# Chapter 8 Effects of Climatic Conditions on Pollution

# Chapter 8 Effects of Climatic Conditions on Pollution

## 8-1 Geography and Climate of the Island of Trinidad

The Island of Trinidad has an area of 4,828 square kilometers and is roughly rectangular in shape. Topographically, the island may be sub-divided into three mountain ranges. The highest elevation of the northern range is 941 meters; those in the central and southern are 303 and 304 meters, respectively.

The island is divided into nine hydrometric areas as shown in Figure 8-3, according to hydrologic and climatological characteristics. The climate of the island is tropical, with two rather distinct seasons: the dry season from January to May and the wet season from June to December. The average annual temperature is 26 degrees Centigrade. There is a wide variation of rainfall both by area and by season. Isohyetals of annual rainfall are presented in Figure 8-1. Monthly averages of other climatological parameters; e.g., wind velocity, humidity, sunshine and evaporation are shown in Figure 8-2.

## 8-2 Study Area

### 8-2-1 General

The study area falls within the southern range of the Island of Trinidad. It is about 72 kilometers long with a complex geological structure. There are many small and large rivers including three big swamps that dominate the hydrological environment of the area. Usually the small rivers do not have any flow in the dry season but act as a very efficient drainage network during the wet season.

### 8-2-2 Rainfall

The hydrometric areas that influence the southern range are Areas 3, 4, 5, 6, 7 and 8. In order to study the rainfall pattern in the study area, daily rainfall data from seven stations in and around the study area were collected and analyzed. Figure 8-3 is a graphical representation of monthly average rainfall.

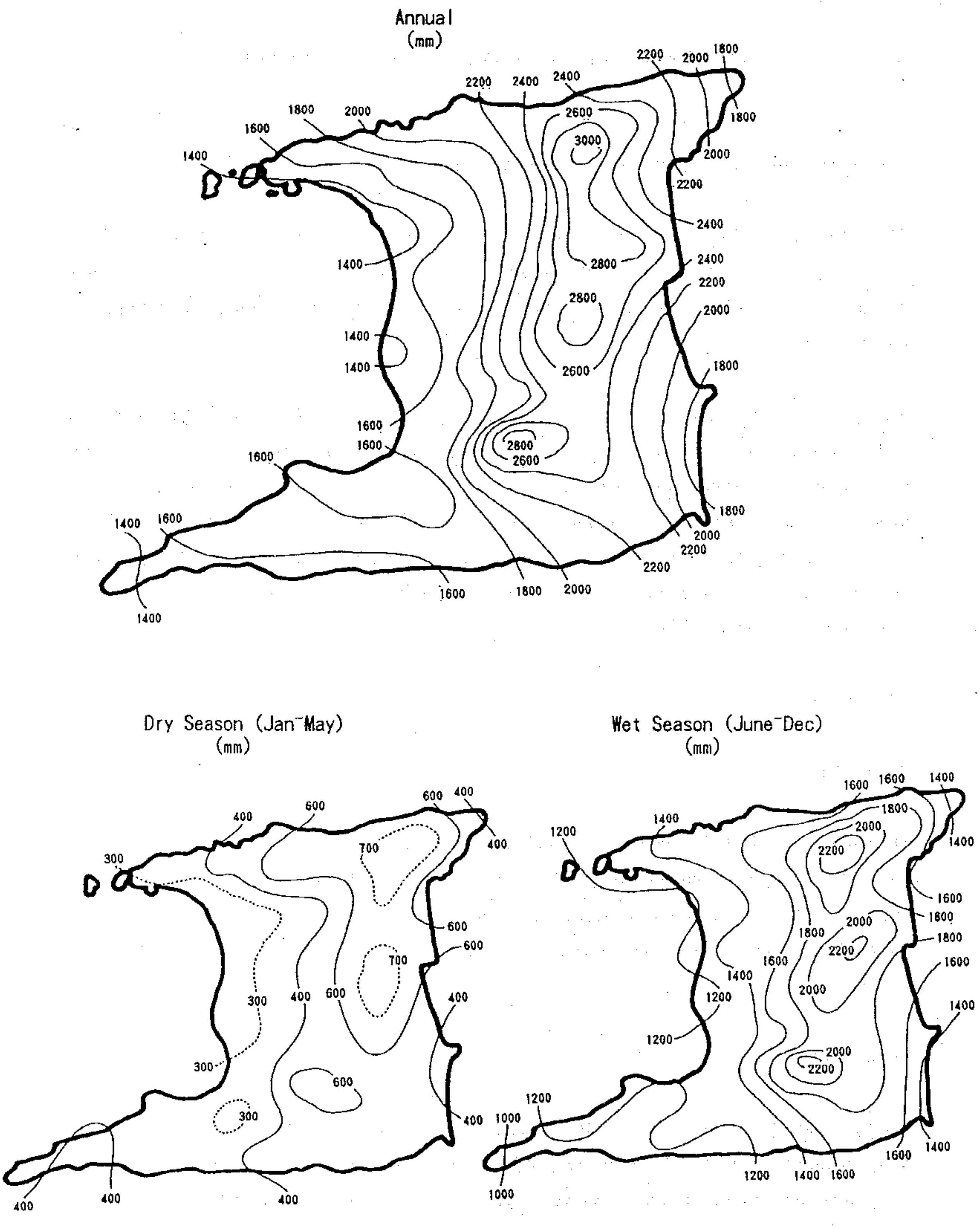



**Figure 8-1 Isohyetals of Rainfall**

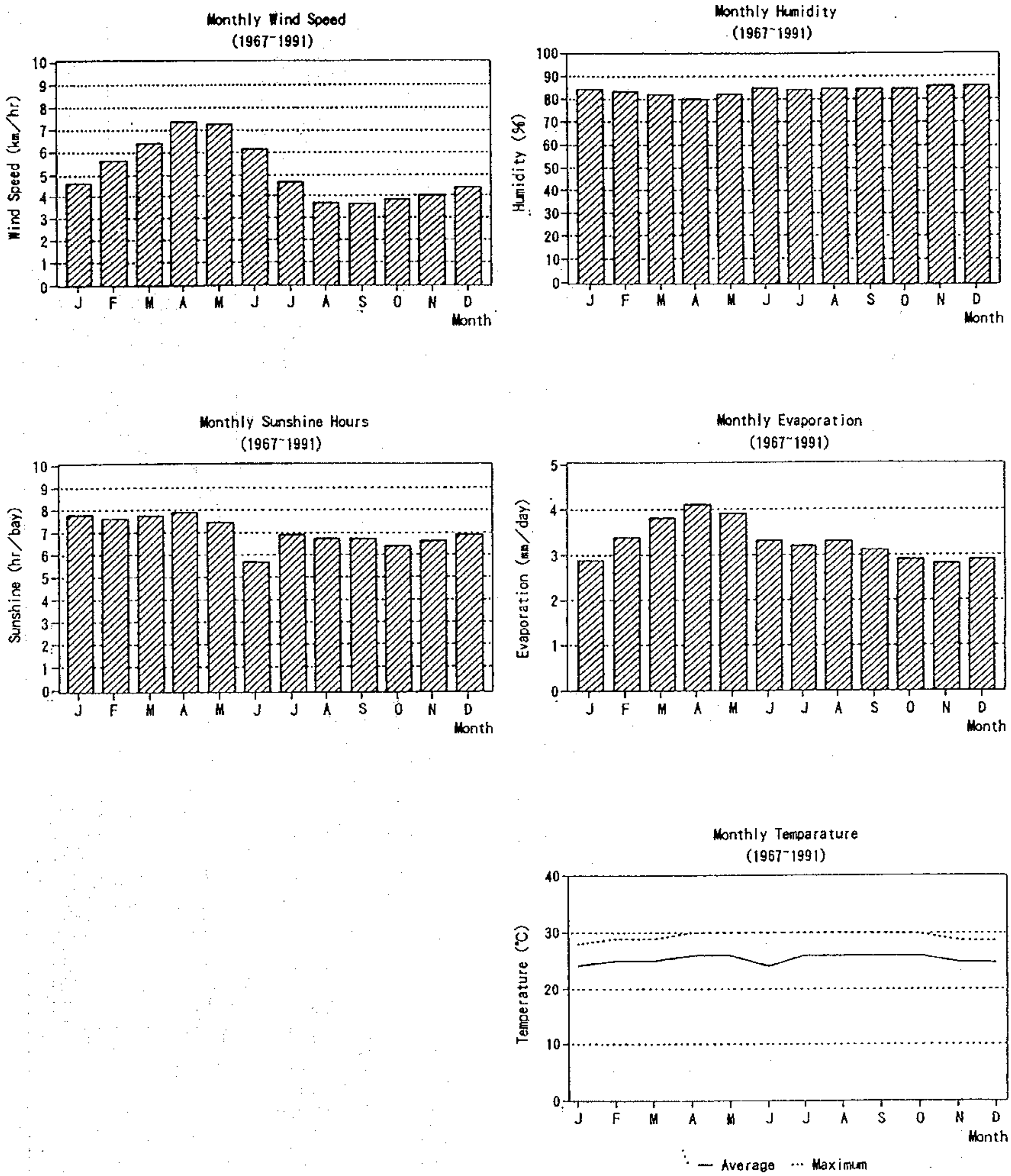



**Figure 8-2 Monthly Average of Climatological Data**

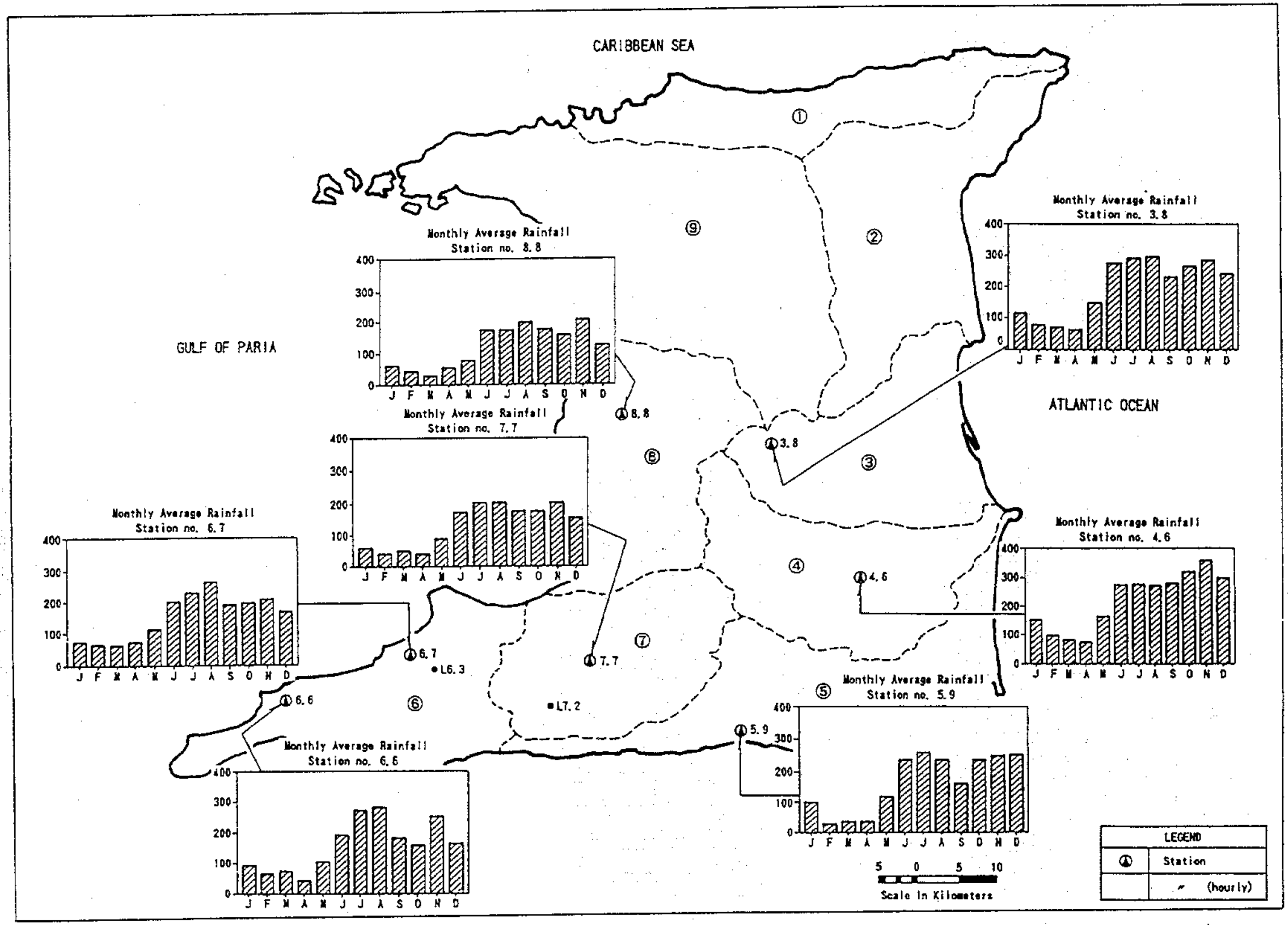



Figure 8-3 Monthly Average of Rainfall in the Study Area

### 8-2-3 River Network

The river network in the study area consists of the Guapo, Vance, Silver Stream, Molai, Cunapo, Timital and Coora Rivers and their tributaries. Due to the steep slopes, these rivers are capable of carrying the flood discharges within short periods. All these rivers ultimately empty themselves into the Gulf of Paria. The study points designated by the Minutes of Meeting of February 9, 1993 are indicated on Figure 8-4.

## 8-3 Hydrometeorology and Oil Pollution

### 8-3-1 Waste Water from the Petroleum Facilities

In the study area oil is produced with water. Both oil and water are sent to gathering stations and tank farms. In the tank farms sufficient time is allowed for separation into oil and water. The separated water in the lower part of the tanks is drained out through bleed valves. Oil with reduced water content is sent to Pointe-a-Pierre Refinery for processing. The drained water contains oil and therefore passes a series of separators such as earthen pits, skimmer pits, and API separators. Oil that separates from water and flows to the surface is skimmed and returned to tanks or pits. Water is allowed to be discharged to natural streams after such treatment. At the discharge points, most water streams are still black or brown, and never as transparent as clean water should be.

As is explained in other chapters, the study team has established that what is regarded as water here is an oil-in-water emulsion containing oil at very high content and constitutes a much more serious menace to the environment than visible floating oil escaping the facilities to the environment. The effluent water, actually an oil-in-water emulsion, flows down the rivers or channels and eventually reaches the Gulf of Paria. On the way there are oil catches, dams and booms across the streams intended to stop and recover floating oil and to prevent it from flowing further down. These oil catches and dams, analysis of the effectiveness of which in connection with climatic and hydrometric parameters is a subject of this study, are virtually ineffective; the oil-in-water emulsion passes unchecked through these catches and dams by being thoroughly mixed with the river water.

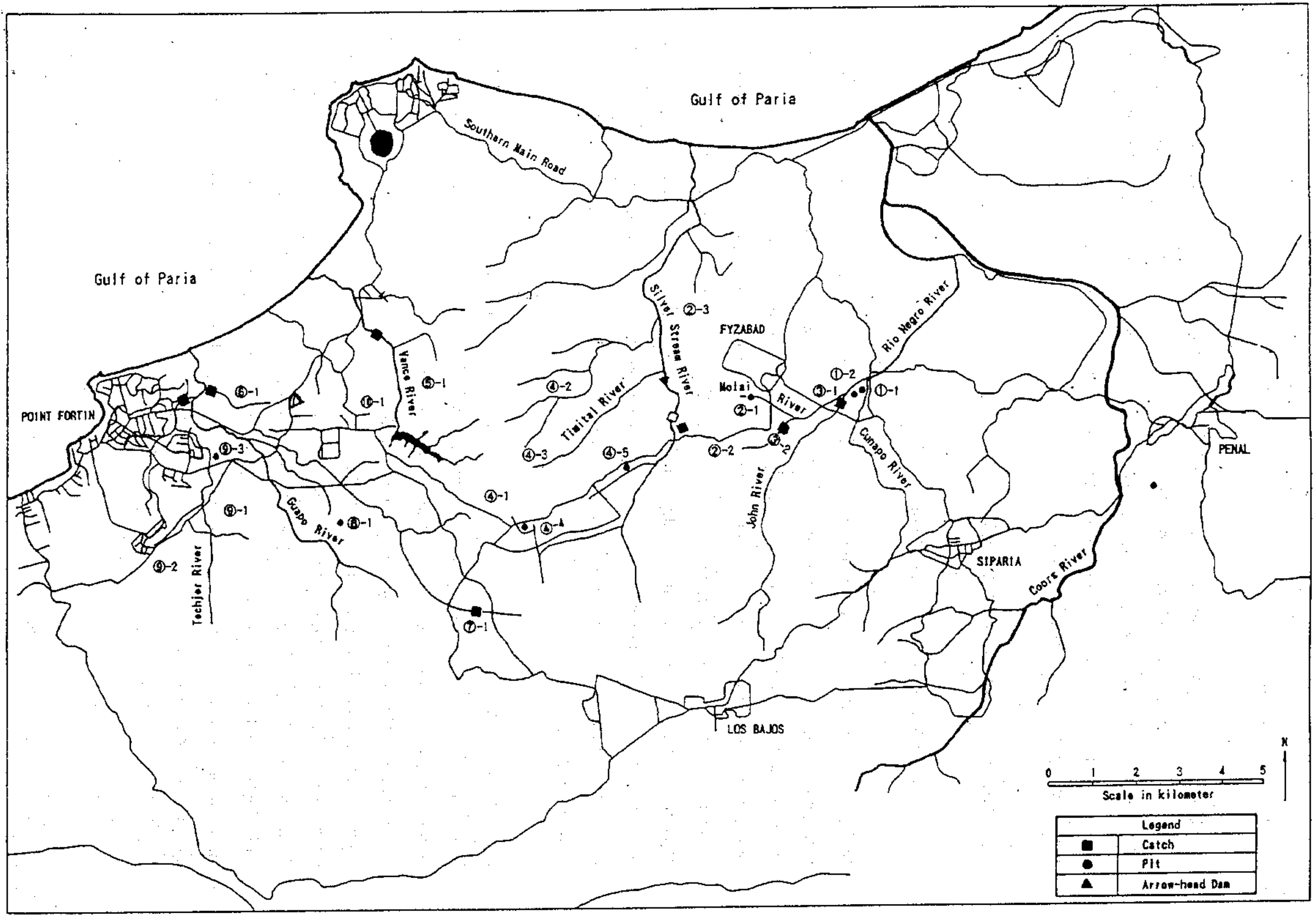



Figure 8-4 River Network in the Study Area

In Pointe-a-Pierre Refinery, oily water is produced in the course of processing, tank draining, sludge disposal, etc. Depending upon which part of the refinery oily water comes from, such oily water is channeled to pass through oil savers, oil catches, API separators and guard basins, and finally discharged to the Gulf of Paria via the Guaracara River. Water from No. 1 Gauging Area is discharged directly to the Gulf of Paria, not by way of the Guaracara River.

### 8-3-2 Rainfall and Pollution

The facilities mentioned above are all intended for stopping and recovering floating oil that has been discharged from the upstream production facilities and for preventing the downstream areas from being polluted by the floating oil. As mentioned above, these facilities are utterly ineffective for emulsions uniformly mixed with the bulk of water. When it rains heavily these facilities cannot even perform their intended functions properly. The combined effects of heavy rainfall and steep slopes of the rivers cause flush floods that overflow these catches and dams. As a result, the accumulated oil in the catches is washed away. The vortexes which the water rapidly flowing underneath the hanging walls generates conceivably entrains the floating oil.

In the refinery, heavy rainfalls adversely affect the oil-water separators in the same way. Normally, the designs of oil savers and separators do not consider rainwater runoff that could enter sewage systems leading to the savers and separators. If runoff from a heavy rainfall finds its way through these oil savers and separators, the accumulated oil there will be washed away and cause petroleum pollution.

The rainfall could spread oil pollution to the surroundings from oil leaks on the pipeline and, from joints, wells, pumps, etc. During the first field survey the study team noticed at various places in the study area that damage actually spread to the surrounding vegetation from the points of leak. Rainfall helps extend oil pollution to the surroundings.

## 8-4 Field Surveys and Major Findings

In order to identify the hydrometry-related problems of the effluent water treating facilities in the study area, two field surveys were carried out. On both occasions essential data and information were collected from the relevant agencies. Such data and information have been analyzed. Other activities of the survey include measurements of river cross sections, dimensions of treating facilities, flow velocities in streams and interviews with experts in the production and refining fields. Although the first field survey took place in the rainy season, severe flooding conditions could not be observed due to exceptionally dry weather experienced during the survey period. However, trends of the flooding effect were understood on a couple of occasions. During the second field survey done during the dry season, extensive field visits were made and additional data were collected. Rainy season and dry season performances were compared.

Most oil-catches were built more than twenty years ago. Silt and sludge have accumulated at the dams and have decreased the baffle areas, or their capacities. F20 and the TRINMAR Secondary Catch, being sources of pollution to the Guapo River and Point Ligoure Beach, respectively, are built at very low elevations. The decreased capacities and low elevations make these catches unable to function properly even in normal rainfalls.

The reasons why the API separators in Pointe-a-Pierre Refinery do not function properly are the same as that mentioned above. API Separator No. 3 and Oil Stock Sump have a severe flooding problem. API Separators Nos. 1 and 2 also have a flooding problem. The drainage area for API Separator No. 3 is too large; the runoff load placed on this separator is many times bigger than its design capacity. In the case of Oil Stock Sump, the low elevation and the capacity are not intended to accommodate the rain water runoff. Hydraulic bypasses to API Separators Nos. 1, 2 and 3 are not functioning any more. If they should operate normally, the loads on API Separators Nos. 1 and 2 would be decreased to some extent, but no significant change would happen in the case of API Separator No. 3, because there is too much runoff water.

