ELECTRICITY GENERATING AUTHORITY OF THAILAND

ENVIRONMENTAL IMPACT ASSESSMENT

OF

WANG NOI COMBINED CYCLE POWER PLANT PROJECT

VOLUME II
NVIRONMENTAL IMPACT ASSESSMENT

EGAT - INVESTMENT PROGRAM SUPPORT PROJECT

(WORLD BANK PARTIAL CREDIT GUARANTEE)

Prepared by

SOUTHEAST ASIA TECHNOLOGY CO. LTD.

May 1994

932135

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แบบ สวล. ๔

ใบอนุญาต

เป็นผู้มีสิทธิทำรายงานเกี่ยวกับการศึกษา
และมาตรการป้องกันและแก้ไขผลกระทบกระเทือนต่อคุณภาพสิ่งแวดล้อม

ใบอนุญาตที่ ๙ / ๒๕๓๖

อาศัยอำนาจตามความในมาตรา ๑๙ แห่งพระราชบัญญัติส่งเสริมและรักษาคุณภาพสิ่งแวดล้อมแห่งชาติ พ.ศ. ๒๕๑๘ คณะกรรมการสิ่งแวดล้อมแห่งชาติออกใบอนุญาตฉบับนี้ ให้แก่ บริษัท เซ้าอีสท์เอเชียเทคโนโลยี่ จำกัด

เพื่อแสดงว่าเป็นผู้มีสิทธิทำรายงานเกี่ยวกับการศึกษาและมาตรการป้องกันและแก้ไขผลกระทบกระเทือนต่อคุณภาพสิ่งแวดล้อมมีกำหนด ๕ ปี ตั้งแต่วันที่ ๑๒ เดือน ตุลาคม พ.ศ. ๒๕๓๖ ถึงวันที่ ๑๑ เดือน ตุลาคม พ.ศ. ๒๕๔๑ โดยกำหนดเงื่อนไขดังต่อไปนี้

(๑) ไม่มีเงื่อนไข

(๒)

(๓)

(๔)

สำเนาถูกต้อง

SEATEC
SOUTHEAST ASIA TECHNOLOGY COMPANY LIMITED

ให้ไว้ ณ วันที่ ๑๘ เดือน ตุลาคม พ.ศ. ๒๕๓๖

(ลงชื่อ) ....

(นายสันทัด สมชีวิตา)

เลขาธิการสำนักงานนโยบายและแผนสิ่งแวดล้อม

ซีเทค : SEATEC

SOUTHEAST ASIA TECHNOLOGY CO. LTD.

หนังสือรับรองการจัดทำรายงาน

วันที่ 1 เดือน มิถุนายน พ.ศ. 2537

หนังสือฉบับนี้ขอ รับรองว่า บริษัท เซ้าท์อีสท์เอเชียเทคโนโลยี่ จำกัด เป็นผู้จัดทำรายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อม โครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ให้แก่ การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย เพื่อขออนุญาตตั้งโรงไฟฟ้า โดยคณะผู้ชำนาญการและเจ้าหน้าที่ผู้รับผิดชอบในการจัดทำรายงานดังต่อไปนี้

ผู้ชำนาญการ	**ลายมือชื่อ**
นายปกรณ์ ปาการเสรี	
เจ้าหน้าที่	**ลายมือชื่อ**
นายชาลี เกษรีภรณ์	
นายเกรียงไกร ชมชาติ	
นางปานหทัย วีระเสถียร	ปานหทัย วีระเสถียร

(นายสุรศักดิ์ เมืองมั่น)

รองผู้จัดการใหญ่บริหาร

SEATEC

SOUTHEAST ASIA TECHNOLOGY COMPANY LIMITED

สำนักงานใหญ่ : 257 ซอยเจริญมิตร สุขุมวิท 71 กรุงเทพฯ 10110 โทร : 390-1081 โทรสาร : 381-1627
สำนักงานทองหล่อ : 123 สุขุมวิท 57 กรุงเทพฯ 10110 โทร : 392-2711 โทรสาร : 381-1142
Head Office : 257 Charoenmitr, Sukhumvit 71, Bangkok 10110, THAILAND. Tel : (662) 390-1081 Fax : (662) 381-1627
Thong Lor Office : 123 Sukhumvit 57, Bangkok 10110, THAILAND. Tel : (662) 392-2711 Fax : (662) 381-1142

ฝสล.
รับ 540
วันที่ ๒๐ ก.ย. ๒๕๓๗

ช. ฝสล.
รับ 637

การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย
รับที่ 46450
วันที่ 15 ก.ย. 2537

ที่ วว 0804/7857

ถึง การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย

สำนักงานนโยบายและแผนสิ่งแวดล้อม ขอส่งสำเนาหนังสือที่ วว 0804/7790 ลงวันที่ 8 กันยายน 2537 เรื่อง แจ้งมติคณะกรรมการผู้ชำนาญการพิจารณารายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมเพิ่มเติมโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1-3 (3×600 MW) ของการไฟฟ้าฝ่ายผลิตแห่งประเทศไทย เมื่อคราวประชุมครั้งที่ 1ภ/2537 วันที่ 15 สิงหาคม 2537 มาเพื่อโปรดทราบ

สำนักงานนโยบายและแผนสิ่งแวดล้อม
12 กันยายน 2537

กทล.
รับ 1069
วันที่ 21/9/37

กศล.
รับ 681

กองวิเคราะห์ผลกระทบสิ่งแวดล้อม
โทร. 2792792
โทรสาร 2785469

○ ต้นฉบับ
△ ต้นสิ่งแนบ
× ไม่มีสิ่งแนบ
16 ก.ย. 2537

สิ่งแนบ ☑ ครบ ☐ ไม่ครบ ☐ ยังไม่ได้รับ

☐ ไม่พึงสิ่งแนบ ☑ เก็บสิ่งแนบ

สิ่งแนบ กฟผ. รับที่ 46450 ลงวันที่ 15 ก.ย. 37

ที่ วว 0804/ ๗๗๙๐

สำนักงานนโยบายและแผนสิ่งแวดล้อม
ซอยพิบูลวัฒนา 7 ถนนพระรามที่ 6
กรุงเทพฯ 10400

๘ กันยายน 2537

เรื่อง แจ้งมติคณะกรรมการผู้ชำนาญการพิจารณารายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมด้านโครงการอุตสาหกรรม เรื่อง รายงานการศึกษาผลกระทบสิ่งแวดล้อมเพิ่มเติมโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 – 3 (3 x 600 MW) ของการไฟฟ้าฝ่ายผลิตแห่งประเทศไทย เมื่อคราวประชุมครั้งที่ 13/2537 วันที่ 15 สิงหาคม 2537

เรียน เลขาธิการคณะกรรมการพัฒนาการเศรษฐกิจและสังคมแห่งชาติ

อ้างถึง หนังสือสำนักงานนโยบายและแผนสิ่งแวดล้อม ที่ วว.0804/5338 ลงวันที่ 29 มิถุนายน 2537

สิ่งที่ส่งมาด้วย
1. สำเนาหนังสือการไฟฟ้าฝ่ายผลิตแห่งประเทศไทย ที่ กฟผ. 90200/36325 ลงวันที่ 2 สิงหาคม 2537
2. มติคณะกรรมการผู้ชำนาญการพิจารณารายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมด้านโครงการอุตสาหกรรม ในคราวประชุมครั้งที่ 13/2537 เมื่อวันที่ 15 สิงหาคม 2537 เรื่อง รายงานการศึกษาผลกระทบสิ่งแวดล้อมเพิ่มเติมโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 – 3 (3 x 600 เมกกะวัตต์) เมื่อคราวประชุมครั้งที่ 13/2537 วันที่ 15 สิงหาคม 2537

ตามที่ สำนักงานนโยบายและแผนสิ่งแวดล้อมได้แจ้งมติคณะกรรมการสิ่งแวดล้อมแห่งชาติ ในคราวประชุมครั้งที่ 5/2537 เมื่อวันที่ 8 มิถุนายน 2537 เรื่องรายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1-6 ความละเอียดตามหนังสือที่อ้างถึงนั้น ต่อมา การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย ได้พิจารณาทางเลือกเพิ่มเติมเพื่อก่อสร้างเป็นโรงไฟฟ้าขนาดชุดละ 600 เมกกะวัตต์ จำนวน 3 ชุด และได้ส่งรายงานการศึกษาผลกระทบสิ่งแวดล้อมเพิ่มเติม

/โครงการ...

โครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 - 3 (3x600 MW) ให้สำนักงานฯ พิจารณา ดังรายละเอียดในสิ่งที่ส่งมาด้วยหมายเลข 1

สำนักงานนโยบายและแผนสิ่งแวดล้อมได้นำรายงานการศึกษาผลกระทบสิ่งแวดล้อมเพิ่มเติม โครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 - 3 (3 x 600 MW) เสนอต่อคณะกรรมการผู้ชำนาญการพิจารณารายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมด้านโครงการอุตสาหกรรม เมื่อคราวประชุมครั้งที่ 13/2537 วันที่ 15 สิงหาคม 2537 ซึ่งคณะกรรมการฯ มีมติเห็นชอบในรายงานฯดังกล่าว โดยกำหนดให้การไฟฟ้าฝ่ายผลิตแห่งประเทศไทยต้องปฏิบัติตามมาตรการลดผลกระทบ และมาตรการติดตามตรวจสอบคุณภาพสิ่งแวดล้อมที่เสนอไว้ในรายงานฯ ของโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 - 6 ฉบับเดิมที่ได้รับความเห็นชอบจากคณะกรรมการสิ่งแวดล้อมแห่งชาติไปแล้ว และในรายงานฯ เพิ่มเติมโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 - 3 (3 x 600 MW)รวมทั้งต้องปฏิบัติตามมาตรการที่กำหนดเพิ่มเติมโดยคณะกรรมการผู้ชำนาญการฯ ดังรายละเอียดปรากฏในสิ่งที่ส่งมาด้วยหมายเลข 2

จึงเรียนมาเพื่อโปรดทราบ

ขอแสดงความนับถือ

(นายศักดิ์สิทธิ์ ตรีเดช)
รองเลขาธิการฯ รักษาราชการแทน
เลขาธิการสำนักงานนโยบายและแผนสิ่งแวดล้อม

สำเนาถูกต้อง
(นางสุปราณี แตงไทย)
เจ้าหน้าที่บริหารงานธุรการ 5

กองวิเคราะห์ผลกระทบสิ่งแวดล้อม
โทร. 2792792
โทรสาร. 2785469

สิ่งที่ส่งมาด้วย

ที่ กฟผ. 90200/ 36325

การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย
นนทบุรี 11000

๒ สิงหาคม 2537

เรื่อง นำส่งรายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมเพิ่มเติม โครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย

เรียน เลขาธิการสำนักงานนโยบายและแผนสิ่งแวดล้อม

อ้างถึง หนังสือสำนักงานนโยบายและแผนสิ่งแวดล้อม ที่ วว. 0804/5337 ลงวันที่ 29 มิถุนายน 2537

สิ่งที่ส่งมาด้วย รายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมเพิ่มเติม โครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย 3 x 600 MW (1800 MW)

ตามหนังสือที่อ้างถึง คณะกรรมการสิ่งแวดล้อมแห่งชาติ ได้มีมติเห็นชอบกับรายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อม สำหรับโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ที่มีขนาดกำลังผลิต 1800 MW (6 x 300 MW) ในคราวประชุมครั้งที่ 5/2537 เมื่อวันที่ 8 มิถุนายน 2537 ความละเอียดแจ้งแล้ว นั้น

เนื่องจาก การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย (กฟผ.) ได้ดำเนินการศึกษาข้อจำกัดในการขนส่งอุปกรณ์หนักของโรงไฟฟ้าไปยังสถานที่ตั้งโครงการ พบว่า มีความเป็นไปได้ที่จะขนส่งอุปกรณ์หนักของโรงไฟฟ้าขนาดใหญ่ และโรงไฟฟ้าที่มีขนาดกำลังผลิตชุดละ 600 MW มีราคาค่าลงทุนที่ประกอบด้วยค่าอุปกรณ์และค่าก่อสร้าง และค่าเชื้อเพลิงที่ใช้ ตลอดจนขนาดของพื้นที่ที่ใช้ในการก่อสร้าง น้อยกว่าโรงไฟฟ้าที่มีขนาดกำลังผลิตชุดละ 300 MW จำนวน 2 ชุด กฟผ. จึงได้พิจารณาทางเลือกเพิ่มเติม ในกรณีก่อสร้างโรงไฟฟ้าขนาดกำลังผลิต ชุดละ 600 MW จำนวน 3 ชุด และได้จัดทำรายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมเพิ่มเติม โครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย (3 x 600 MW) โดยมอบหมายให้ บริษัท เซ้าท์อีสท์เอเชียเทคโนโลยี่ จำกัด เป็นผู้ดำเนินการ และขอนำส่งรายงานฯ ดังกล่าว มายังสำนักงานนโยบายและแผนสิ่งแวดล้อม เพื่อดำเนินการตามขั้นตอนต่อไป

จึงเรียนมาเพื่อโปรดพิจารณา ทั้งนี้ กฟผ. หวังเป็นอย่างยิ่งว่าคงจะได้รับความอนุเคราะห์ด้วยดีเช่นเคย และขอขอบคุณมา ณ โอกาสนี้

ขอแสดงความนับถือ

(นายสมบูรณ์ มณีนาวา)
ผู้ว่าการการไฟฟ้าฝ่ายผลิตแห่งประเทศไทย

สำเนาถูกต้อง

(นางสุปราณี แตงไทย)
เจ้าหน้าที่บริหารงานธุรการ 5

ฝ่ายสิ่งแวดล้อม
โทร. 436-1100 , 436-1130
โทรสาร. 436-6166 , 433-6317

สิ่งที่ส่งมาด้วย

มติคณะกรรมการผู้ชำนาญการพิจารณารายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อม ด้านโครงการอุตสาหกรรม เรื่องรายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 - 3 (3 x 600 MW) ในคราวประชุมครั้งที่ 13/2537 วันที่ 15 สิงหาคม 2537

