ENGINEERING REPORT FOR PAIES WATER SUPPLY SYSTEM KITTI MUNICIPALITY, SECTION I, POHNPEI FEDERATED STATES OF MICRONESIA

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Special thanks must go to Mr Armen Thoses and Mr Dernel Panuel who provided essential information and guidance to facilitate the work and site investigations.

SUMMARY

The Paies water supply system is located in Kitti Municipality and has not been in operation for more than a year. It is a gravity system supplying approximately 90 people, and consists of a river intake, a storage tank, transmission lines and distribution lines servicing 11 households. The system has the capacity to connect the remaining 15 households within the community.

A desk hydrologic evaluation of the source shows that the safe yield is more than sufficient to meet the average daily demand of the whole community for the next 20 years, and the storage capacity available will cover the projected demand for two days. The pipe sizes of both the transmission and the distribution system are adequate to cover the demand for the next 20 years. A water quality investigation has not yet been conducted.

A physical inspection of the distribution system has revealed that there is a large break on the transmission pipeline, which is the direct cause of the system being out of operation.

A hydraulic analysis of the system has indicated that the pressure in the transmission line is too high for the type of pipe installed. This would account for the large number of breaks that have been occurring on the transmission line. Four options are identified to solve the problem.

It is strongly recommended that a slow sand filter be constructed to function both as a break pressure tank and as filter. Further rehabilitation and construction work needed is listed below in two phases according to priority.

Phase 1: Construct a slow sand filter, install the remaining 15 house connections, repair transmission and distribution pipelines, install 543 ft (166 m) of 3” diameter (80 mm) PVC pipeline.	US$ 27,250
Phase 2: Rehabilitate storage tank and chlorination unit	To be determined

INTRODUCTION

An engineering assessment of the Paies water supply system on Pohnpei, Federated States of Micronesia was carried out in January 1996 as part of SOPAC's Work Program.

It was carried out in response to a request made by Senator Wagner M. Lawrence to the Office of Planning and Statistics, for technical assistance for the improvement of infrastructural facilities in the municipalities of Kitti and Madolenihmw.

The Paies system is located in Section I in Kitti Municipality (Figure 1). The system covers approximately 210 people. The system has not been in operation for more than a year. The system is presently covering 11 houses, but there is an additional 15 houses in the community that need to be connected.

INVENTORY OF THE SYSTEM

The system, which is a gravity system consists of a river intake, a screening box, a storage tank, a chlorination unit, 6" diameter (150 mm) galvanised iron, 3" diameter (80 mm) GI/PVC transmission pipelines and 4" diameter (100 mm) PVC distribution pipelines.

The river intake is located at an elevation of 743 ft (226 m) above mean sea level. The intake area has a tendency to fill up with gravel and stones brought down by the stream and the leaf racks in front of the intake get clogged up with leaves. The intake needs cleaning on a regular basis.

The screening box is located at an elevation of 738 ft (225 m) approximately 120 ft (37 m) from the intake. The dimensions of the box are: width 5 ft (1.5 m), depth 10 ft (3 m) and height 5 ft (1.5 m), with a 6" diameter (150 mm) GI inlet (from the intake) and a 3" diameter (80 mm) outlet. The material used in the screening box is gravel and stones. Two 3" diameter (80 mm) gatevalves need replacement.

The transmission line from the dam to the tank has a total length of 3,277 ft (1,000 m) and consists of 1,921 ft (586 m) of 3" diameter (80 mm) GI and 1,356 ft (414 m) of 3" diameter (80 mm) PVC. Upon inspection of the transmission line a break was found at the connection of the GI pipe to the PVC pipeline which accounts for there being no water in the system. Although houses are not supposed to be connected to the transmission line, two houses are being supplied.

The rectangular concrete storage tank has a capacity of 60,000 gallons (230 cubic metres) and is located within a fenced area. Both the inlet and the outlet pipes are located at the bottom of the tank. At the time of inspection the tank was empty and had been so for quite some time. It was therefore not possible to determine whether it was watertight.
The chlorination unit is located just before the storage tank within the fenced area. The unit uses hypochlorite solution as the chlorination agent. As the system has not been in operation for some time the chlorination unit was not in use. An overall inspection of the unit needs to be done once the system is back in operation.