## 8-5 Approach to the Problem

### 8-5-1 Probability Analysis and Selection of Rainfall

Data have been collected from the seven stations on the Island of Trinidad. Considering the distances between the stations and the study area and differences that exist in the rainfall pattern among stations, the rainfall of three stations -- Stations 6.7, 7.7 and 8.8 -- were selected for analysis. Probability analysis of daily maximum rainfall of the three stations was performed, with the results presented in Table 8-1. Of these results, rainfall over the five year return period was chosen for analysis.

**Table 8-1 Probability of Daily Maximum Rainfall**

(Unit: Millimeters)

| Return Period Years | Station No. 6.7 | Station No. 7.7 | Station No 8.8 |
|---|---|---|---|
| 5 | 86.0 | 84.0 | 96.0 |
| 10 | 95.0 | 94.0 | 110.0 |
| 20 | 103.0 | 103.0 | 122.0 |
| 30 | 107.0 | 108.0 | 129.0 |
| 40 | 110.0 | 112.0 | 134.0 |
| 50 | 113.0 | 114.0 | 138.0 |
| 100 | 120.0 | 122.0 | 149.0 |

(Source: Study team)

### 8-5-2 Determination of Catchment Area

In order to determine the peak runoff volumes at the oil catches and Arrowhead Dam, the drainage area for each catch was delineated on a topographic map of one to 25,000 scale. In the case of the API separators in Pointe-a-Pierre Refinery, a topographic map of one to 5,000 was used.

### 8-5-3 Peak Runoff Calculation and Capacity Check

Calculation was performed using the following rational formula:

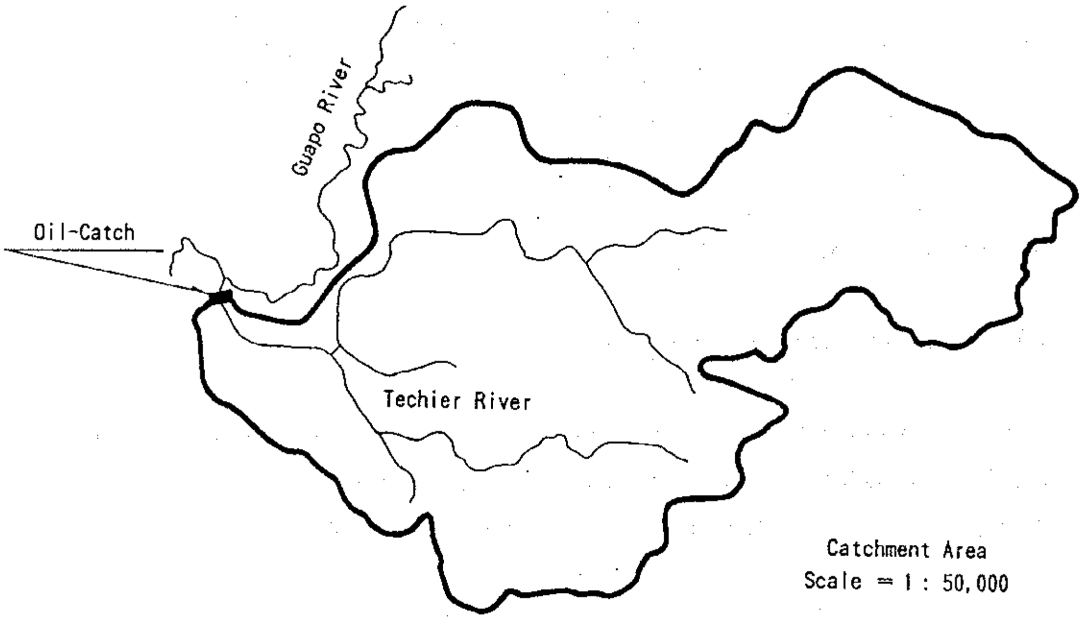
$$Q = 1/3.6 \times f \times r \times A$$
$$= 0.2778 \times f \times r \times A$$

Details of this equation are presented in the following sections.

## 8-6 Calculation and Results

### 8-6-1 Oil Catches

#### (1) Techier River Catch




#### 1) Peak Runoff Calculation

Conditions:

| | | | |
|---|---|---|---|
| Conditions: | Catchment area | = | 10.68 sq.km |
| | Length (catch to far end) | = | 5.35 km |
| | EL. difference | = | 0.037 km |
| | Slope | = | 0.007 |
| | Rainfall | = | 86.0 mm (st.no 6.7) |

Formulas: Peak Runoff Qp = 0.2778 x f x r x A in ($m^3/s$)

Where f = runoff coefficient

A = catchment area in (sq.km)

0.2778 = conversion factor

r = rainfall intensity in (mm/hr)

= $R24/24 \times (24/Tc)^{0.7}$

where R24 = one day rainfall

Tc = concentration time = L/W in hour

where L = river length in km

W = flood concentration velocity and

$= 72 \times (H/L)^{0.6}$ in km/hr

where H = elevation difference in km

L = river length in km

72 = conversion factor

Calculations:

$$W = 72 \times (H/L)^{0.6}$$
$$= 72 \times (0.037/5.35)^{0.6}$$
$$= 3.64 \text{ km/hr}$$
$$Tc = L/W = 5.35/3.64 = 1.47 \text{ hr}$$
$$\text{Now } r = R24/24 \times (24/Tc)^{0.7}$$
$$= 86/24 \times (24/1.47)^{0.7}$$
$$= 25.0 \text{ mm/hr}$$

Therefore, Peak runoff $Qp = 0.2778 \times f \times r \times A$

$= 0.2778 \times 0.35 \times 25.0 \times 10.68$

$= 25.96\ m^3/sec$ $(2.43\ m^3/s/km^2)$

**2) Capacity Check**

Capacity is checked using Manning's and continuity equations:

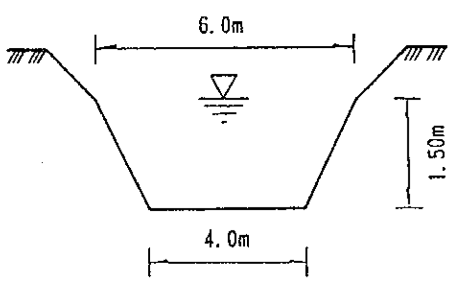
$V = 1/n \times R^{2/3} \times S^{1/2}$ (Manning's)

$Q = A \times V$ (continuity)

Details of the parameters are given in the following paragraph.

Capacity of the river:

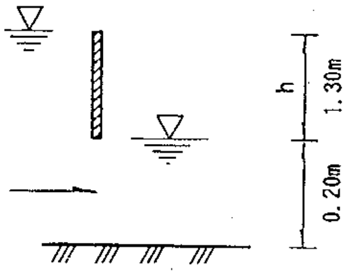
| | |
|---|---|
| Area (A) | = 7.50 $m^2$ |
| Wetted perimeter (P) | = 7.60 m |
| Hydraulic radius (R)=A/P | = 0.987 m |
| Flow velocity (V) | = 2.697 m/s |
| Slope | = 1/150 |
| Roughness Coefficient (n) | = 0.03 |
| **Maximum capacity (Qmax)** | = 20.23 $m^3/s$ |



River Cross Section

Capacity of the catch baffle:

$$Q_{max} = c \times a \times (2gh)^{1/2}$$
$$= 0.60 \times 0.20 \times 5.80 \times (2 \times 9.80 \times 1.30)^{1/2}$$
$$= 0.696 \times 5.05$$
$$= 3.50\ m^3/s$$



Baffle Cross Section

note: c = discharge coefficient

a = area of the baffle ($m^2$)

g = gravitational acceleration ($m/sec^2$)

h = water level difference (m)

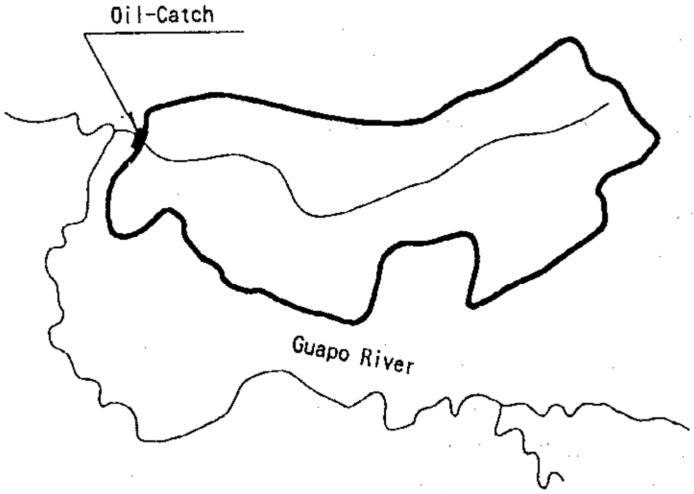
H = water depth over the weir (m)

b = weir width (m)

### 3) Conclusions

The calculated peak runoff is 25.96 $m^3/s$. On the other hand, the river cross section and the catch baffle have the capacity of 20.23 $m^3/s$ and 3.50 $m^3/s$, respectively. Therefore, neither the river cross section nor the catch baffle has sufficient capacity to carry the peak runoff volume.

## (2) F20 River Catch



Catchment Area
Scale = 1 : 25,000

## 1) Peak Runoff Calculation

Conditions: Catchment area = 1.01 sq. km

Length (catch to far end) = 1.88 km

EL. difference = 0.015 km

Slope = 0.008

Rainfall = 86 mm (st. no 6.7)

Calculations:

$W = 72 \times (H/L)^{0.6}$

$= 72 \times (0.015/1.88)^{0.6}$

$= 3.98$ km/hr

$Tc = L/W = 1.88/3.98 = 0.47$ hr

Now $r = R24/24 \times (24/Tc)^{0.7}$

$= 86/24 \times (24/0.47)^{0.7}$

$= 56.0$ mm/hr

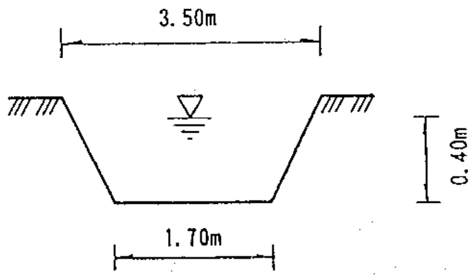
Therefore, Peak runoff $Qp = 0.2778 \times f \times r \times A$

$= 0.2778 \times 0.35 \times 56.0 \times 1.01$

$= 5.50\ m^3/sec\ (5.44\ m^3/s/km^2)$

## 2) Capacity Check

Capacity of the river:



River Cross Section

$A = 1.04\ m^2$

$P = 3.67$ m

$R = 0.283$ m

$V = 0.129$ m/s

$S = 1/125$

$n = 0.03$

Maximum capacity (Qmax) = $0.134\ m^3/s$

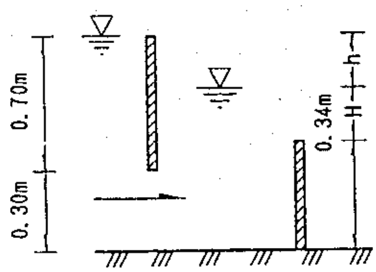
Capacity of the catch baffle:

The maximum capacity (Qmax) is calculated using two formulas. One uses water elevation difference (maximum); i.e. (h) and the other water depth (H) over the weir at that h. Trial-and-error calculations are done until the values of Qmax by both methods become equal or very close. The Qmax thus obtained represents the maximum capacity.

Qmax(baffle) $= c \times a \times (2 \times g \times h)^{1/2}$ (eq. for submerged orifice)

$= 0.60 \times 0.30 \times 2.5 \times (2 \times 9.8 \times 0.205)^{1/2}$

$= 0.902\ m^3/s$



Baffle Cross Section

Qmax(weir) $= 2/3 \times c \times b \times (2g)^{1/2} \times H^{1.5}$ (eq. for rectangular weir)

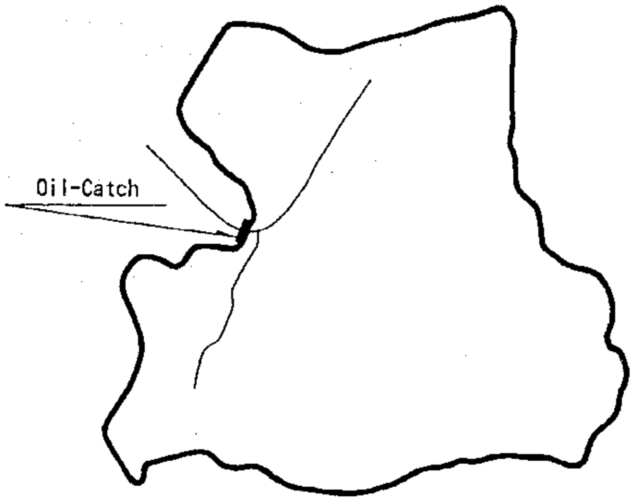
$= 0.67 \times 0.60 \times 2.5 \times (2 \times 9.8)^{1/2} \times 0.345^{1.5}$

$= 0.902\ m^3/s$

**3) Conclusion**

The peak runoff is 5.5 $m^3/s$ whereas the river cross section and the catch baffle have capacities of only 0.134 and 0.902 $m^3/s$, respectively. Therefore, neither the river cross section nor the baffle is capable of carrying the peak runoff volume.

### (3) TB-33 Catch




Catchment Area
Scale = 1 : 50,000

#### 1) Peak Runoff Calculation

| | | | |
|---|---|---|---|
| Conditions: | Catchment area | = | 7.90 sq.km |
| | Length (catch to far end) | = | 2.78 km |
| | EL. difference | = | 0.014 km |
| | Slope | = | 0.005 |
| | Rainfall | = | 84.0 mm (st. no 7.7) |

Calculations:

$$W = 72 \times (H/L)^{0.6}$$
$$= 72 \times (0.014/2.78)^{0.6}$$
$$= 3.01 \text{ km/hr}$$

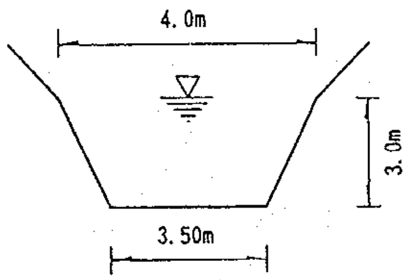
$$Tc = L/W = 2.78/3.01 = 0.92 \text{ hr}$$

$$\text{Now } r = R24/24 \times (24/Tc)^{0.7}$$
$$= 84/24 \times (24/0.92)^{0.7}$$
$$= 34.0 \text{ mm/hr}$$

$$\text{Therefore, Peak runoff } Qp = 0.2778 \times f \times r \times A$$
$$= 0.2778 \times 0.35 \times 34.0 \times 7.90$$
$$= 26.38 \text{ m}^3\text{/sec } (3.34 \text{ m}^3\text{/s/km}^2)$$

## 2) Capacity Check

Capacity of the river:



River Cross Section

A = 11.25 $m^2$

P = 9.52 m

R = 1.18 m

V = 2.635 m/s

S = 1/200

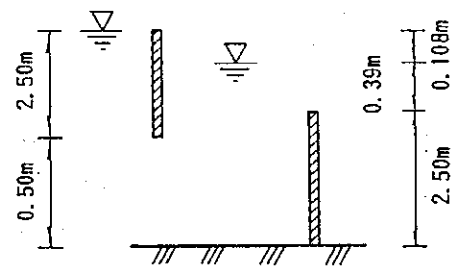
n = 0.03

Maximum capacity (Qmax) = 29.64 $m^3/s$

Capacity of the catch baffle:

$$Q_{max}(baffle) = c \times a \times (2gh)^{1/2}$$
$$= 0.60 \times 0.50 \times 3.5 \times (2 \times 9.8 \times 0.108)^{1/2}$$
$$= 1.528 \ m^3/s$$

$$Q_{max}(weir) = 2/3 \times c \times b \times (2g)^{1/2} \times H^{1.5}$$
$$= 0.67 \times 0.60 \times 3.50 \times (19.60)^{1/2} \times 0.392^{1.5}$$
$$= 1.529 \ m^3/s$$

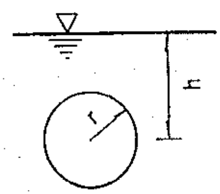


Baffle Cross Section

Capacity of 3 dogleg pipes:

$$Q = c \times pai \times r^2 \times (2gh)^{1/2} \times 3$$
$$= 0.59 \times 3.14 \times (0.15)^2 \times (2 \times 9.8 \times 0.242)^{1/2} \times 3$$
$$= 0.279 \ m^3/s$$

Capacity of the catch outlet pipe:



Pipe Cross Section

$$Q = c \times pai \times r^2 \times (2gh)^{1/2}$$
$$= 0.59 \times 3.14 \times (0.13)^2 \times (2 \times 9.8 \times 1.43)^{1/2}$$
$$= 0.167 \ m^3/s$$

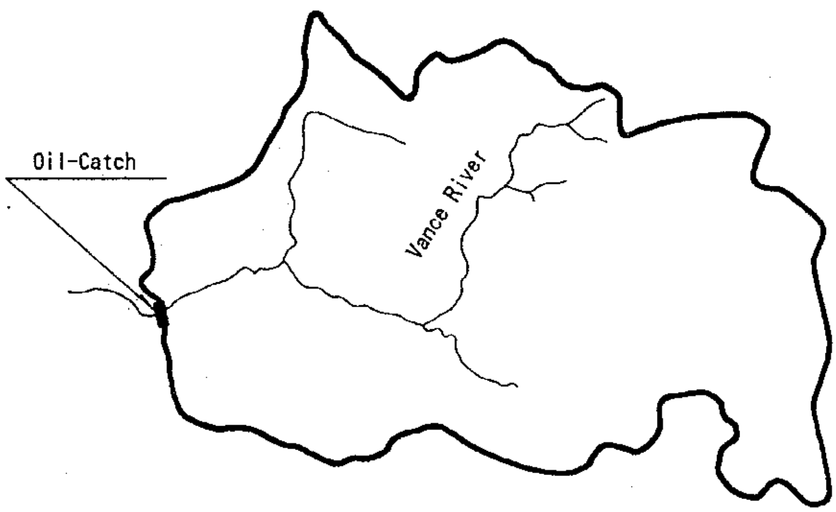
Total capacity of the catch:

$$Q\ total = 1.529 + 0.279 + 0.167$$
$$= 1.972\ m^3/s$$

**3) Conclusion**

The calculation shows that the river cross section has a capacity of 29.64 $m^3/s$ which is bigger than the peak runoff volume of 26.38 $m^3/s$. However, the catch has a total capacity of only 1.972 $m^3/s$. Therefore, the catch does not have enough baffle area to carry the peak runoff volume.

**(4) Vance River Catch**




Catchment Area
Scale = 1 : 50,000

**1) Peak Runoff Calculation**

| | | | |
|---|---|---|---|
| Conditions: | Catchment area | = | 9.72 sq.km |
| | Length (catch to far end | = | 6.25 km |
| | EL. difference | = | 0.025 km |
| | Slope | = | 0.004 |
| | Rainfall | = | 86.0 mm (st. 6.7) |

Calculations: $W = 72 \times (H/L)^{0.6}$

$= 72 \times (0.025/6.25)^{0.6}$

$= 2.62$ km/hr

$Tc = L/W = 6.25/2.62 = 2.39$ hr

Now $r = R24/24 \times (24/Tc)^{0.7}$

$= 86/24 \times (24/2.39)^{0.7}$

$= 18.0$ mm/hr

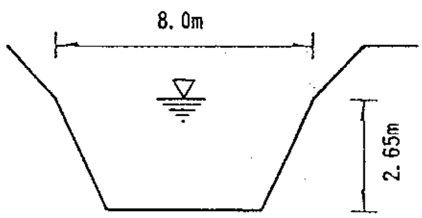
Therefore, Peak runoff $Qp = 0.2778 \times f \times r \times A$

$= 0.2778 \times 0.35 \times 18.0 \times 9.72$

$= 17.0$ $m^3$/sec (1.74 $m^3/s/km^2$)

**2) Capacity Check**

Capacity of the river:



River Cross Section

$A = 18.55$ $m^2$

$P = 11.67$ m

$R = 1.59$ m

$V = 2.873$ m/s

$S = 1/250$

$n = 0.03$

Maximum capacity (Qmax) = 53.29 $m^3/s$

Capacity of the catch baffle:

$Qmax = c \times a \times (2gh)^{1/2}$

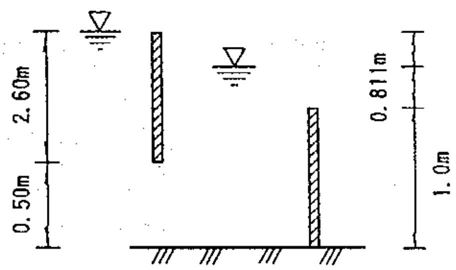
$= 0.60 \times 0.50 \times 6.0 \times (2 \times 9.8 \times 0.539)^{1/2}$

$= 5.851$ $m^3/s$

$Qmax = 2/3 \times c \times b \times (2g)^{1/2} \times H^{1.5}$

$= 0.67 \times 0.60 \times 4.50 \times (19.60)^{1/2} \times 0.811^{1.5}$

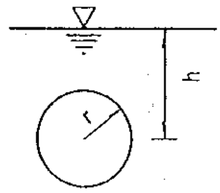
$= 5.849$ $m^3/s$



Baffle Cross Section

Capacity of the catch outlet pipe:

$$Q = c \times pai \times r^2 \times (2gh)^{1/2}$$
$$= 0.59 \times 3.14 \times (0.08)^2 \times \sqrt{2 \times 9.8 \times 1.63}$$
$$= 0.067 \ m^3/s$$



Pipe Cross Section

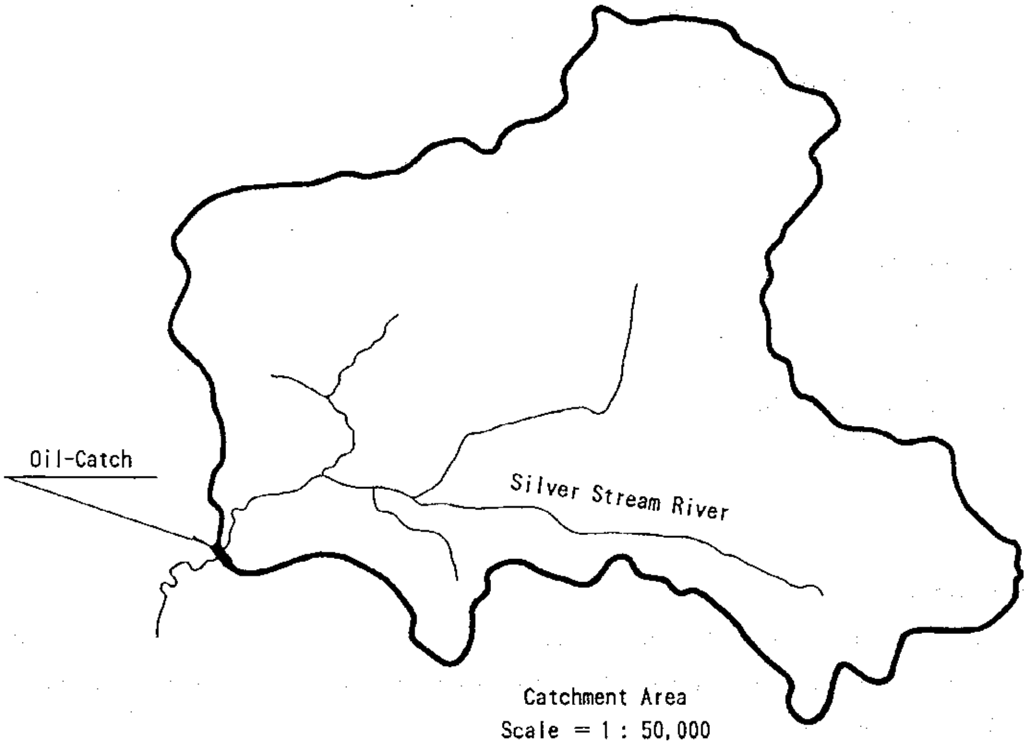
Total capacity of the catch:

$$Q\ total = 5.581 + 0.067$$
$$= 5.648 \ m^3/s$$

**3) Conclusion**

The calculation shows that the river cross section can carry 53.29 $m^3/s$ against the peak runoff volume 17.0 $m^3/s$. However, the catch has a total capacity of only 5.648 $m^3/s$, constrained by the baffle and the pipe duct.