คณะกรรมการผู้ชำนาญการพิจารณารายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อม ด้านโครงการอุตสาหกรรมได้พิจารณารายงานการวิเคราะห์ผลกระทบสิ่งแวดล้อมโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 - 3 (3 x 600 MW) ของการไฟฟ้าฝ่ายผลิตแห่งประเทศไทยแล้ว มีมติเห็นชอบในรายงานฯ โดยกำหนดให้การไฟฟ้าฝ่ายผลิตแห่งประเทศไทยดำเนินการดังต่อไปนี้

1. การไฟฟ้าฝ่ายผลิตแห่งประเทศไทยต้องปฏิบัติตามมาตรการลดผลกระทบและมาตรการติดตามตรวจสอบคุณภาพสิ่งแวดล้อม ตามที่ได้เสนอไว้ในรายงานการศึกษาผลกระทบสิ่งแวดล้อมโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 - 6 ฉบับเดิม ที่ได้รับความเห็นชอบจากคณะกรรมการสิ่งแวดล้อมแห่งชาติแล้ว รวมทั้งในรายงานเพิ่มเติมโครงการโรงไฟฟ้าพลังความร้อนร่วมวังน้อย ชุดที่ 1 - 3

2. การไฟฟ้าฝ่ายผลิตแห่งประเทศไทยต้องปฏิบัติตามมาตรการที่กำหนดเพิ่มเติมโดยคณะกรรมการสิ่งแวดล้อมแห่งชาติ ดังต่อไปนี้

2.1 ให้พิจารณาการใช้น้ำหมุนเวียนในโรงไฟฟ้า โดยนำกลับมาใช้ประโยชน์ให้มากที่สุด เพื่อเป็นการใช้ทรัพยากรน้ำอย่างคุ้มค่า และเพื่อลดผลกระทบจากการระบายน้ำทิ้งออกสู่แหล่งน้ำสาธารณะ

2.2 เห็นควรให้ใช้สารละลายที่มีองค์ประกอบของฟอสเฟตต่ำในโรงไฟฟ้า เพื่อป้องกันการเกิดผลกระทบต่อคุณภาพน้ำใน Holding Pond และแหล่งน้ำธรรมชาติ แต่ถ้าจำเป็นต้องใช้จะต้องมีวิธีกำจัด และให้มีมาตรการควบคุมฟอสเฟตเป็นพิเศษ

2.3 ให้นำ Resin ที่หมดสภาพการใช้งานแล้วไปกำจัดอย่างถูกวิธี หรืออาจพิจารณานำไปกำจัดที่ศูนย์บริการกำจัดกากอุตสาหกรรม และถ้าจะให้หน่วยงานท้องถิ่นเป็นผู้กำจัด การไฟฟ้าฝ่ายผลิตแห่งประเทศไทยจะต้องเป็นผู้รับผิดชอบค่าใช้จ่ายส่วนนี้

2.4 การไฟฟ้าฝ่ายผลิตแห่งประเทศไทยควรพิจารณานำ Waste Oil ไปเป็นเชื้อเพลิงสำหรับโรงไฟฟ้าอื่นที่ใช้น้ำมันเตาเป็นเชื้อเพลิง

2.5 ให้มีมาตรการลดผลกระทบด้านเสียงดังรบกวน โดยติดตั้งอุปกรณ์ลดเสียง (Silencer) ในตำแหน่งที่ก่อให้เกิดเสียงดัง

2.6 ให้มีการตรวจสุขภาพพนักงานด้านสมรรถนะการทำงานเฉพาะด้านเช่นการตรวจการรับฟังเสียง โดยการตรวจสุขภาพพนักงานก่อนรับเข้าทำงาน และการตรวจสุขภาพประจำปี

2.7 ให้การไฟฟ้าฝ่ายผลิตแห่งประเทศไทยพิจารณาดำเนินการปลูกต้นไม้ในบริเวณพื้นที่โรงไฟฟ้าให้มีต้นไม้หนาแน่นที่สุด เพื่อให้บริเวณโครงการมีทัศนียภาพที่ดี

2.8 เมื่อผลการติดตามตรวจสอบคุณภาพสิ่งแวดล้อมได้แสดงให้เห็นถึงแนวโน้มที่จะก่อให้เกิดปัญหาสิ่งแวดล้อม การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย ต้องดำเนินการปรับปรุงแก้ไขปัญหาเหล่านั้นโดยเร็วและต้องปฏิบัติตามมาตรการลดผลกระทบและมาตรการติดตามตรวจสอบคุณภาพสิ่งแวดล้อมโดยเคร่งครัด เพื่อประโยชน์ในการพิจารณาความเหมาะสมของการกำหนดระยะเวลาการติดตามตรวจสอบต่อไป

2.9 หากเกิดเหตุการณ์ใดๆก็ตามที่อาจก่อให้เกิดผลกระทบต่อคุณภาพสิ่งแวดล้อม การไฟฟ้าฝ่ายผลิตแห่งประเทศไทยต้องแจ้งให้สำนักงานนโยบายและแผนสิ่งแวดล้อมทราบโดยเร็ว เพื่อสำนักงานฯ จะได้ให้ความร่วมมือในการแก้ไขปัญหาดังกล่าว

2.10 การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย ต้องเสนอรายงานสรุปการปฏิบัติตามมาตรการลดผลกระทบ และมาตรการติดตามตรวจสอบคุณภาพสิ่งแวดล้อม ให้สำนักงานนโยบายและแผนสิ่งแวดล้อมทราบทุก 6 เดือน

2.11 หากการไฟฟ้าฝ่ายผลิตแห่งประเทศไทยมีความจำเป็นต้องเปลี่ยนรายละเอียดโครงการหรือการใช้เชื้อเพลิงเป็นชนิดอื่นที่ต่างไปจากที่เสนอไว้ในรายงานฯ การไฟฟ้าฝ่ายผลิตแห่งประเทศไทยจะต้องเสนอรายละเอียดที่เปลี่ยนแปลงพร้อมทั้งประเมินผลกระทบและเสนอมาตรการลดผลกระทบ อันเนื่องมาจากการเปลี่ยนแปลงนั้น ให้สำนักงานนโยบายและแผนสิ่งแวดล้อม พิจารณาให้ความเห็นชอบก่อนดำเนินการเปลี่ยนแปลง

3. การไฟฟ้าฝ่ายผลิตแห่งประเทศไทย ต้องจัดทำรายงานฉบับสมบูรณ์ พร้อมกับผนวกรายละเอียดการติดตั้งระบบ Cooling Tower ซึ่งต้องมีประสิทธิภาพไม่ด้อยไปกว่าระบบ Cooling Tower เดิมที่เคยเสนอไว้

ENVIRONMENTAL IMPACT ASSESSMENT
WANG NOI COMBINED CYCLE POWER PLANT PROJECT (3 X 600 MW)

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INTRODUCTION

1. Background

The combined Cycle Power Plant Project is initiated according to the Electricity Generating Development Plan of the Electricity Generating Authority of Thailand (EGAT) for the year 1992-2006 which was approved by the Cabinet on September 12, 1992. As a consequently the Wang Noi Combined Cycle Power Plant was included into the Plan with the approval of the Cabinet on October 5, 1993. to realize the Project, EGAT the Southeast Asia Technology Co.Ltd. (SEATEC) to prepare an environmental impact assessment study for the Power Plant comprising six 300-MW generators. The study report was approved by the National Environment Board in the meeting no. 5/2537 on June 8, 1994.

During the EIA study period, EGAT also carried out the feasibility study for the transportation of heavy equipments to the project site. The study reveals that the transpartation of the equipments is feasible. In addition, investment cost of a plant with a 600-MW generator which includes costs for equipments, construction and fuel as well as area required for the plant is lower than that of a plant with two 300-MW generators.

As a result, SEATEC prepared an additional EIA for the Wang Noi Combined Cycle Power Plant based on the same installed power of 1,800 MW but replacing six 300-MW generators with three 600-MW generators.

2. Objective

The objective of the study is to explain significant changes of the existing environmental conditions as a result of changes in project characteristic, and recommend appropriate mitigation measures and monitoring programs.

PROJECT DESCRIPTION

1. Project Location

The Power Plant Block 1-3 (3 x 600 MW) is to be constructed on an area of 718 rai in Tambon Khao Ngam and Wang Chula, Amphoe Wang Noi, Ayudhaya Province which is the same location of the former project Block 1-6 (6 x 300 MW) as depicted in Figures 1 and 2.

2. Type, Size and Description of Power Plant.

The Power Plant is a base load type with a total installed power of 1,800 MW. the generating system comprises 3 sets of 600 MW generator each. Each set is compesed of 2 sets of 200-MW gas turbine and set of 200-MW steam turbine.

The generating system has the following design criteria.

	Natural Gas	Diesel
Exhaust gas flow (kg/h)	$2{,}264 \times 10^3$	$2{,}261 \times 10^3$
Exhaust gas velocity (m/s)	30.5	30.5
(HRSG) Exhaust temperature (°C)	100	100
Emission at 15% percent O_2		
NOx (ppmvd)	75	75
NOx as NO_2 (kg/h)	300	280
UHC (ppmvd)	7	7
UHC (kg/h) as CH_4	10	10
CO (ppmvd)	10	10
CO (kg/h)	25	23
Particulates (kg/h)	10	36
SO_2 (ppmvd)	-	110
SO_2 (kg/h)	-	500
Capacity (%)	20	20
Fuel Consumption (kg/s)	15.82	13.74
Gas Consumption (MMCFD)	45	
Heat Consumption (kg/h)	2.53×10^9	2.24×10^9
Stack Height (m)	35	35
Stack Diameter (m)	8	8

Cooling Tower	
Type	Rectangular concrete, multiple cell, counter flow, induced mechanical draft
Total heat load rejected (mJ/s)	as required by the cycle
Cooling tower outlet water temp (°C)	32-36

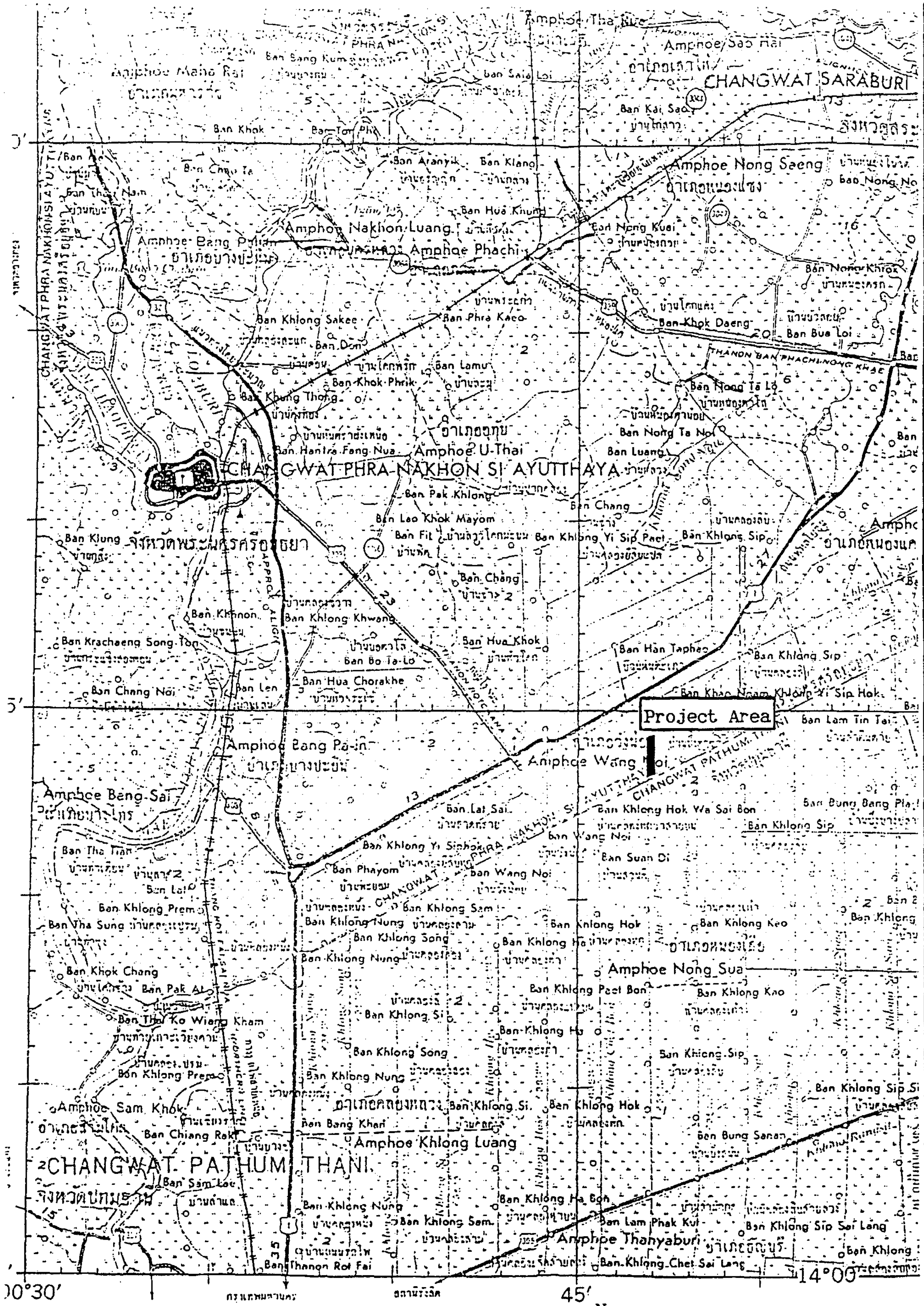
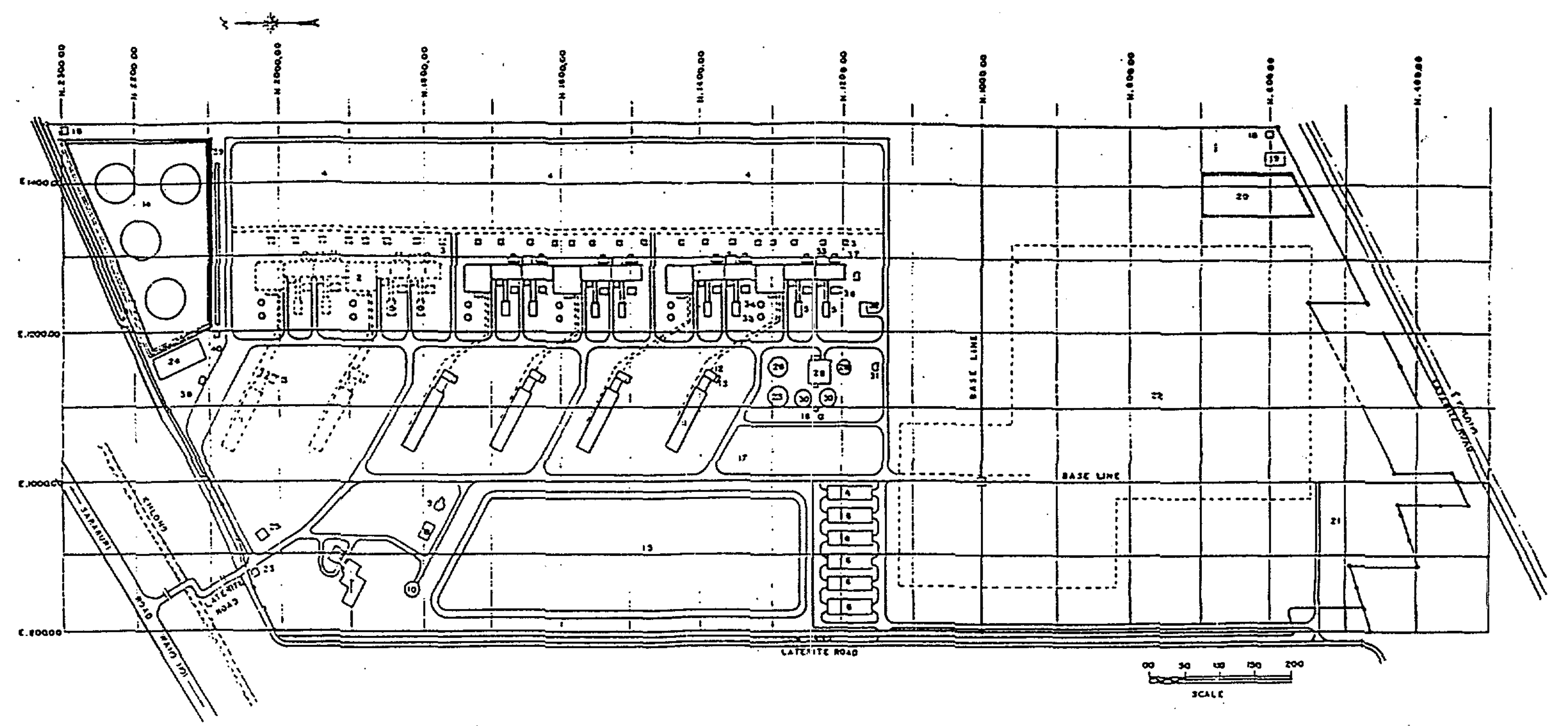