The distribution system consists of 2,980 ft (908 m) of 4" diameter (100 mm) PVC pipes. The layout of the system is as shown in Figure 2. At present 9 houses are hooked up to the distribution system. All pipes are buried, with river crossings using GI pipes. As there was no water in the system at the time it was not possible to determine whether there were any leaks in the system.

ANALYSIS OF THE SYSTEM

Water demand

The daily water consumption has been estimated as follows:

	gpd (lpd)
Domestic water consumption (per person)	110 (416)
Pigs (per pig)	30 (114)
Poultry (per 100 chickens)	10 (38)

gpd = gallons per day; lpd = litres per day

According to the Federated States of Micronesia (FSM) - Second National Development Plan, the national population growth rate over the last forty years has exceeded 3 % per annum. However, as people have a tendency to move from the rural areas to the urban areas, as well

as leave the FSM, the annual growth rate for the next 10 years (1994-2004) has been estimated at 2 %, while the growth rate for the years 2004-2014 has been estimated at 1 %. For the Paies system the projected population and daily water demand for a twenty year period is as follows:

Year	**1994**	**2004**	**2014**
Population	210	256	283
Domestic water demand	23,100 gpd (87,443)	28,160 gpd (106,597 lpd)	31,130 gpd (117,840 lpd)
Livestock	3,900 gpd (14,763 lpd)	4,754 gpd (17,996 lpd)	5,251 gpd (19,877 lpd)
Total	**27,000 (102,206 lpd)**	**32,914 gpd (124,593 lpd)**	**36,381 gpd (137,717 lpd)**

gpd = gallons per day; lpd = litres per day

Water Supply

With the dam located at an elevation of 743 ft (226 m), the catchment area covers approximately 0.098 sq. miles (0.25 sq. km) as shown in Figure 1.

Based on the USGS report "Water Resources of Pohnpei, Caroline Islands" a figure of 1.5 cubic feet per second per square mile has been used as a basis for estimating the 30-day low flow under a 5-year drought condition. This results in a safe yield of 95,015 gpd (359,670 lpd), which is more than sufficient to cover the average daily water demand of the Paies system for the next twenty years. The storage tank with a storage capacity of 60,000 gallons (230 cubic metres) will supply the average demand for about two days.

Water quality

No water quality investigation was conducted at the present intake. It is recommended that water quality tests be conducted as soon as possible. The water quality tests that should be conducted are faecal and total coliform bacteria, nitrate, pH, conductivity and turbidity.

Transmission and distribution system

The hydraulic analysis of the transmission line indicates that the pressure in the pipes becomes too high (Table 1 and Figure 2). The static pressure in the transmission line just before the storage tank is 166 psi (383 ft). This pressure is too high as the pipes are pressure class 150 psi (347 ft). This would account for the large number of breaks that have been occurring on the transmission line. To solve this problem there are several options available:

1. Replace the 3" diameter (80 mm) PVC pipeline with 3" diameter (80 mm) GI pipes which are of a higher pressure class. This would consist of the installation of approximately 1,356 ft (414 m) of 3" diameter (80 mm) GI The estimated cost is US$ 10,000.

2. Install a pressure release valve. This would reduce the pressure in the PVC pipeline to an acceptable level. However, as pressure release valves tend to need more maintenance and repairs this would not be the most appropriate solution. Estimated cost US$ 4,000.

3. Construct a break pressure tank. This would consist of the construction of a 1,000 gallon (4 cubic metres) capacity tank at elevation 528 ft (161 m) above mean sea level, approximately 1,921 ft (586 m) from the intake. This would reduce the pressure in the PVC pipeline to an acceptable level. However, if at a later date a slow sand filter was to be constructed, for the purpose of improving the water quality the break pressure tank would be made redundant. The estimated cost is US$ 4,000.

4. Construct a slow sand filter. This would consist of the construction of a slow sand filter at tank at an elevation of 528 ft (161 m) above mean sea level, approximately 1,921 ft (586 m) from the intake. The construction of a slow sand filter would not only reduce the pressure in the pipelines to an acceptable level, it would also improve the water quality. Estimated cost US$ 25,000.

Based on the above mentioned options, the most appropriate option to deal with the high pressures would be to replace the 3" diameter (80 mm) PVC pipes with 3" diameter (80 mm) GI pipes. However, as it is assumed that a slow sand filter would need to be constructed to improve the water quality, it would not be cost efficient to replace the pipelines as well. Based on these considerations it is evident that the construction of a slow sand filter would be the most appropriate long term solution.