## (5) Cocoa Catch




Catchment Area
Scale = 1 : 50,000

### 1) Peak Runoff Calculation

Conditions: Catchment area = 14.34 sq.km

Length (catch to far end) = 4.25 km

EL. difference = 0.021 km

Slope = 0.005

Rainfall = 86.0 mm (st. no 6.7)

Calculations:

$W = 72 \times (H/L)^{0.6}$

$= 72 \times (0.021/4.25)^{0.6}$

$= 2.98$ km/hr

$Tc = L/W = 4.25/2.98 = 1.43$ hr

Now $r = R24/24 \times (24/Tc)^{0.7}$

$= 86/24 \times (24/1.43)^{0.7}$

$= 26.0$ mm/hr

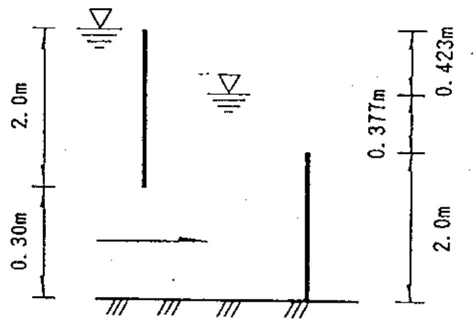
Therefore, Peak runoff $Q_p = 0.2778 \times f \times r \times A$

$= 0.2778 \times 0.35 \times 26.0 \times 14.34$

$= 36.25\ m^3/sec\ (2.53\ m^3/s/km^2)$

**2) Capacity Check**

Capacity of the catch baffle:



Baffle Cross Section

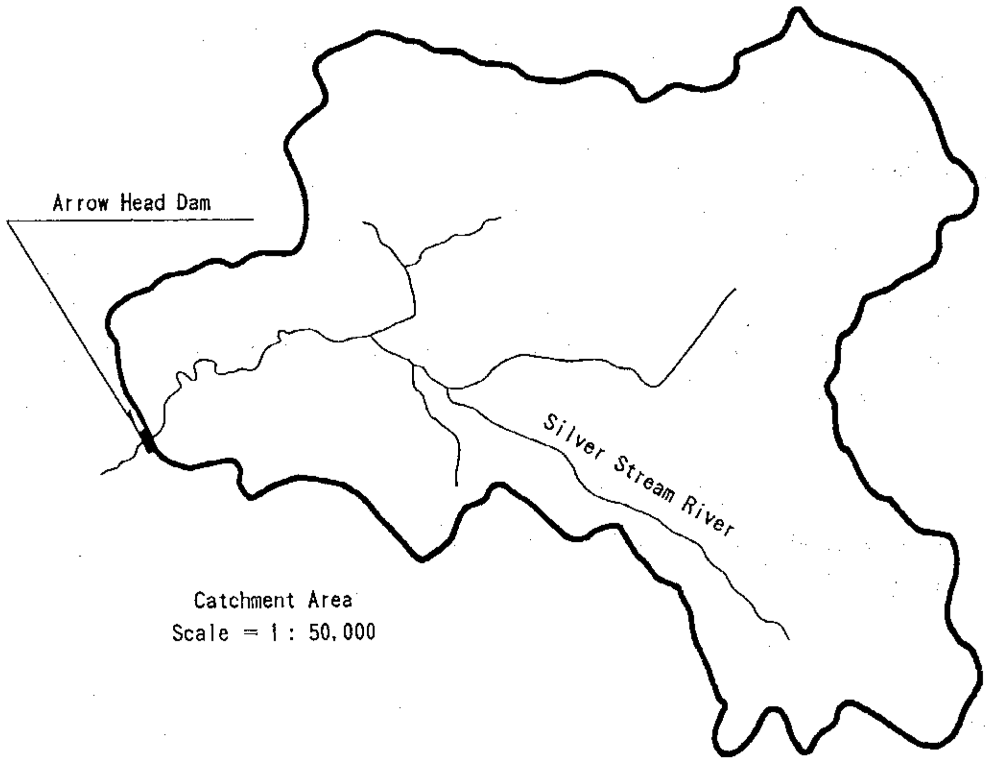
$$Q_{max} = c \times a \times (2gh)^{1/2}$$
$$= 0.60 \times 0.30 \times 33.0 \times (2 \times 9.8 \times 0.377)^{1/2}$$
$$= 16.147\ m^3/s$$

$$Q_{max} = 2/3 \times c \times b \times (2g)^{1/2} \times H^{1.5}$$
$$= 0.67 \times 0.60 \times 33.0 \times (19.60)^{1/2} \times 0.423^{1.5}$$
$$= 16.158\ m^3/s$$

**3) Conclusion**

According to the calculation the catch baffle has a maximum capacity to carry 16.159 $m^3/s$ against the peak runoff volume of 36.25 $m^3/s$.

## (6) Arrow Head Dam




### 1) Peak Runoff Calculation

Conditions: Catchment area = 15.94 sq.km
Length (dam to far end) = 6.25 km
EL. difference = 0.031 km
Slope = 0.005
Rainfall = 86 mm (st. no 6.7)

Calculations:

$$W = 72 \times (H/L)^{0.6}$$
$$= 72 \times (0.031/6.25)^{0.6}$$
$$= 2.98 \text{ km/hr}$$

$$Tc = L/W = 6.25/2.98 = 2.10 \text{ hr}$$

Assuming r to be the same as that for Cocoa Catch; i.e. 26.0 mm/hr:

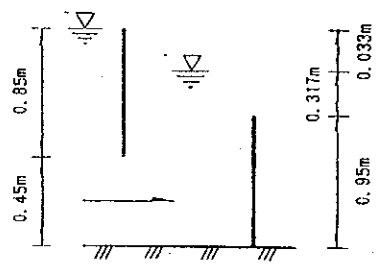
$$Peak\ runoff\ Qp = 0.2778 \times f \times r \times A$$
$$= 0.2778 \times 0.35 \times 26.0 \times 15.94$$
$$= 40.3\ m^3/sec\ (2.53\ m^3/s/km^2)$$

**2) Capacity Check**

Capacity of the dam baffle:

$$Qmax = c \times a \times (2gh)^{1/2}$$
$$= 0.60 \times 0.45 \times 160.0 \times (2 \times 9.8 \times 0.033)^{1/2}$$
$$= 34.743\ m^3/s$$

$$Qmax = 2/3 \times c \times b \times (2g)^{1/2} \times H^{1.5}$$
$$= 0.67 \times 0.60 \times 110.0 \times (19.60)^{1/2} \times 0.317^{1.5}$$
$$= 34.741\ m^3/s$$

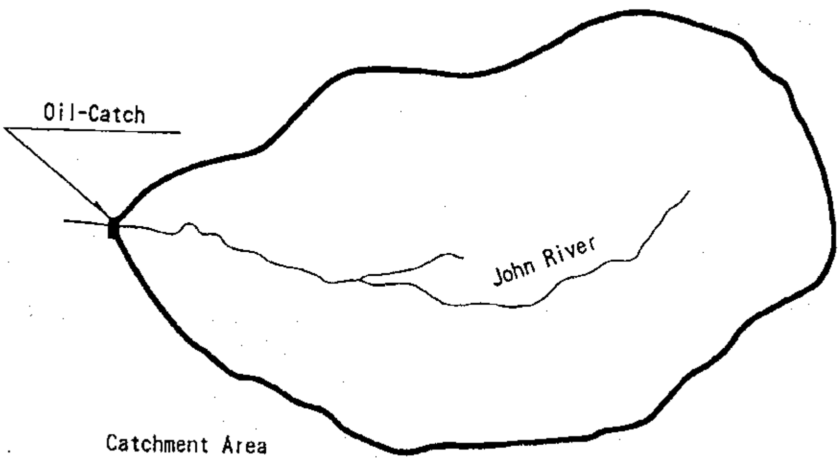


Baffle Cross Section

**3) Conclusion**

The dam baffle has a capacity of only 34.741 $m^3/s$, whereas the peak runoff volume is 40.30 $m^3/s$.

**(7) John River Catch**



Catchment Area
Scale = 1 : 50,000

### 1) Peak Runoff Calculation

Conditions: Catchment area = 9.59 sq.km

Length (catch to far end) = 8.0 km

EL. difference = 0.056 km

Slope = 0.007

Rainfall = 86 mm (st. no 6.7)

Calculations:

$$W = 72 \times (H/L)^{0.6}$$
$$= 72 \times (0.056/8.0)^{0.6}$$
$$= 3.67 \text{ km/hr}$$

$$Tc = L/W = 8.0/3.67 = 2.18 \text{ hr}$$

$$\text{Now } r = R24/24 \times (24/Tc)^{0.7}$$
$$= 86/24 \times (24/2.18)^{0.7}$$
$$= 19.0 \text{ mm/hr}$$

Therefore, Peak runoff

$$Qp = 0.2778 \times f \times r \times A$$
$$= 0.2778 \times 0.35 \times 19.0 \times 9.59$$
$$= 17.72 \text{ m}^3/\text{sec } (2.22 \text{ m}^3/\text{s/km}^2)$$

### 2) Capacity Check

Capacity of the river

$A = 9.45$ m$^2$

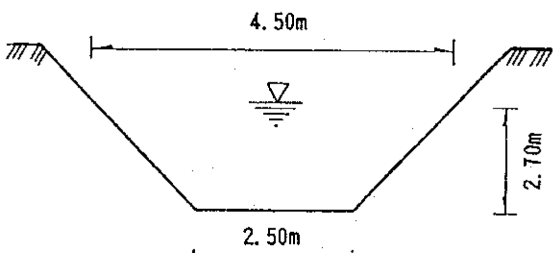
$P = 8.26$ m

$R = 1.14$ m

$V = 2.978$ m/s

$n = 0.03$

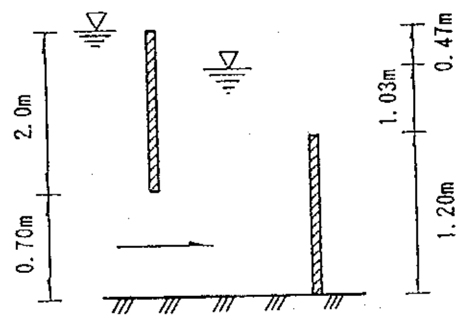
$S = 1/150$



River Cross Section

Maximum capacity (Qmax) = 28.143 cu.m./s

Capacity of the catch baffle:




Baffle Cross Section

$$Q_{max}(\text{baffle}) = c \times a \times (2gh)^{1/2}$$
$$= 0.60 \times 0.70 \times 8.0 \times (2 \times 9.8 \times 0.47)^{1/2}$$
$$= 10.209\ m^3/s$$

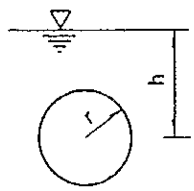
$$Q_{max}(\text{weir}) = 2/3 \times c \times b \times (2g)^{1/2} \times H^{1.5}$$
$$= 0.67 \times 0.60 \times 5.50 \times (19.60)^{1/2} \times 1.029^{1.5}$$
$$= 10.217\ m^3/s$$

Capacity of the catch inlet pipe:

$$Q = c \times pai \times r^2 \times (2gh)^{1/2}$$
$$= 0.59 \times 3.14 \times 0.05^2 \times (2 \times 9.8 \times 1.75)^{1/2}$$
$$= 0.027\ m^3/s$$

Total capacity of the catch:

$$Q\ total = 10.209 + 0.027$$
$$= 10.236\ m^3/s$$




**3) Conclusion**

The result of the calculation shows that the catch has a capacity of only 10.236 $m^3/s$, which is smaller than the peak runoff volume of 17.72 $m^3/s$.

**(8) TRINMAR Secondary Catch**

No topographic map is available. Calculation is done using assumptions made on the basis of the field survey and interviews.

## 1) Peak Runoff Calculation

Conditions:

| | | |
|---|---|---|
| Catchment area | = | 0.30 sq.km |
| Length | = | 1.50 km |
| EL. difference | = | 0.002 km |
| Slope | = | 0.0013 (assumed) |
| Rainfall | = | 86 mm (st. no 6.7) |

Calculations:

$$W = 72 \times (H/L)^{0.6}$$
$$= 72 \times (0.002/1.50)^{0.6}$$
$$= 1.36 \text{ km/hr}$$

$$Tc = L/W = 1.50/1.36 = 1.10 \text{ hr}$$

$$\text{Now } r = R24/24 \times (24/Tc)^{0.7}$$
$$= 86/24 \times (24/1.10)^{0.7}$$
$$= 31.0 \text{ mm/hr}$$

Therefore, Peak runoff $Qp = 0.2778 \times f \times r \times A$

$$= 0.2778 \times 0.50 \times 31.0 \times 0.30$$
$$= 1.29 \text{ m}^3/\text{sec} \ (4.30 \text{ m}^3/\text{s/km}^2)$$

## 2) Capacity Check

Capacity of the Channel

$A = 0.91 \text{ m}^2$

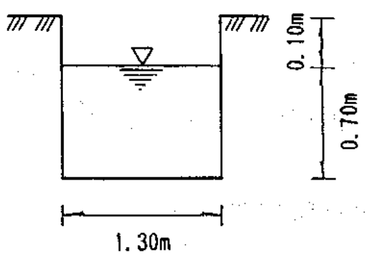
$P = 2.70 \text{ m}$

$R = 0.337 \text{ m}$

$V = 0.132 \text{ m/s}$

$n = 0.03$

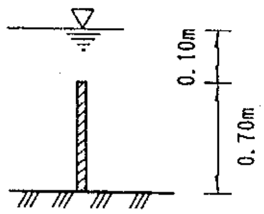
$S = 1/750$




Channel Cross Section

Maximum capacity (Qmax) = 0.12 $m^3/s$

FLow over the weir:




Weir Cross Section

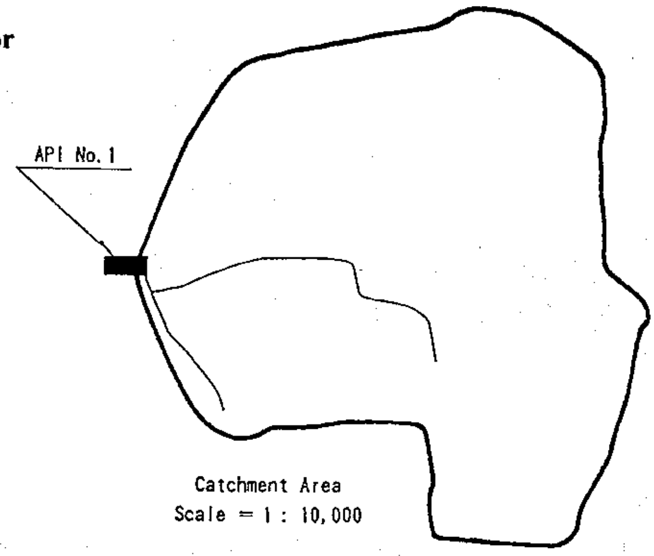
$$Q = 2/3 \times c \times b \times (2g)^{1/2} \times H^{3/2}$$
$$= 0.67 \times 0.60 \times 1.30 \times (2 \times 9.80)^{1/2} \times 0.10^{1.5}$$
$$= 0.075\ m^3/s$$

### 3) Conclusion

The calculated peak runoff volume is 1.29 $m^3/s$. Therefore, the channel, with a capacity of only 0.12 $m^3/s$, is not capable of carrying the peak flow. The weir before the catch raises the water level upstream of the channel. If the water depth over the weir exceeds ten centimeters, overflow occurs. If the flow over the weir exceeds 0.075 $m^3/s$, overflow occurs.

### 8-6-2 API Separators

#### (1) No. 1 API Separator




#### 1) Peak Runoff Calculation

Conditions:

| | | |
|---|---|---|
| Catchment area | = | 0.43 sq. km |
| Length (catch to far end) | = | 0.77 km |
| EL. difference | = | 0.0008 km |
| Slope | = | 0.001 |
| Rainfall | = | 96.0 mm (st. no 8.8) |

Calculations:

$$W = 72 \times (H/L)^{0.6}$$
$$= 72 \times (0.0008/0.77)^{0.6}$$
$$= 1.17 \text{ km/hr}$$

$$Tc = L/W = 0.77/1.17 = 0.66 \text{ hr}$$

$$\text{Now } r = R24/24 \times (24/Tc)^{0.7}$$
$$= 96/24 \times (24/0.66)^{0.7}$$
$$= 50.00 \text{ mm/hr}$$

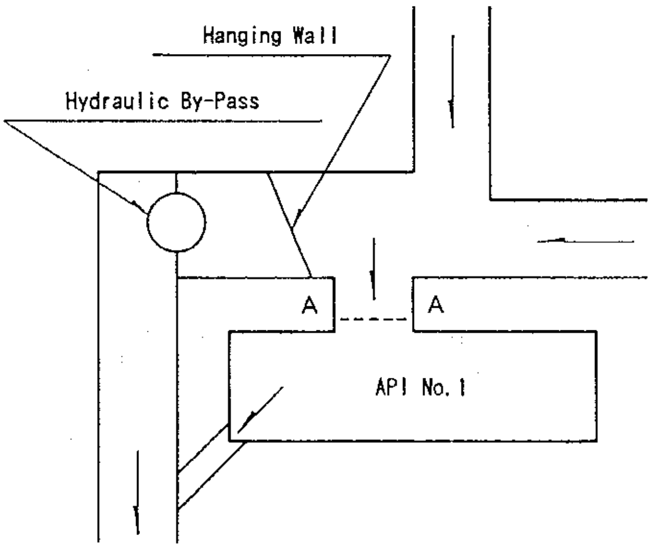
Therefore, Peak runoff $Qp = 0.2778 \times f \times r \times A$

$$= 0.2778 \times 0.70 \times 50.0 \times 0.43$$
$$= 4.20 \text{ m}^3\text{/sec } (9.80 \text{ m}^3\text{/s/km}^2)$$

2) **Capacity Check**

Conditions:

From an interview with refinery officials it has been found that the hydraulic bypass is out of order. Therefore, the runoff water has only one way to flow; i.e. to the inlet channel and then to the separator. A plan view of the separator and cross section of the inlet channel are presented below.




Capacity of the inlet channel:

$A = 2.70\ m^2$

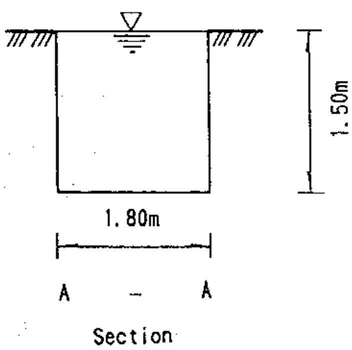
$P = 4.80\ m$

$R = 0.563\ m$

$V = 2.041\ m/s$

$n = 0.015$

$S = 1/500$ (assumed)

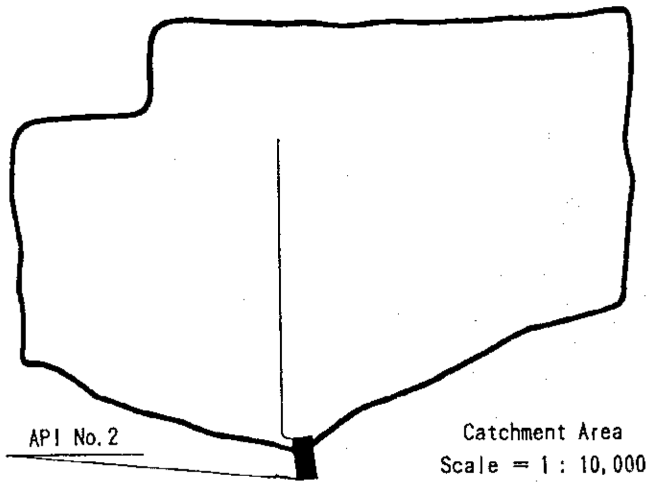



Maximum capacity (Qmx) = 5.511 cu.m/s

### 3) Conclusion

The capacity of the inlet channel is sufficient to carry the peak runoff volume of 4.20 $m^3/s$.