FIGURE 1 WANG NOI COMBINED CYCLE POWER PLANT PROJECT AREA

N

0 5 10 km



FACILITIES LEGEND

1.	GAS TURBINE & GENERATOR	11.	COOLING TOWER	21.	RESIDENT AREA	31.	COMPRESSED GAS STORAGE BUILDING
2.	STEAM TURBINE GENERATOR	12.	CIRCULATING WATER PUMP HOUSE	22.	SUBSTATION AREA	32.	EMERGENCY DIESEL GENERATOR BUILDING
3.	TRANSFORMER	13.	CHLORINATION BUILDING	23.	GUARD HOUSE	33.	LOCAL AREA COMBUSTION TURBINE ELECTRICAL BUILDING
4.	SWITCHYARD AREA	14.	FUEL OIL STORAGE TANKS	24.	HEAVY FUEL OIL TREATMENT UNIT	34.	CONDENSATE STORAGE TANK
5.	HEAT RECOVERY STEAM GENERATOR	15.	RAW WATER STORAGE RESERVOIR	25.	GAS STATION	35.	DEMINERALIZED STORAGE TANK
6.	WORKSHOP BUILDING & WAREHOUSE	16.	WATER TREATMENT PLANTAREA	26.	FIRE/SERVICE WATER STORAGE TANK	36.	CT COOLING WATER MODULE
7.	OFFICE BUILDING	17.	DEEP WELL UNDERGROUND & ELEVATED TANK	27.	PLANT DEMINERALIZED WATER STORAGE TANK	37.	CT AIR FILTER
8.	CANTEEN	18.	DRAINAGE PUMP STATION	28.	WATER TREATMENT BUILDING	38.	FUEL OIL UNLOADING AREA
9.	FIRST AIDS	19.	SANITARY TREATMENT STATION	29.	NEUTRALIZATION BASIN	39.	FULE OIL FORWARDING STATION
10.	HELICOPTER PORT	20.	HOLDING POND	30.	SOLIDS CONTACT UNIT	40.	FUEL AREA SUS BUILDING

FIGURE 2 MASTER PLAN SITE LAYOUT OF WANG NOI COMBINED CYCLE POWER PLANT

ENVIRONMENTAL IMPACT ASSESSMENT

Air Quality

The generating system of the Power Plant is changed from combustion turbine of 100 MW each to 200 MW and HRSG of 50 MW each to 100 MW. Therefore, one block has an installed capacity of 600 MW instead of 300 MW while the total installed capacity is still 1,800 MW. Table 1 and 2 compare description of the previous and existing power plants.

Such a change is taken for the mathematical model. According to Tables 3 and 4, Figures 3 and 4, it is found that maximum ground level concentrations of NO_2 and SO_2 are better than those of the previous project (6 x 300 MW) as presented in the previously approved EIA report (June 8, 1994) and reproduced in Tables 5 and 6. In case of CT, 1-h and 24-h maximum GLC are 18.9 and 84.4 ug/cu.m., respectively, which are below the standard of 320 ug/cu.m. For SO_2, 24-h maximum GLC are 3.8 and 10.5 ug/cu.m.

In case of HRSG, 1-h maximum GLC is found to be 154.9 ug/cu.m. which is also below the standard.

Therefore, it can be concluded that a 3 x 600 MW power plant has an advantage of reduction of fuel consumption and thus reducing pollution problems.

Water Consumption

Water to be consummed in the Power Plant Block 1-3 (3 x 600 MW) is shown in Figure 5 as a water balance block diagram. Consumption of water can be divided into 4 types as follows.

- cooling tower	90%
- gas turbine	5%
- HRSG unit	2.5%
- service water	2.5%

When compared with the prevISous project (6 x 300 MW), the existing project (3 x 600 MW) consumes about 1% less water (Table 7). It is not significant.

Other environmental components will not be significantly affected from what has been asssessed for the previous project (6 x 300 MW).

TABLE 1

Comparison of Technical Design Criteria between former and Revised generating schemes (3 x 600 MW) : Diesel

Description	For 6 x 300 MW		For 3 x 600 MW	
	CT1	CT2	CT1	CT2
Capacity (MW)	100	100	200	200
Operation (H/Day)	4	4	4	4
Fuel				
Type	Distillate Oil # 2		Distillate Oil # 2	
Consumption Rate (kg/sec)	8.36	8.36	13.74	13.74
% S	1	1	0.5	0.5
Stack				
Height (m)	60	60	35	35
Diameter (m)	5.5	5.5	8	8
Velocity (m/sec)	30.5	30.5	30.5	30.5
Temperature (°C)	540	540	570	570
Gas Emission (g/sec)				
NOx*	47.2	47.2	77.8	77.8
SO_2	162.8	162.8	139	139
Emission Control System				
NOx	S/W Inj	S/W Inj	S/W Inj	S/W Inj

Remark : * Expressed as NO_2 , about 95 weight % of NOx is NO (AP–42, US. EPA, 1985)

TABLE 2

Comparison of Technical Design Criteria between former and revised generating schemes (3 x 600 MW) : Natural Gas

Description	For 6 x 300 MW				For 3 x 600 MW			
	CT1	CT2	HRSG 1	HRSG 2	CT1	CT2	HRSG 1	HRSG 2
Capacity (MW)	100	100	50	50	200	200	100	100
Operation (H/Day)	24	24	24	24	24	24	24	24
Fuel								
Type	Natural Gas		–	–	Natural Gas		–	–
Consumption Rate (MMSCFD)	27.5	27.5	–	–	45	45	–	–
Stack								
Height (m)	60	60	60	60	35	35	35	35
Diameter (m)	5.5	5.5	5.5	5.5	8	8	8	8
Velocity (m/sec)	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5
Temperature (°C)	540	540	150	150	570	570	100	100
Gas Emission (g/sec)								
NOx**	–	–	45.8	45.8	–	–	83.3	83.3
Emission Control System								
NOx	S/W Inj	S/W Inj	S/W Inj	S/W Inj	S/W Inj	S/W Inj	S/W Inj	S/W Inj

Remark : * In case of open cycle or combine mode, fuel gas is emitted through only 2 stacks

** Expressed as NO_2 , about 95 weight % of NOx is NO (AP–42, US. EPA, 1985)

TABLE 3

Maximum Concentration of Ambient Air from the Project

(Combustion Turbine for (6 x 200 MW : Diesel)

Parameter	Normal Case (4–h operation)			Worst Case* (24–h operation)			Ambient Standard (ug/cu.m.)
	Concentration (ug/cu.m)	Dist. (Km.)	Dir	Concentration (ug/cu.m)	Dist. (Km.)	Dir	
NO_2 : 1 h	18.93	10.5	NE	84.35	1.6	NW	320
: 3 h	14.58	7.6	N	28.12	1.6	NW	–
SO_2 : 1 h	33.8	10.5	NE	150.6	1.6	NW	–
: 24 h	3.8	10.5	SW	10.5	7.6	N	300
: 1 Year	0.3	7.6	N	1.3	7.6	N	100

Remark : * hardly occur

F:932135/TAB-3.WK1/37-B-0088/DB

TABLE 4

Maximum Concentration at GLC of NO_2 from HRSG*

(3 x 600 MW : Natural Gas)

h	Concentration (ug/cu.m)	Dist. (Km.)	Dir	Ambient Standard (ug/cu.m.)
1	154.95	1.5	S	320
3	79.77	1.3	ENE	–

Remark : * Complete operation

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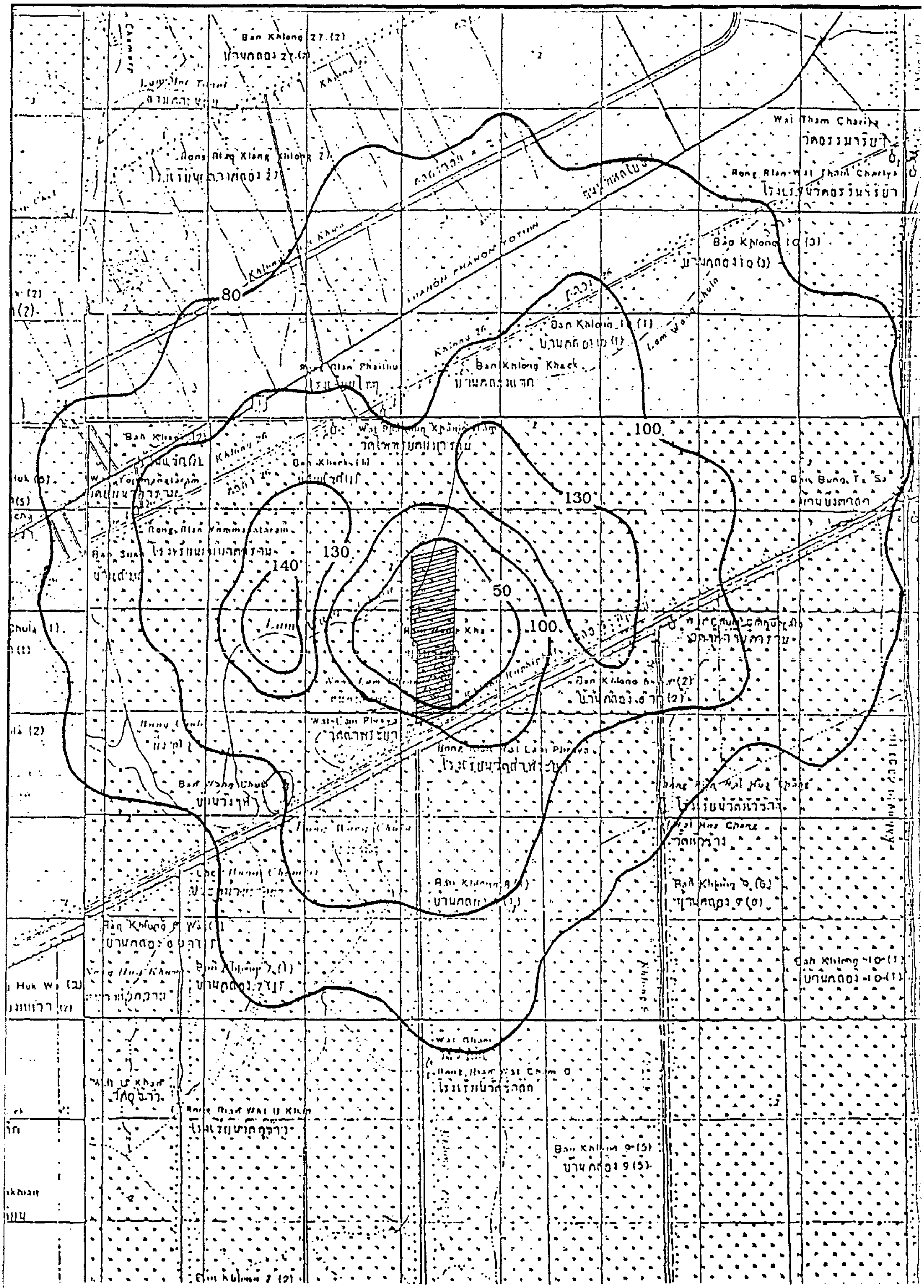


FIGURE 3 MAX 1 h CONCENTRATION AT GLC OF NO_2 FROM THE PROJECT : 35 m STACK HEIGHT FOR HRSG ONLY (µg/cu.m.)