When the system is back in operation it will be necessary to inspect/test the transmission and distribution pipelines, and perform any repair works that might be necessary.

An analysis of the system including the proposed slow sand filter (see Tables 1 - 4 and Figures 2 - 5) shows that the present pipe sizes of both the transmission and the distribution system are adequate to cover the demand for the next 20 years.

It must be noted that as the system has been overdesigned, based on the number of households being served, a large amount of water will flow through the system. With the current layout of the system a total of approximately 15,000 gph (56,781 lph) could flow in the transmission line to the tank. To avoid a serious overflow at the tank it is necessary to install a float valve, or as an alternative throttle the valve on the inlet of the tank.

RECOMMENDATIONS

It is strongly recommended that a slow sand filter be constructed at an elevation of 528 ft (161 m) as the current high pressure in the transmission line will continue to cause breaks in the pipeline. The hydraulic analysis of the system show that the main reason for the present problems with the system are due to the extremely high pressure in the pipeline from the intake to the storage tank. It will be necessary to throttle the valve on the inlet to the filter to restrict the flow through the filter.

As the first phase of rehabilitating the system it is recommended that in addition to constructing a slow sand filter and testing and repairing the existing transmission and distribution pipelines, the 15 houses that are presently not being supplied by the system be connected to the distribution system. Furthermore, the system needs to be extended by 543 ft (166 m) of 3" diameter (80 mm) PVC to cover the entire community.

Phase two works would be to inspect and test both the storage tank and the chlorination unit and perform any rehabilitation work that might be necessary. It is essential that a caretaker be appointed to operate and maintain the system. This is especially important when the chlorination unit is put back into operation. It is suggested that, if possible Mr. Armen Thoses be appointed caretaker as he already has some knowledge of the system and as his house is located right next to the storage tank and chlorination unit.

The phasing of the works and the cost estimates are given below.

Phase 1

Description of work	Estimated cost
Construct a slow sand filter	US$ 25,000
15 House connections.	US$ 700
Repair of transmission and distribution pipelines	US$ 1,000
Construct 543 ft. (166 m) of 3” diameter (80 mm) PVC	US$ 550
Total	**US$ 27,250**

Phase 2

Description of work	Estimated cost
Rehabilitate storage tank	To be determined
Rehabilitate chlorination unit	To be determined
Total	**To be determined**