## (2) No. 2 API Separators




### 1) Peak Runoff Calculation

| | | |
|---|---|---|
| Conditions: | Catchment area | = 0.37 sq.km |
| | Length (catch to far end) | = 0.72 km |
| | EL. difference | = 0.00082 km |
| | Slope | = 0.0011 |
| | Rainfall | = 96.0 mm (st. no 8.8) |

Calculations:

$$W = 72 \times (H/L)^{0.6}$$
$$= 72 \times (0.00082/0.72)^{0.6}$$
$$= 1.23 \text{ km/hr}$$

$$Tc = L/W = 0.72/1.23 = 0.59 \text{ hr}$$

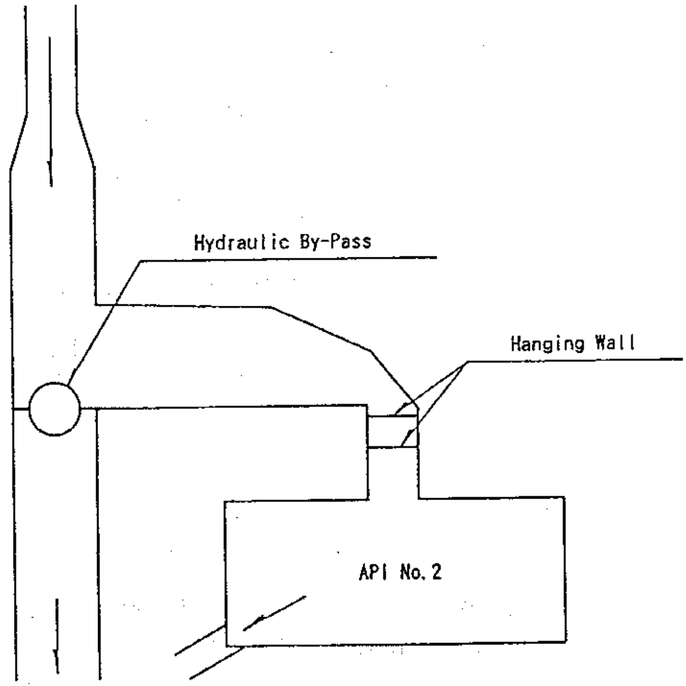
$$\text{Now } r = R24/24 \times (24/Tc)^{0.7}$$
$$= 96/24 \times (24/0.59)^{0.7}$$
$$= 54.00 \text{ mm/hr}$$

$$\text{Therefore, Peak runoff } Qp = 0.2778 \times f \times r \times A$$
$$= 0.2778 \times 0.70 \times 54.0 \times 0.37$$
$$= 3.89 \text{ m}^3/\text{sec} \ (10.51 \text{ m}^3/\text{s/km}^2)$$

**2) Capacity Check**

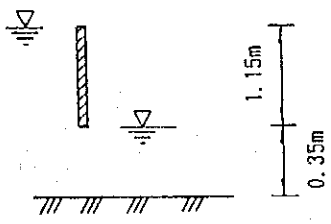
Condition:

As in the case of API Separator No. 1, the hydraulic bypass of this separator is not functional. Therefore, all water goes to the separator through the inlet channel. The plan view and cross section of the inlet channel are presented below.




Capacity of the baffle:

$$Q_{max} = c \times a \times (2gh)^{1/2}$$
$$= 0.60 \times 0.51 \times (2 \times 9.8 \times 1.15)^{1/2}$$
$$= 1.45 \text{ m}^3/\text{s}$$

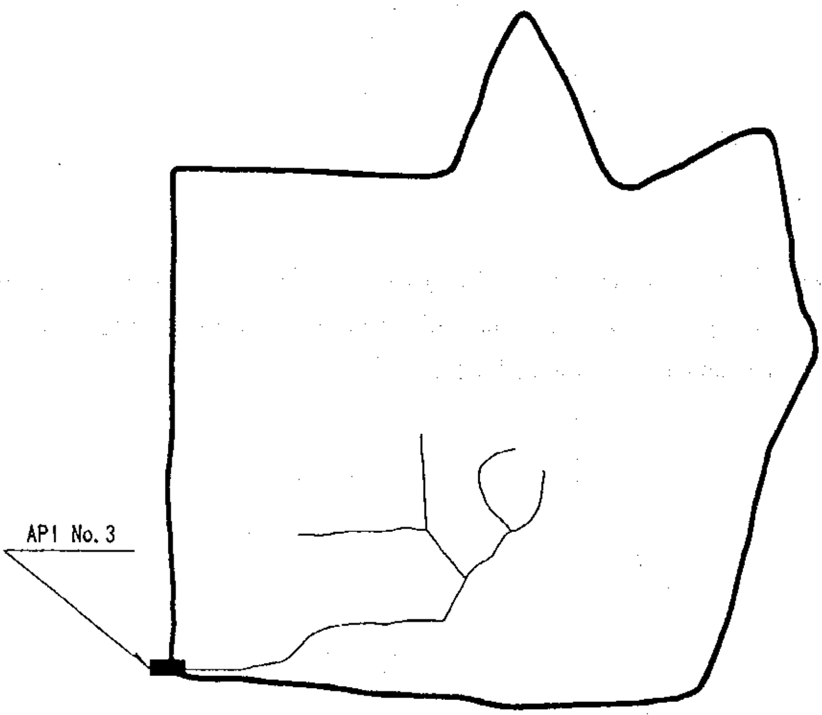



Baffle Cross Section

### 3) Conclusion

The baffle of the inlet channel is too small with respect to the peak runoff volume of 3.89 $m^3/s$.

## (3) No. 3 API Separator




Catchment Area
Scale = 1 : 10,000

### 1) Peak Runoff Calculation

Conditions: Catchment area = 0.72 sq. km
Length (catch to far end) = 1.01 km
EL. difference = 0.002 km
Slope = 0.002
Rainfall = 96.0 mm (st. no 8.8)

Calculations:

$$W = 72 \times (H/L)^{0.6}$$
$$= 72 \times (0.002/1.01)^{0.6}$$
$$= 1.72 \text{ km/hr}$$

$$T_c = L/W = 1.01/1.72 = 0.59 \text{ hr}$$

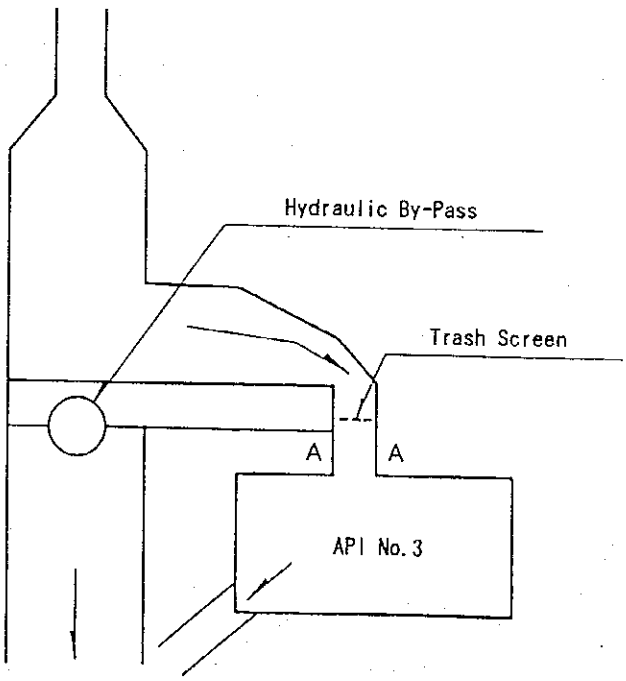
$$\begin{aligned} \text{Now } r &= R24/24 \times (24/T_c)^{0.7} \\ &= 96/24 \times (24/0.59)^{0.7} \\ &= 54.00 \text{ mm/hr} \end{aligned}$$

$$\begin{aligned} \text{Therefore, Peak runoff } Q_p &= 0.2778 \times f \times r \times A \\ &= 0.2778 \times 0.70 \times 54.0 \times 0.72 \\ &= 7.56 \text{ m}^3/\text{sec } (10.50 \text{ m}^3/\text{s/km}^2) \end{aligned}$$

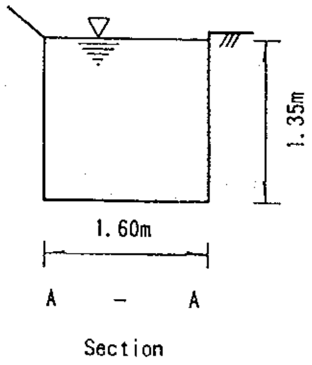
**2) Capacity Check**

Condition:

In this case also the hydraulic bypass is not functioning. Therefore, all water goes to the separator through the inlet channel. A plan view and cross section of the inlet channel are presented below.



Capacity of the inlet channel:

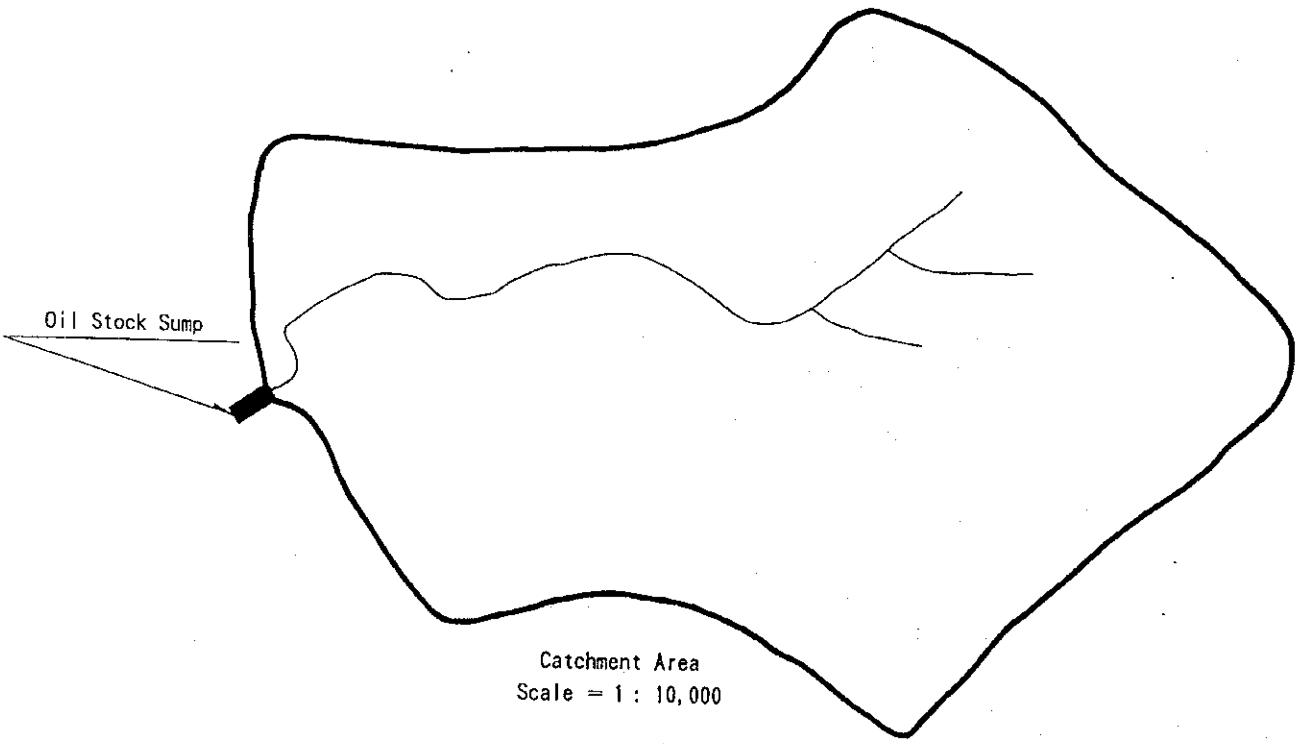



A = 2.16 $m^2$
P = 4.55 m
R = 0.474 m
V = 1.82 m/s
n = 0.015
S = 1/500 (assumed)
Maximum capacity (Qmx) = 3.931 cu.m/s

**3) Conclusion**

The inlet channel has a maximum capacity of 3.931 $m^3/s$ whereas the peak runoff volume is 7.56 $m^3/s$. Therefore, the separator has not enough capacity to carry the peak runoff volume.

### 8-6-3 Oil Stock Sump



## (1) Peak Runoff Calculation

Conditions: Catchment area = 0.86 sq.km

Length (catch to far end) = 1.42 km

EL. difference = 0.006 km

Slope = 0.0042

Rainfall = 96.0 mm (st. no 8.8)

Calculations:

$$W = 72 \times (H/L)^{0.6}$$
$$= 72 \times (0.006/1.42)^{0.6}$$
$$= 2.71 \text{ km/hr}$$

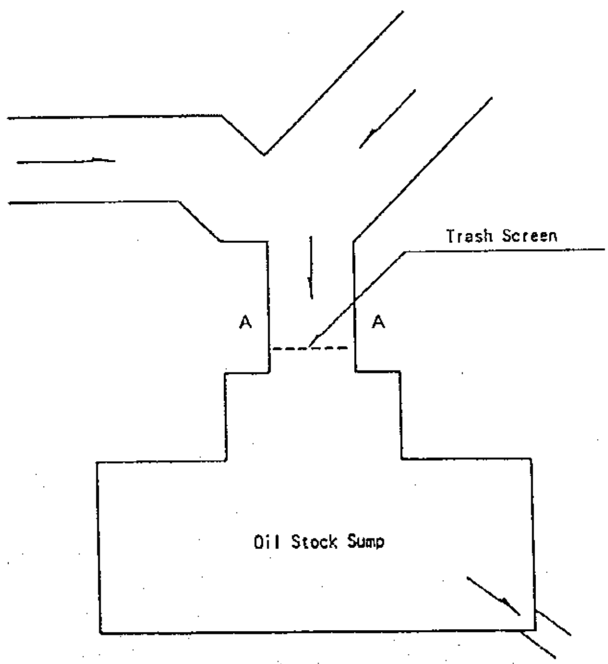
$$Tc = L/W = 1.42/2.71 = 0.52 \text{ hr}$$

$$\text{Now } r = R24/24 \times (24/Tc)^{0.7}$$
$$= 96/24 \times (24/0.52)^{0.7}$$
$$= 58.50 \text{ mm/hr}$$

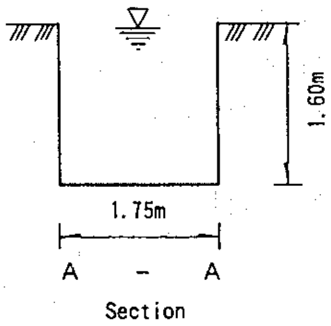
$$\text{Therefore, Peak runoff } Qp = 0.2778 \times f \times r \times A$$
$$= 0.2778 \times 0.70 \times 58.5 \times 0.86$$
$$= 9.78\ m^3/sec\ (11.40\ m^3/s/km^2)$$

## (2) Capacity Check

A plan view of the oil-stock sump is presented below.



Capacity of the inlet channel:




$A = 2.80\ m^2$

$P = 4.95\ m$

$R = 0.566\ m$

$V = 2.05\ m/s$

$n = 0.015$

$S = 1/500$

Maximum capacity ($Q_{mx}$) $= 5.74\ m^3/s$

## (3) Conclusion

The result of calculation shows that the capacity of the inlet channel is 5.74 $m^3/s$ against the peak runoff volume of 9.78 $m^3/s$. Therefore, the inlet channel is not capable of carrying the peak runoff volume.

## 8-7 Conclusions and Recommendations

Table 8-2 summarizes the results of calculations.

**Table 8-2 Results of the Calculations**

| Oil-catches | | | | |
|---|---|---|---|---|
| Item | Peak runoff $m^3/s$ | Capacity $m^3/s$ River | Capacity $m^3/s$ Baffle | Remarks |
| Techier | 25.96 | 20.23 | 3.50 | Neither river cross sections nor baffle sections are capable of carrying peak runoff volumes. |
| F20 | 5.50 | 0.134 | 0.902 | Same as above |
| TB33 | 26.38 | 29.64 | 1.972 | River cross section is capable of carrying the peak runoff volume but the baffle is not. |
| Vance | 17.0 | 53.29 | 5.648 | Same as above |
| Cocoa | 36.25 | -- | 16.159 | The baffle does not have enough capacity to carry peak runoff volume. |
| Arrow-head | 40.30 | -- | 34.74 | Same as above |
| John | 17.72 | 28.143 | 10.236 | River cross section is capable of carrying the peak runoff volume but the baffle is not. |
| TRINMAR | 1.29 | 0.12 | 0.075 (Flow over weir) | Channel does not have enough capacity for peak runoff volume. |

| Item | Peak runoff $m^3/s$ | Inlet channel Cap. $m^3/s$ | Remarks |
|---|---|---|---|
| **API Separators** | | | |
| No. 1 | 4.20 | 5.511 | The separator has enough capacity to carry the peak runoff volume. |
| No. 2 | 3.89 | 1.45 | The separator is not capable of carrying the peak runoff volume. |
| No. 3 | 7.56 | 3.931 | Same as above |
| **Oil Stock Sump** | | | |
| Oil stock sump | 9.78 | 5.74 | Same as above |

### 8-7-1 Oil Catches

Table 8-2 shows that for all the catches and dam, either of the river cross section or baffle, or both, is not capable of carrying the peak runoff volume. This means that if oil is present at the catches, oil will be washed away when it pours very heavily. Although the catches and dams are found inadequate and not capable of performing their intended purposes of stopping floating oil in the case of heavy downpours, the study team would not recommend re-designs, modifications or expansions of any of these catches and dams. The measures to control and prevent oil pollution should be made to be unaffected by the climatic or weather conditions, by such appropriate measures as separating oily water and storm water, rather than being designed to absorb fluctuations of load that may occur if storm water is allowed to enter the water treating facilities. Instead, the study team recommends that the very idea of stopping and collecting oil by the catches and dams on the public streams should be abandoned, because this is not the right way to control petroleum pollution.

First and foremost, there should never be oil floating on the public streams before discussing the capacity of catches and dams to stop oil that has escaped to the public streams. Second, catches and dams, designed to stop the floating oil, are utterly ineffective against the water-miscible oil-in-water emulsion produced with crude oil, the most serious source of oil pollution in the study area of Trinidad and Tobago, now being discharged from the production facilities to the public water streams and freely flowing down the rivers through the catches and dams to the sea.

The project scheme the study team recommends in Chapter 20, Project Scheme for the Master Plan, would ensure prevention of floating oil from entering the public stream and reduction of oil content in effluent water to lower than 50 ppm, either in the form of floating oil, in the form of water-miscible oil-in-water solution, or dissolved form. After the implementation of the recommendations there should never be oil floating at the catches and dams as long as normal operating conditions are maintained. If floating oil appears at the catches or dams on account of an accidental discharge of oil, such a situation should be regarded as an emergency. Emergency personnel and equipment should be mobilized immediately and oil should be collected promptly.

**8-7-2 API Separators in Pointe-a-Pierre Refinery**

No. 1 API Separator is the only one that has enough capacity to handle the peak runoff volume. If the hydraulic by-pass works properly the load will further decrease.

In the case of No. 2 API Separator, if the hydraulic by-pass works well the load would decrease substantially. Flooding would occur if it pours very heavily. Therefore, in order to make the system completely flood-free, diversion of some runoff and installation of a hydraulic by-pass with an appropriate cross section are recommended.

The inlet channel of No. 3 API Separator has only 50 percent capacity. A larger channel cross section and an appropriate hydraulic by-pass may solve the problem. Considering the large peak runoff volume, segregation of storm water from the effluent water would be the best option as a permanent solution.

Apart from the huge runoff volume, the low elevation is also a problem in the case of the Oil-stock Sump. Even if appropriate inlet channel dimensions are provided, the severe flooding problem would remain unsolved unless the level of the sump is raised. Therefore, elevation of the level and expansion of the inlet channel dimensions are recommended.

# Chapter 9 Pollution Prevention at the Production Facilities

# Chapter 9 Pollution Prevention at the Production Facilities

## 9-1 Analysis of Present Conditions

### 9-1-1 Crude Oil Production

Trinidad and Tobago has a total of about 500 million barrels of proven crude oil reserves. The daily production averages 144,000 B/D, 24 percent onshore and 76 percent offshore, having been declining over the last five years. Exploitation of the heavy oil reserves by steam injection plays an important role to minimize the decline of production caused by the loss of primary production. Thermal crude oil, crude oil produced under steam injection, currently constitutes seven percent of the total production nationwide. Additional secondary production by applying water flooding and carbon dioxide injection also contributes to a certain extent.

The combination of natural depletion of the reservoirs and the expanded use of steam injection has resulted in a steady increase in water production in recent years. The production of water is currently estimated to be 50,000 B/D, of which approximately 90 percent is discharged to inland waterways and eventually to the sea.

The onshore oilfields related to this study are located in the Southern Basin of the Western District in Trinidad. The area extends from northern Brighton, Vessigny, passing through Guapo, Point Fortin Central, Cruse, Parryland, Palo Seco, Central Los Bajos, Coora/Quarry, to Forest Reserve, Bernstein and Fyzabad Fields.

These fields are relatively old, discovered between 1920 and 1940. The former Trintoc and Trintopec were two of the major operators in this district up to 1993; now Petrotrin is the sole operator and is responsible for management of all the onshore oilfields mentioned above. Petrotrin currently produces about 30,000 barrels per day from onshore oil fields. The number of production wells in this district is approximately 2,100; daily average production level per well is 10 to 15 barrels.

There are some flowing wells in several oilfields; however, almost all producing wells are sucker-rod pumping wells.

The nature of reservoir fluid is suitable for recovery by steam injection. In addition, associated gas is available as fuel for steam generation. Steam injection is therefore done to many wells and a significant amount of crude oil is produced in this way. This is one of the characteristics of this area.

As a means of enhanced oil recovery, gas lift and $CO_2$ injection are also adopted on small scales at Forest Reserve and Oropouche in this district. Sea water injection was once done in the past but is now suspended.

Crude oil and produced water from production wells are collected at gathering stations, or alternatively called tank battery, and transported to the tank farms in the area. At the tank farms, water is separated and bled from the tank bottoms. Crude oils are fiscalized at the tank farms and transported to Pointe-a-Pierre Refinery for processing.

