the water supply of 800,000 gpd to DEC from this proposed pipeline pacticularly in the vicinity of Puerto Rico Rd 2 between Mayaguez and Anasco.[1]

1 El Mani Industrial Area: Owner Miguel A. Garcia Mendez;
Planners Sacmag of San Juan; 9 lots each 10 acres.

Quality of Water

An analysis of treated water from Mayaguez treatment plant is appended to this report. The water quality is good and could be used for most purposes without further treatment.

Estimated Cost of Water

PRASA has stipulated that industries requiring water from the Mayaguez-Anasco pipeline must construct a storage tank having a capacity at least equivalent to the average day demand of the industry.

Industries will also be required to contribute to the cost of the project on the basis $100 for each equivalent residential unit using 400 gpd. This would amount to $200,000 in the case of an industry requiring 800,000 gpd. This sum would, however, be "negotiable". In addition; standard rates would be charged for water, this would amount to about $320 per day.

Penuelas-Tallaboa

The Toa Vaca Project

This is a large, long term water supply project designed in five stages. Stage one is scheduled for completion in June 1972 and will make available about 9 mgd for industrial use in the Penuelas-Tallaboa area (Figure 1). Stage 2 will be constructed in about 1980.

The source of water in the Toa Vaca project is provided by a dam which impounds 55,000 acre ft of water. The initial yield is 23 mgd and the ultimate yield 250 mgd. Irrigation requirements account for 14 mgd of the 23 mgd and the remainder, 9 mgd is available for other uses.

Quantity of Water Available to Industry

Water from Toa Vaca dam will supply 9 mgd the water treatment plant of Ponce. This plant is at present supplied with about 8 to 9 mgd from Lake Garzas. The water from Lake Garzas will be available for use by industry after completion of the Toa Vaca project and a pipeline from the existing line to the industrial area, at[2] Penuelas. (Figure 1). It is estimated that the last component to be constructed, that is the pipeline to the industrial area; should be completed by the end of 1971 or early 1972.

A plan of the proposed pipeline route is available if required.

Water Quality

The water available to industry will be raw water from Lake Garzas. This water is at present supplied to one of the treatment plants at Ponce. An analysis of the water was not immediately available in PRASA records but is being obtained by other means.

Estimated Cost of Water

The charges for raw water made available under this project are being studied[3]. It is estimated by PRASA that charges for raw water will be about 10c per cubic meter, that is about 38 cents per 1000 gallons or $324 per day.

2 Industrial Area-Finca Valdivieso

3 By Buck Seifer and Jost, New Jersey.

UNDEVELOPED GROUNDWATER AREAS

Guanajibo Valley and Sabana Grande

Discussion with the USGS Department in San Juan and a superficial review of USGS reports, indicate that good groundwater potential exists in the Guanajibo Valley between San German and Hormigueros. There is also some groundwater in the Sabana Grande area but, as with the Guanajibo Valley, a number of wells may be necessary because aquifers consisting of sands and gravels have relatively poor transmissibility. Recharge in these areas is good.

Cabo Rojo

It is reported that the largest volumes of groundwater occur in limestone formations located about 1 mile to the north east of Cabo Rojo. PRASA have some wells in this area, and specific capacity of these wells is 75 gpm/ft. The limestone aquifes here is reported to be thick and relatively pure, offering excellent conditions for high groundwater yields.