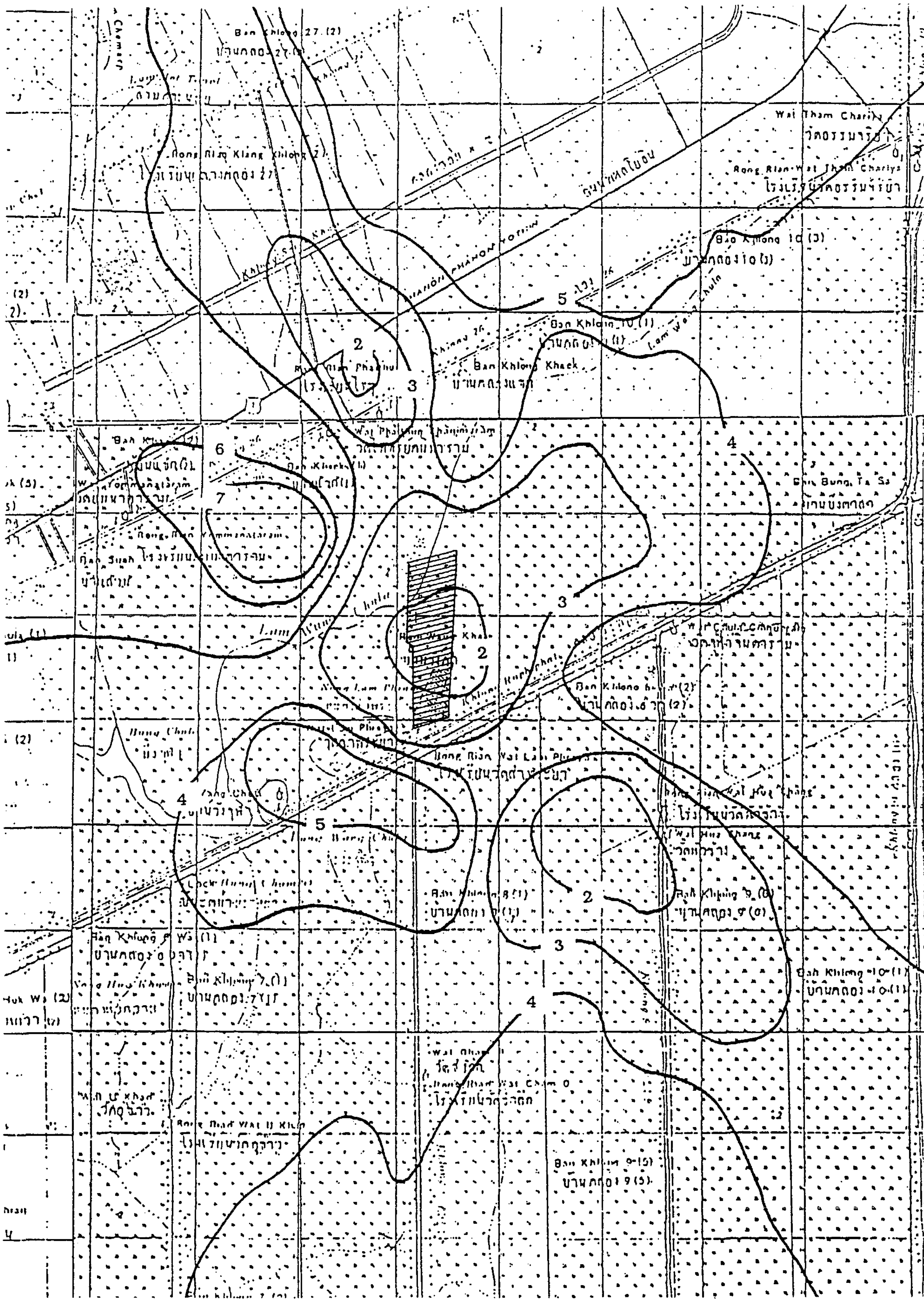


FIGURE 4 MAX 24 h CONCENTRATION AT GLC OF SO_2 FROM THE PROJECT : 24 h OPERATION FOR CT ONLY (µg/cu.m)

TABLE 5

Maximum Concentration of Ambient Air from the Project

(Combustion Turbine)

(12 x 100 MW : Diesel)

Parameter	Normal Case (4–h operation)			Worst Case* (24–h operation)			Ambient Standa (ug/cu.m.)
	Concentration (ug/cu.m)	Dist. (Km.)	Dir	Concentration (ug/cu.m)	Dist. (Km.)	Dir	
NO_2 : 1 h	29.3	10.5	NE	142.7	1.7	E	320
: 3 h	20.4	7.6	N	74.2	2.2	ENE	–
SO_2 : 1 h	101.0	10.5	NE	492.1	1.7	E	–
: 24 h	11.9	10.5	SW	41.5	4.5	N	300
: 1 Year	1.1	8.1	N	5.6	7.6	N	100

Remark : * hardly occur

F:932135/TAB–5.WK1/37–B–0088/

TABLE 6

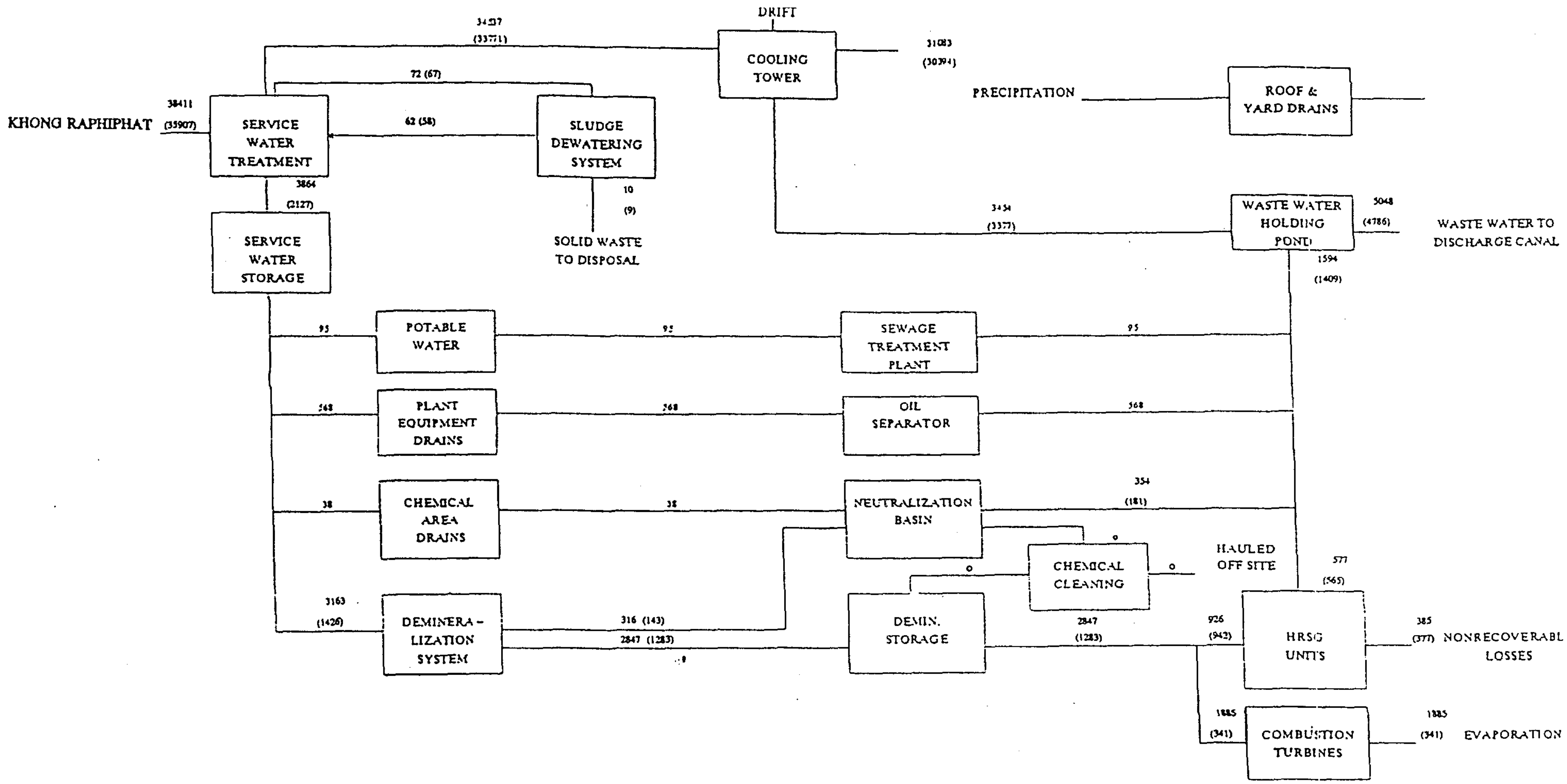
MAXIMUM CONCENTRATION AT GLC OF NO_2 FROM HRSG*

(6 x 300 MW : Natural Gas)

H	Conc. (ug/cu.m)	Dist. (km.)	Dir.	Ambient Standard
1	190.3	1.1	N	320
3	103.5	2.6	NNE	–

Remark : * complete operation

F:932135/TABLE–6.WK1/37–B–0088/DB



NOTES :

1. FLOWS ARE IN LITRES PER MINUTE.
2. FLOWS ARE BASED ON OIL FUEL. 100 PERCENT LOAD FACTOR. 3 PERCENT HRSG'S STEAM LOSSES, AND 75 PPMVD NO_x EMISSION LIMIT AT MEAN ANNUAL AMBIENT TEMPERATURE
3. FLOWS IN PARANTHESIS ARE BASED ON GAS FUEL. 100 PERCENT LOAD FACTOR. 3 PERCENT HRSG'S STEAM LOSSES, AND 75 PPMVD NO_x EMISSION LIMIT AT MEAN MINIMUM AMBIENT TEMPERATURE.
4. CIRCULATING WATER SYSTEM FLOWS ARE BASED ON OPERATION AT 10 CYCLE OF CONCENTRATION AND MEAN ANNUAL ENVIROMENTAL CONDITIONS
5. FLOWS ARE BASED ON THREE 600 MW BLOCKS

FIGURE 5 PRELIMINARY WATER MASS BALANCE

TABLE 7

Comparison of Water Consumption between former and revised generating schemes

Water Consumption for	Consumption Rate	Changes
1. Cooling Tower	varied with size of power plant	No change
2. GT NOx Injection	varied with size of gas turbine	8% reduction
3. HRSG	varied with size of boiler	16% reduction
4. Service Water	varied with size of power plant	No change

F:932135/TABLE-7.WK1/37-B-0088/DB

MITIGATION MEASURES AND MONITORING PROGRAMES

Air Quality

With reference to the specific design data and the model, it was found that NO_2 and SO_2 concentrations are below the standard limits (in case of diesel fuel). In addition, NO_2 concentration is also below the standard. A mitigation measure that is taken is to install 35-m stacks. Other mitigation measures and monitoring programs are maintained.

(1) Ambient Air Quality

Parameters	:	- Nitrogen dioxide - Sulphur dioxide - Wind speed and wind direction
Locations	:	- 5 stations as shown in Figure 6 1. Wat Rat Bamroong School 2. Suwaphan Sanitwong Phittaya School 3. Wat Chula Chindaram School 4. Hiranpong Anusorn School 5. Wat Sawang Arom School
Frequency	:	Twice annually, i.e., in the northeast and southwest monsoon seasons. Each measurement must be conducted for 7 days continuously.
Methodology	:	Follow method recommended by MOSTE or equivalent.

(2) Stack Gas

Parameters	:	- Sulphur dioxide (for distillate oil No.2) - Nitrogen oxides (for NG or distillate oil No.2)
Locations	:	- CT stacks or/and - HRSG stacks
Frequency	:	Twice annually concurrently with ambient air monitoring.
Methodology	:	Stack gas sampling method
Details	:	The results must also include details on quantity of fuel used and percentage of sulphur in the fuel, as well as capacity of production during monitoring.