There are also offshore oilfields named 'Soldado', located between 20 and 50 kilometers to the north of Point Ligoure, operated by TRINMAR. The present production is 31,000 barrels per day. All the fiscalized crude oils from 24 offshore platforms are transported to Point Ligoure Tank Farm. Water is reduced to 2 percent, and the crude oil is sent to Bernstein Main Storage via a trunk line.

The dry crudes from the oil fields in the Western District, Point Ligoure, Point Fortin, Guapo, etc., are all transported to the Bernstein in-transit tanks. Recently, wet crudes from Fyzabad began to be transported to Bernstein; Bernstein Main Storage now plays the role of the central tank farm for the oilfields in the Western District. Associated gas is produced in this area and is used as fuel for steam generation, for gas lifting, as refinery fuel and for other miscellaneous uses. For this purpose, there are several compressor stations for gas transportation.

### 9-1-2 Characteristics of Oilfields

The reservoir top depth of oil fields in this area varies from 300 to 11,000 feet. The sandstone reservoir has a thickness of 50 to 250 feet. Flowing wells account for about 10 percent of total production wells, while other production wells are conventional sucker-rod pumping wells.

Average oil production per well is approximately 15 barrels per day plus water. The approximate overall field-wide crude oil production in this district is:

Heavy oil by EOR (from steam injection): 10,000 B/D

Primary production: 20,000 B/D

Table 9-1 shows approximate production by field.

**Table 9-1 Crude Oil Production - Onshore**

(Unit: Barrels per day)

| | primary | thermal |
|---|---|---|
| EAST | | |
| Penal | 620 | |
| Barrackpore | 1,900 | |
| Cathill | 460 | |
| Guayaguayare | 1,310 | |
| WEST | | |
| Forest Reserve | 2,500 | 920 |
| Palo Seco(TTOC) | 1,370 | |
| Brighton | 620 | |
| Parryland | 920 | |
| Point Fortin C | 3,200 | |
| Apex/Quarry | 400 | 1,020 |
| C Los Bajos | 300 | 1,590 |
| Coora | 100 | |
| Erin | 220 | |
| Fyzabad | 1,640 | 370 |
| Guapo | 750 | 1,470 |
| McKenzie | 250 | |
| Moruga | 160 | |
| Palo Seco | 3,250 | 2,800 |

Source: Petrotrin, Operating Division, Weekly Operations, Jan. 31, 1994

Most crude oils produced in this area are heavy oils with their API gravities at around 15. Petrotrin has 20 land drilling rigs including workover rigs; routine workover is being done for sub-surface well maintenance. Tubular materials and sizes are as follows:

Tubing size: 2 3/8", 2 7/8",
Grade: H-40, J-55, N-80
Line Pipe; API 5L grade A, B, X42, X46, X52, X56,(SMLS)

### 9-1-3 Oil Field Operation

The oilfield management and daily operation are carried out by the Production Operation Department of Petrotrin. This department is responsible for production, maintenance, and oil transfer activities excluding those concerning reservoirs and exploration work.

Oils produced from all wells are collected at gathering stations, then sent to adjacent tank farms, and subsequently transported to Pointe-a-Pierre Refinery via Bernstein (Western area) or Barrackpore (Eastern area). One gathering station receives oil from 10 to 60 wells, normally from 15 to 20 wells. These numbers increase in the thermal area. Wells are normally operated continuously, not intermittently. Motor-driven sucker rod pumps are most commonly used. Operation of several wells is now suspended in order to restore the bottom hole pressure.

Oil spills from leaking stuffing boxes of Christmas trees are observed at some production wells; these are presumably caused by mechanical dynamic imbalance of the sucker rod pumping systems.

## 9-2 Review of Production Method, Enhanced Oil Recovery

### 9-2-1 Steam Injection

Most crude oils fall in the class of heavy oil, with their specific gravities at around 0.95. Their sulfur contents are low at about 0.5 percent. The viscosity of crude oil varies from 105 to 3,000 Centipoise (CP), typically between 300 and 500 CP. There is a wide variation in reservoir top depth, ranging from 300 feet to 11,000 feet, and also in reservoir thickness. Steam is injected to the sandstone layers lying 1,000 to 1,500 feet underground, with permeability of the formations ranging from 10 to 850 milli-darcy.

In the Western District, contrary to the Eastern District, Enhanced Oil Recovery (EOR) by steam injection has continuously been carried out. Steam injection has been practiced since the 1970s. Some fields practice cyclic operation and others continuous operation.

| | |
|---|---|
| Injection volume, barrels per day: | 200 - 500 |
| Type: | Pattern injection |
| Source of water: | Water wells |
| Fuel for steam generation: | Associated gas |
| Total gas production in the area, MMSCFD: | 40 - 50 |

As a result of steam injection, a considerable amount of water, actually an oil-in-water emulsion, is produced along with crude oil. Water for steam generation is taken from wells about 400 feet deep. In this area, there exists a large aquifer at a relatively shallow depth. The fresh water taken from the wells is transported to settling tanks and distributed to all steam generating stations, and used after treatment and purification. Such steam generating stations are located at several places in this area. Table 9-2 gives production of oil, that of water and amounts of steam injected.

**Table 9-2 Steam Injection Activity**

(Unit: Barrels per day)

| | PRODUCTION | | INJECTION |
|---|---|---|---|
| | OIL | WATER | STEAM |
| Forest Reserve(Project III) | 920 | 8,000 | |
| Palo Seco | 2,800 | 17,000 | 11,700 |
| Guapo | 1,500 | 6,600 | 11,000 |
| Central Los Bajos | 1,600 | 5,800 | 8,500 |
| Apex/Quarry | 1,000 | 4,600 | 4,500 |
| Fyzabad | 300 | 2,500 | 2,000 |
| Total | 8,120 | 44,500 | |

Source: Petrotrin, Steamflood Characteristics to 1993 December

One typical steam injection project underway in the Forest Reserve area is called Project-III. Table 9-3 indicates the reservoir characteristics of Project III.

**Table 9-3 Reservoir Characteristics of Project III**

| | |
|---|---|
| Properties of reservoir rock | |
| Porosity, % | 33 |
| Permeability, md | 200 |
| Connate Water Saturation, % | 30 |
| Sand Grain Density, Lbs/$ft^3$ | 165.0 |
| Sand Grain Specific Heat, BTU/lb-F | 0.17 |
| Rock Compressibility, vol/vol/psi | $3 \times 10^{-6}$ |
| Properties of reservoir fluid | |
| Bottom Hole Pressure, psi | 523 |
| Bottom Hole Temperature, degree F | 100 |
| Gas Oil Ratio, SCF/bbl | 85 |
| Formation Volume Factor, bbl/bbl | 1.03 |
| Water Compressibility /psi | $3.2 \times 10^{-6}$ |
| Oil Compressibility /psi | $7.7 \times 10^{-6}$ |

Source: Petrotrin, Heavy Oil Project - Forest Reserve

Project-III is underway in the Middle Field of the Forest Reserve oilfield, aiming to produce 13 million barrels during a period of 25 years, assuming recovery rates of 60 to 70 percent on the original oil in place. Fourteen new wells have already been drilled. The peak production will be 670 BOPD in 2001, with an estimated peak injection of 3,000 BWPD contemplated for seven years after the start of steam injection. For the purpose of treating water produced by this project, a new water treatment facility is reportedly planned in Bernstein Main Storage. The water for steam generation will come from water wells in this area and treated at a water treatment center to remove iron and solid particles and also to soften water. The steam for injection will be at 600 psi and 650 degrees F.

Steam injection lines are:

| | | |
|---|---|---|
| Size | 3 inch, | 4 inch |
| All welded flange connection | | |
| Expansion allowance is designed | | |
| Material | schedule 80, normal carbon steel | |

### 9-2-2 New Steam Injection Projects

In addition, two new steam injection projects have started; these are:

1. Cruse-E Expansion
2. Forest Reserve Expansion

These projects inject 600 psi steam into 1,000 to 1,500 feet deep sandstone reservoirs (inverted 5 spot pattern injection). As a result of these projects, the effluent water coming to Bernstein Main Storage will increase from the present 12,000 to 35,000 B/D.

The dry crude from Los Bajos is now transported to Pointe-a-Pierre Refinery through Bernstein Main Storage. Petrotrin plans to make Bernstein the center of onshore oil and water treatment in the Western District.

Other exploratory drilling activities are underway at the Point Fortin Central oilfield, for example, where a 5,000 feet deep new appraisal well has been drilled.

### 9-2-3 Effects of the Planned Projects on Pollution

As mentioned above, water coming to Bernstein Main Storage will increase to 35,000 B/D from the present 12,000 B/D. The incremental portion is a tough oil-in-water emulsion that needs to be treated adequately in the main storage before being discharged to the public waterways in order to minimize the Silver Stream River pollution. Petrotrin is working on this subject. The study team proposes a scheme that should solve this problem.

### 9-2-4 Other EOR Activities

In the Eastern oilfield, the following kinds of EOR activities will continue. Unlike the Western district, steam injection is not used.

| | |
|---|---|
| Water flood (fresh water) | Trinity (eastern) |
| (brackish water with 1,500 ppm salt content) | Cathill (eastern) |
| (sea water) | Geleota (eastern) |

Gas lift operation is also done using associated gas. There is a gas distribution grid in this area which enables the associated gas to be effectively used for gas lift operation.

$CO_2$ injection to oil reservoirs has been done on a minor scale. With this operation, the pipeline sometimes suffers from corrosion.

## 9-3 Pollution Source in Production Activities

### 9-3-1 Gathering Stations

Oil and water produced from pumping wells come to the gathering stations, alternatively called tank batteries. In principle, water is not bled at intermediate medium-sized gathering stations to avoid causing pollution; however, water that contains oil is discharged to the public waterways in some cases, especially from small gathering stations.

This is the primary source of oil pollution. Oil content of the effluent water is more than 1,000 ppm, and salt content varies from 2,500 to 35,000 ppm.

### 9-3-2 Wellheads

Around the pumping wellheads in this district totaling approximately 2,100, oil pollution caused by leakage of well fluids at the stuffing boxes of the Christmas trees is noticed. Mechanically, this is directly related to dynamic mal-alignment of the pumping system and deterioration of gland packing. This is, however, one of the symptoms of more serious systemic deterioration of the total maintenance system and housekeeping.

Crude oils leaking from individual wells are led to adjacent small oil saving pits and occasionally skimmed and recovered by the field operation personnel. In spite of periodic skimming activities, a significant portion of the oil flows to the public domain in the rainy season, June to December. Although the amount of oil leaking from each individual wellhead may not be large, the leakage from many wells together could amount to a significant volume. This could be a second source of the environmental pollution.

### 9-3-3 Pipelines

The third source of oil pollution is leakage from the 2-inch pipelines from wellheads to gathering stations. Due to the non-corrosive nature of crude oil in this district, this is not as serious a problem as the above two causes. Proper inspection and maintenance can solve this problem.

### 9-3-4 Oil Catches in Rivers

In order to stop and recover oil that has already escaped to public waterways, several oil catchment pits are installed at several selected locations; these are TB-33, Cocoa Catch, Arrowhead Dam, John River Catch, etc. The areas upstream and also downstream of these pits are heavily polluted with floating black oil. What appears to be a brown-colored oil-in-water type emulsion is seen flowing around catchments or dams without being stopped.

## 9-4 Major Findings, Pollution in the Study Area

### 9-4-1 Degree of Pollution in the Area

During the field surveys the study team has visited sites of oil pollution and investigated these areas in detail to grasp the severity of oil pollution. As shown in Figure 9-1, the study team has chosen eighteen typical sites and observed them. The sources of pollution were evaluated and countermeasures studied. As criteria of degree of pollution, the following measures are introduced.

**A:** Slightly polluted, but not needing immediate remedial measures

**B**: Polluted, not so serious but needing remedial measures

**C**: Serious, needing remedial action with top priority

(1) **Site No. 1** Pollution rank: **A**

**Location**: Mouth of the Oropouche River, the largest river in this area

**Appearance**: The river is brown with poor transparency. The sea in the immediate proximity to the mouth is brown due to the suspended oil particles. An oil slick was not observed when the team visited. Oil content of water in this region is around 500 ppm. No visible floating tar or heavy oil was observed when the team visited.

**Source of pollution**: Fyzabad Oilfield. The oil leaking from wellheads/gathering stations and the effluent water streams from tank farms flow into the John River, Molai River and Gunapo River and comes down diluted to this point.

**Action to be taken**: None

(2) **Site No. 2** Pollution rank: **A**

**Location**: The Silver Stream River, fairly close to the sea (Otaheite Bay), a rather small river three meters across.

**Appearance**: Muddy brown color with poor transparency, no oil slick but tar was observed when the team visited.

**Source of pollution**: Forest Reserve Oilfield and related facilities.

**Action to be taken**: None

(3) **Site No. 3** Pollution rank: **A**

**Location**: The Vance River, fairly close to the sea, a small river two meters across

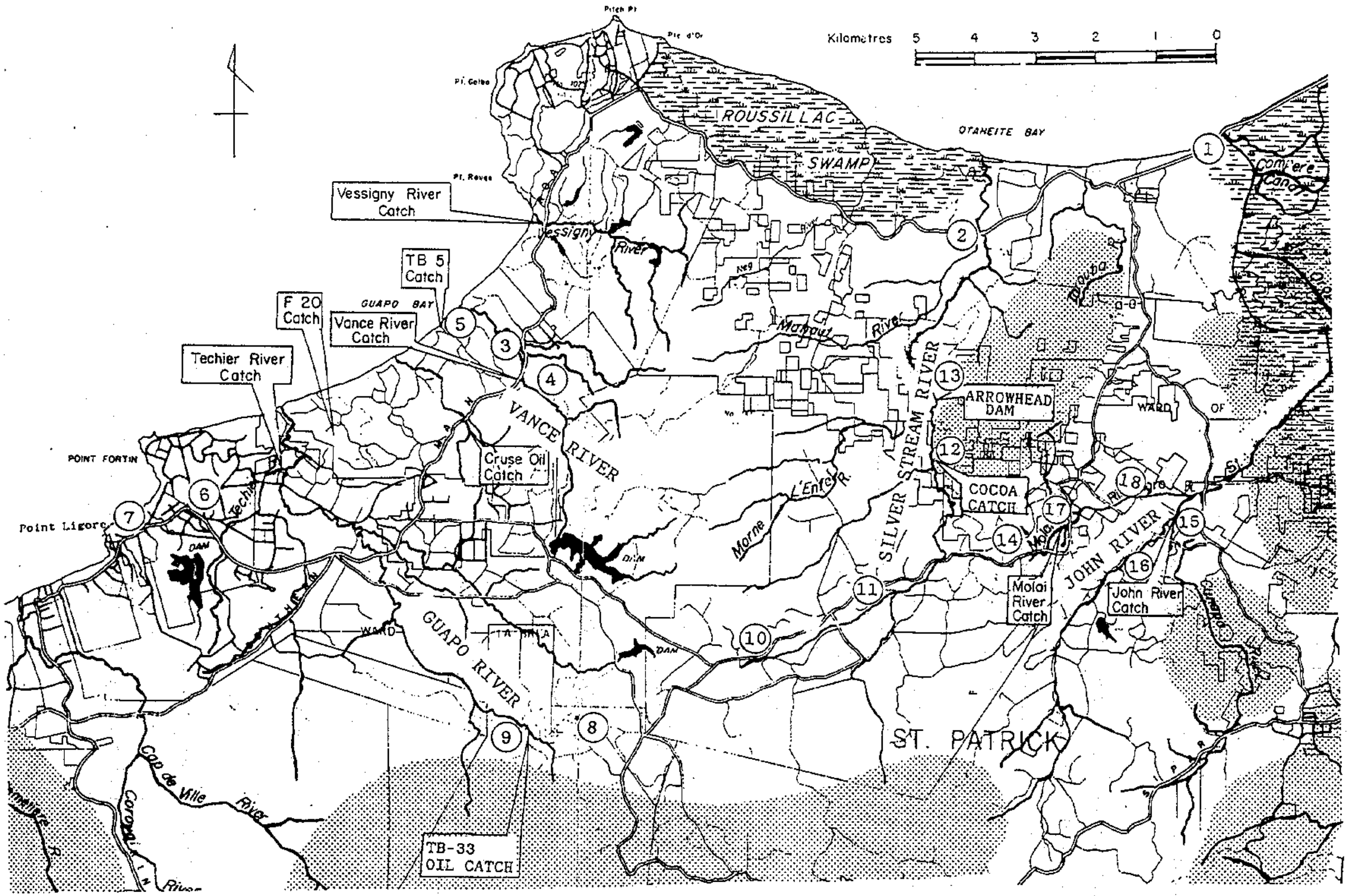



Figure 9-1 Representative Sites in the Study Area

**Appearance**: Deposits of dry heavy oil were observed adhering to the plants and grasses growing on both river banks. These tar deposits were presumably carried from the upstream oilfield areas by flood water in the rainy season. The river bed is cemented. Oil slicks were observed on the water surface.

**Source of pollution**: Parryland and Guapo Oilfields

**Action to be taken**: Cleaning of oil deposits is necessary.

(4) **Site No. 4** Pollution rank **B**

**Location**: Vance river oil catch, upstream of Site No. 3

**Appearance**: Light brown color of relatively good transparency. Some oil slicks were observed on the upstream side.

**Source of pollution**: Parryland and Guapo Oilfields

**Action to be taken**: Floating oil should be skimmed from the pit more often.

(5) **Site No. 5** Pollution rank: **C**

**Location**: TB-5, effluent water pit, located within 100 meters of the sea.

**Appearance**: Black oil is seen floating in the pit. The effluent water pit from TB-5 is a real problem. The pit is nothing but a water disposal pond made between the tank farm and sea. Apparently, oil is not skimmed properly. If a flood occurs in the rainy season, heavy oil floating in the pit will be immediately and directly washed to the sea passing the oil catch. This is one of the most important sources of coastline oil pollution.

**Source of pollution**: Bleed water from crude oil tanks

**Actions to be taken**: 1. Oil should be skimmed more properly and more often. 2. Rain water must be prevented from entering the oily water system.

(6) **Site No. 6** Pollution rank **C**

**Location**: Point Fortin Main Storage, effluent water pit

**Appearance**: Black oil is floating in the pit. Oil fences and oil skimming pumps are installed. However, oil in not prevented from flowing out from the pit into the forest, causing soil contamination in this area. Oil permeates into the ground.

**Source of pollution**: Bleed water from crude oil tanks

**Actions to be taken**: 1. More frequent skimming of floating oil is necessary. 2. Appropriate effluent water treatment facilities needs to be installed. 3. Soil rehabilitation is necessary. 4. New sludge disposal methods should be considered.

(7) **Site No. 7** Pollution rank **C**

**Location**: TRINMAR, Point Ligoure Main Storage, the one kilometer river from disposal pit to the sea.

**Appearance**: Although effluent water itself was not so dirty when the study team visited, black oil tar covers the whole area alongside the river stream. Although up-to-date effluent water processing facilities are operational (API, CPI, Induced Gas Flotation Unit), a certain amount of heavy oil obviously flows out to the above public stream, perhaps intermittently for some reasons not identified when the visits were made. Segregation of rain water and effluent water would not be enough.

At the second oil catchment pit, a significant amount of heavy oil is trapped. In addition, oil slicks were clearly visible even at the discharge point to the sea lagoon. This should be regarded as a direct cause of oil pollution along the coast line.

**Source of pollution**: Asphaltic oil leaking from the tank farm

**Actions to be taken**: 1. Spilled oil remaining alongside the river should be removed. 2. Causes for allowing oil to escape through the API and CPI separators to the river must be identified and appropriate preventive measures taken. In addition, careful monitoring should be routinely done to discover any trace of leakage.

**(8) Site No. 8** Pollution rank **C**

**Location**: Central Los Bajos, effluent water from API pit

**Appearance**: The main problem is a brown colored oil-in-water emulsion. The water is produced with crude oil as a result of steam injection. Evidently, the API separators cannot separate this tight difficult-to-break emulsion.

**Source of pollution**: Effluent water from the wash tanks (thermal)

**Action to be taken**: A new water treating facility for breaking the emulsion is necessary. The study team recommends that this water be transported to Bernstein Main Storage to be treated by the proposed waste water treating system there.

**(9) Site No. 9** Pollution rank **C**

**Location**: TB-33, oil catchment

**Appearance**: Heavy oil is floating and river banks are heavily polluted with black oil. The sources are probably bleed water containing oil discharged from gathering stations in this area. Water does not have the brown color observed in waters produced from thermal wells.

**Source of pollution**: Oil wells and gathering stations in Palo Seco and Central Los Bajos Oilfields.

**Actions to be taken**: It is necessary to discontinue the bleeding of oil-containing water to the environment by all means.

**(10) Site No. 10** Pollution rank **A**

**Location**: Forest Reserve Main Storage, effluent water from oil skimming pit

**Appearance**: Although a considerable amount of oil is floating on the earthen pit surface, effluent water seems rather good in comparison with other tank farms.

**Source of pollution**: Bleed water from crude oil tank

**Action to be taken**: It is necessary to prevent rain water from flowing to the pit.

**(11) Site No. 11** Pollution rank **C**

**Location**: Forest Reserve Bernstein Storage, API separator

**Appearance**: The effluent water streams from two parallel API separators show a chocolate brown color, forming a tough emulsion that is characteristic of the water accompanying the thermal crude oil. The color is similar to that of the effluent water from Central Los Bajos Storage (Site No. 8).

**Source of pollution**: Effluent water from wash tanks (primary and thermal)

**Action to be taken**: It is necessary to install new water treating facilities for breaking the emulsion.

**(12) Site No. 12** Pollution rank **B**

**Location**: Cocoa Catch, in the Silver Stream River, downstream of Forest Reserve Main and Bernstein Main Storage.

**Appearance**: A considerable amount of heavy oil and debris were floating close to the weir. Oil slicks were observed.

**Source of pollution**: Considering the fact that Forest Reserve Main Storage and Forest Reserve Bernstein Storage do not discharge such heavy oil during normal operation, these heavy oils might have come in the flood season from gathering stations and production wells alongside the Silver Stream River.