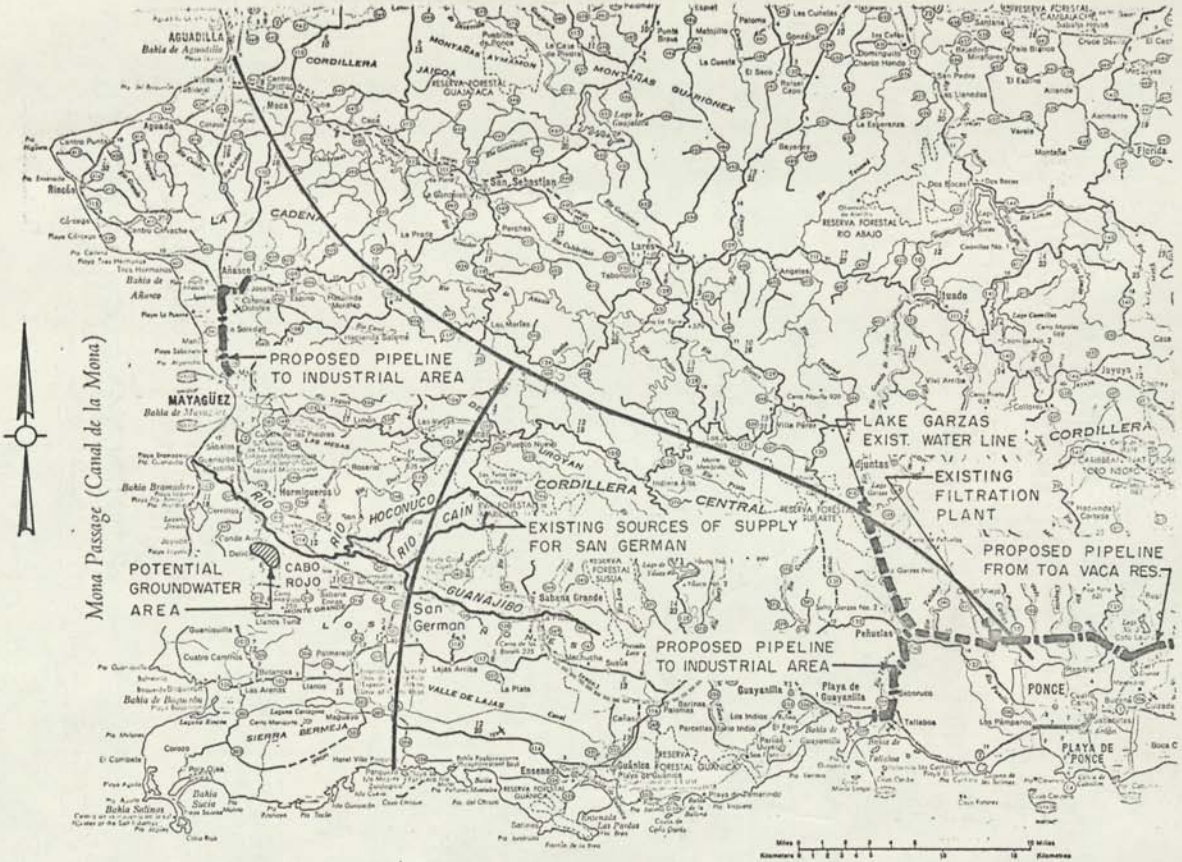


FIGURE I - EXISTING AND POTENTIAL WATER SOURCES

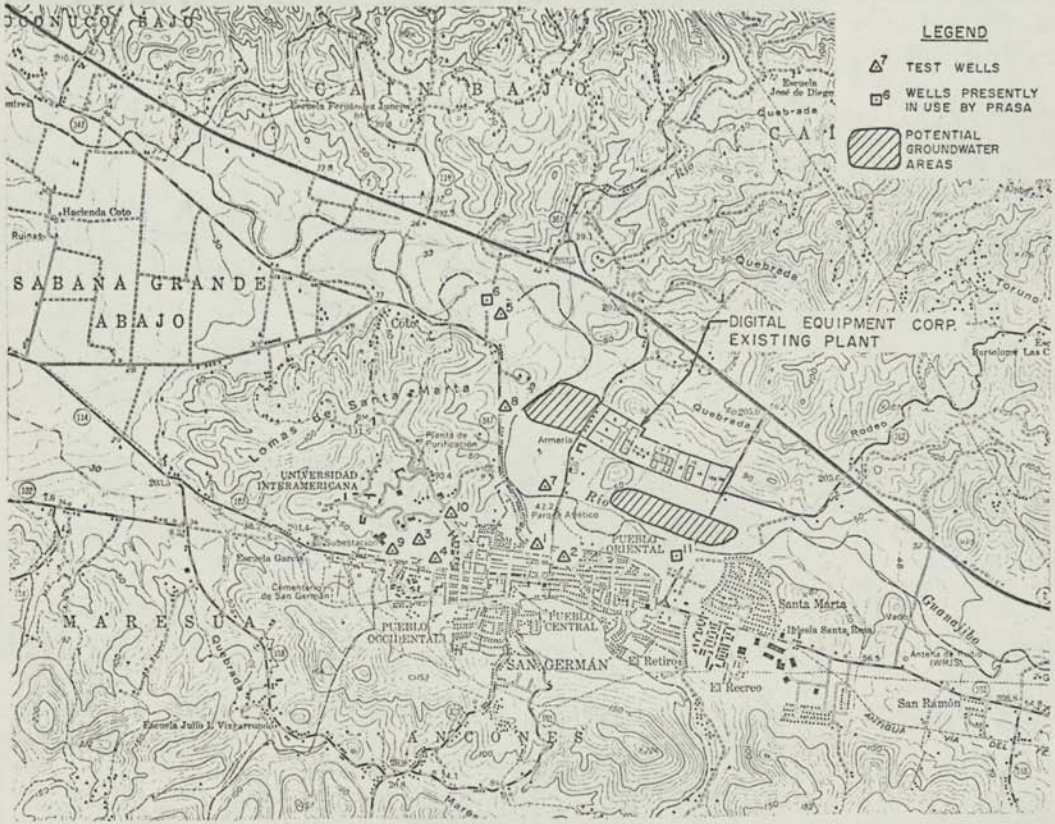
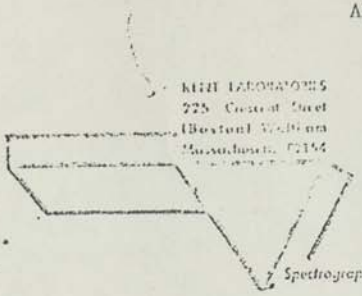


FIGURE 2 - GROUNDWATER SOURCES IN SAN GERMAN

APPENDICES

1. Analysis of Treated Water - San German.
2. Logs of Wells in San German - USGS.
3. Reconnaissance of the Water Resources of the Guanajibo Valley, Cabo Rojo, Puerto Rico, by R.B. Anders, USGS.
4. Letter from Geological Services of Puerto Rico Inc. dated May 15, 1971.
5. Analysis of Treated Water at Mayaguez
6. Analysis of Treated Water at Ponce.

APPENDIX 1



KEIL LABORATORIES
225 Central Street
(Boston Suburban)
Massachusetts 02154

Spectrographic and Chemical Analytical Services . (617) 891-7989

Laboratory No. A-2043

September 18, 1970

Order No. 351269

Digital Equipment Corporation
Thompson Street
PTE Building No. 7-1
Maynard, Massachusetts

Attention: Mr. ronald Calabro

Concerning: Analysis of Water from San Corman

Results:

Total Solids = 122.5 ppm

Ash. = 114.5 ppm

Total Hardness = 139 ppm $CaCO_3$

Na = 19.1 ppm $CaCO_3$

Fe = 0.075 ppm $CaCO_3$

K = 0.77 ppm $CaCO_3$

Silica = 0.75 ppm $CaCO_3$

Mn = 0.0073 ppm $CaCO_3$

Carbonic Acid = 23 ppm $CaCO_3$
Carbonate (CO_3^{--}) = 0.5 ppm $CaCO_3$
Bicarbonate (HCO_3^{-}) = 309 ppm $CaCO_3$

pH = 7.60

Alkalinity = 100 ppm $CaCO_3$

Chlorides = 48.5 ppm $CaCO_3$

Nitrates < 1 ppm

Sulphates = 7.0 ppm $CaCO_3$

Fluorides < 1 ppm

Tubidity < 2 units

Color ≅ 30 units

Other elements:

	ppm
Al	0.30
Cu	0.018
Ag	0.047
Pb	0.032
Ba	0.009
Sr	0.080
Cr	0.021
Ni	0.0075

Rockwell Kent III

LOGS OF WELLS IN SAN GERMAN

From U.S.G.S., SAN JUAN:

Location-See Map Appended (Figure 2).

No. 6 Acueductos well

Yield 340 gpm, drawdown 16 ft.

Transmissibility 12000.

Screens: 0-10 ft solid casing, 20 in diameter.

10 ft - 40 ft screened

Remarks: Aquifer depth 30 ft, extracts water from river.

No. 7 Drilled by Viva's Drilling Company

Very low yield, subsequently abandoned.

Log:

0-3	topsoil
3-7	sand
7-12	clay, brown with some rock
12-15	clay, brown with some rock
15-19	clay, yellow
19-24	broken rock and clay, yellow ("tosca")
24-29	clay with streaks of color
29-37	clay with streaks of color
37-40	broken rock and clay, grey
40-73	serpenline

No. 8 Drilled by Vivas in 1961

Yield 60 gpm

Logs: Not Available

No. 11 Acueductos well.

Yield 750 gpm, drawdown 24 ft.

Transmissibility: Not determined.

Screens: Not recorded

Log:

0-6	topsoil
6-10	boulders
10-30	brown limestone with boulders
30-100	hard blue rock

Remarks: Water is obtained between 6 ft and 30 ft. The "blue limestone" cannot be limestone according to the USGS geologist.

APPENDIX 3

Open-File Report 2

RECONNAISSANCE OF THE WATER RESOURCES OF THE CENTRAL GUANAJIBO VALLEY, CABO ROJO, PUERTO RICO

by

Robert B. Anders

U. S. Geological Survey

Prepared in cooperation

with the Commonwealth of Puerto Rico

1958

Summary

An estimated annual minimum of 25,000 acre-feet of surface water flows past Hormigueros in Río Guanajibo. Daily discharge exceeded 30 cubic feet per second (19 mgd) 80 percent of the time.

Dry-season flow measured in the principal tributaries to Río Guanajibo between San Germán and Hormigueros since 1959, ranged from 0.7 to 26.4 cfs.

The principal ground-water aquifers, in Río Guanajibo valley between San Germán and Hormigueros, are the alluvium and underlying limestone.

About 40,000 acre-feet of ground water is in transient storage in the valley above a depth of 200 feet.

Maximum specific capacities and well yields occur in the western part of the valley where the limestone exceeds 100 feet in thickness. Maximum specific capacity and discharge of wells in limestone are 75 gpm/ft and 1,500 gpm, respectively. Maximum specific capacity and discharge of wells in alluvium are 65 gpm/ft and 400 gpm, respectively.

Wells in volcanic rock in the adjacent hills usually yield less than 10 gpm.

Ground-water use in 1966 was less than 4 million gallons per day (4,500 acre-feet per year).

Both surface and ground water are suitable for domestic, agricultural, and most industrial uses.