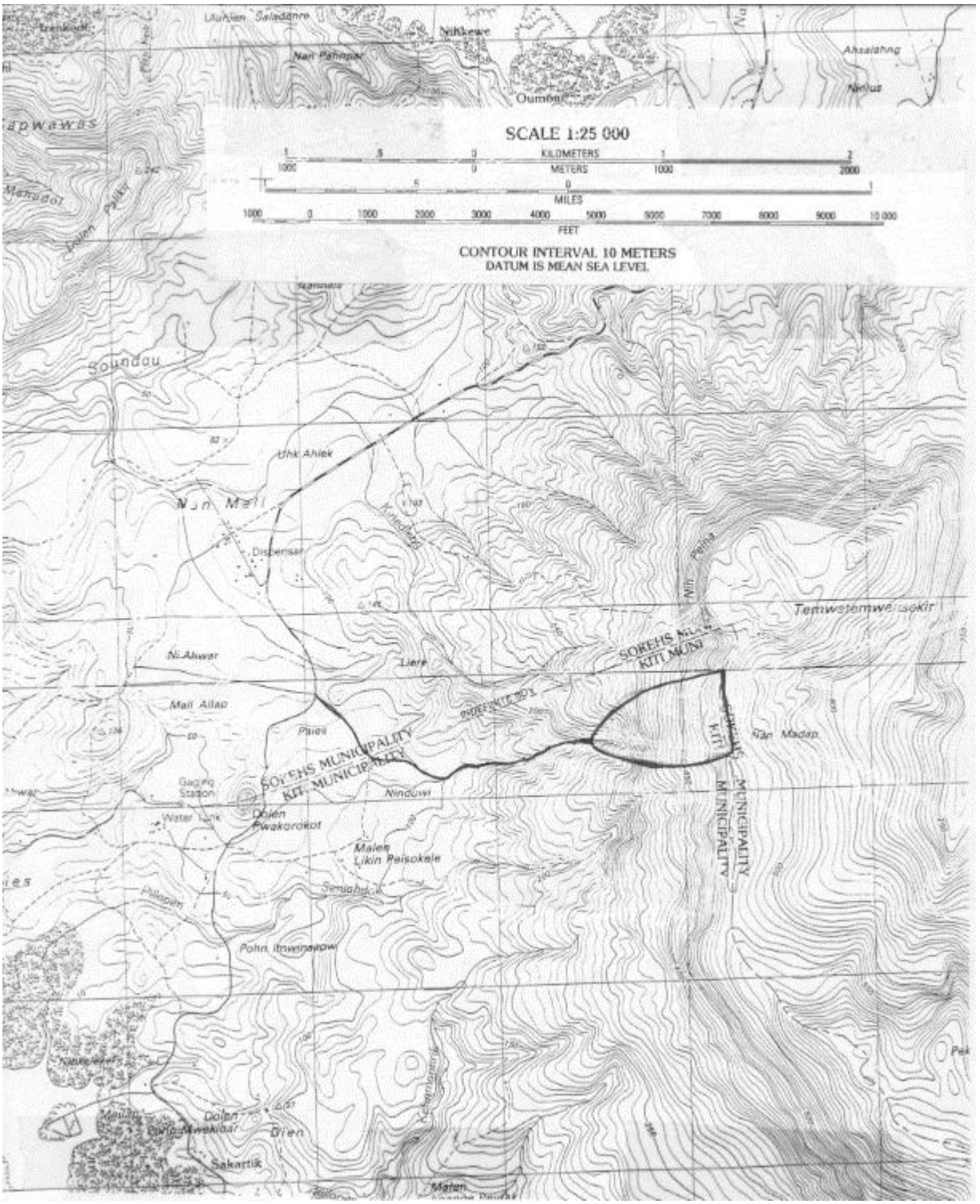


Figure 1. Location map of the Paies water supply system

Table 1. Hydraulic Analysis of the Paies Water System - Existing situation 1996.

Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
Dam							743	
Dam - A	3" (80 mm) G.I.	1,921 (586 m)	19 (1.2 l/s)	0.3	6	737	528	209
A - Tank	3" (80 mm) PVC	1,356 (414 m)	19 (1.2 l/s)	0.16	3	734	360	374
Tank	..						360	
Tank - B	4" (100 mm) PVC	2,980 (908 m)	53 (3.3 l/s)	0.3	9	351	290	61

Average flow from dam to storage tank. Peak flow from storage tank to distribution system (see Figure 2). Peak factor: 3. Point A is where the pipeline changes from G.I. to PVC. Point B is the end of the existing pipeline.