**Actions to be taken**: Routine cleaning and maintenance should be carried out more often and in a proper way.

(13) **Site No. 13** Pollution rank **B**

**Location**: Arrowhead Dam, Silver Stream River, downstream of Cocoa Catch (Site No. 12)

**Appearance**: Oil-stained debris is floating. No oil slick was observed.

**Source of pollution**: Same as Cocoa Catch

**Action to be taken**: Periodic routine cleaning is required.

(14) **Site No. 14** Pollution rank **B**

This facility is out of service now. The following was an observation during the first field survey which took place in September to October, 1993.

**Location**: Fyzabad Storage, API skimming pit.

**Appearance**: Oil slicks were observed at the outlet of the API separator. Effluent water is a brown-colored emulsion generated from thermal operation, but is not as bad as that from the Los Bajos storage. Meanwhile, the sludge disposal pit here is a problem during the flood season; the floating oil may overflow out of the pit.

**Source of pollution**: Effluent water from the wash tanks, and bleed water from the crude oil tanks.

**Actions to be taken**: It is necessary to skim the floating oil more often to prevent it from entering the public stream.

(15) **Site No. 15** Pollution rank **C**

**Location**: John River oil catchment area, Fyzabad

**Appearance**: Heavy oil is flowing on the surface of chocolate colored thermal emulsion water. The origins of this surface oil may be leaking production wells.

**Sources of pollution**: Production wells and gathering stations in Fyzabad oilfield.

**Actions to be taken**: Stop bleeding thermal water at the gathering stations to the public streams.

**(16) Site No. 16** Pollution rank **C**

**Location**: The John River, 500 meter upstream of Oil Catch.

**Appearance**: Black oil was flowing down on the surface of the brown colored thermal emulsion water.

**Sources of pollution**: Same as Site No. 15

**Actions to be taken**: Same as Site No. 15

**(17) Site No. 17** Pollution rank **B**

**Location**: The Molai River, dogleg pit for oil catch

**Appearance**: The river is of chocolate brown color. Dry black oil sticks to the grasses. The dogleg seems to be working properly. Judging from black oil deposit found downstream of the pit, the water must have overflowed the pit in heavy downpours.

**Sources of pollution**: Gathering stations and wellheads at the Fyzabad oilfield.

**Action to be taken**: Prevention of oil leakages

**(18) Site No. 18** Pollution Rank **B**

**Location**: The Molai River, one kilometer downstream of the dogleg pit

**Appearance**: Oil slicks were observed. Dry black oil remains at the pit. Oil sticks to the grasses.

**Sources of pollution**: Same as Site No. 17

**Action to be taken**: Same as site No. 17

## 9-5 Major Issues of Pollution and Pollution Prevention

A report was presented in June 1992 by the Environmental Department of the former Trintoc. The report recommends establishment of Petrotrin's Environment Unit and proposes an action plan for implementation of environmental conservation programs. According to the recommendation a base-line monitoring program was initiated on the effluents discharged from the exploration activities and production facilities.

The following items were monitored: temperature, pH, total dissolved and suspended solids, sulfides, dissolved oxygen, chlorides, oil and grease and chemical oxygen demand. The objectives of the program were to provide data which would help measure the effectiveness of the existing pollution control facilities and also help identify problem areas which would need continuous monitoring. The data collected served to formulate the framework of the environmental monitoring program for the company's operations.

A monitoring program thus formulated for effluent streams from the company's operations commenced in August 1992 and will continue through the end of 1995. After this monitoring, the program will be reviewed. The objectives of this program are to establish a base line for specific contaminants discharged to the environment, to provide data that should be necessary for the design of pollution control facilities, and to document the effects of the control programs.

### 9-5-1 Environmental Monitoring Programs

Proper disposal of water produced with crude oil could not be more important for prevention and control of petroleum pollution as far as the objective of this study is concerned. The amount of water will increase over the economic life of an oil field. Environmental monitoring of water quality is the first essential element in the formulation of the control program. In line with this concept, Petrotrin has established its environmental monitoring program for their onshore oilfields.

The data collected should be of value in pollution prevention and control. The data can be used to specify how and where water and wastes should be handled and disposed of. The major objectives in implementing the environmental monitoring program for discharged produced water are:

1. To clarify and quantify major contaminants present in the effluent water produced from exploration and production operations,

2. To obtain data for identifying the sources of pollution,

3. To provide a water quality data base to establish realistic company standards.

The monitoring program has been under way, taking samples at the following locations:

EASTERN DISTRICT OILFIELDS

- Guayaguayare
- Cathill
- Trinity
- Barrackpore
- Penal
- Oropouche

WESTERN DISTRICT OILFIELDS

- Forest Reserve Main
- Forest Reserve Bernstein
- Forest Reserve Arrowhead
- Brighton
- Vessigny
- Point Fortin Central.

The entire quantity of produced water from onshore oilfields is discharged to rivers. The sampling points Nos. 1, 2 and 3 were selected as follows:

No. 1 Effluent discharge point,
No. 2 100 meters upstream of the discharge point,
No. 3 100 to 200 meters downstream of the discharge point.

Table 9-4. shows some of the data obtained at Bernstein Point No. 3 over a period of one year from September 1992 to August 1993.

Control programs are currently being developed to identify sources of emissions from the company's operations. These programs include procedures for spill clean-up, maintenance of pollution control facilities and management of the existing oil savers (API separators, sumps, catchment pits), as well as procedures for the prevention of chronic pollution.

**Table 9-4 Monitoring Results**

| | pH | Temp. | DO | TDS | TSS | O&G | Cl | S |
|---|---|---|---|---|---|---|---|---|
| 1992 | | | | | | | | |
| Sept. | 8.0 | 30.2 | 1.4 | 360 | - | 20 | 213 | 0.6 |
| Oct. | 7.6 | 32.6 | 0.7 | 3,150 | - | 861 | 1,420 | 0.6 |
| Nov. | 7.2 | 28.6 | 0.6 | 2,592 | - | 146 | 994 | 0.5 |
| Dec. | 8.0 | 28.6 | 0.5 | 4,100 | 8,900 | 198 | 2,201 | 1.4 |
| 1993 | | | | | | | | |
| Jan. | 8.5 | - | 0.8 | 5,380 | 88 | 73 | 2,130 | 5.4 |
| Feb. | 7.6 | 31.2 | 0.5 | 5,820 | 214 | 198 | 1,775 | 1.4 |
| Mar. | 7.8 | 30.6 | 0.2 | 2,950 | 268 | 2 | 2,272 | 3.7 |
| Apr. | 7.4 | 28.3 | 0.5 | 2,476 | 65 | 274 | 1,539 | 1.6 |
| May | 8.0 | 33.0 | 0.3 | 3,880 | 1,444 | 492 | 1,952 | 5.4 |
| June | 8.1 | 32.6 | <0.1 | 5,100 | 331 | 531 | 2,307 | 3.4 |
| July | 7.9 | 29.3 | 0.3 | 2,700 | 99 | 942 | 1,242 | 3.6 |
| Aug. | 7.9 | 30.2 | 0.5 | 4,320 | 107 | 358 | 1,775 | 2.6 |
| Max. | 8.5 | 33.0 | 1.4 | 5820 | 8900 | 942 | 2307 | 5.4 |
| Min. | 7.2 | 28.3 | <0.1 | 360 | 65 | 2 | 213 | 0.5 |

Source: Ministry of Energy and Energy Industries

Note:
- pH: Measure of acidity with 7 being neutral
- Temp: Temperature in Centigrade
- DO: Dissolved Oxygen in ppm
- TDS: Total Dissolved Solids in ppm
- TSS: Total Suspended Solids in ppm
- O&G: Oil and grease in milligrams per liter
- Cl: Chlorine ions in ppm
- S: Sulfur ions in ppm

### 9-5-2 Chronic Contamination

The Environment Department of Petrotrin is identifying the sources of chronic pollution, developing alternative operating procedures and incorporating these issues in the training and educational programs for operators. Petrotrin is also setting up clean-up standards for the already polluted environment.

## 9-6 Conclusions

The major issues in the area of oil pollution due to the operation of the facilities may be classified as follows:

1. The heavy oil that has leaked from the crude oil production facilities or that has been bled from the isolated crude oil gathering tanks is allowed to flow to the public domain.

2. The effluent water from the major tank farms associated with primary oil production is large in quantity and discharged to the public domain without being rid of oil to the standard.

3. The effluent water from wash tanks, which is actually an oil-in-water type emulsion, produced from steam injection operations defies the effects of traditional gravity-induced separators and flows to the rivers virtually would being rid of emulsified oil.

Although it will entail some additional cost, the solution to No. 1 is rather simple. Minimum but effective modifications of the production facilities to prevent leakage, careful daily surveillance and maintenance, and periodic routine collecting operations of oil that has leaked can prevent this type of pollution.

The other two issues are more complicated and their solutions are difficult and costlier. The concentrations of oil are highest at the discharge points and become gradually thinner as the effluents become diluted with the river water and sea water. Although it becomes thinner, the emulsions remain unbroken, thereby causing petroleum pollution all the way down the rivers to the sea and along the coast lines. As thermal crude oil production increases in this area, treatment of this type of effluent water will become an even more serious and important problem. The installation of traditional gravity-induced separators, modification of the catches and dams, and injection of chemicals into the effluent streams will be virtually ineffective and application of other technologies would be necessary. This question is discussed in other chapters.

## 9-7 Other Alternatives

Re-injection of the effluent water into idle wells can be a solution. However, this can never be justified without thorough study on the effects such a practice could have upon the underground environment, and possible effects upon the life of people and industries. An independent study is required for this approach. The study team is not in a position to make any further comment on re-injection.

Closing down of extremely uneconomic thermal production wells will greatly reduce the amount of produced water, and hence the load on the water treating facilities that have to be installed. It is estimated that the ratio of the produced thermal crude oil and produced water is at present approximately one to ten in the worst cases. There is certainly a threshold ratio beyond which production cost, including the cost of water treatment, will no longer justify production.

# Chapter 10 Crude Tank Farms and Transportation Facilities

# Chapter 10 Crude Tank Farms and Transportation Facilities

Crude oil collected at the gathering stations is sent to the tank farms. Associated water is separated and disposed of at the tank farms. After fiscalization, dry crude is transported to Pointe-a-Pierre Refinery. In the Western District, there are several tank farms as shown in Figure 10-3. Four major tank farms were studied in this chapter.

## 10-1 Bernstein Main Storage

### 10-1-1 Tank Layout and Operation

Located in the Forest Reserve oilfield, wet crude comes from the Forest Reserve Main, Middle, and Bernstein oilfields. Fyzabad crude, both primary and thermal, began to be transported to Bernstein wash tanks recently. The total crude oil throughput is 5,500 B/D, with associated water of 12,000 B/D. There are in-transit tanks, where crude oil coming from other Western district tank farms stays in transit before being pumped to Pointe-a-Pierre Refinery.

**Table 10-1 Tank Configuration - Bernstein**

(Unit: barrels)

| | | | |
|---|---|---|---|
| In-Transit Tanks | No. 13 (78,000), | No. 14 (78,000), | No. 15 (78,000) |
| Fis. Tanks | No. 11 (18.500), | No. 12 (61,000), | No. 7 (20,000) |
| Thermal Wash Tank | No. 16 (5,000) | | |
| Primary Wash Tank | No. 5 (5,000), | No. 17 (5,000) | |

Source: Petrotrin

The primary crude, or crude oil produced without steam enhancement, enters the wash tanks Nos. 5 and 17, and thermal crude the wash tank No. 16. They are subsequently sent to the fiscalization tanks. The Fyzabad wet crude oil, both primary and thermal, enters the wash tank No. 5.

The water content in crude oil is measured at the laboratory in the tank farm. If found to meet the specifications of less than two percent water, the crude oil is transferred to the in-transit tanks. There are three trunk lines coming to the Bernstein in-transit tanks;
namely:

1. 10 inch line, (from Vessigny, Brighton, Guapo)
2. 8 inch line, (from TRINMAR, Pt. Fortin)
3. 8 inch line, (from F/R Main)

Crude oil is not necessarily continuously, but intermittently brought in. The crude oil enters the in-transit tanks and is then transported to Pointe-a-Pierre Refinery.

The wash tanks are inspected once a year. The fiscalization tanks are cleaned when the bottom sludge level rises. The bottom sludges of the API separators for primary crude normally consist of sedimented sand, while those from thermal crude consist of clay. The sludges are removed once a year. The bottoms of tanks are coated with coal tar for protection against corrosion.

### 10-1-2 Effluent Water Treatment

The most serious problem with the effluent water in this tank farm is a tough emulsion of oil-in-water type formed conceivably in the oil reservoirs as a result of steam injection operation, as is the case with the effluent water from the wash tank No. 16. The effluent water from the primary wash tanks, Nos. 5 and 17 tanks, is relatively clean.

From the fiscalization tanks, water is bled for about two to three hours a day. The bleeding operation is finished when oil is detected in the drained water by the change in color. The bled water goes to the API separators.

As shown in Figure 10-1, both primary and thermal waters separated at the wash tanks are bled to the earthen pits to allow some time for sedimentation of sand, and subsequently fed to the parallel API separators where floating oil is recovered.

The API separator is a detention bath designed to give enough time for oil and water to separate by the difference between their specific gravities. Two parallel API separators are used, supposedly to give adequate time for emulsified oil to be separated and skimmed.

The volume of emulsified water has been steadily increasing. The oil and grease content of the effluent water discharged to the river is also increasing, though with some fluctuations. In addition, the accumulation of sand in the API separators is becoming faster and increases the need for cleaning operations. This causes the efficiency of the separator to suffer.

The water effluent from the API separators goes to the final earthen pit for separation of oil and solid before being discharged to public water.

The skimmed oil collected from the API separators is sent to a concrete-made slop pit. After being allowed to stand for some time for separation, what may be regarded as oil is returned to the primary wash tanks (Nos. 5 and 17) by the periodic operation of a reciprocating pump.

When the new steam injection projects -- Cruse-E, and Forest Reserve Expansions -- start, water coming to Bernstein Tank Farm will increase to 30,000 B/D. In addition, dry crude will also be transported from Los Bajos to Bernstein. It is Petrotrin's long-term plan to make Bernstein the center of onshore oil fields in the Western District.

New and appropriate water treating facilities should be installed to control and prevent pollution problems, to cope with the increasing load.

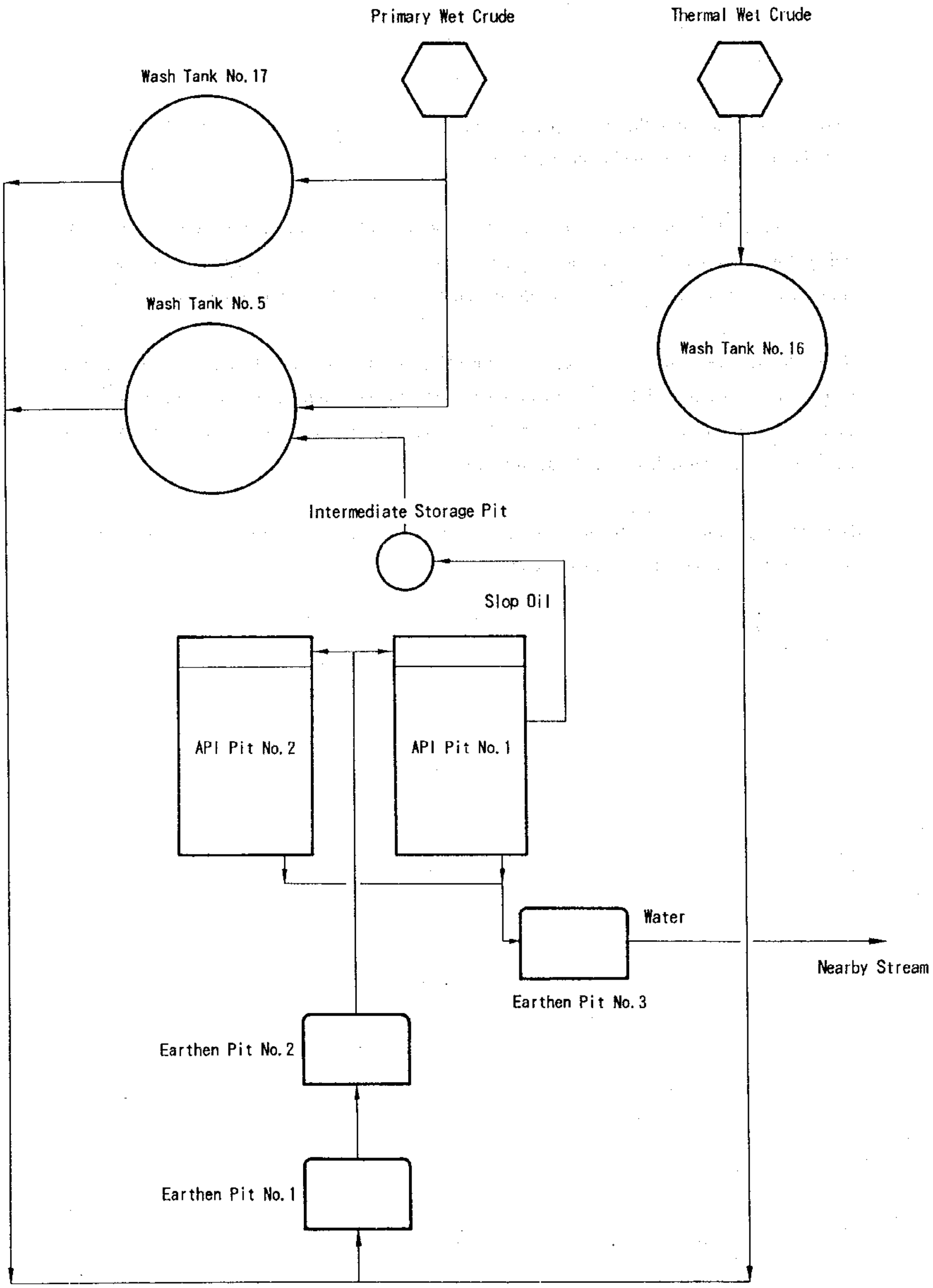



**Figure 10-1 Water Treating Facilities - Bernstein**

### 10-1-3 Pollution Prevention

Obviously, the oil-in-water type emulsion leaving the API separators for the environment is a substantial cause of pollution. The following countermeasures could easily be conceived for this type of pollution. However, none of them alone can solve the problem. Some of them do not fit the conditions and purposes. What is needed is to install a complete water treating system that can reduce the oil content of the effluent to below 50 ppm. The measures proposed by this report, namely combination of dissolved air flotation with coagulation plus adsorption by activated carbon, seem to be the only practical solution.

1. Cleaning of the API separators to maintain their performance
2. Use of an appropriate reverse-demulsifier
3. Air flotation or gas flotation
4. Use of activated charcoal
5. Filtration
6. Hydrocyclones
7. Re-injection of the water to the downholes

## 10-2 Los Bajos Tank Farm

### 10-2-1 Tank Layout and Operation

Los Bajos Tank Farm is located at the Palo Seco oilfield. Wet crude oil comes from the neighboring oilfields such as Palo Seco, Erin, McKenzie, Central Los Bajos, and Coora/Quarry. Crude oil throughput is 15,000 B/D, with 17,000 B/D water concurrently produced. Table 10-2 shows the present tank capacities and uses.

Produced crude oil enters the wash tank (No. 2) for separation of oil and water. The separated crude oil is transferred to the fiscalization tanks through the receiving tank (No. 4). The fluid at the inlet of the wash tank is pressurized. Drainage from the tank is by gravity. The interface between the oil and water is 16 to 18 feet above the wash tank bottom.

From the fiscalization tank, crude oil is transported to Pointe-a-Pierre Refinery via Fyzabad. All crude oil gathered at Los Bajos Tank Farm is now transported to the in-transit tanks at Bernstein Tank Farm.

**Table 10-2 Tank Configuration - Los Bajos**

(Unit: Barrels)

| Tank No. | Capacity | Uses |
|---|---|---|
| 1 | 66,000 | Fiscalization (out of service) |
| 9 | 63,000 | Fiscalization |
| 3 | 36,000 | Royalty storage fiscalization |
| 5 | 12,000 | ibid |
| 7 | 12,000 | ibid |
| 8 | 12,000 | ibid |
| 2 | 36,000 | Wash Tank, (sludge type; sand) |
| 4 | 8,000 | Receiving |
| 10 | 37,000 | Water tank for workover |
| 6 | 13,700 | ibid |

Source: Petrotrin

### 10-2-2 Effluent Water Treatment

Water separated in the wash tank is drained to a small concrete pit through a dogleg pipe attached to the wash tank; the floating oil is recovered and recycled back to the wash tank. The effluent water is discharged to the public stream. This effluent water resembles that from Bernstein Tank Farm, a brown colored oil-in-water type emulsion.

In this tank farm as well, the oil-in-water type emulsion is evidently the direct cause of petroleum pollution.

The small concrete pit is designed for a flow rate estimated for the production of primary crude. Consequently, the capacity is not enough for the present high flow rate. The fluid velocity is too high. Besides this unit being too small to separate the non-emulsified oil, this unit does nothing to the tough emulsion and just lets it flow through to the public stream. This study proposes that all of the waste water be sent to Bernstein Main Storage to be treated with that which originates at Bernstein.

The salinity of effluent water ranges from 2,000 to 5,000 ppm after being diluted by steam condensate.

### 10-2-3 Utilization of Effluent Water

Two tanks (Nos. 3 and 6) are used as effluent water tanks (oil-in-water emulsion), and often transported to the well sites by lorry, then utilized as well-workover fluid. This operation contributes to reducing the quantity of effluent water that is discharged to the environment.

## 10-3 Point Fortin Tank Farm

### 10-3-1 Tank Layout and Operation

Point Fortin Tank Farm is located in the western part of the Point Fortin Central oilfield. Crude oil is transported from the gathering stations of Parryland, Cruse, and Point Fortin Central oilfields. Table 10-3 shows the tank configuration.