CONTENTS

TABLES

ILLUSTRATIONS

Physical setting

The central Guanajibo valley is a 16 square-mile flood plain lying about 8 miles southeast of Mayaguez (fig. 1). The valley is bounded by hills on the north and south and by water gaps less than a half mile wide near San Germán on the east and Hormigueros on the west.

The hills flanking the valley are composed of igneous and metamorphic rock with lesser amounts of limestone and shale.

The valley was once much deeper but has been filled with detrital clay, silt, sand, and gravel, and one or more beds of limestone. The detrital material was brought into the valley by the ancestral Río Guanajibo or by streams draining the adjacent hills.

The depth to the base of the alluvium is not known in most parts of the central Guanajibo valley, as most wells do not reach the underlying bedrock. In the parts of the valley where records are available, the thickness of the sand and gravel zones in the alluvium ranges from less than 1 foot to more than 30 feet.

The limestones underlie the alluvium and are more than 100 feet thick in the western part of the valley. They become thinner and less pure to the east and are not present where the valley is narrow near San Germán.

The valley receives an average annual rainfall of about 65 inches, according to the U. S. Weather Bureau station at Cabo Rojo. However, yearly rainfall varies appreciably, ranging during the period 1959-1966 from a low of about 37 inches in 1966 to a high of about 75 inches in 1965.

The central Guanajibo valley area contains 3 towns with an aggregate population of about 50,000. The main sources of income are from sugarcane production and processing and from light industry.

Hydrology

Surface water

Río Guanajibo and principal tributaries in the central Guanajibo valley are perennial. However, responding to changing climatic conditions, principally rainfall, streamflow ranges from very low flow in the smaller streams during droughts to several thousand cubic feet per second during floods in Río Guanajibo near Hormigueros.

The flow of Río Guanajibo near Hormigueros was measured monthly 1959-66. The discharge ranged from a minimum of 9 cfs (cubic feet per second) to a maximum of 756 cfs. The range of these measurements is shown in figure 2. The figure illustrates the wide range in discharge which may occur from year to year for any given month. The flow of the river responds primarily to rain that falls in the Sabana Grande and central Guanajibo valleys and the adjacent hills. Minimum flows occur in the period from January through April.

A duration curve for the discharge of Río Guanajibo near Hormigueros is given in figure 3. The curve is useful in estimating the percent of time a given flow may be equalled or exceeded and in obtaining some estimate of the magnitude of the average yearly discharge. The graph shows that about 90 percent, 80 percent, and 50 percent of the time the discharge of Río Guanajibo near Hormigueros equalled or exceeded, respectively, 22, 31, and 68 cfs. The 68 cfs (50,000 acre-ft/yr) approximates the average discharge for an average year. During dry years the average discharge was considerably less, possibly as low as 35 cfs (25,000 acre-ft/yr).

Table 1.—Dry-season discharge measurements of Río Guanajibo and tributary streams, 1959 through 1966.

Name and location	Discharge, cfs							
	Feb.1959	Mar. 1960	Feb. 1961	Feb. 1962	Mar. 1963	Mar. 1964	Feb. 1965	Apr. 1966
Río Guanajibo at San Germán	8.6	10.5	14.8	10.7	5.8	6.6	3.7	5.6
Río Hoconuco near Highway 2	—	8.3	10.9	4.1	0.7	2.1	1.4	1.4
Río Rosario at Highway 319 (Old Highway 103)	10.4	6.9	26.4	11.2	—	—	—	—
Río Rosario at Highway 2	—	—	—	—	7.8	13.0	8.5	14.2
Río Guanajibo at Highway 114 (Old Highway 2)	33.7	36.0	70.5	25.7	9.5	28.2	11.9	13.7

The low-lying flood plains of Río Guanajibo and its tributaries are subject to frequent floods. The floods are reported to drain very slowly and hence may provide an excellent opportunity to recharge the ground-water aquifers in this area.

The flow of the larger streams in the central Guanajibo valley has been measured at the sites shown in figure 4 in the early part of each year since 1959. During this part of the year, rainfall and river flow are generally at or near their yearly lows. These measurements are shown in table 1. Although many of the measurements were made when streamflow was small, they probably do not represent the minimum discharge.

Ground Water

Rainfall and frequent flooding of the alluvium in the central Guanajibo valley are the principal sources of recharge to the ground-water aquifer. A small amount of water, estimated at 50 acre-feet a year, passes underground through the San Germán narrows into the central valley.

A comparison of streamflow records, rainfall records for Cabo Rojo, and pan evaporation records at Lajas, located about 2 1/2 miles southwest of San Germán, indicates that the aquifer normally receives little or no recharge when monthly rainfall is less than 1.5 inches.

At present (1967), ground-water withdrawals in the central Guanajibo valley total about 4 mgd. Increased ground-water withdrawals, especially during extended periods of low rainfall, will lower ground-water levels and increase recharge by infiltration from the streams.

The amount of water which wells may be expected to yield in parts of the central Guanajibo valley is shown in figure 5. The most promising area is designated A. It lies north of Cabo Rojo where the limestone is thick and permeable and where the sustained yield of new wells should exceed 500 gpm.

In area A, 10 mgd is available to properly-spaced wells. Surrounding this part of the valley and extending through the San Germán and Hormigueros narrows is area B, in which wells may be expected to yield from 200 to 500 gpm. Wells in B obtain their water from sand, gravel, and limestone, or sand and gravel alone. The maximum yield of wells reported to derive their water exclusively from the sand and gravel was 400 gpm. Wells in the remaining parts of the valley, area C, are believed to yield less than 200 gpm. When using the map, it should be kept in mind that its reliability decreases with distance from the control points.

The yield of wells in the igneous rocks in the hills adjacent to the valley is generally less than 10 gpm.

Large quantities of water are believed to be available in the alluvium-filled valley. The sands, gravels, and limestone above a depth of 200 feet are estimated to contain 40,000 acre-feet of water in transient storage. The availability of this water to wells depends, among other things, upon aquifer characteristics, well-completion practices, and water levels.

The transmissibility of the sand and gravel and the limestone aquifers varies over a wide range. The transmissibility of the alluvial sands and gravels in the narrows near San Germán is in the order of magnitude of 10,000 gpd/ft (gallons per day per foot). Westward in the wider parts of the valley, transmissibility probably ranges from a few hundred or less to possibly more than 10,000 gpd/ft. The transmissibility of the limestone where it is thick and relatively pure, as in the area north of Cabo Rojo, is higher than 10,000 gpd/ft. The transmissibility progressively decreases toward the east, where the limestone is thin and contains larger amounts of silt and clay.

The yield of wells is directly related to specific capacity. The specific capacity of wells in the central Guanajibo valley ranged from less than 1 gpm/ft (gallon per minute per foot of drawdown) for an alluvial well about a mile southwest of Hormigueros, to 75 gpm/ft for 2 limestone wells about a mile northeast of Cabo Rojo. The maximum specific capacity in sands and gravels was about 65 gpm/ft, for 2 wells in the narrows near San Germán. The sands and gravels here are coarser and contain less clay than those underlying the wider parts of the valley.

Water levels in wells in the central Guanajibo valley are close to the surface. The deepest water level in any of the wells was 20 feet below the surface, and it was affected by pumping. A map showing the approximate altitude of the water table is shown in figure 6. The map shows that the principal direction of ground-water flow is westward toward the narrows near Hormigueros.