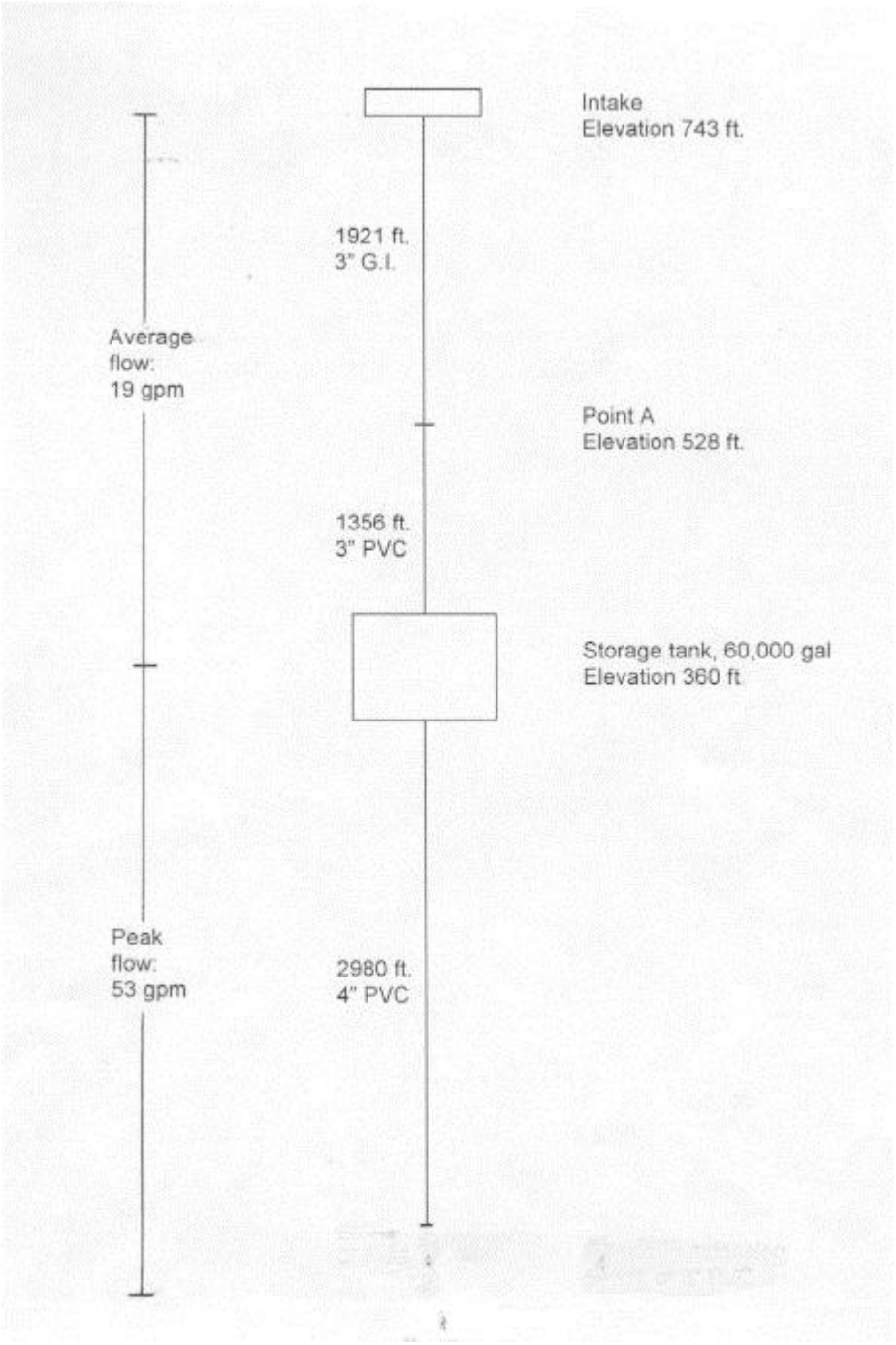


Figure 2. Schematic layout of the Paies water supply system – present situation

Table 2. Hydraulic Analysis of the Paies Water System - 1996.
(including the planned slow sand filter and the extension of the transmission line to the road).