**Table 10-3 Tank Configuration - Point Fortin**

(Unit: Barrels)

| Tank | Capacity | Present status |
|---|---|---|
| Wash Tank | | Not available |
| No. 1 Tank | 4,000 | Under repair |
| No. 2 Tank | 11,000 | Fiscalization |
| No. 3 Tank | 11,000 | Fiscalization |
| No. 4 Tank | 11,000 | Deteriorated |

Source: Petrotrin

The total crude throughput is 4,500 B/D with associated water production of 3,500 B/D. The crude oil comes mainly from the non-thermal wells. The type of effluent water is quite different from those at Bernstein and Los Bajos. Water is not brown although it also forms an oil-in-water emulsion. The problems with this tank farm are undissolved or unemulsified oil and water-in-oil type emulsion escaping with the effluent water. The water bled from the fiscalization tanks goes to two concrete-made oil savers where floating oil is recovered, then the water is led to an earthen dogleg pit, where floating oil is again recovered.

Oil is not skimmed continuously from the concrete oil savers, because there is no pump solely for skimming. The oil transfer pump is used for skimming during its idle time. This means that the pumping capacity for skimming is not enough and therefore the floating oil in oil savers frequently goes out of the oil savers and flows to the dogleg pit. Floating oil in the oil savers should be recycled back to the wash tank more often to prevent oil from escaping.

Before the fluid enters the oil saver, a reverse emulsion breaker is injected into the fluid. Its effect is questionable. Since the existing oil saver allows a significant amount of oil that comes with the effluent water to escape, oil inevitably goes to the earthen pit. Oil should periodically be skimmed from the earthen pits. Although oil should be skimmed more frequently, oil cannot be completely prevented from escaping and polluting the environment, once it is in the earthen pits. A new water treating system is needed.

The temporary pit for tank sludge located next to the earthen pits is another cause of pollution. An effective standard procedure for sludge disposal should be established and practiced to prevent pollution.

## 10-4 Point Ligoure Tank Farm (TRINMAR)

### 10-4-1 Tank Layout and Operation

The total amount of fluid coming from the offshore Soldado oilfield to Point Ligoure Tank Farm is 48,000 B/D, of which oil accounts for 31,000 B/D, the rest being water. The operator of the oil fields is TRINMAR. Petrotrin and TEXACO have 66.7 and 33.3 percent shares, respectively. Table 10-4 shows the configuration.

Crude oil comes to Point Ligoure Tank Farm continuously from offshore oil fields via a 16-inch pipeline. The API gravity of this crude oil is 21. The crude oil is classified as an asphaltenic heavy crude oil. An emulsion breaker is injected into the pipeline at the boundary between the offshore and onshore sections.

Before entering the wash tank (No. 10), associated gas is separated in the gas boot and vented to the atmosphere. Introduction of gas into the wash tank would disturb the interface between oil and water and thus increase the formation of a water-in-oil type emulsion. Crude oil overflows the weir installed in the upper part of the wash tank and goes to the settling tanks. The settled crude oil is sent to Pointe-a-Pierre Refinery via Bernstein Tank Farm with intermittent pump operation.

**Table 10-4 Tank Configuration and Process Equipment - Point Ligoure**

(Unit: Barrels)

| Tank | Capacity | Present status |
|---|---|---|
| No. 10 Tank | 50,000 | Wash tank |
| No. 6 Tank | 5,000 | Settling |
| No. 7 Tank | 5,000 | Settling |
| No. 8 Tank | 5,000 | Settling |
| No. 4 Tank | 15,000 | Slop |
| No. 3 Tank | 10,000 | Heated oil fiscalization |
| No. 2 Tank | 2,000 | Heated oil fiscalization |

Process Equipment:
- Heater Treater of slop oil
- API Separators Nos. 1, 2, 3, 4
- CPI Separator
- Gas Flotation Unit

Source: TRINMAR

### 10-4-2 Crude Oil Characteristics

The offshore Soldado crude is produced mainly by gas lifting and transported to this tank farm. Steam is not injected. The crude oil treated here has totally different characteristics from those of the onshore crude oil in the scope of this study. There is no tough oil-in-water emulsion problem, as that being experienced at Bernstein or Los Bajos. The relatively high salinity of the produced water may be the reason why such an emulsion is not formed.

However, another type of emulsion problem exists in this tank farm. In addition to about 16,000 B/D water discharged from Wash Tank No. 10, about 1,000 B/D "rag" in TRINMAR's terminology is formed. This is a water-in-oil type emulsion which looks like black oil or chocolate mousse drawn from the middle layer of the wash tank.

### 10-4-3 Effluent Water Treatment

Figure 10-2 is a schematic diagram of the water treating facilities. The effluent water from Wash Tank No. 10, estimated at 16,000 B/D, is processed by a recently installed CPI and an induced gas flotation unit. The effluent water bypasses the existing API separator complex and then flows to the adjacent river stream through an 8-inch line. The design oil content at the outlet of the gas flotation unit is 48 ppm.

There are four API separators. About 1,000 of B/D black colored rag, really a water-in-oil type emulsion, from Wash Tank No. 10 is directed to the API separators. The floating rag and scums are collected by skimming and sent to Slop Oil Tank No. 4. Slop oil is pumped to the heater treater where oil is recovered. The bleed water from Crude Oil Settling Tanks Nos. 6, 7 and 8 is also processed by the API separators. The rain water drainage is completely separated from the oily water processing system.

The disposal of sludges is another problem in this tank farm. Due to the asphaltenic nature of the crude oil, sludge accumulates on the bottom of the wash tank faster than in other tank farms. The bottom sludge of Wash Tank No. 10 is periodically drained to the API separators.

Oil is recovered in Slop Tank No. 4 and subsequently treated by the heater treater. The effluent water goes to the earthen pit and flows to the nearby stream. The bottom sludge in the API separator is periodically sucked by vacuum and removed from the yard.

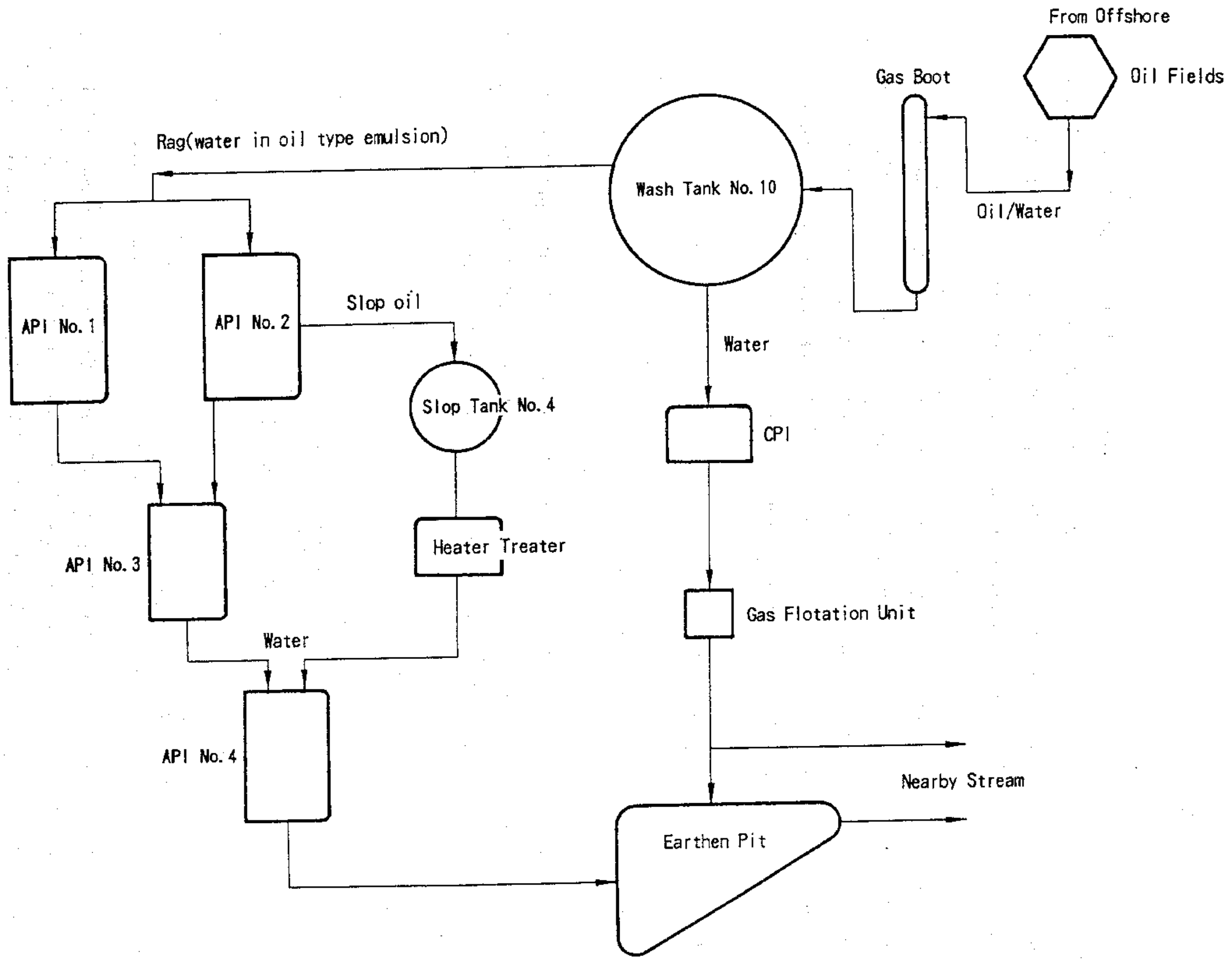



**Figure 10-2 Water Treating Facilities - Point Ligoure**

### 10-4-4 Pollution Prevention

The effluent water discharged from this tank farm probably contains oil-in-water type emulsion. This is a source of petroleum pollution. Even more serious a problem but not noticed as it should be is the sticky asphaltenic heavy oil which escapes conceivably from this tank farm, and floats on the river and on the Gulf of Paria as far as one kilometer from the seashore.

The black sticky oil is actually the "rag", a water-in-oil type emulsion escaping from the API separators. Supposedly effective emulsion breakers are used to treat the rag in the API separators. How effective they are is questionable in view of the fact that the emulsion is actually seen on the rivers and on the sea. Variations of the conditions in the wash tank make it difficult to establish the effectiveness of the emulsion breakers.

## 10-5 Transportation (Trunk Pipeline)

### 10-5-1 Line Specifications and Operation

The trunk pipelines are crude oil pipelines from the fiscalization tanks in the tank farms to Pointe-a-Pierre Refinery. An 8-inch line, a 10-inch line and 12-inch line are used as trunk pipelines in this region. Piping specifications used in the upstream section in this area are as follows:

---

Size, inch
- 4, 6, 8, 10, 12, 16, and 3
- The 3-inch line is screw connected.
- Others are of seamless welded flange connections.
- (Electric resistance welded pipe is not used.)

Materials
- API GRADE 5L
- A, B, X-42,
- X-46, 52, 56, 60, 65, 70, 80

---

The maximum operating pressure of the trunk lines is 390 psig. The standards and codes of API are applicable. Some 25 to 50 years have passed since these trunk lines were installed. In addition to the oil lines, there are $CO_2$ and sea water lines, of which the latter now is not operational. The Maintenance and Engineering Service Division of Petrotrin controls all these lines and performs daily maintenance.

About 90 percent of the trunk pipelines are laid underground with outside asphalt coating. Fiscalized crude oils are sent from the western tank farms to Pointe-a-Pierre Refinery via Bernstein Tank Farm by the 12-inch trunk pipeline.

Figure 10-3 shows the arrangement of the trunklines with respect to the tank farms in the Western District.

### 10-5-2 Corrosion Protection

Since the crude oil is not a sour one, corrosion on the inside walls of the pipes accounts only for 10 percent of the total reported incidents. External corrosion predominates accounting for about 90 percent of the total reported incidents. As protection against corrosion, sacrificial anodes are used for the above-ground portion, and the impressed current method is applied to the underground portion. A corrosion inhibitor is injected.

The most reported cases of external corrosion are pittings resulting from breakdown of the coating. As remedial measure for the pitting corrosion, half sleeves or full sleeves are welded. Hot tapping is also applied when it is needed to branch the pipelines while they are in service.

The painting on the trunklines is as follows:

Anti-rust painting, double layers.
Aluminum or enamel paining, double layers.
Under-ground portion is asphalt coated, 6/1,000 to 8/1,000 inch thickness.

The trunklines are inspected once a week. Each time one or two persons patrol along the trunklines and watch for leakages or seepages.

### 10-5-3 Pollution Prevention

The study team surveyed certain selected above-ground portions of the trunklines.

It is difficult to know the conditions of the buried portion, or 90 percent of the total length, unless symptoms conspicuously appear on the surface. The trunklines have been operating without major breakdowns.

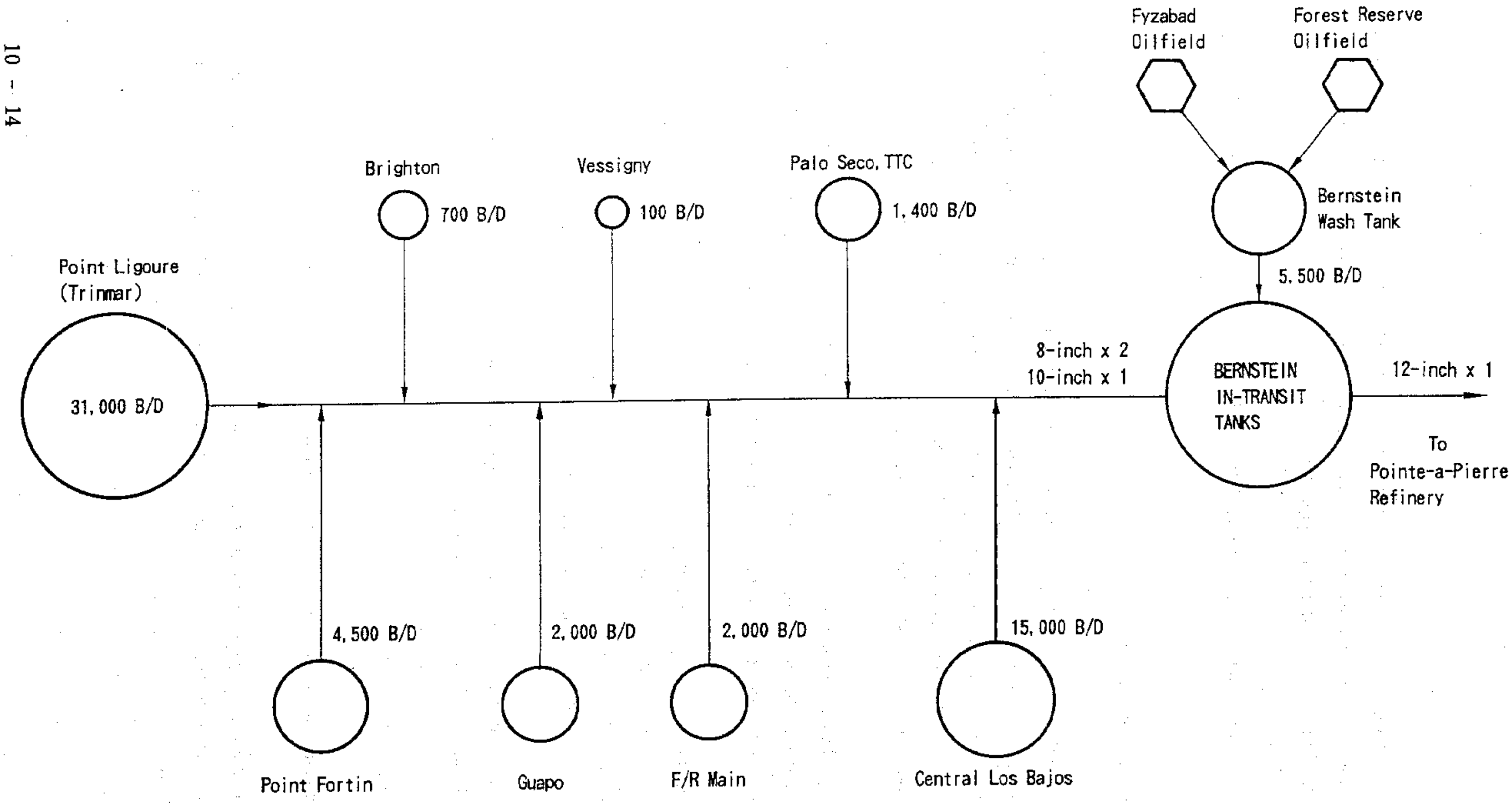



**Figure 10-3 Schematic Diagram - Tank Farms and Trunkline**

Minor cases of soil contamination by oil were seen at various places along the 3-inch or 4-inch oil lines in the oil field. These are apparently caused by leakage or oil from pipelines. The leaking portion of the pipes should be repaired and remedial actions should be taken for the soil in these areas.

# Chapter 11 Pointe-a-Pierre Refinery

# Chapter 11 Pointe-a-Pierre Refinery

This chapter summarizes the conditions of Pointe-a-Pierre Refinery and proposed improvements from the viewpoint of pollution control.

## 11-1 General

Pointe-a-Pierre Refinery is located about 40 kilometers to the south of Port of Spain. The refinery commenced operation in 1918. Major expansions have taken place since TEXACO purchased the refinery in 1956. The refinery capacity was expanded to 355,000 bpd by 1973, which then made it one of the top 20 refineries in the world. In 1985, the government purchased the refinery and other assets from TEXACO. These assets were subsequently vested in Trintoc.

Trintoc embarked on an upgrading and modernization program of the refinery to increase the production of higher-valued lighter products targeted for the international market by increasing conversion capacity. This upgrading project includes construction of new process units, rehabilitation of the existing facilities, upgrading of instrumentation and process control systems and environmental protection facilities. The upgrading project will be completed by the end of 1995. The refinery is expected to be more competitive both in price and quality of products on completion of this upgrading project.

The refinery has been operated by Petrotrin since its establishment in 1993.

## 11-2 Current Situation of the Refinery

### 11-2-1 Process Flow Scheme and Crude Oil Treatment

The refinery process flow scheme and the crude oil processing are summarized below. Both the process flow scheme and crude oil processing have important bearings on water pollution control.

**(1) Process Flow Scheme**

Currently, the refinery has the following process units and is operating them according to the flow scheme shown on Figure 11-1.

| | Capacity, 1,000 bpsd |
|---|---|
| Crude distillation | 160 |
| Vacuum distillation | 128 |
| Naphtha Hydrotreating/Catalytic Reforming | 10 |
| Kerosene/Atmospheric Gas Oil Hydrotreating | 14 |
| Catalytic Cracking | 28 |
| Visbreaking | 10 |
| Alkylation (Product) | 1.8 |
| Lubes (Product) | 2.1 |

**(2) Crude Oil Processing**

The refinery processes chiefly indigenous crude oils, very heavy crude oils with API gravities of about 20 degrees or heavier. Naturally, the yields of lighter fractions are low. The refinery plans to increase production of lighter fractions; the refinery is processing a certain amount of lighter Venezuelan crude oils to satisfy this purpose. The refinery currently operates two crude distillation units, Nos. 1 and 8 Crude Units. No. 8 Crude Unit is the main one while No. 1 Crude Unit is operated as a balance maker. The official capacity of No. 8 Crude Unit is 100,000 bpd; however, actual throughput of the indigenous crude is about 60,000 bpd, and that of the Venezuelan crudes is about 30,000 bpd. The capacity of No. 1 Crude Unit is 40,000 bpd.

The BS&W of crude oil transported from tank farms is controlled to less than 2 percent. Since water that contains emulsions is drained almost thoroughly in the tank farms to meet this specification, emulsion problems are not as serious in the refinery as in the tank farms.

In the refinery, crude oil stands in the crude tanks for more than 24 hours to allow water to settle further after being received. The bottom water is bled before the crude is charged to the crude units.

No. 8 Crude Unit has single-staged parallel desalters. The operation of the desalters is sometimes upset by mud contamination; but this does not necessarily entail any specific problems with waste water treatment. No. 1 Crude Unit does not have a desalter.