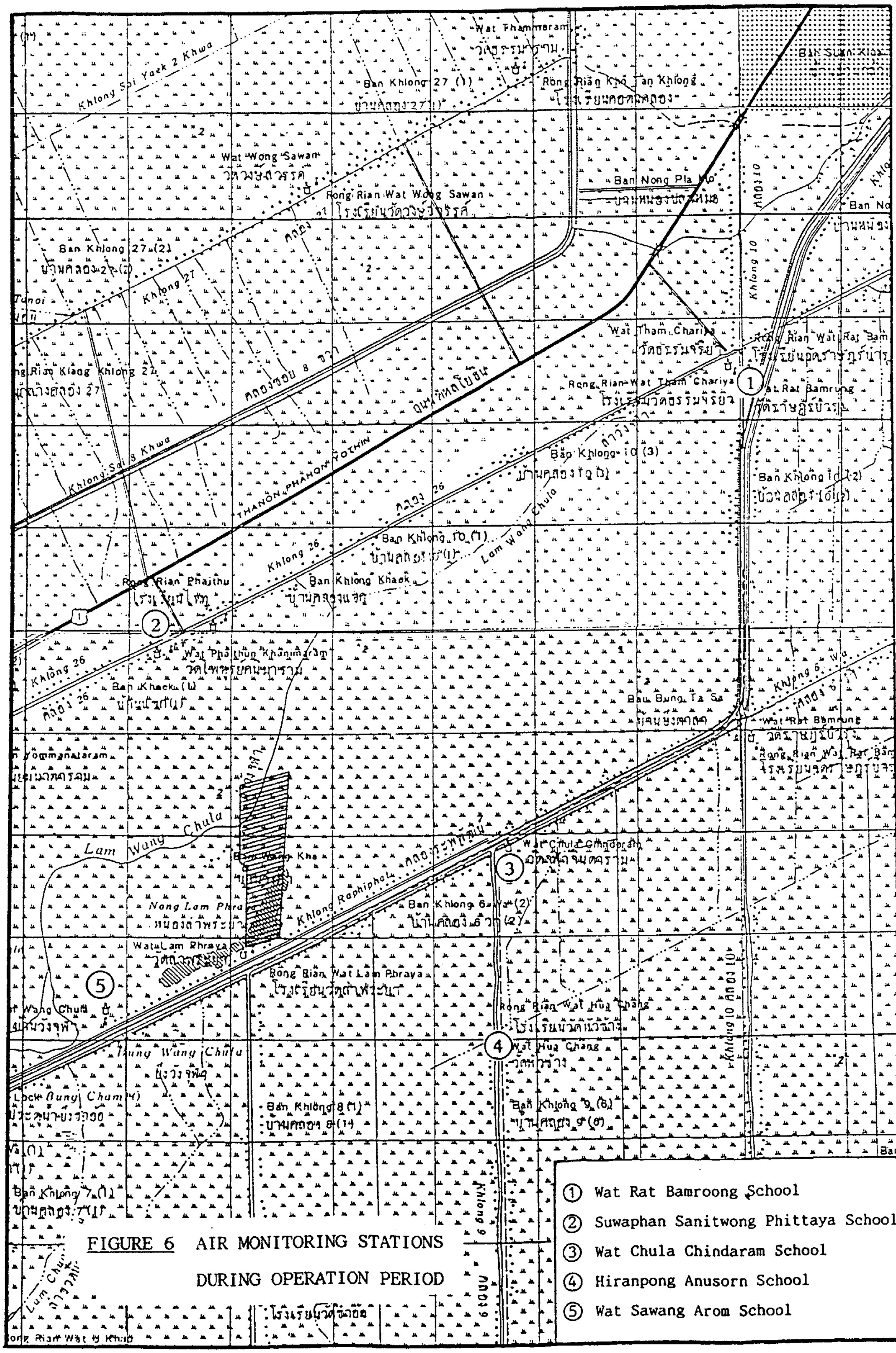


FIGURE 6 AIR MONITORING STATIONS DURING OPERATION PERIOD

SUMMARY OF MITIGATION MEASURES AND MONITORING PROGRAMS
FOR WANG NOI COMBINED CYCLE POWER PLANT

Environmental Resources	Locations	Mitigation Measures/Parameters	Frequency	Estimate Cost (Baht/Year)
1. Air Quality		– Emission Control System (NO_x)		can't seperated from the instrument cost
	– CT Stacks or/and HRSG Stacks	– SO_2, NO_2	– twice a year, for NG	50,000
		– SO_2, NO_2	– twice a year, for distillate oil No.2	70,000
	– 3 Stations, outside the project site	– SO_2, NO_2	– twice a year, for 7 consecutive days	300,000
2. Noise		– Installed Silencer in Release Valve area		can't seperated from the instrument cost
	– Wat Lam Phraya	– Leq (24)	– twice a year, for 3 Consecutive days	30,000
3. Water Quality		– WasteWater treatment plant		can't seperated from the instrument cost
Surface Water	– 6 Stations, in surface water body near the project site	– Temperature, pH, Conductivity, Turbidity, DO, BOD, COD, Alkalinity, Hardness, Nitrate, Grease & Oil, Phosphate, Fe, Sulfate, TS, SS, DS, Pb, Cr, Cd, Zn, Cu, Ni and Coliform bacteria	– twice a year	150,000
Groundwater	– 1 well in the project site	– pH, Conductivity, Turbidity, DS, SS, Alkalinity, Hardness, Ca, Mg, Fe, Mn, Sulfate and Nitrate	– four times/year	10,000

SUMMARY OF MITIGATION MEASURES AND MONITORING PROGRAMS FOR WANG NOI COMBINED CYCLE POWER PLANT (cont'd)

Environmental Resources	Locations	Mitigation Measures/Parameters	Frequency	Estimate Cost (Baht/Year)
4. Aquatic Ecology	- 4 Stations (same as surface water quality monitoring stations)	- Plankton and Benthic Organisme	- Same period as surface water quality	20,000
5. Land Subsidence	- 2 stations, in the project site		- Once a year	10,000
6. Socio-economics	- Nearby community	- Make a Survey on changes in oeeupation, ineome and other socio-economic parameters of villagers by interviews	- Every 2 year	20,000
7. Fuel		- Install continuous gas detcetors to monitor Teakage of watural gas pipitine		can't seperated from the instrument cost
8. Oecupational Health and Safety	- Workers in the project site	- Set the enough protect instruments such as safety hat, shoes, grove, ear plug - set to annual check for efficiency competence such as hearing ability, etc.	- Once a year	200,000

F:932135/T-MITIGA.WK1/37-B-0088/DB

Cooling Tower Characteristic

THE COOLING TOWERS ARE SPECIFIED TO BE OF THE RECTANGULAR , CONCRETE CONSTRUCTION , MULTIPLE BACK-TO-BACK CELL , COUTERFLOW , INDUCED MECHANICAL DRAFT TYPE. THE DESIGN CRITERIA FOR EACH TOWER IS AS FOLLOWS.

DESIGN WATER FLOWRATE	: 13,667 LITRES/SECOND
INLET WATER TEMPERATURE	: 44.0 ^{o} C
OUTLET WATER TEMPERATURE	: 36.0 ^{o} C
INLET AIR WET-BULB TEMPERATURE	: 29.9 ^{o} C
MAXIMUM DRAFT LOSS	: 0.002% OF WATER FLOWRATE
DESIGN HEAT REJECT TO ATMOSHERE	: 453,350 $^{kj}/_{sec}$

FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT

WANG NOI COMBINED CYCLE POWER PLANT PROJECT BLOCK 1-6

MAIN REPORT

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SUMMARY OF IMPACTS, MITIGATION MEASURES AND MONITORING PROGRAMS

SUMMARY OF IMPACTS, MITIGATION MEASURES AND MONITORING PROGRAMS FOR WANG NOI COMBINED CYCLE POWER PLANT

Environmental Resources/Values	Environmental Impacts	Mitigation Measures	Monitoring Programs
1. Physical Environmental Resources			
1.1 Air Quality	Construction Phase – Dust dispersion from construction activities such as land preparation and transportation is expected.	– Spray of water twice a day on open land to reduce dust dispersion is recommended.	– Monitoring is recommended for TSP at Wat Lam Phraya, every 4 month Each measurement must be performed for 3 consecutive days.
	Operation Phase – At the first stage, at CT stack height of 60 m, GLC of SO_2 around the project site is acceptable. – At the final stage, at HRSG stack height of 60 m, GLC of SO_2 and NO_2 is acceptable.	– Stack height of CT units should be kept at 60 m minimum. – Stack height of HRSG should be kept at 60 m minimum.	– Monitoring is recommended for NO2, SO2 and wind speed and direction at 5 stations, for 7 consecutive days. The frequency is twice a year. – Monitoring of stack gas for SO_2 and NO_2 at CT and HRSG is recommended with ambient air quality monitoring.
1.2 Noise	Construction Phase – Maximum predicted noise of 76–101 dBA at source will reduce to 70 dBA at the distance of 400–500 m away from the source. This will affect Wat Lam Phraya and nearby community, as compared with standard of 55–60 dBA.	– Loud noise equipment must be avoided at night time. – Regular check–up and maintenance of equipment is necessary. – Noise protection apparatus must be provided to workers.	– Monitoring of Leq (24) for 24 h. twice a year at Wat Lam Phraya during construction phase is suggested.
	Operation Phase – Noise level at the distance of 60, 120 and 200 m away from the plant center will reduce to 49, 43 and 39 dBA thus causing no effects to nearby community.	– No mitigation measure is required.	– No monitoring program is required.
1.3 Surface Water Hydrology	Construction Phase – Soils spilled during transport might block the water way	– Prevention of soil spillage from trucks into the water way is recommended	– Monitoring program of Khlong conditions during construction period is recommended

TABLE 4-1 (Cont'd)

Environmental Resources/Values	Environmental Impacts	Mitigation Measures	Monitoring Programs
	Operation Phase – Impacts due to serious shortage of water in some periods.	– Cooperation of EGAT with RID for proper water management must be carried out. – Construction of a raw water reservoir for 5-d storage in necessary.	– Water situation in relation to the Plant must be closely monitored.
1.4 Surface Water Quality	Construction Phase – Construction of intake station will cause short term increase in turbidity, color and SS in Khlong Raphiphat. – Dredging of canal bed for installation of suction pipe will increase turbidity, color and SS and decrease in DO. – Construction of on-site structures such as buildings, ponds, auxilliary equipments, etc. will generate short term impacts to existing storm drainage canal, Wang Chula canal due mainly to surface soil erosion, in terms of turbidity, color and SS. – Contamination of wastewater from labor camp in surface water body causes increase in BOD, total and faecal coliform and decrease in DO.	– Provision of a temporary holding pond for storing runoff to allow sedimentation and siltation. – Proper handling or disposal of residual construction materials and other solid wastes is required. – Proper wastewater and solid wastes treatment and disposal for labor camp is required. – Provision of well-designed toilets with proper treatment unit.	– Monitoring of water quality in Chao Phraya River and Khlong Raphiphat for temperature, pH, conductivity, turbidity, SS, TDS, alkalinity, hardness, DO, BOD, grease & oil and color must be conducted at least once in rainy season (October).
	Operation Phase – Discharge of effluent of 5,197 l/min (diesel oil fuel) and 4,916 l/min (gas fuel) into Khlong 26 will affect downstream water quality in terms of SS, TDS, hardness, sulfate, conductivity and copolymers using in cooling system. – Contamination of chemicals may be harmful to aquatic lives.	– Treatment of holding pond effluent to reduce SS, conductivity and TDS is required. – Treated effluent should partly be recycled or reused. – Study on toxicological effects of chemicals using in cooling system on indigenous plants and aquatic organisms is required.	– Monitoring of water quality in Khlong Raphiphat and Khlong 26 for temperature, pH, conductivity, turbidity, SS, TDS, alkalinity, hardness, DO, BOD, H2S and grease & oil must be conducted twice a year in rainy season (October) and in dry season (April). – Additional monitoring of water quality for Pb, Cr, Cu, Zn, Hg, Mn, Ni and Cd in dry season and pesticides in rainy season must be conducted.

TABLE 4-1 (Cont'd)

Environmental Resources/Values	Environmental Impacts	Mitigation Measures	Monitoring Programs
1.5 Groundwater	Construction Phase – Contamination of seepage from septic tanks in labor camp into groundwater is possible.	– Installation of septic tanks at least 30 m away from the nearest groundwater source will prevent the contamination.	
	Operation Phase – Amount of water for domestic supply is within the yield of groundwater wells in this area. Therefore, no impact is expected.	– Withdrawal at optimal rate is necessary to prevent land subsidence. – Monitoring of drawdomw from test wells is recommended.	– Monitoring of land subsidence is required. – Monitoring of drawdown is required.
	– Groudwater quality is suitable for domestic use but must be treated, if used for drinking.	– Water for drinking purpose must be treated. – Monitoring of groundwater quality is recommended.	– Monitoring of groundwater quality twice a year is recommended for pH, conductivity, turbidity, dissolved solids, suspended solids, alkalinity, hardness, calcium, iron, magnesium, chloride, sulfate and nitrate.
2. Ecological Environmental Resources			
2.1 Terrestrial Ecology	Construction Phase – Birds, reptiles and amphibians will migrate from the project site to nearby areas of similar nature in terms of food and habitat thus no impact will be significant.	– No mitigation measure is required.	
	Operation Phase – Same as in construction phase	– No mitigation measure is required.	
2.2 Aquatic Ecology and Fisheries	Construction Phase – Short term effect due to increase in turbidity from construction of intake structure will affect aquatic organisms in Khlong Raphiphat.	– The construction period is short and Khlong Raphiphat is not important in terms of fisheries.	

TABLE 4-1 (Cont'd)

Environmental Resources/Values	Environmental Impacts	Mitigation Measures	Monitoring Programs
	– Short term effect due to increase in turbidity from soil erosion of the plant construction will affect plankton, benthos and fishes in Khlong Raphiphat and Khlong 26.	– Most soil and land preparation must be done in dry season. – A temporary holding pond must be constructed for storage of runoff to allow sedimentation.	– Monitoring must be set for aquatic ecology, i.e. plankton, and benthos, at the intake point, and 1 km upstream and downstream of the intake point at least once in rainy season.
	Operation Phase – At the raw water intake pump station, young fish and fish eggs will be pumped into the intake. Degree of mortality depends on design of intake structure. Floating weeds will also affect the intake.	– Intake pipe inlet must be installed at least 2 m below the surface due to low density of plankton organisms and fish eggs at that depth. – Screening structure must be placed at the inlet of intake pipe to prevent aquatic organisms, floating debris and aquatic weeds.	– Same as for construction phase.
	– Large volume of water discharged from the power plant will increase water in Khlong 26 for natural fisheries and aquaculture. – Changes in flow regime of Khlong 26 will alter group composition of aquatic organisms.	– A fisheries management unit, fish stocking program and control of aquatic weeds in Khlong Raphiphat and Khlong 26 should be established.	
3. Human Use Values			
3.1 Land Use	Construction Phase – Transport of soil from the pit will create a large well and water transmission pipeline will disturb a small scale on land use.		
	Operation Phase – The power plant will require a large amount of water and drain its wastewater into Khlong 26. If wastewater is contaminated with toxic substances, it will be harmful to fruit trees and aquatic lives. This will alter land use pattern.	– The Plant must have a storage reservoir to reserve raw water for 5 days to prevent conflict of water use with villagers. This is to prevent shortage of water for fruit orchards and changes in land use to other activities.	

TABLE 4-1 (Cont'd)

Environmental Resources/Values	Environmental Impacts	Mitigation Measures	Monitoring Programs
		– The treated effluent, though helping increase in water flow of Khlong 26, must be treated to conform to the standards. This is to protect fruit trees and aquatic lives so that people will not change the purpose of land use.	
	– Upon plant completion, infrastructure will be developed from agricultural area to residential one.	– Local agencies must control development in the area conforming to the master plan.	
3.2 Transportation	Construction Phase – Transport of soil for earthwork and land reclamation will have minor effects on traffic, since inner lateritic road will be used. – Transport of construction materials will come mainly from Bangkok. However, ready mixed concrete is transported from the nearby Siam Cement plant. – Transport of machine and equipment will be via Route No. 1 which is already expanded to 10-lane highway thus giving minor effects. – Daily commuting and minor supplies to the site will increase traffic volume in Amphoe Wang Noi. – Installation of raw water transmission pipeline will disturb traffic flow.	– Transport of construction materials should be done out of rush hours. – Speed limits of trucks should be controlled at 60 km/h. – Traffic signs and lighting should be provided together with traffic controllers. – Weight of trucks should be limited at 25 tons. – Carefull inspection of trucks not to make roads dirty should be done.	– No mitigation program is required.
	Operation Phase – Project activities will induce traffic to the project area and the vicinity.	– Traffic signs and lighting should be provided together with traffic controllers. – Cooperation with government agencies to increase traffic safety will be done.	