Quality of Water

The surface and ground water in the central Guanajibo valley generally is of good chemical quality and is suitable for domestic, irrigation, and many industrial needs.

Good-quality water is available in all streams in the central valley during times of low and high flow. The range in water-quality characteristics for flows from less than 1 cfs to over 500 cfs is given in the following table.

Table 2.—Surface-water quality characteristics

		Minimum	Maximum
Dissolved solids	Milligrams/liter	70	375
Hardness, calcium and magnesium	"	95	291
Chloride, Cl	"	4.5	21
Sulfate, SO_4	"	0.0	32
Silica, SiO_2	"	17	46
Nitrate, NO_3	"	0.0	4.4
pH		7.1	8.6

Although ground water of good quality is available in most areas of the central Guanajibo valley, its mineral content tends to be somewhat higher than that of the streams. In general, the ground water is suitable for public supply, irrigation, and many industrial uses. For comparative purposes, the range in some of the constituents of ground water is given in the following table.

Table 3.—Ground-water quality characteristics

		Minimum	Maximum
Dissolved solids	Milligrams/liter	250	425
Hardness, calcium and magnesium	"	178	380
Chloride, Cl	"	17	64
Sulfate, SO_4	"	9.9	22
Silica, SiO_2	"	26	48
pH		7.3	8.1

Notes on report

The purpose of this study was to give a preliminary evaluation of the water resources in the Río Guanajibo valley between San Germán and Hormigueros. The study consisted of compiling and analyzing the hydrologic data in the files of the U. S. Geological Survey, augmented by what data could be obtained in the field over a two-month period. The information consisted primarily of monthly and seasonal streamflow measurements, periodic ground-water level and well-discharge measurements, geologic maps, chemical analyses of ground and surface water, and interviews of people living or working in the area.

The study was made possible by the continuing agreement between the Commonwealth of Puerto Rico and the United States Geological Survey to conduct water-resources investigations, based on essentially equal amounts of funds contributed by the two principal parties. Commonwealth contributions came from these agencies:

Puerto Rico Legislative Assembly

Puerto Rico Water Resources Authority (PRWRA)

Puerto Rico Aqueduct & Sewer Authority (PRASA)

Puerto Rico Industrial Development Company (PRIDCO)

Many of the data used to arrive at the evaluations in this report are not included here. Additional information may be obtained from:

Water Resources Division
U. S. Geological Survey
San Juan, Puerto Rico

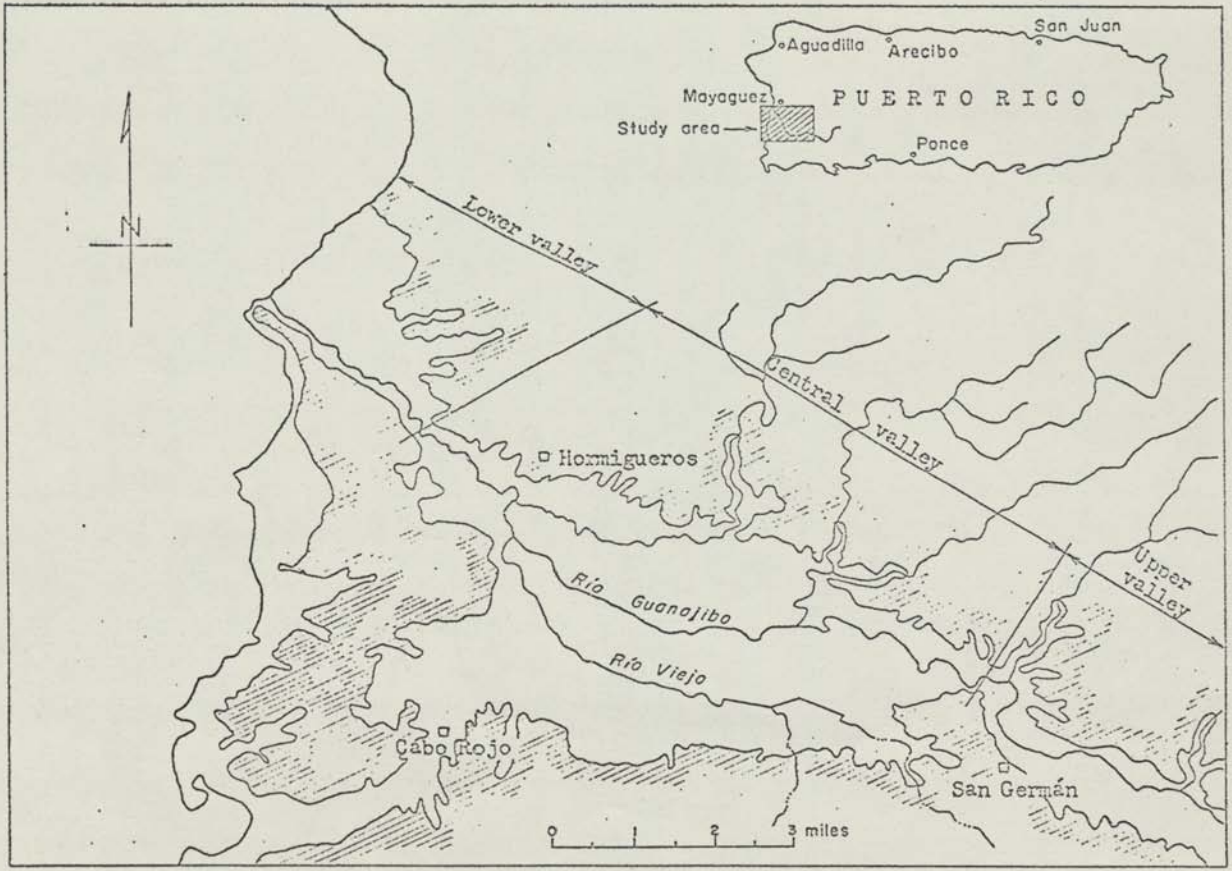


Figure 1.-- Location of study area.