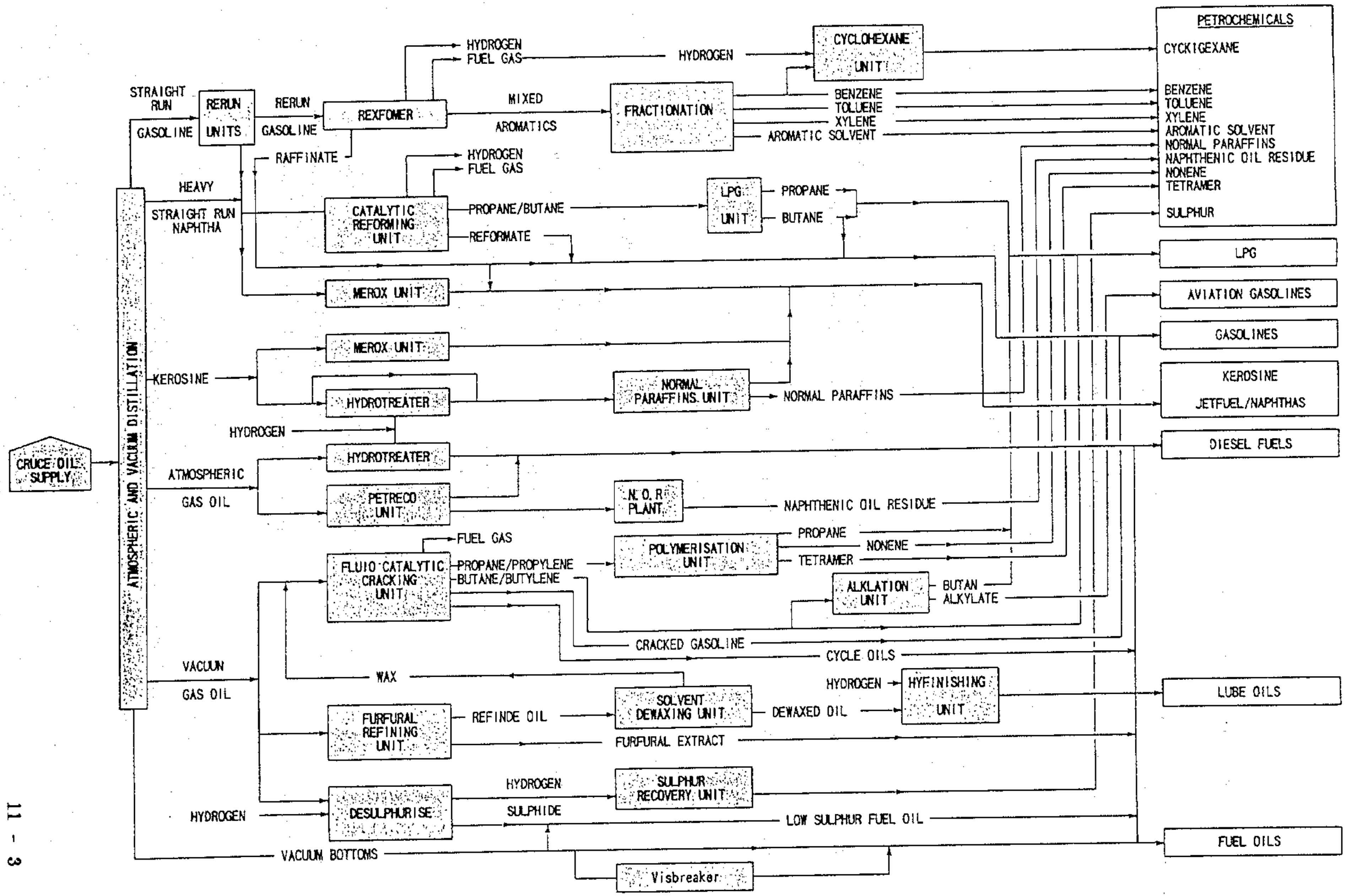



**Figure 11-1 Processing Diagram of Pointe-a-Pierre Refinery**

### 11-2-2 Waste Water Treatment

Currently, the refinery has a waste water treatment system consisting of:

- No. 1, 2, 3, 4 API separators (gravity-induced separators) and corresponding guard basins,
- Several catches (oil recovery weir),
- A boom in the lower reach of the Guaracara River (fixed oil fence made by steel pipes),
- Several systems of waste water ditches:

Oily waste water and chemical waste water streams from processing units flow in these ditches. The ditches channel them to the API separators. Storm water also flows in these ditches.

Table 11-1 shows the current quality standard of the refinery effluent.

**Table 11-1 Quality Standard**

| Item | Standard | Target | Test method |
|---|---|---|---|
| pH | 6.0-9.0 | 6.0-9.0 | pH meter |
| Oil & Grease | 50 ppm | 150 ppm | ASTM D-4281 freon method |
| BOD | none | none | |
| COD | none | none | |
| SS | none | 5,000 ppm | Gravimetric method |
| TDS | none | 5,000 ppm | TDS meter |

Source: Petrotrin

The refinery has been monitoring the quality of water taken at several pre-determined points since its monitoring program was established. The supervising Ministry, the Ministry of Energy and Energy Industries, also monitors the quality of water once a month. The refinery's monitoring program is as follows:

Measured items:

pH, Temperature, Electric conductivity, Dissolved oxygen,
Turbidity, Oil & Grease, TDS, TSS

Frequency:

Once a week

Locations:

- No. 1, 2, 3, 4 API separator outlets,
- No. 2 API separator's Guard basin outlet,
- Simpson oil catch outlet,
- Oil-stock main sump outlet,
- Pond area,
- Downstream of the Guaracara River boom,
- Mouth of the Guaracara River,
- Marine terminal,
- Middle point between the Guaracara River mouth and the ship terminal.

Table 11-2 summarizes oil and grease data obtained by the monitoring program.

**Table 11-2 Oil and Grease Data**

(Unit: ppm)

| Location | Period | Data No. | Min. | Max. | Mean | Std. dev. |
|---|---|---|---|---|---|---|
| No. 1 API | Mar. 1992-Jun. 1993 | 12 | 100 | 6,612 | 2,950 | 2,577 |
| No. 2 API | Mar. 1992-Sep. 1993 | 22 | 80 | 4,367 | 809 | 1,138 |
| No. 3 API | Mar. 1992-Sep. 1993 | 19 | 14 | 762 | 211 | 177 |
| No. 4 API | Mar. 1992-Sep. 1993 | 22 | 28 | 275 | 107 | 72 |
| 2 API GB | Mar. 1992-Sep. 1993 | 18 | 59 | 1,569 | 383 | 410 |
| Guara. R. | Mar. 1992-Sep. 1993 | 19 | 1 | 1,283 | 124 | 299 |
| Oil S.M.S | Mar. 1992-Sep. 1993 | 22 | 29 | 2,656 | 404 | 574 |
| Bond A.S. | Mar. 1992-Sep. 1993 | 23 | 11 | 1,381 | 390 | 395 |
| Simp. O.C. | Mar. 1992-Sep. 1993 | 23 | 34 | 1,790 | 257 | 394 |

Source: the Ministry of Energy and Energy Industries

The measured oil and grease exceeded the standard value of 50 ppm by a wide margin. Major problems are not found in other items.

The FCC and alkylation units use a closed cooling water system. All other units use sea water for cooling in a once-through fashion; accordingly, a large amount of water is discharged. As mentioned, all process waste waters flow into the oily waste water systems and are treated by the API separators. Storm waters are not separated from the process waters, and are treated by the

API separators together with the process waters.

A refinery study report entitled "DESIGN CHECK ON NOS. 1 TO 4 API OIL-WATER SEPARATORS IN THE POINTE-A-PIERRE REFINERY" made the following comparison between the design flows and storm flows. These data show that the storm flow rates of all Nos. 1 to 4 API separators are far higher than their design flows.

**Table 11-3 Flow Rate of API Separator**

| API Separator | Design flow (bpd) | Storm flow (bpd) | Storm flow/Design flow |
|---|---|---|---|
| No. 1 | 474,470 | 3,437,857 | 7.2 |
| No. 2 | 123,106 | 2,410,649 | 19.6 |
| No. 3 | 128,235 | 8,677,444 | 67.7 |
| No. 4 | 461,646 | * | |

Note: * Secluded from storm water runoff.

The Guaracara River oil boom is installed as the final guard against the flow of oil leaking from all API Separators, Nos. 1, 2, 3, and 4, and the corresponding guard basins. The oil boom is made of 16-inch steel pipes with skirt plates. One unit boom is about six meters long and one meter deep; and several such booms are connected to span across the river. The study team observed black oil accumulated upstream of the boom. The team also observed oil films widespread downstream of the boom.

The refinery presumes that the oil and grease target of 150 ppm is achievable by careful operation and careful maintenance of the API separators. Careful operation means keeping the thickness of surface oil layer of the API separators less than two inches. Careful maintenance means:

- to keep the API separators always clean of sludges,
- to keep the inlet screens always clean,
- to maintain the oil recovery pumps always in good operating condition, thereby preventing oil from accumulating on water.

The API separators used to be cleaned every four to five years, but they have been cleaned every year since 1992. The last time an API separator was cleaned, sludge was found to have accumulated to 3.5 feet against the design depth of seven feet. Accumulation of sludge is caused by sedimentation of solid matter from the desalter waste water. The solid matter is either that extracted from the crude oil or mud carried by storm water.

Slop oil recovered from the API separators and other oil recovery facilities is fed to the D-3 column. Composition of the slop oil is typically 46 percent water, 53 percent oil and one percent solid. The recovered slop oil is sent to No. 53 Tank where water is settled for more than 24 hours; subsequently, oil is fed to the D-3 column and water is cut off to No. 2 API separator. Emulsion is transported to No. 54 Tank. Allowable water content of the feed to D-3 is up to seven percent; it normally stands at five percent. The D-3 column is operated from four to six days a month, the number of operating days varying depending on the amount of the recovered slop oil.

### 11-2-3 Situation of Waste Disposal

Currently, there is no regulation to control disposal of wastes in Trinidad and Tobago. All the wastes generated in the refinery are dumped into open pits dug in the refinery premises. Detailed data and information about the kinds and quantities of wastes generated in the refinery are not available. Through the first and second field surveys, the study team found that the most serious issue about waste disposal is the treatment of oily sludge generated from cleaning of tanks and API separators. Water residing at the bottom of the pits, which contains oil either suspended or dissolved, is periodically pumped out to the river; however, the oil contained in the water cannot be collected by the Guaracara River boom, and flows to the sea. The oily sludges held in the pits overflow during the rainy season and cause oil pollution.

Tank cleaning is performed at intervals of from three to five years. Tanks are opened and cleaned when the accumulated sludge reaches the lower part of the suction nozzle, 30 centimeters high. Sludges are raked out manually by workers wearing gas masks and dumped into the pits. Neither heat nor chemicals are used.

Treatment of accumulated lead-containing sludges generated from cleaning of gasoline tanks is another serious issue in view of their very poisonous nature. They must be treated in an appropriate manner.

Petrotrin believes that oily sludges will be effectively treated by naturally occurring bacteria by merely spreading the oily sludges on the ground. A couple of such new projects have been launched recently.

### 11-2-4 Current Situation of Air Pollution

#### (1) Noxious Gas in Pointe-a-Pierre Refinery

In general, noxious gases generated from refineries are:

- NOx, SOx and particulate matter contained in flue gases,
- Hydrocarbon vapors.

As far as the findings of the field surveys are concerned, the study team did not identify any problem in the refinery with respect to NOx, particulate matter or hydrocarbon vapors. The problem of air pollution from Pointe-a-Pierre Refinery is limited to the emission of SOx. In the refinery, the total amount of hydrogen sulfide generated in the hydrotreating unit was fired at a flare stack during the first and second field surveys. This released $SO_2$ to the atmosphere and caused a serious problem of offensive odor in the refinery and leeward public areas. During the first field survey period, study team members sometimes smelled strong offensive odors and suffered from sore throat in the refinery area. To confirm the situation, the study team conducted environmental measurements of $SO_2$ during the second field survey period on the refinery premises and in the leeward public areas. The results are summarized below.

#### (2) Summary of Environmental Measurement

Date: February 25, 1994

Measurement conditions:

- Wind direction: East
- Wind velocity: 7 - 10 meters/sec
- Total number of measurement locations: 12
- Time: 9:30 am to 11;30 am
- Measuring equipment: Detector tube system (Komyo)

Results:

- Near Police Dept.: 0.25 ppm
- Near Shopping center: 0.5 ppm
- West end of Admin. building: 0.1 ppm
- Other locations: Not detected

According to the Japanese Basic Law of Environmental Control, the environmental standards for $SO_2$ are less than 0.04 ppm for the daily average of one-hour averages and, at the same time, less than 0.1 ppm for the one-hour average. Since $SO_2$ is a toxic gas, the observed conditions at Pointe-a-Pierre Refinery must be classified as serious. The total generation of $SO_2$ is 0.5

MMSCFD. The refinery has a sulfuric acid plant. This plant produces sulfuric acid from spent sulfuric acid from the alkylation unit and hydrogen sulfide from the hydrotreating unit; however, this sulfuric acid plant is very old and was out of service during the surveys. That is why hydrogen sulfide, which is normally recovered as sulfur, was burned at the stack and caused the odor problem. The hydrogen sulfide produced at the FCC unit and hydrotreaters is recovered after being extracted by the diethanolamine (DEA) process.

The sulfuric acid plant was under repair to improve reliability, to be put in service again between June and July 1994. This must have improved the situation observed during the field survey. As part of the upgrading project, a new 55,000 bpd VGO hydrotreater will become operational. With this plant a new sulfur recovery unit will be installed. By this, the $SO_2$ problem will be completely solved.

## 11-3 Upgrading Project and Related Improvements

As mentioned, the upgrading plan of Pointe-a-Pierre Refinery launched by the former Trintoc has been succeeded by Petrotrin. The construction is underway with completion scheduled for the end of 1995. Table 11-4 shows the capacities of the new and modified process units. For more details reference should be made to Chapter 16.

In addition, the upgrading project includes construction of molten sulfur transportation facilities, sulfur solidification facilities, unloading facilities and expansion of the existing power plant and waste water treatment facilities. Also, a centralized control room will be built to replace the old pneumatic instruments with a state-of-the-art Distributed Control System (DCS).

**Table 11-4 Upgrading Project**

(Unit: thousand bpd)

| Process unit | New | Current | After revamp |
|---|---|---|---|
| Hydrogen unit, MMSCFD | 30 | | |
| Sulfur recovery unit, tons/day | 183 | | |
| Visbreaker | 32 | | |
| Crude distillation unit | | 160 | 175 |
| Naphtha Hydrotreating unit/ Catalytic reforming unit | | 10 | 25 |
| VGO hydrotreating unit | | - | 55 |
| Catalytic cracking unit | | 28 | 30 |
| Visbreaking unit | | 10 | 0 |

Source: the Ministry of Energy and Energy Industries

## 11-4 Upgrading of the Waste Water Treatment System

The upgrading project includes plans for improving the waste water treatment systems. These are outlined below.

### (1) Separation of Storm Water from Process Water

Separation of storm water from process water is planned. The detailed plan is explained in Chapter 16. The separation will be rather easy in the West Area, or tank area, but difficult in the East and South Areas, or process area. The Human Resources Area, or Employee's Welfare area including the golf course, is large. The huge amount of storm water flowing from this area is currently routed to No. 3 API Separator. This water will bypass No. 3 API Separator according to the plan.

### (2) Automatic Operation of Oil Recovery Pumps

To maintain the surface oil of each API separator, guard basin, pit, etc. always at minimum, the pumps for recovering oil will be automated. By this, surface oil flowing from these facilities will be minimized.

## 11-5 Major Issues on Environmental Control

### 11-5-1 Issues in Waste Water Treatment

### (1) Separation of Oily Waste Waters from Storm Waters

No waste water treatment system functions well if the flow rate to the system exceeds the design capacity. In Pointe-a-Pierre Refinery, the flow rates of API separators exceed the design capacities by unbelievably wide margins. In such a situation, the oil particles contained in the inlet water pass through the API separators, since the time necessary for most particles to float to the surface cannot be provided. In addition, the surface oil that should be recovered by API separators is washed downstream by rapid currents caused by sudden inflows of storm water, which frequently occur in the rainy season.

The guard basin is the final guard of the refinery waste water treatment system. The presence of oil on the surface of the guard basin must be regarded as intolerable. Booms or oilfences cannot stop the floating oil but let it pass if the current is rapid.

Complete separation of oily waste water from storm water is essential in stabilizing the water flow to within the design rate and achieving satisfactory operation of the waste water treatment system.

**(2) Upgrading of Waste Water Treatment Facility**

The API separators are practically the only waste water treatment facility that Point-a-Pierre Refinery has. As is well known, API separators are designed to collect oil drops larger than 150 microns in diameter. API separators are usually used for pre-treater before the secondary waste water treatment. An API separator alone cannot achieve the 50 ppm target of oil and grease for normal refinery waste water. Appropriate secondary treatment, air-flotation system for example, is needed for Pointe-a-Pierre Refinery.

**(3) Maintenance**

No component of a waste water treatment system -- API separator, air-flotation system, pumps and lines, filters, instrumentation and electric equipment -- functions well without the right maintenance. All these must be well maintained according to an established maintenance program.

### 11-5-2 Issues in Wastes Disposal

Oily sludges are dumped into the open pits where storm water flows in and causes overflows. In addition, the oily water at the bottoms of the pits will permeate the soil and contaminate the underground water. Oily sludges must be treated adequately and not dumped in open pits with resultant contamination of the underground water. Other wastes should also be adequately controlled and treated as recommended in Chapter 13.

### 11-5-3 Issues in Air Pollution Control

The problem of $SO_2$ must have been ameliorated with the completion of the repair work on the sulfuric acid plant which was underway during the field surveys. Completion was scheduled in June or July 1994. This problem will be completely solved on commissioning of the new sulfur recovery unit, planned as part of the upgrading project. There will be no major issue with respect to air pollution control after 1996.

### 11-5-4 Issues in Upgrading Project

Separation of the storm water and oily water to be done by the upgrading plan is only a portion of what should be done in the entire Pointe-a-Pierre Refinery. As mentioned, complete separation is essential to enable the waste water treatment system to function properly. Otherwise, the new waste water treating system this study proposes will not function satisfactorily and the 50 ppm target will be difficult to achieve. The upgrading plan also includes automatic operation of the oil recovery pumps at the API separators, an important improvement to help enable the API separators to function adequately. The improvements being planned by the upgrading plan could perhaps achieve a target of oil and grease at 150 ppm, but cannot attain the target of 50 ppm.

## 11-6 Conclusion

### 11-6-1 Improvement of Water Pollution Control

**(1) Basic Concept**

It is essential in the satisfactory operation of waste water treatment facilities such as API separator, PPI, CPI, coagulation sedimentation, air-flotation, etc. that flow rates be kept constant and within the design rates. This in turn means that complete separation of storm water from oily process water is essential in water pollution control as a means of keeping the flow rates stable without fluctuation. On the basis of this principle, any modern refinery has at least two waste water systems: a clean waste water system and an oily waste water system.

In the case of Pointe-a-Pierre Refinery the existing waste water treatment system should be converted into a clean water system and a new oily waste water system installed above ground. By this, the possibility of oil flowing to the Guaracara River will be essentially eliminated.

**(2) Principle of Countermeasures**

Countermeasures are mainly as stated below:

- To install spill walls about 15 centimeters high in each process unit and pump house to separate storm water from oily process water.

- To install oily waste water pits in each unit. Some of the existing pits may be used for this purpose by cutting off the underground waste water piping.

- A pump shall be installed at each pit with a device to automatically control the level. Two different pits should be used, one for waste water containing chemicals (caustic soda and amines) and one for water not containing them. Such chemicals adversely affect COD levels and should therefore be neutralized before treatment. In anticipation of COD regulations to be enforced in the future, chemical-containing waste water should be segregated and separately treated.

- To connect by pipes the drain nozzles of each tank to the oily pit installed in each tank yard, thereby realizing a closed system of the tank drain. A pump with an automatic level-controlling device will be installed at each pit.

- Two systems of buffer tanks are to be provided: one for chemical-containing waste water and the other for non-chemical-containing waste water. The existing idle tanks may be used for this purpose. These tanks will act as the first-stage gravity-induced separators before the API separators. A swing-type suction nozzle will be installed in these tanks to selectively recover oil floating on water.

- To install piping from each automatic level-controlling pump to the buffer tanks. The piping system should be installed on the existing piping racks.

- Downstream of the buffer tanks, a system consisting of a series of new waste water treating facilities shall be installed. As is explained in Chapter 19, the results of experiments done during the second field survey indicate that secondary treatment by a system consisting of air-flotation and its auxiliary equipment can reduce the oil content of the effluent streams of all the API separators to the target level of 50 ppm. The new waste water treatment system for the oily water to be recommended by the study will consist of buffer tanks, an API separator, a CPI, an air-flotation unit and a guard basin.

### 11-6-2 Improvement of Waste Disposal Control

#### (1) Basic Concept

Primarily for the purpose of properly treating oily sludges now dumped in open pits, thereby preventing them from causing pollution of the water as they do now, and disposing of oil-containing scums to be produced from the air-flotation at the tank farms, a concept of centralized wastes treatment, or Waste Treatment Center, is proposed. As Chapter 13 explains, two such Waste Treatment Centers would be needed, one in Pointe-a-Pierre Refinery and the other at Bernstein Main Storage. The wastes generated at other tank farms would be collected to Bernstein Main Storage for centralized treatment.

### (2) Subject Wastes

Oily sludges collected when API separators and tanks are cleaned are currently dumped into open earthen pits. This practice causes water pollution. Such wastes will be treated at Waste Treatment Centers.

#### (a) Tank Sludges

The tank sludge would be treated first in a tank to recover oil for reducing the volume of the sludge. This could involve washing, chemical treatment, application of heat, and mixing. The sludge will be solidified after such treatment and the solid sludge will be transported to the Waste Treatment Center for incineration with other wastes.

#### (b) Sludges from API/CPI Separators

The sludges from API/CPI separators are dripping wet and contain plenty of oil and water. They will be transported to the waste treatment center. There they will be settled and concentrated. They should be pressed or centrifuged to squeeze out oil and water. The solid sludge or cake thus produced will be incinerated. Recovered oil will be transported to the slop tank and mixed with crude oil, to be fed to the crude units. The separated water will be pumped to the oily buffer tank to be treated by the new waste water treating system together with other oily waste waters.

#### (c) Flotation Scum

Air flotation scum would be generated from the waste water treating systems proposed for Pointe-a-Pierre Refinery and Bernstein Main Storage. The flotation scum is also wet with oil and water. At each center the same treatment as that applied to the oily sludges, i.e. centrifuging and incinerating solidified cake, would be adopted. In Bernstein Main Storage, as will be explained in Chapter 19, a facility for activated carbon adsorption will be installed downstream of the air-flotation system. This has been found indispensable to achieving the oil and grease target of 50 ppm. Such masses are recovered mixed with the flotation scum. Waste waters generated by the centrifuges or related equipment will be treated by the new waste water treating system at Bernstein Tank Farm or Pointe-a-Pierre Refinery.

#### (d) Other Wastes

Other wastes generated at the refinery are:

- General combustible wastes (waste wood, waste rags, etc.),
- General non-combustible wastes (iron scrap, bricks, stones, concrete rubble, etc.),
- Spent catalysts,

- Others.

Treatment of waste lubricant oils brought from service stations will become an important subject in the future. In the disposal of wastes it must be established that only those wastes which never release oil are allowed to be buried. Otherwise, soils will be contaminated. All wastes that contain oil, or that could ooze oil, should be incinerated. This should be taken into account in the selection of the type of incinerators.

### (3) Facilities Installed at the Center

The waste disposal treatment center would be equipped with:

- Incinerator (Provisions for preventing air pollution should be incorporated.),
- A dehydrator,
- Sludge receiving and handling facilities (hoppers, tanks, conveyers, etc.),
- Pumps, piping, instrumentation, electrical equipment, etc.