TABLE 4-1 (Cont'd)

Environmental Resources/Values	Environmental Impacts	Mitigation Measures	Monitoring Programs
3.3 Water Use	Construction Phase – The plant requires about 400 cu.m./d or 0.012 MCM/month or 0.144 cu.m./yr. of water from West Raphiphat for construction activities during January 1994 to November 1995. This amount is only 0.6% of monthly runoff in Khlong Raphiphat during dry season. Therefore, insignificant effect on water use is expected.		
	Operation Phase Khlong Raphiphat, A.Nong Khae, Saraburi – The Plant utilizes water of about 1.25 MCM/month from Khlong Raphiphat at Phra Sri Silp Regulator. The amount of water required is about 6% of the total runoff in Khlong Raphiphat during dry season (21 MCM/month). In addition, groundwater will be withdrawn as a back-up for construction activities. No impact is then expected. – In case the pasak Project is completed, runoff in Chao phraya will be increased by 50% thus no impact is expected.	– Cooperation between EGAT and RID is recommended.	
4. Quality of Life Values			
4.1 Socio-economics	Construction Phase – Noise and dust from transport and construction activities may disturb people living near and around the site.	– Dust from transport and construction activities must be prevented by means of water spraying on uncovered areas or gravel/dirt roads and also by planting of grass in some finished areas. – In order to keep noise levels within the standard, selection of low noise machine and provision of regular maintenance as well as avoidance of working and transporting during the night time is recommended.	

TABLE 4-1 (Cont'd)

Environmental Resources/Values	Environmental Impacts	Mitigation Measures	Monitoring Programs
	– Immigration of construction workers into the area may give rise to disorder, insecurity and unpeacefulness of villages.	– EGAT should provide infrastructure to construction workers such as houses, bathrooms, toilets, wastewater treatment system, solid waste management, etc. and selection of workers.	
	– Villagers will benefit from retailed trading of daily consumer products to construction workers.		
	– Villagers will earn more income by being hired as construction workers.	– Local people must be given priority in employment opportunity.	
	– There will be resistance movement to the Project if there is no sufficient information or acknowledgement about the Project to villagers.	– EGAT should give more understanding of the Project to villagers especially those living in the vicinity of the Plant.	
	Operation Phase		
	– Villagers will earn more income by being hired or employed as project personnel.	– EGAT must give priority in employment opportunity to local people. This will also help solving housing problem.	
	– The area will be developed into more urbanized area due to establishment of the Plant.	– EGAT must provide better physical infrastructure to the villages such as roads, electricity, etc.	
	– Villagers will experience from a change in social pattern or their way of living due to more income generation and development of the area,	– EGAT should participate as a committee member in Tambon's or village's organization in order to receive information concerning needs of communities and to take chance in spreading project informations to heads of communities.	
		– Project personnel must make familiar with local people.	
		– EGAT should provide a suggestion box and PR staff to directly receive comments from public.	
		– EGAT should interview people to investigate changes in occupation, income and other socio-economic parameters every 2 year.	

TABLE 4-1 (Cont'd)

Environmental Resources/Values	Environmental Impacts	Mitigation Measures	Monitoring Programs
	– Air and water pollution, if not properly treated, will adversely affect agricultural produce and also health status.	– Wastewater from the Plant must be treated to acceptable levels to prevent deterioration of Khlong 26 water quatity and thus adversely affecting agricultural farming and health of people. – Air and noise pollution must be strictly controlled.	– Monitoring of surface water quality is conducted. – Monitoring of air quality and noise level is conducted.
4.2 Public Health	Construction Phase		
	– Sanitary conditions in worker camp should be maintained in good conditions to prevent poor quality of life, unhygienic conditions, etc.	– Provision of good sanitary conditions such as well-designed housing units, hygienic toilets and bathrooms and clean drinking water.	
	– Noise and dust disturbance to local people is expected.	– Loud noise equipment and heavy trucks must be avoided during night time. In addition, dust must be controlled.	
	– Accidents caused by heavy trucks to local people will be a major problem.	– Safety measures for traffic and transport must be established.	
	– Most of construction workers are untrained for specific work and have limited knowledge leading to lack of safety awareness, improper attitudes, lack of knowledge for specific job, etc.	– Good and close supervision must be provided for workers. Medical unit with adequate staff and equipments must also be made available at site. In addition, transport service for injured workers must be provided.	
	Operation Phase		
	– Maintenance workers and operators will be the high risk group to working accidents due to improper management, fatique, etc.	– Regular medical surveillance is to be provided for these personnel. – Stringent supervision and control and proper management are necessary to minimize the accidents. The medical center must be established.	
	– Transport accidents are likely to occur.	– Safety regulations must be provided within the plant and personnel must be aware of safety.	
	– Laboratory personnel will be subject to health hazards from chemicals in terms of skin irritation. Long term exposure will lead to respiratory tract disease and defection of kidney and liver.	– Air quality must be maintained within the national ambient air quality standard and must be monitored regularly.	

TABLE 4-1 (Cont'd)

Environmental Resources/Values	Environmental Impacts	Mitigation Measures	Monitoring Programs
4.3 Occupational Health and Safety	– Noise from operation of machine such as gas turbine and intake area will not exceed 85 dBA which complies with the standard of Ministry of Interior (90 dBA). Thus no serious effect from noise is expected.	– Maintenance of machine should be done regularly. – Insulation of turbine casing should be replaced periodically to reduce noise and vibration. – Control room should be provided in case of continuous exposure to noise. – Ear protection equipment should be provided for employees. – Monitoring of noise should be conducted regularly.	– Monitoring of noise at generator and instrument air unit should be done once a year.
		– Hearing loss should be tested for workers who work in noisy areas.	– Test for hearing loss should be done annually for workers being exposed to loud noise.
	– Since the machine that causes heat is covered in the enclosure therefore such heat will not cause any adverse health effects to workers.	– Heat insulation is provided.	– WGBT should be monitored once a year
	– Accidents may occur from unsafe acts of workers especially during maintenance. If preventive measures are effectively implemented and followed up, impacts will not be serious.	– Proper management and close supervision should be implemented.	– Sickness and accidents of all levels must be recorded throughout the course of operation.
	– Leakage of gas pipeline may cause serious damages.	– Regular check-up of pipe conditions is recommended.	– Continuous gas detector with on line system should be installed for monitoring purpose.
4.4 Aesthetic Values and Tourism	Construction Phase – Construction of the power plant will create dust, noise and vibration. – No tourist sites are near the power plant thus no impacts are expected.		
	Operation Phase – Smoke from the power plant will reduce aesthetic quality of the site.	– Provision of green belts and areas should be done.	
	– The power plant will induce housing and industrial development in the area.	– Local agencies should control establishment of housing estates and factories.	

CHAPTER 1

INTRODUCTION

CHAPTER 1
INTRODUCTION

1.1 GENERAL BACKGROUND

In September 1991, the working group on electricity demand forecast estimated electricity demands for the Seventh to Ninth National Economic and Social Development Plans (NESDP) as follows:

NESDP		Electricity Demand (MW)		Increase	
No.	Year	From	To	MW	%
7	1992 - 1996	8,045	13,075	5,030	10.20
8	1997 - 2001	13,075	19,000	5,925	7.76
9	2002 - 2006	19,000	25,515	6,515	6.07

To accomplish the forecasted demands plus the 15% reserve margin for the system, EGAT has conducted a power development plan for the years 1992-2006 which includes the establishment of the Wang Noi Combined Cycle Power Plant with a total installed capacity of 4 x 100 MW. The project is an urgent and scheduled to be completed for implementation by March 1995. However, with the delay of the Ao Phai project and the uncertainty of natural gas supply from Malaysia for the lower central region combined cycle power plant project, together with the expected increase of natural gas supply from the Gulf of Thailand and the policy to establish a power plant close to a load center so that the impact of power transmission line is minimized, the power installation of the Wang Noi Power Plant is then enlarged to 6 x 300 MW.

The current installed capacity of the overall EGAT system in 1993 was 12,179.5 MW, of which 2,416.5 MW was from hydropower plants, 6,101.5 MW from thermal power plants, 3,423.6 MW from combined cycle power plants, 224 MW from gas turbine power plants, and 13.9 MW from other power plants including geothermal, diesel and non-conventional energy power plants. It is therefore necessary for EGAT to accelerate the establishment of the planned urgent power plant projects including the Wang Noi Power Plant Project.

EGAT has awarded the Southeast Asia Technology Co. Ltd. (SEATEC) to undertake the Environmental Impact Assessment (EIA) of the Wang Noi Combined Cycle Power Plant Project in accordance with the contract No. EGAT 46-7-95-0043 dated November 17, 1993. The study period was estimated around 3 months. The Report is to be submitted to the Office of Environmental Policy and Planning (OEPP) for review and approval.

1.2 OBJECTIVES OF EIA STUDY

According to the Terms of Reference, the following objectives are specified for this EIA study.

1) To define the study area which would be directly and indirectly affected by the development of the proposed project.
2) To describe the existing characteristics and quality of environmental resources and values of significance.
3) To characterize the physical, biological and socio-economic aspects that would directly affect, or indirectly alternate, limit or support project design, project cost and benefit.
4) To identify the principal changes of the environment anticipated as a result of the project development.
5) To predict the short and long term impacts of the proposed project of significance and magnitude of the predicted impact.
6) To recommend the short and long term measures to prevent or mitigate the adverse environmental effects and/or maximize the positive results of the proposed project upon the local and regional environment.
7) To recommend appropriate guideline for environmental monitoring program with the relevant cost estimate for the proposed project.

1.3 SCOPE OF WORK

In accordance to the TOR, it is required that the EIA study of the Wang Noi Combined Cycle Power Plant Project involve analysis and interpretation of literatures for review of existing conditions and collection of additional field data that would lead to accurate and validate findings and practical recommendations.

The study of existing environmental conditions encompasses both project area and regional scale. The area of great concern is placed heavily over effects of gaseous emission on sensitive receptors. Air quality modelling study is performed to identify impacts from gaseous emitted from natural gas and diesel oil as main sources of fuel. Water consumption for and wastewater and solid wastes from the Plant are also studied and discussed. In addition, other environmental resources and values which would affect and would be affected by plant realization are investigated, such as noise, land resources, ecosystem and socio-economics.

For individual aspects, the study includes existing (ambient) conditions with past conditions and future trend (qualitative and/or quantitative), impact assessment, mitigation measures and monitoring programs. The potential impacts are identified for both short-term and long-term periods.

1.3.1 Types and Priority of Affected Environmental Resources and Values

Prior to the study, EGAT submitted the TOR to OEPP for review and approval. After the consideration, OEPP required that the study must conform to the guideline for preparation of EIA study of an industrial project as issued by OEPP in September 1992. All four environmental resources and values, namely, physical resources, ecological resources, human use values and quality of life values, must be covered in the scope of study. In addition, OEPP revised the study priority specifically for the Wang Noi Combined Cycle Power Plant Project as follows.

First Priority

- Air quality
- Surface water hydrology and water resources (and groundwater, if withdrawn for plant use.)
- Water quality, wastewater discharge and characteristics of receiving water body
- Ecological resources
- Water use
- Socio-economics
- Noise
- Public health
- Occupational health and safety

Second Priority

- Soil/land quality
- Land use
- Solid wastes

Third Priority

- Transportation
- Aesthetics

In carrying out this specific study, the Consultant has followed the OEPP's revised study priority and put the level of effort for each study aspect based on the given study priorities.

1.3.2 Study Area

The study area for individual environmental resources/values is determined after the site reconnaissance and review of literatures concerning the project and the project areas.

Table 1-1 summarizes the affected areas under this study.

1.4 GENERAL SEQUENCE OF WORK

In undertaking this study, the following sequence of work adopted was as follows:

1) Data collection

2) Analysis of data obtained in (1) including screening for useful data/information and accuracy analysis, mathematical/statistical analysis, tabulation and cross-tabulation as needed, etc.

3) Description of past/existing environmental conditions of each parameter and projection of possible future conditions without the proposed plant.

4) Detailed review of project features, their characteristics, all requirements (such as fuel oil, natural gas supply, water supply, land, etc.) staged implementation plan, construction schedule, operation requirements, and operation plan, engineering feasibility, and economic/financial analysis.

5) Matnematical modelling of parameters concerned especially Air Quality Modelling, corresponding to each increment until the ultimate installed capacity.

6) Based on results in (3), (4), and (5) above, projections of the with-project conditions of each environmental parameter in the future were carried out qualitatively and/or quantitatively for each increment.

7) Identification of interrelationships among environmental parameters and/or their effects.

8) Recommendation for an integrated plan for mitigation/enhancement of adverse/positive effects of the Project, both short-term and long-term, based on results obtained in (6) or (7).

9) Recommendation for a monitoring program and an environmental development plan, for the Project, based on the results obtained in (6) and (7) above, will be performed.

TABLE 1-1

AREAS TO BE AFFECTED BY PROPOSED PROJECT

No.	Environmental Parameters	Affected Areas
1	Air quality	Within 5 km from the power plant site, based on climatological conditions.
2	Surface water hydrology	At the intake point in Chao Phraya River and Khlong Raphiphat
3	Water resources	Within Lower Chao Phraya River Basin
4	Groundwater hydrology and quality	Within 2 km from the power plant site.
5	Surface water quality	At the intake points in Chao Phraya River and Khlong Raphiphat and discharge point in Khlong Raphiphat
6	Aquatic ecological resources/fisheries	At the locations as specified in (5)
7	Terrestrial ecology	Within 5 km from the power plant site.
8	Water use	At the intake points in Chao Phraya River and Khlong Raphiphat and also on site and in nearby communities.
9	Socio-economics	Same as in (1).
10	Noise	Same as in (4).
11	Public health	Within Wang Noi district.
12	Occupational health and safety	Within the plant boundary.
13	Soil and land quality	Same as in (1).
14	Land use	Same as in (1).
15	Solid wastes	Mainly on site and at the dumping area. Also within nearby communities.
16	Transportation	Roads connecting project site and nearby areas, especially access roads.
17	Aesthetics	Mainly on site, at intake points and at discharge point. Also within 5 km from the power plant site.

CHAPTER 2

PROJECT DESCRIPTION

CHAPTER 2
PROJECT DESCRIPTION

2.1 INTRODUCTION

Due to many advantages of a combined cycle power plant in comparison with a conventional thermal power plant such as lower construction cost, shorter construction time, lower cooling water required, more flexibility of operation, shorter start-up time and from EGAT experience in operation of the existing combined cycle power plants such as Bang Pakong combined cycle power plant block No. 1, 2, 3 and 4; Rayong combined cycle power plant block No. 1, 2, 3 and 4;and Nam Phong combined cycle power plant block No. 1, it revealed that the efficiency of the combined cycle power plant is higher than the modern conventional thermal power plant while the availability and reliability is almost the same. Therefore, EGAT planned to implement several projects of combined cycle power plant using natural gas as main fuel. One among them is the Wang Noi Combined Cycle Power Plant.