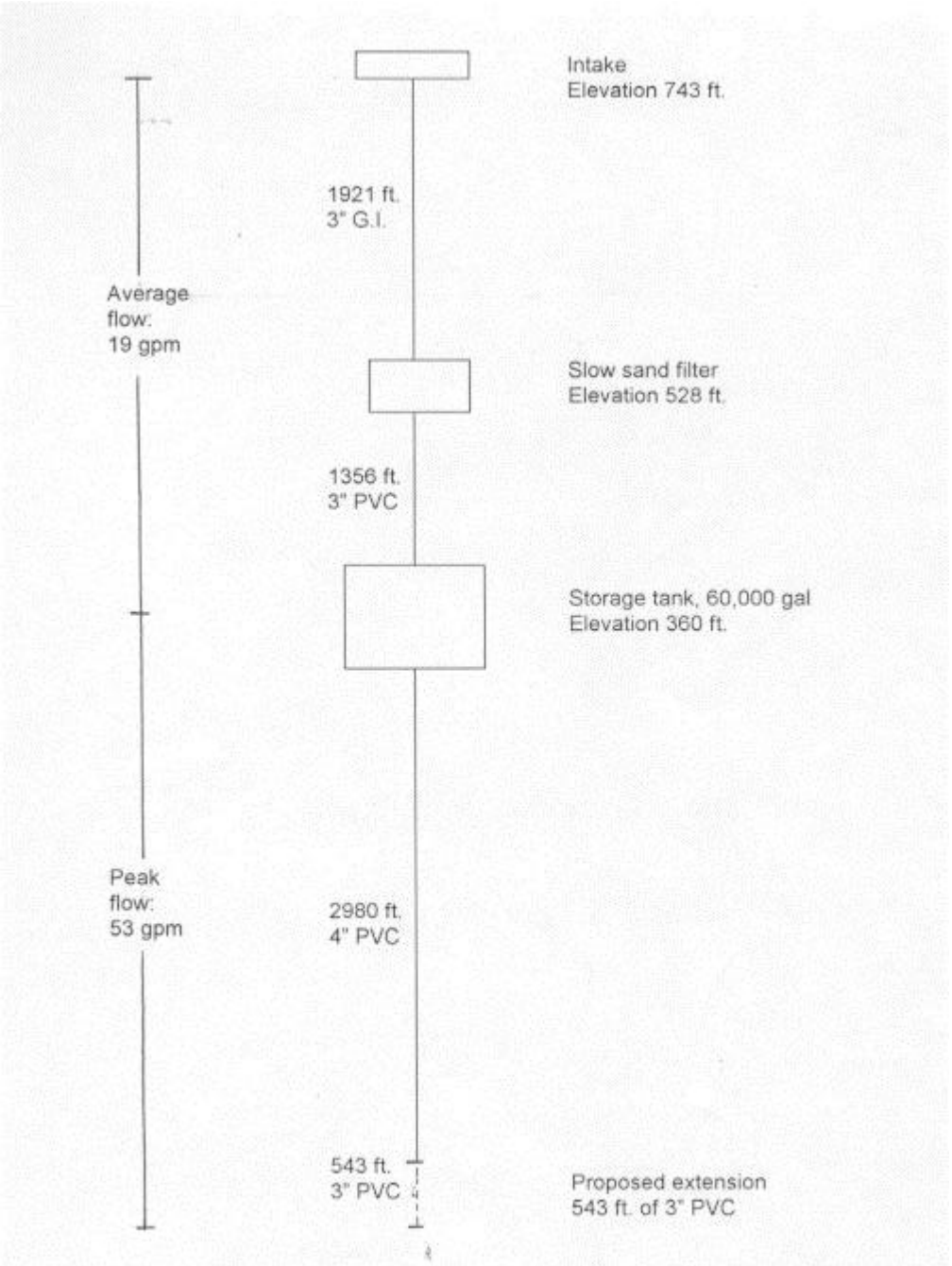
Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
Dam							743	
Dam - SSF	3" (80 mm) G.I.	1,921 (586 m)	19 (1.2 l/s)	0.3	6	737	528	209
Slow sand filter (SSF)							528	
SSF - Tank	3" (80 mm) PVC	1,356 (414 m)	19 (1.2 l/s)	0.16	3	525	360	165
Tank							360	
Tank - B	4" (100 mm) PVC	2,980 (908 m)	53 (3.3 l/s)	0.3	9	351	290	61
B - Road	3" (80 mm) PVC	543 (166 m)	10 (0.6 l/s)	0.16	1	350	290	60

Average flow from dam to storage tank. Peak flow from storage tank to distribution system (see Figure 3). Peak factor: 3.
Point A is where the pipeline changes from G.I. to PVC. Point B is the end of the existing pipeline.

Table 3. Hydraulic Analysis of the Paies Water System for the Year 2006.

Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
Dam							743	
Dam - SSF	3" (80 mm) G.I.	1,921 (586 m)	23 (1.5 l/s)	0.46	9	734	528	206
Slow sand filter (SSF)							528	
SSF - Tank	3" (80 mm) PVC	1,356 (414 m)	23 (1.5 l/s)	0.37	5	523	360	163
Tank							360	
Tank - B	4" (100 mm) PVC	2,980 (908 m)	63 (4.0 l/s)	0.39	12	348	290	58
B - Road	3" (80 mm) PVC	543 (166 m)	12 (0.8 l/s)	0.16	1	347	290	57

Average flow from dam to storage tank. Peak flow from storage tank to distribution system (see Figure 4). Peak factor: 3
Point A is where the pipeline changes from G.I. to PVC. Point B is the end of the existing pipeline.



Annex 3B Schematic layout of the Paies water supply system including slow sand filter and extension - 1996 flows.