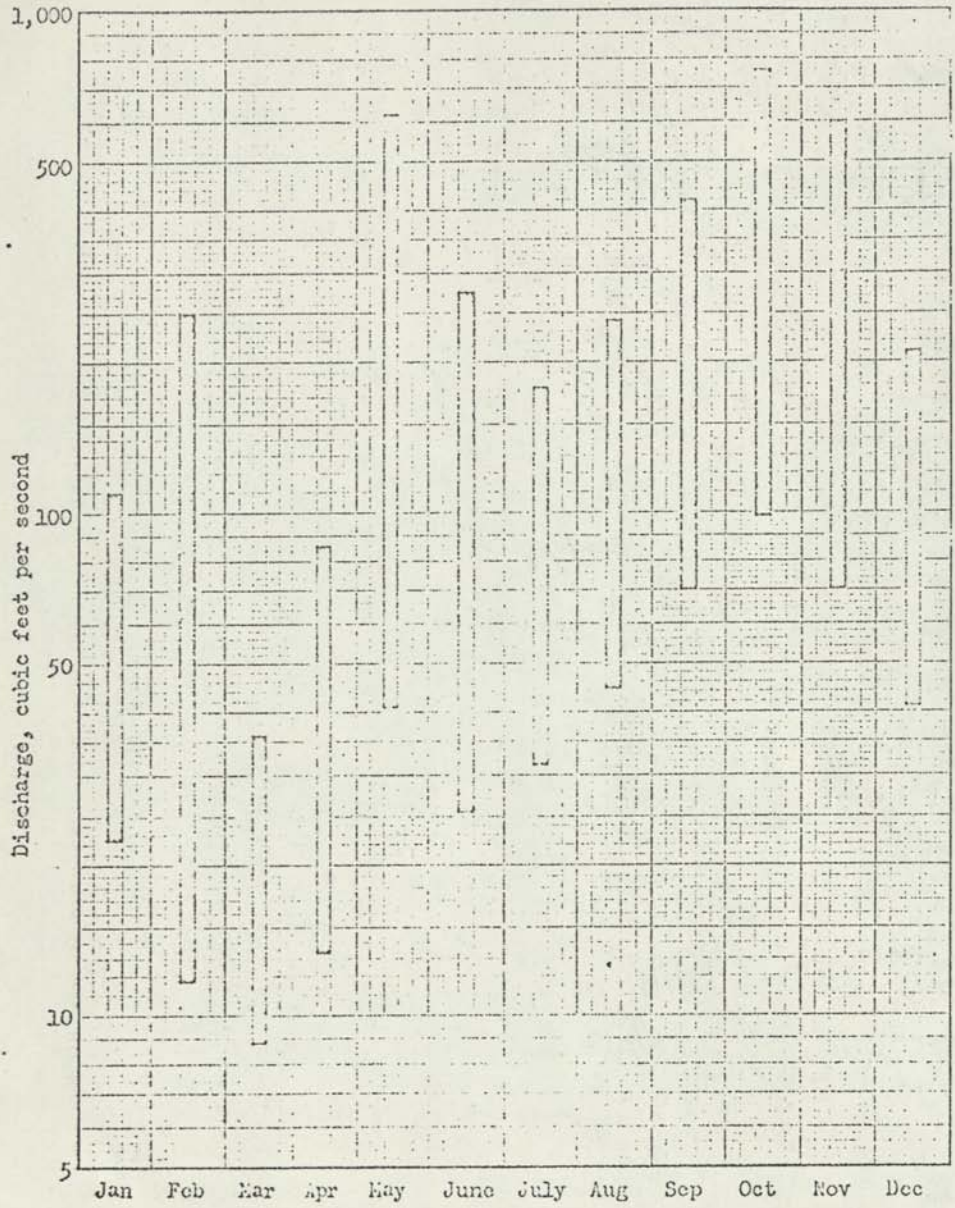


Figure 2.— Range of discharge, monthly measurements of Río Guanajibo near Hormigueros, 1959-66.

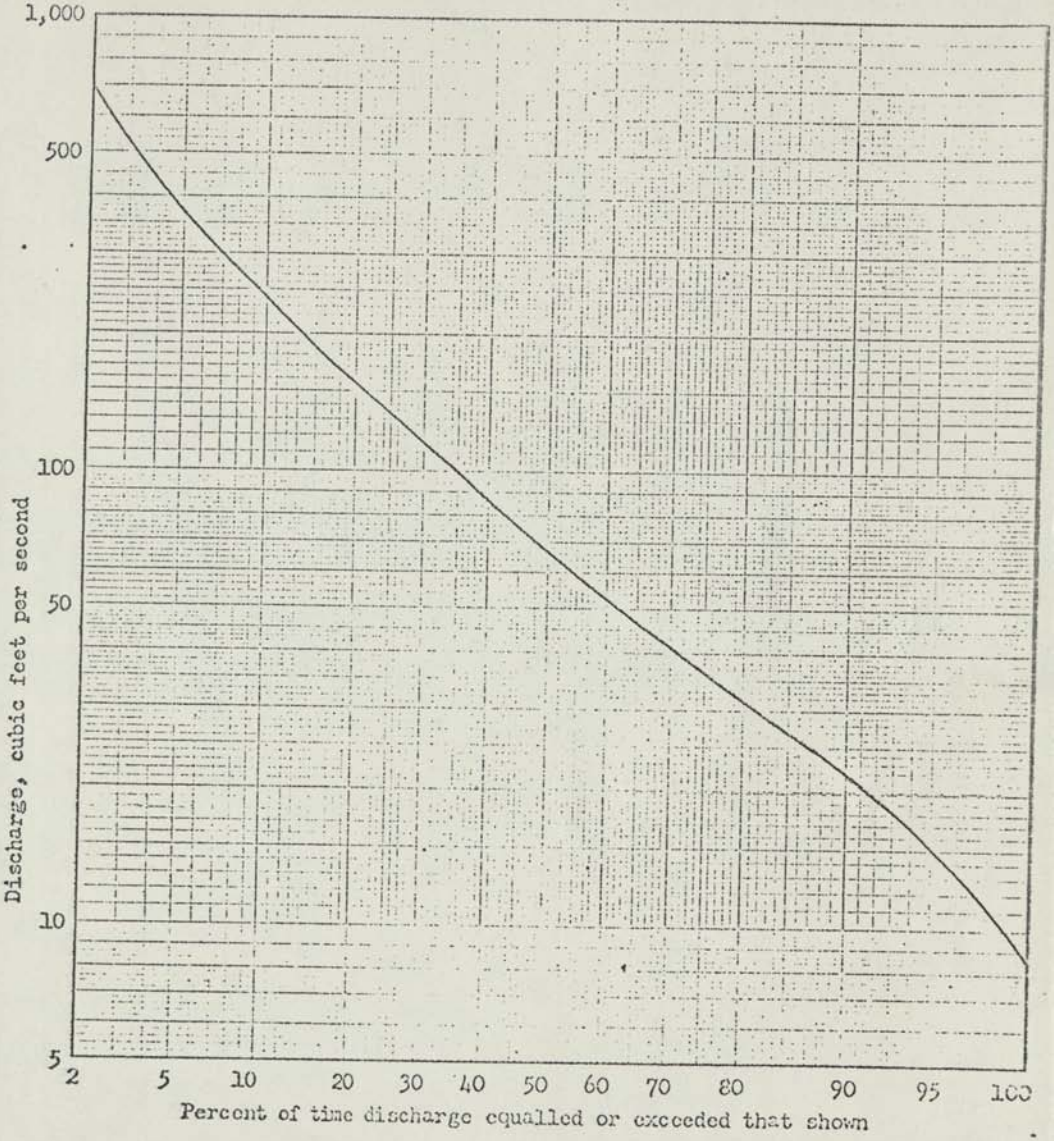


Figure 3.— Duration curve, monthly measurements of Río Guanajibo near Hormigueros, 1959-66.