2.2 PROJECT SITE

The proposed Power Plant is located in an area of 718 rai in Tambon Khao Ngam and Wang Chula in Amphoe Wang Noi, Ayudhaya province as depicted in Figure 2-1.

2.3 PROJECT COMPONENTS

The Wang Noi Combined Cycle Power Plant is designed to be a base load power plant and its plant factor is at around 80 %. In the first year of operation when only combustion turbines are put into grid system and distillate oil is used, in case of fuel gas pipeline is not ready, the operating hour will be around 1,500 h/yr and the Power Plant will serve only for system daily peak load demand.

The proposed Power Plant is to be equipped with 6 blocks of electricity generator, composed of 4 blocks in the first stage and 2 blocks for future extension. Each block has a generating capacity of 300 MW, totalling of 1800 MW. The main components comprising in each block are 2 units of combustion turbine generator, 2 units of heat recovery steam generator, and 1 unit of steam turbine generator.

Power generation from the Wang Noi Combined Cycle Power Plant will be transmitted from its switchyard through 230 KV four-circuit line to Bang Pa-In 2 substation for further distribution.

The master plan site layout of the Power Plant is shown in Figure 2-2.

The descriptions of the Project are as follows:

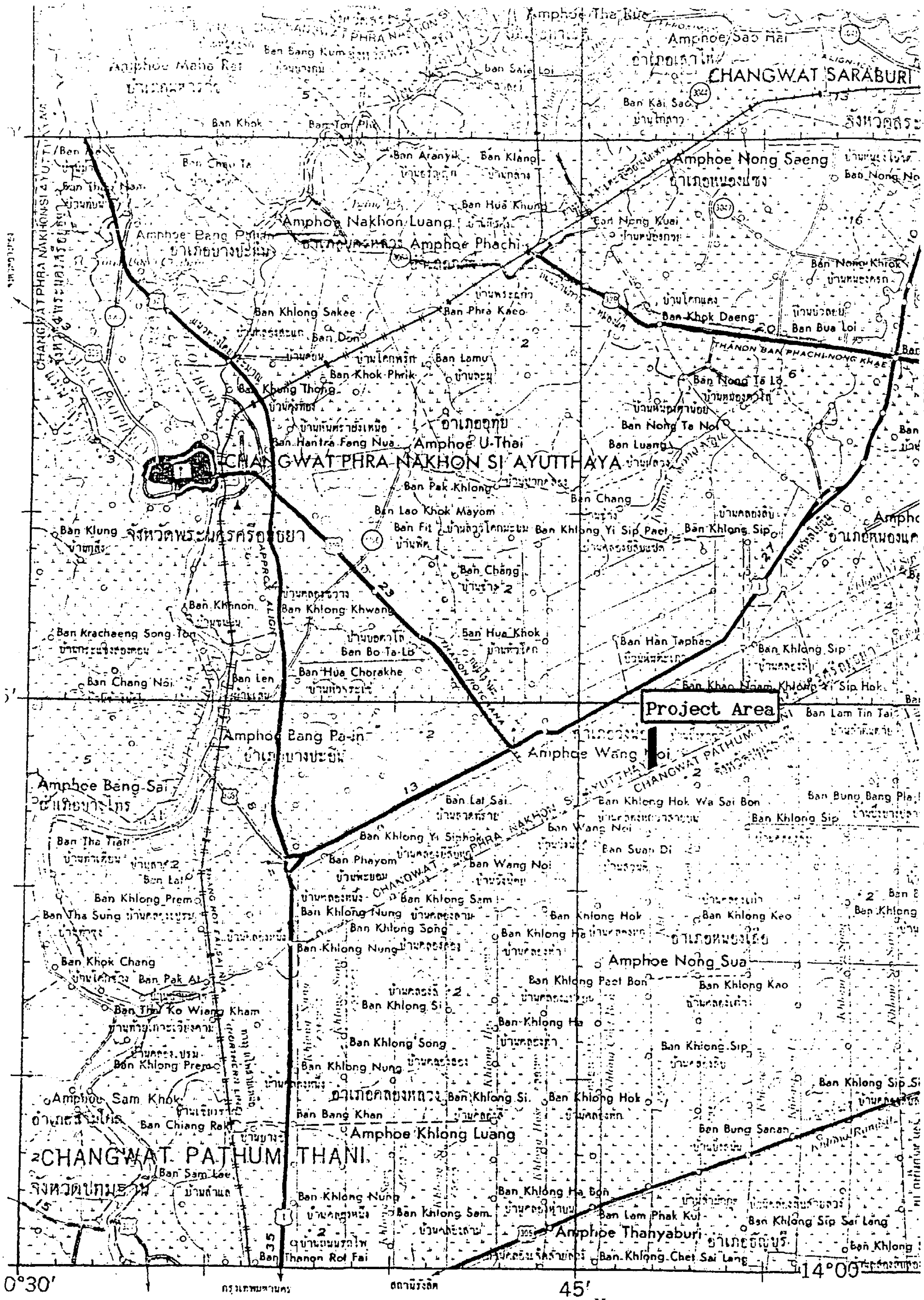
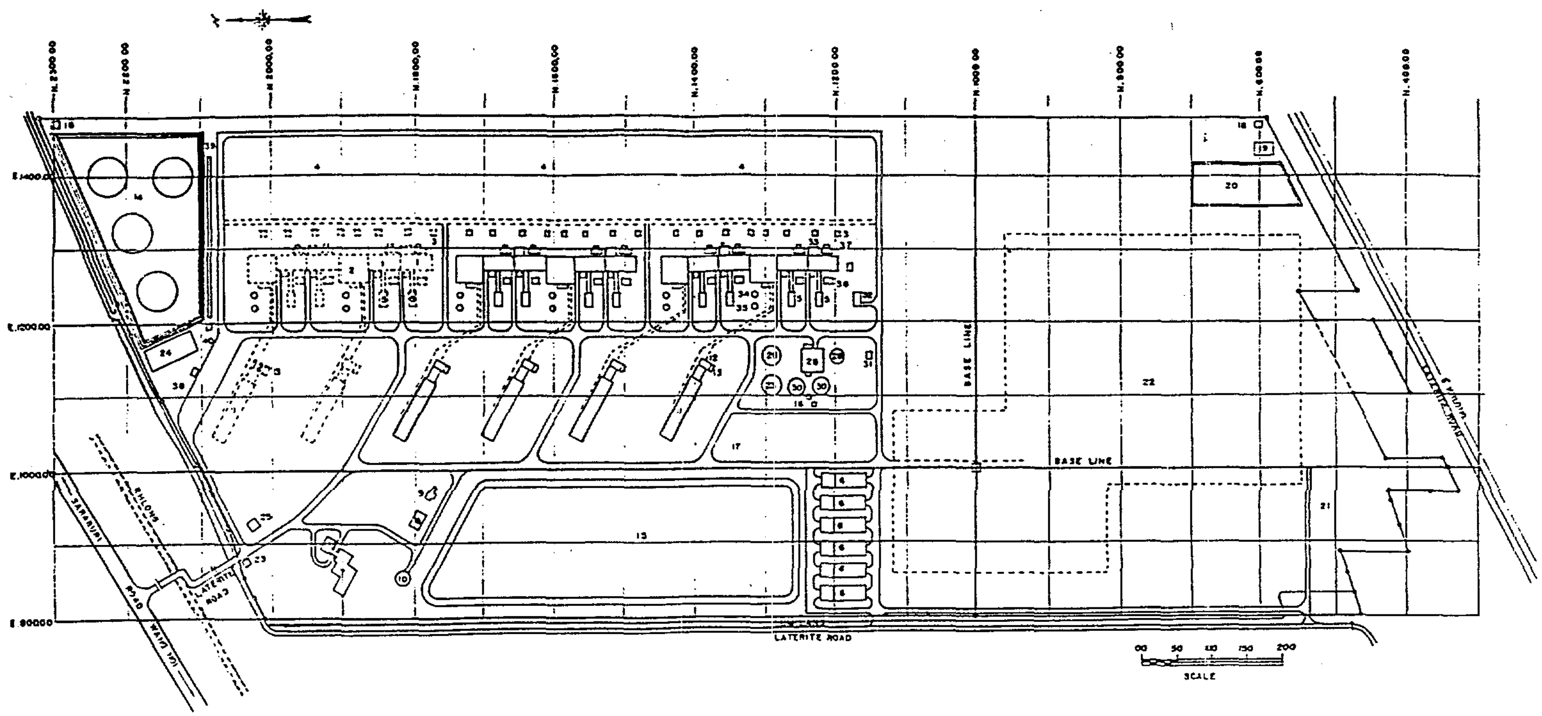


FIGURE 2-1 WANG NOI COMBINED CYCLE POWER PLANT PROJECT AREA



FACILITIES LEGEND

1. GAS TURBINE & GENERATOR
2. STEAM TURBINE GENERATOR
3. TRANSFORMER
4. SWITCHYARD AREA
5. HEAT RECOVERY STEAM GENERATOR
6. WORKSHOP BUILDING & WAREHOUSE
7. OFFICE BUILDING
8. CANTEEN
9. FIRST AIDS
10. HELICOPTER PORT
11. COOLING TOWER
12. CIRCULATING WATER PUMP HOUSE
13. CHLORINATION BUILDING
14. FUEL OIL STORAGE TANKS
15. RAW WATER STORAGE RESERVOIR
16. WATER TREATMENT PLANTAREA
17. DEEP WELL UNDERGROUND & ELEVATED TANK
18. DRAINAGE PUMP STATION
19. SANITARY TREATMENT STATION
20. HOLDING POND
21. RESIDENT AREA
22. SUBSTATION AREA
23. GUARD HOUSE
24. HEAVY FUEL OIL TREATMENT UNIT
25. GAS STATION
26. FIRE/SERVICE WATER STORAGE TANK
27. PLANT DEMINERALIZED WATER STORAGE TANK
28. WATER TREATMENT BUILDING
29. NEUTRALIZATION BASIN
30. SOLIDS CONTACT UNIT
31. COMPRESSED GAS STORAGE BUILDING
32. EMERGENCY DIESEL GENERATOR BUILDING
33. LOCAL AREA COMBUSTION TURBINE ELECTRICAL BUILDING
34. CONDENSATE STORAGE TANK
35. DEMINERALIZED STORAGE TANK
36. CT COOLING WATER MODULE
37. CT AIR FILTER
38. FUEL OIL UNLOADING AREA
39. FULE OIL FORWARDING STATION
40. FUEL AREA SUS BUILDING

FIGURE 2-2 MASTER PLAN SITE LAYOUT OF WANG NOI COMBINED CYCLE POWER PLANT

2.3.1 Electricity Generating Block and Major Equipment

The design, performance and construction critiria of the electricity generating block and the major equipment of the combined cycle power plant are summarized as follows:

1) Site Design Conditions

EGAT's site conditions to be used as design and performance criteria are as follows.

Ambient design temperatures, °C	
Dry-bulb temperature	
For combustion turbine performance	32.6
For auxilliary equipment design	43
Coincident wet-bulb temperature	
For combustion turbine performance	28.9
for auxilliary equipment design	38.1
Design relative humidity, percent	76
Ambient dry-bulb temperature range, °C	10 - 43
Coincident relative humidity range, percent	100 - 75
Barometric pressure, mm Hg	760
Average annual rainfall, mm	1,305
Average annual relative humidity, percent	76
Site elevation above mean sea level, m msl	10.7

2) Electricity Generating Block

Design capacity , MW	300
Combustion turbine generator output	100 MW (net) continuous load at 0.85 PF lagging to 0.85 PF leading
Steam turbine generator output, nominal net at high side of generator step-up Transformer terminals, KW	100 MW approx, (for distillate oil and natural gas fuel)

Heat rate at mcr., Kcal/KWh	2,048
Fuel consumption, MMSCFH (Hg)	2.44

3) Combustion Turbine

Number	2
Fuel	Natural gas, distillate oil (No.2)
Type	Stationary, simple cycle, indoor type with a sound attenuation enclosure.
Speed, rpm.	3,000
Exhaust temperature, °C	540 (*estimated)
Exhaust gas flow, kg/h	$2x1.34x10^6$ (*estimated)
Exhaust heat, kJ/kg	44.5 (*estimated)

Remark * Figures obtained from similar EGAT combined cycle power plants.

4) Combustion Turbine Generator

Number	2
Rated voltage, kV nominal	11.5
Output electricity	3 phase, 50 Hertz
Characteristic of cooling	hydrogen cooling
Speed, rpm.	3,000

5) Heat Recovery Steam Generator

Number	2
Type	Outdoor, unfired, forced or natural circulation, dual pressure with two steam drums.
Flue gas inlet temperature, °C	520 (*estimated)
Flue gas outlet temperature, °C	150 (*estimated)
Flue gas flow rate, kg/h	2 x 1.34 x 10^6 (*estimated)

Remark * Figures obtained from the similar EGAT combined cycle power plant.

6) Steam Turbine

Number	1
Type	Single shaft, tandam compound, axial flow, non reheat, bottom exhausting
Throttle steam pressure, bar absolute	
H.P. inlet	78.5 (approx.)
L.P. inlet	8.96 (approx.)
Steam flow, kg/s	
H.P. steam	97.3 (*estimated)
L.P. steam	24.4 (*estimated)
Throttle steam temperature, °C	
H.P. inlet	518 (approx.)
L.P. inlet	228 (approx.)
Turbine exhaust pressure, mm Hg	90
Speed, rpm.	3,000

7) Steam Turbine Generator

Number	1
Rating, min. nominal KVA at 4.1 bar H_2	as required
Voltage, kV nominal	11.5 or manufacturer's standard
Gen output electrical characteristics	3-phase, 50 hertz
Power factor	0.85
Cooling	hydrogen cooling

Remark * Figures obtained from similar EGAT combined cycle power plants.