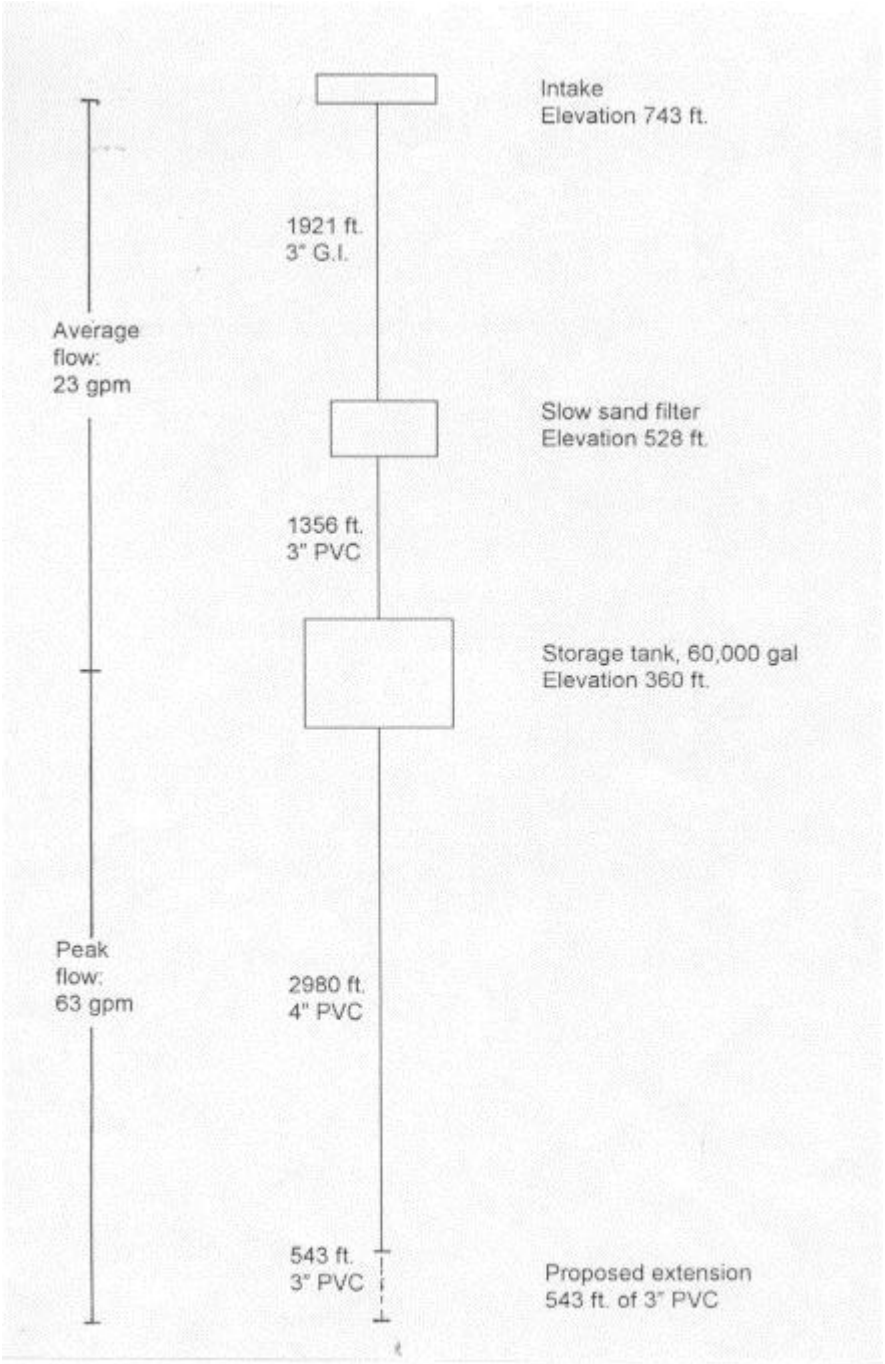


Figure 4 Schematic layout of the Paies water supply system including slow sand filter and extension - 2006 flows.

Table 4. Hydraulic Analysis of the Paies Water System for the Year 2016.

Pipeline	Type of pipe and size	Length (ft)	Demand rate (gpm)	Pressure loss (ft/100ft)	Actual pressure loss (ft)	Pressure at end of line (ft)	Elevation of end of line (ft)	Pressure in pipe (ft)
Dam							743	
Dam - SSF	3" (80 mm) G.I.	1,921 (586 m)	25 (1.6 l/s)	0.46	9	734	528	206
Slow sand filter (SSF)							528	
SSF - Tank	3" (80 mm) PVC	1,356 (414 m)	25 (1.6 l/s)	0.46	6	522	360	162
Tank							360	
Tank - B	4" (100 mm) PVC	2,980 (908 m)	70 (4.4 l/s)	0.39	12	348	290	58
B - Road	3" (80 mm) PVC	543 (166 m)	13 (0.8 l/s)	0.16	1	347	290	57

Average flow from dam to storage tank. Peak flow from storage tank to distribution system (see Figure 5). Peak factor: 3
Point A is where the pipeline changes from G.I. to PVC. Point B is the end of the existing pipeline.