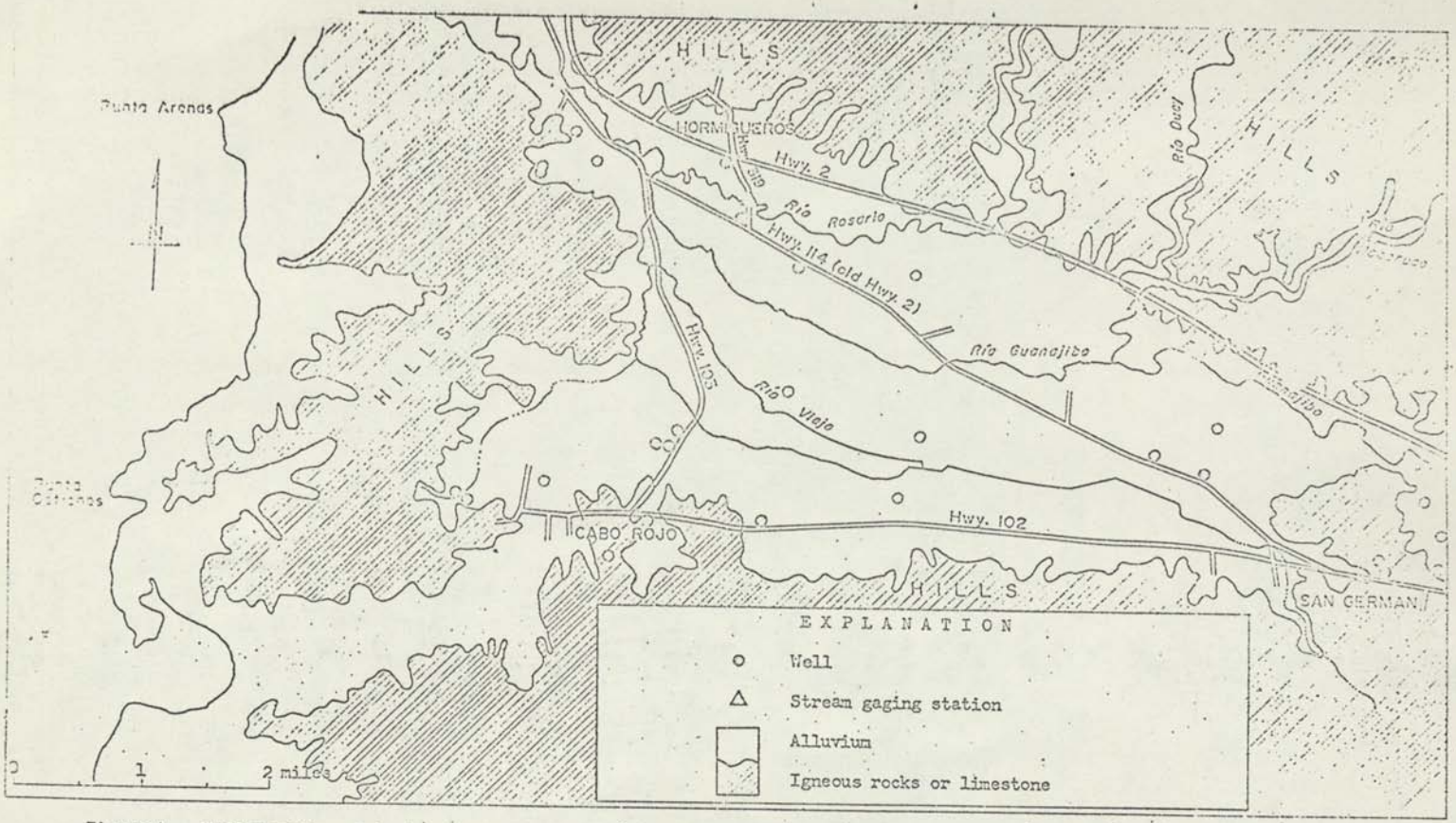


Figure 4.— Well locations and stream-measuring sites, Central Guanajibo valley.

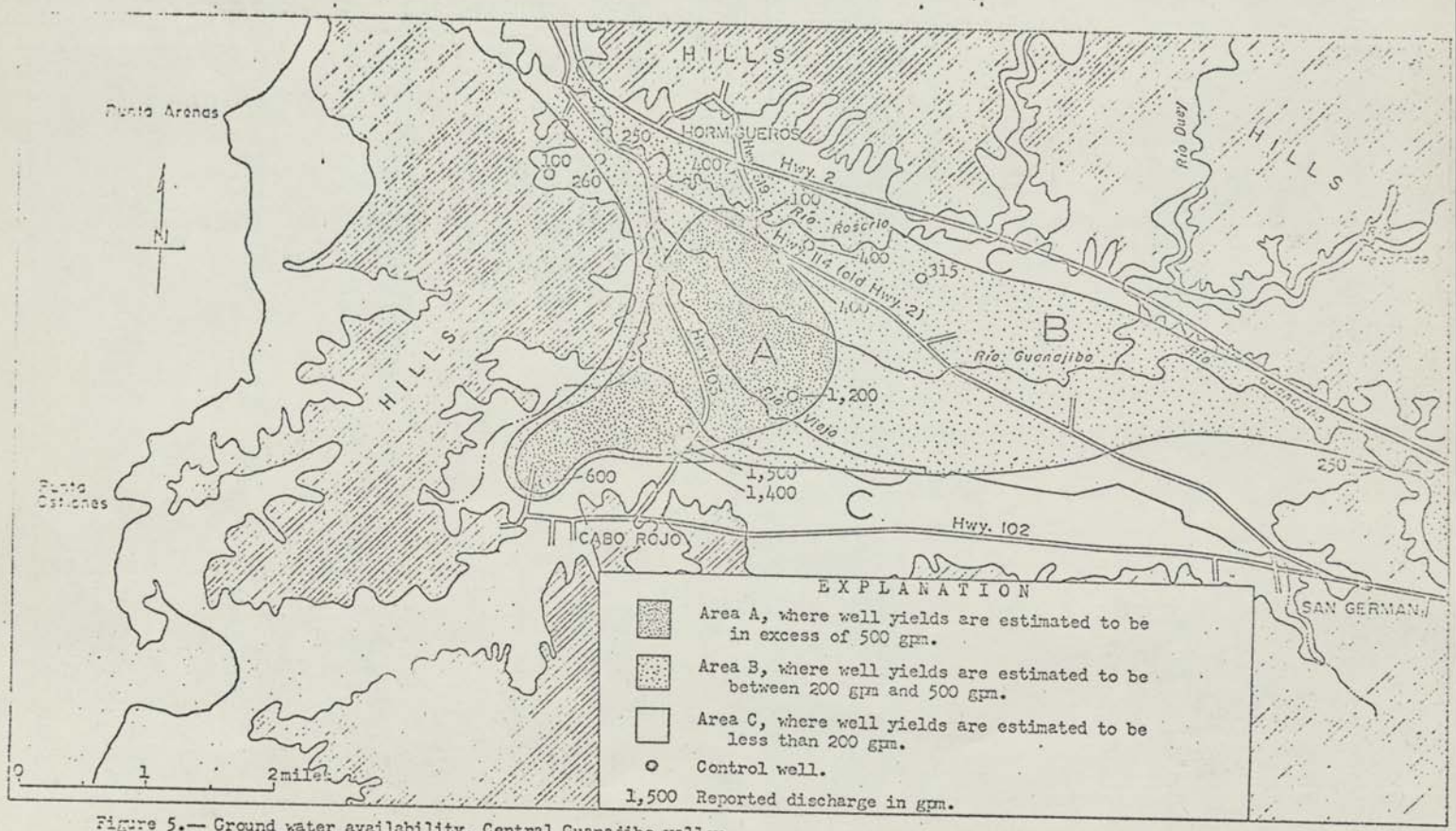


Figure 5.— Ground water availability, Central Guanajibo valley.

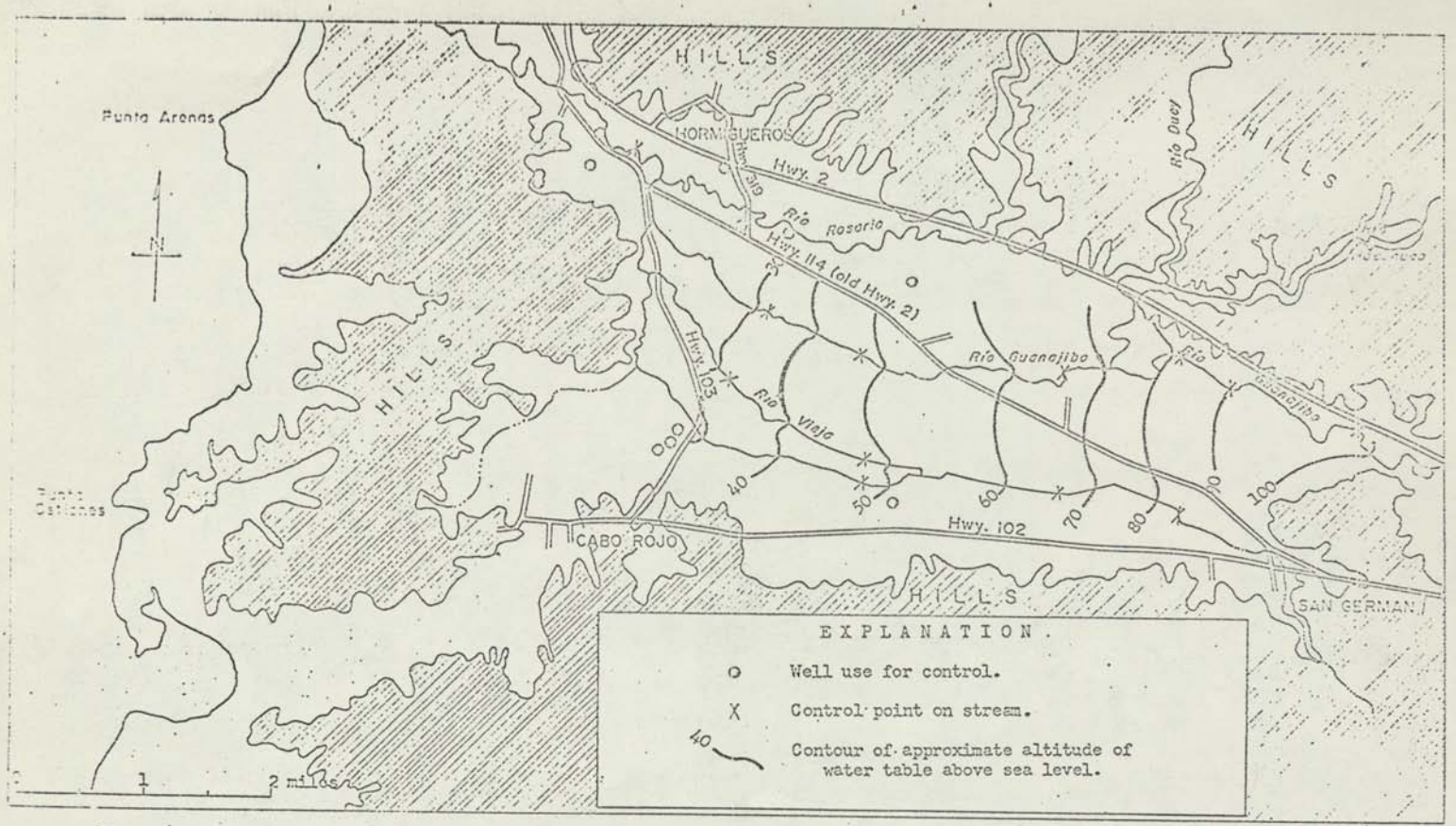


Figure 6.— Approximate altitude of the water table in the Central Guanajibo valley.

APPENDIX 4

Geological Services of Puerto Rico, Inc.

CONSULTING GEOLOGISTS

531-A Sergio Cuevas Bustamante St.

Hato Rey, Puerto Rico 00918

May 15, 1971

Mr. Ray Carlson,
Digital Equipment Corp.
Plant Engineering Dept.
146 Main Street
Maynard, Mass. 001752

Dear Mr. Carlson:

As you requested in your letter of April 13, 1971, a geologic survey was conducted of the property where the Digital Equipment Corp. plant is located at San Gorman, Puerto Rico in order to evaluate potential sites for a 300 gpm water well. The results of this study, pertinent information, and recommendations are discussed below:

Local Geology

Highly weathered impermeable andesitic rocks outcrop at the plant site, and at both southern and northern fringes of the adjacent Guanajibo River Valley. This rock contains a very tight fracture (joint) system which allows little or no movement of the ground water. The andesitic layers are rather thick and the occurence of permeable beds containing exploitable ground water resources is improbable.

Ground Water Conditions

The possibility of developing a 300 gpm well in the andesitic rocks is very remote. The very tight joint system and low permeability charactoristic of the rocks provide for hydrogeologically unimportant formations which at most can provide for only small quantities of water (10 gpm) or domestic wells.

A well at the General Electric plant which is producing between 60 and 75 gpm is located on the same type of formation, but its production is derived from intakes or percolation from adjacent creek through loose unconsolidated soils overlying the andesitic rock. Similar unfavorable conditions occur at the Digital's property without the recharge properties of the loose soils and the nearby creek. The property is too small for the construction of a battery of wells (series of wells).

Potential Ground Water Source

The mayor nearby aquifer is the floodplain sediments of the Guanajibo River Valley which consist of 50 to 60 feet of unconsolidated gravel and sand mixture

with some silt and clay. Due to the high permeability of this deposit, the water moves easily through the pore space between grains of the sediments maintaining the soil saturated with ground water even during dry periods.

Approximately 250 meters east of Digital's property, a well may be drilled on a suitable formation capable of yielding at least 400 gpm of potable water during the rainy season and about 300 gpm during the dry season. Water obtained from this site has to be pumped to the plant area by a pipeline built through the property belonging to "Lore Aggregates" which is located adjacent to the Guanajibo River and next to a strip of sugar cane terrain belonging to Mr. Ernesto Quiñones Zambolín (See location map).

Inquiries made at the just mentioned properties revealed that both owners are flexible enough to allow for a lease contract to locate a well and built a pipeline through their properties. This possibility provides the best alternative to the construction of a water well in the area.

We would like to express our appreciation to Mr. Peter Mackey, Plant Manager of Digital Equipment Corporation for showing us the property and answering our inquiry during the field survey of the area.