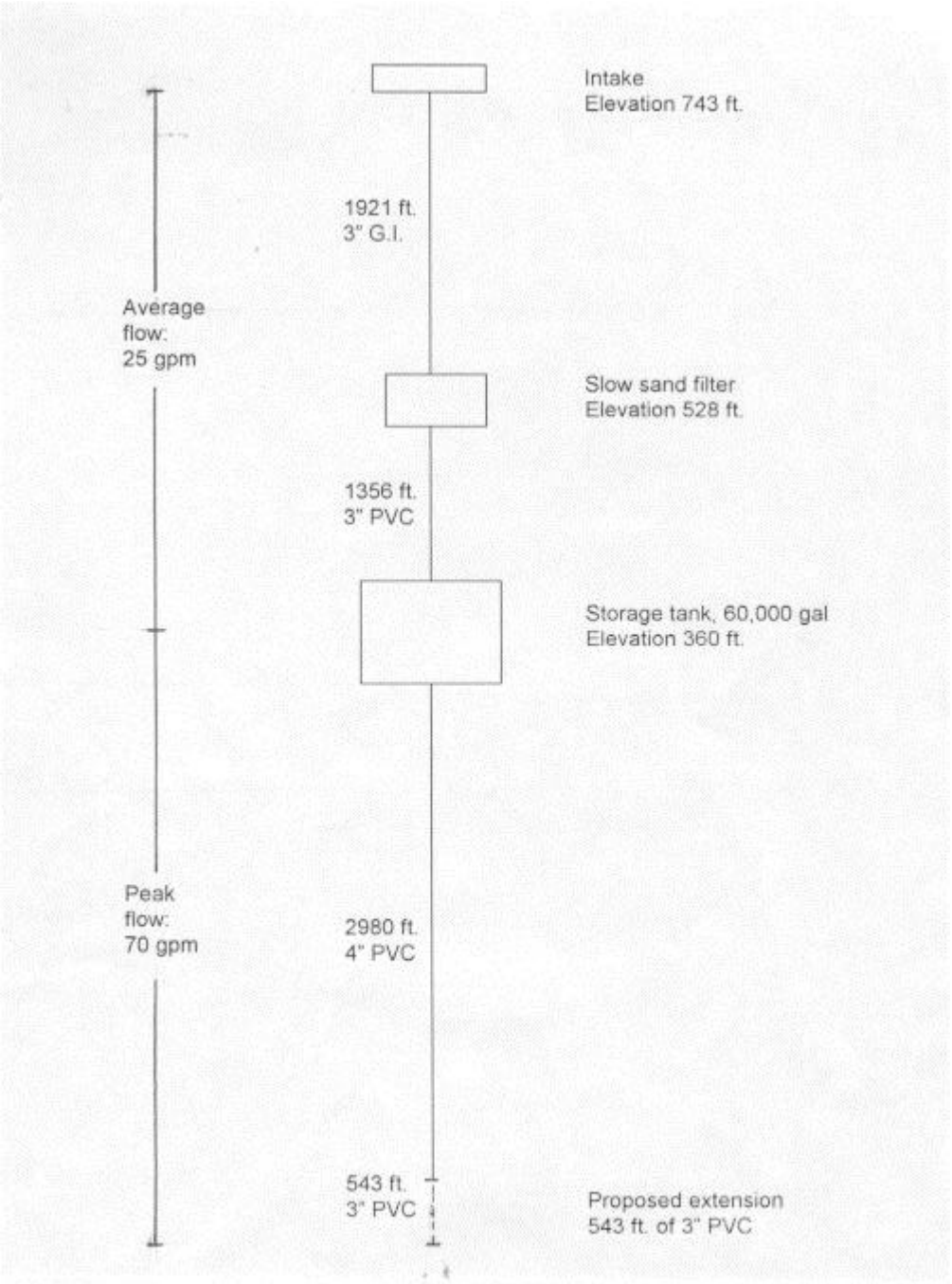


Figure 5 Schematic layout of the Paies water supply system including slow sand filter and extension - 2016 flows.