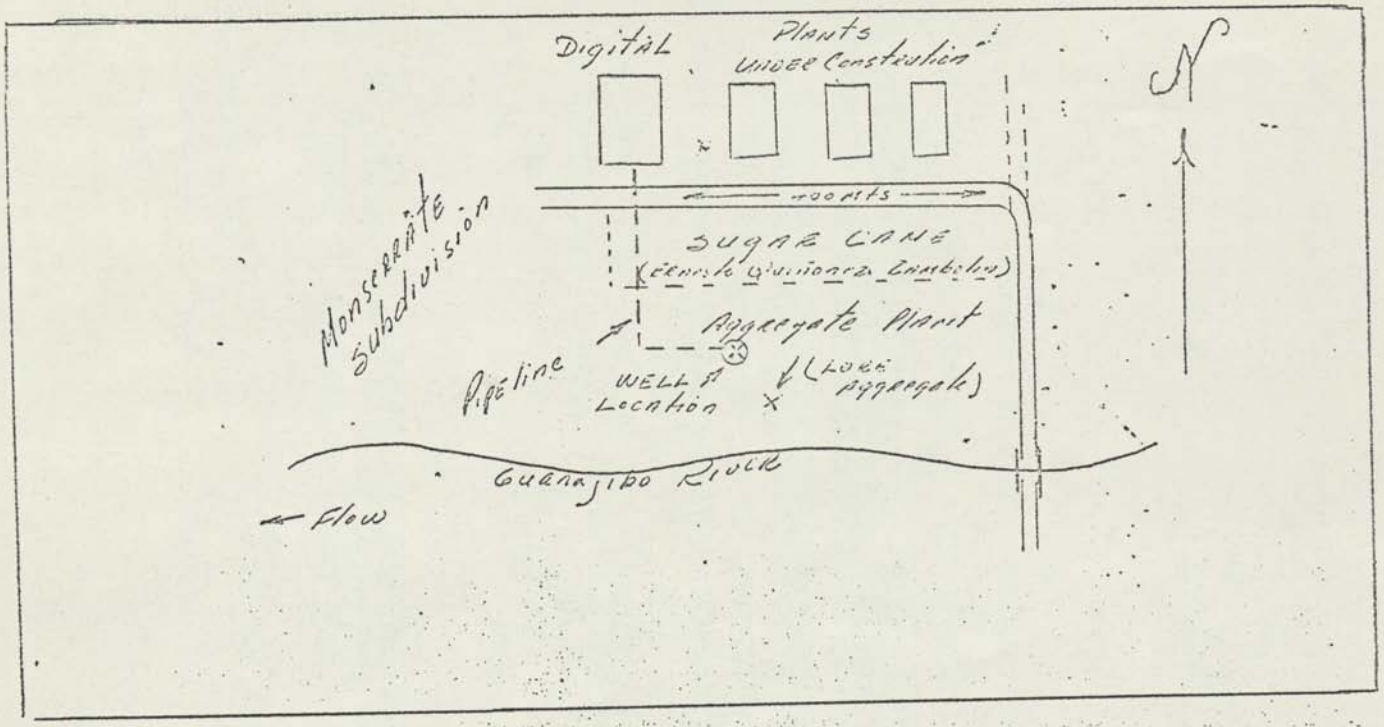
Please contact us, if you need any extra information or explanation of this report or any other doubts you may have concerned with this project.

Sincerely yours,

Mario Soriano Rossy

Mario Soriano Rossy
President

LOCATION MAP OF WELL SITE FOR DIGITAL EQUIPMENT CORPORATION



PUERTO RICO AQUEDUCT AND SEWER AUTHORITY
CENTRAL LABORATORY
PUERTO NUEVO

WATER ANALYSIS

LABORATORY NO. 3292

Sample from:
Town Mayoguez
Ward or St. Maradero
Place Rio Anasco-Canas

Collection:
By B. Morales
Date 7/6/71
Time

Type of Water:
Deep Well
Pto. Maradero Surface
Other

Analysis Requested:
By Div. Produccion
Analyzed
By Acesta-Ayala-Santiago

CHEMICAL CONSTITUENTS:	EXPRESSED AS:			LIMITS U.S.P.H.S. *	
Free Carbon Dioxide	CO_2	0	mg/l		
Dissolved Oxygen	O_2	--	mg/l		
Residual Chlorine	Cl_2	0	mg/l		
Calcium	Ca	28.8	mg/l		
Magnesium	Mg	6.8	mg/l		
Sodium and Potassium	Na	11.0	mg/l		
Total Iron	Fe	0.1	mg/l		0.3 mg/l
Dissolved Iron	Fe	.05	mg/l		
Manganese	Mn	0	mg/l		0.05 mg/l
Oxides	R_2O_3	--	mg/l		
Silica	SiO_2	19.0	mg/l		
Total Alkalinity	$CaCO_3$	74.0	mg/l		
Ph. Alkalinity	$CaCO_3$	0	mg/l		
Carbonate	CO_3	0	mg/l		
Bicarbonate	HCO_3	90.0	mg/l		
Sulfate	SO_4	30.4	mg/l		250 mg/l
Chloride	Cl	13.0	mg/l		250 mg/l
Nitrate	NO_3	0.65	mg/l		45 mg/l
Nitrite	NO_2	0	mg/l		
Fluoride	F	0.5	mg/l		1.0 mg/l
Phosphate	PO_4	0	mg/l		
Sulfide	S	0	mg/l		
Total Dissolved Solids ..... Residue at	103°C	137	mg/l		500 mg/l
Loss on Ignition ..... at	600°C	27	mg/l		

PHYSICAL CHARACTERISTICS:

Turbidity	SiO_2	Stds. 0	Units		5 Units
Color	Pt-Co	Stds. 0	Units		15 Units

OTHER DETERMINATIONS:

Total Hardness ..... 100.0 mg/l Noncarbonate Hardness 26.0 mg/l
Conductivity ..... 250 Micromhos
pH 8.10 Saturation pH 8.08 Saturation Index 0.02

Bacteriological Examination:

M. P. N. Per 100 ml (Coliform Group)

Maximum limits for drinking water established by the U.S. P. H. S. in 1962.

Chemical Engineer

WATER ANALYSIS

LABORATORY NO. 3059

Sample from:		Collection:		Type of Water:		Analysis Requested:
Town	Ponce	By	Hector L. Quiñones		Deep Well	By Div. de Produccion
Ward or St.		Date	8/11/70	X	Surface	Analyzed
Place Pta.	Filtros	Time			Other	By Santiago-Acosta-Aya

CHEMICAL CONSTITUENTS:	EXPRESSED AS:			LIMITS U.S.P.H.S. *
Free Carbon Dioxide	CO_2	10	mg/l	
Dissolved Oxygen	O_2	--	mg/l	
Residual Chlorine	Cl_2	--	mg/l	
Calcium	Ca	35.6	mg/l	
Magnesium	Mg	5.6	mg/l	
Sodium and Potassium	Na	14.5	mg/l	
Total Iron	Fe	0.1	mg/l	0.3 mg/l
Dissolved Iron	Fe	0.5	mg/l	
Manganese	Mn	0	mg/l	0.05 mg/l
Oxides	R_2O_3	--	mg/l	
Silica	SiO_2	19	mg/l	
Total Alkalinity	$CaCO_3$	86	mg/l	
Ph. Alkalinity	$CaCO_3$	0	mg/l	
Carbonate	CO_3	0	mg/l	
Bicarbonate	HCO_3	104	mg/l	
Sulfate	SO_4	36.3	mg/l	250 mg/l
Chloride	Cl	13	mg/l	250 mg/l
Nitrate	NO_3	1.8	mg/l	45 mg/l
Nitrite	NO_2	0.001	mg/l	
Fluoride	F	0.5	mg/l	1.0 mg/l
Phosphate	PO_4	0	mg/l	
Sulfide	S	0	mg/l	
Total Dissolved Solids .. Residue at	103°C	180	mg/l	500 mg/l
Loss on Ignition ..... at	600°C	49	mg/l	

PHYSICAL CHARACTERISTICS:

Turbidity	SiO_2	Stds.	0	Units	5 Units
Color	Pt-Co	Stds.	0	Units	15 Units

OTHER DETERMINATIONS:

Total Hardness ..... 112 mg/l Noncarbonate Hardness 26 mg/l

Conductivity ..... 295 Micrombos

pH 7.3 Saturation pH 7.45 Saturation Index - 0.15

Bacteriological Examination:

M. P. N. Per 100 ml (Coliform Group)

* Maximum limits for drinking water established by the U. S. P. H. S. in 1962

Chemical Engineer