8) Steam Condenser

Number	1
Type	Single shell, two pass, horizontal surface
Tube cleanliness factor	90
Max shell pressure at turbine exhaust (at 90% tube cleanliness factor), mm Hg abs.	90
Circulating water inlet temp,°c	36
Max. circulating water temp. Rise,°c	14
Design circulating	as required by manufacturer's design
Water flow rate, cu.m./h	(*27,500)

9) Cooling Tower

-	Number	1
-	Type	Rectangular concrete, multiple cell, counter flow, induced mechanical draft.
-	Total heat load rejected, mJ/s	as required by the cycle
-	Cooling tower outlet water temp, °C	32-36
-	Evaporation & drift losses, m^3/h	311 (oil fuel) 304 (gas fuel)

Remark * The value of 27,500 cu.m./h is obtained from EGAT Engineering Department.

2.3.2 Operation of Combined Cycle Power Plant

As referred to Figure 2-3, each combustion turbine generator set is cranked to rotate by a cranking motor and start to draw the air via the filter air intake unit. Then the air is compressed by the compressor blades and sent to the combustion chamber. The fuel, either natural gas or distillate oil No.2. is mixed with the compressed air and combusted in the combustion chamber. Hot gas from the combustion chamber pushes the turbine blades to make the shaft rotate. The generator which is directly coupled to the shaft then generates the electric power around 100,000 KW. The hot gas is now called exhaust gas. The exhaust gas from each of two combustion turbine generating units is ducted to the respective heat recovery steam generators located near their corresponding combustion turbine generator units. The exhaust gas leaves the HRSG exhaust stack at a temperature of around 150 °C. Steam generated is piped to the steam turbine generator located in the adjacent steam plant building. Exhaust steam is condensed and collected in the cooling tower/cooled surface condenser. The condensate is pumped to the deaerator. HRSG feed pumps take suction from the deaerator and pump feed water to each heat recovery steam generator. Auxilliary cycles and systems are provided for proper operation of the Power Plant. The generator which is directly coupled to the steam turbine generates the electric power around 100,000 KW.

In an open cycle mode of operation, the diverting damper is closed and isolates the way of exhaust gas to HRSG and lets the exhaust gas to the combustion turbine stack at the temperature of around 540 °C.

2.3.3 Fuel

EGAT has planned to use natural gas as primary fuel and distillate oil No. 2 as back up fuel.

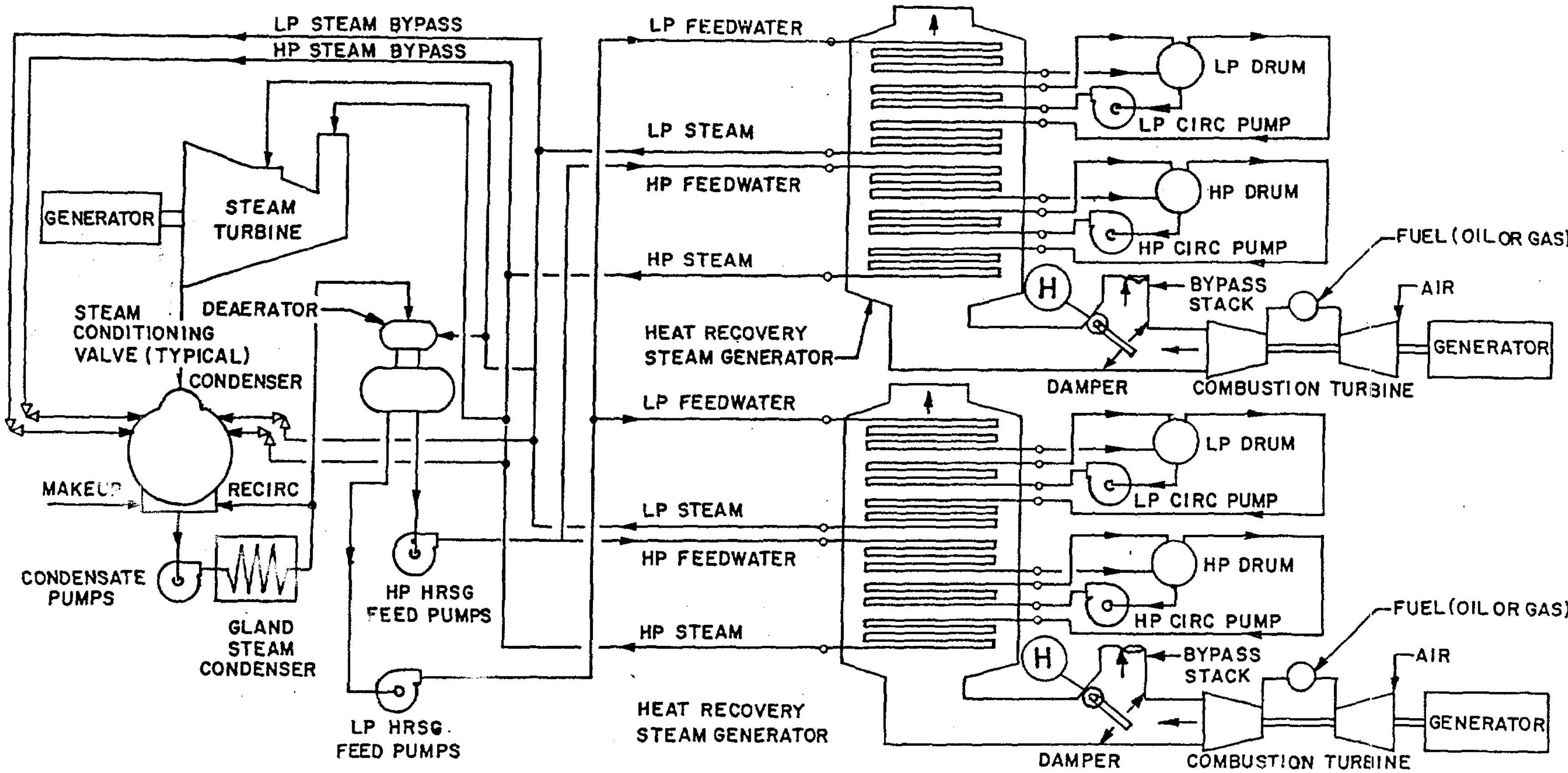


FIGURE 2-3 COMBINED CYCLE PLANT SCHEMATIC DIAGRAM

The specifications of the said fuels are as follows:

1) Natural gas

The properties of the typical natural gas fuel are as follows:

Constituent	Moles, percent by volume
Carbon dioxide	7.62
Nitrogen	1.53
Methane	81.14
Ethane	6.00
Propane	2.33
I - Butane	0.52
N - Butane	0.47
I - Pentane	0.15
N - Pentane	0.10
Hexane plus	0.14

Property	Range	Typical
Specific gravity, at 15 °C	0.6820 to 0.7748	0.7087
Design higher heating value, kJ/kg	43,580 to 44,620	44,450
Minimum gas pressure at contractor's connection, bars G	-	25.86

2) Distillate oil (No.2)

The properties of the distillate oil (No. 2) are as follows:

Property	Range	Typical
Specific gravity	0.887 - 0.825	0.836
Density, kg/l 0.885 - 0.823	0.836	
Pour point, °C	0 to -40	-5
Viscosity, centipoise at 38 °C	2.0 - 3.6	2.9
water and sediment, volume by percent	0 - 0.1	–
Higher heating value, kJ/kg	44,470 - 45,900	
Lower heating value, kJ/kg	--	43,180

Property	Range	Typical
Analysis, percent by weight		
Sulphur	0.05 - 1.0	0.53
Hydrogen	11.8 - 13.9	12.9
Carbon	86.1 - 88.2	86.9

Consumption rates of natural gas and distillate oil No.2 for electricity generation are as follows:

FUEL / ITEM	NATURAL GAS (MMSCFD)	DISTILLATE OIL (NO. 2) (l/operating hour)
1 Combustion Turbine	27.5	36,000
1 Block	55	72,000
6 Blocks	330	432,000

In the first stage, diesel oil will be used as the main fuel since the natrual gas pipeline has not been completed. The gas turbine generators will be operated 4 h/d to serve peak load demand. After the completion of the natural gas pipeline in March 1995, natural gas will be used as the main fuel and diesel oil will be used as the back up fuel during peak period or shortage of natural gas.

Natural gas is supplied from the Gulf of thailand and inland sources by the Petroleum Authority of Thailand (PTT) to the Power Plant. There is no storage facility of natural gas in the plant site.

Diesel oil is used as the back up fuel in case of natural gas shortage, test run operation and after maintenance. Diesel oil is supplied from domestic source via 10-ton trucks. The storage facility comprises 2 tanks. Each tank has a capacity of 29.45 million liter totalling 59.5 million liter. ASTM and API standards are applied for diesel oil storage facility.6

2.4 WATER SUPPLY AND TREATMENT

2.4.1 Raw Water Sources

Initially, there were altogether 4 alternatives of raw water sources for the Power Plant comprising 3 sites in Chao Phraya River and 1 site in Khlong Raphiphat. Figure 2-4 shows locations of alternative raw water intake sites while Table 2-1 summarizes preliminary engineering data of such sites.

Af first, it was concluded by EGAT that alternative 3 and alternative 2 are the first and the second ranks, respectively (Table 2-2). Finally, alternative 2 was cut out due to difficulty in land acquistion. Therefore, alternative 3 was the only site which received prime attention in this study.

However, afterh the Pasak Project had received prime attention from H.M. the King, alternative 1 seemed feasible and thus was taken for reconsideration due to more water stability resulted from the Pasak Project.

2.4.2 Demand and Provision of Raw Water

During the construction period, about 400 cu.m./d (0.012 MCM/month or 0.144 MCM/year) of water will be consumed by pumping from West Raphiphat in front of the Power Plant. In addition, EGAT received an approval from DMR to drill a groundwater well at the depth between 220-250 m and with a diameter of 300 mm to use as a back up source of water for construction activities and as a source for domestic purpose during the operation phase.

During the operation phase, there are 2 stages of operation which require different amount of water as follows:

(1) At the first stage during December 1995 to December 1997, when only gas turbines are operated, the maximum water consumption will be 40,000 cu.m./month or 500,000 cu.m./year. The Power Plant will withdraw 1,000 cu.m./d from groundwater source or 1,370 cu.m./d from West Raphiphat.

(2) At the final stage when a complete scheme is operated in December 1997 onward, the maximum water requirement will be 1.25 MCM/month or 15 MCM/year.

The water will be withdrawn from Khlong Raphiphat at Phra Sri Silp Regulator, A. Nong Khae, Saraburi via pipeline of a diameter of 700 mm and with a length of 17 km. The pipe will be laid along the bank of Khlong Raphiphat to the Power Plant.

Figure 2-5 shows a general flow diagram of main water uses in the Power Plant while Figure 2-6 illustrates a preliminary mass balance.

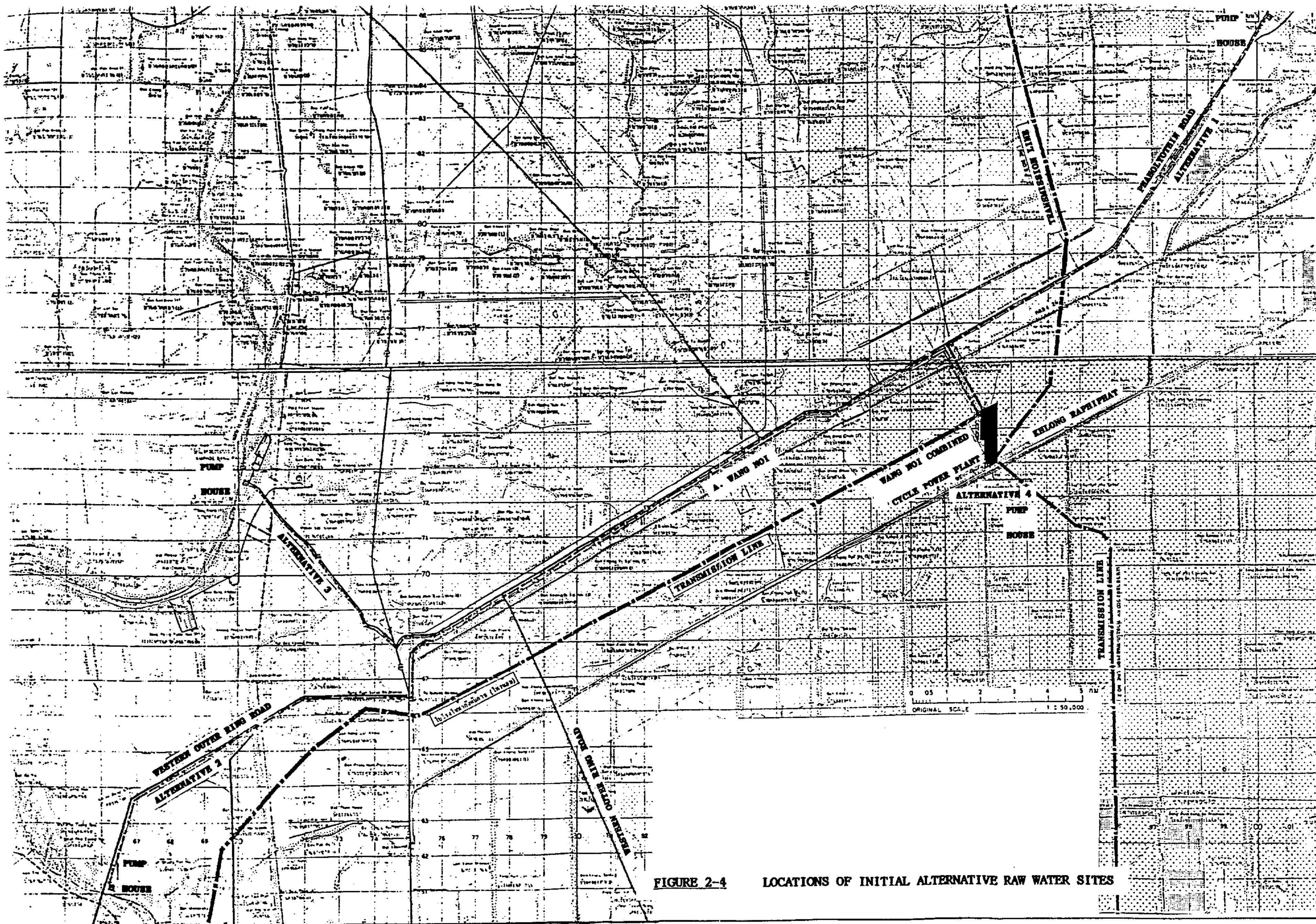


FIGURE 2-4 LOCATIONS OF INITIAL ALTERNATIVE RAW WATER SITES

TABLE 2-1

PRELIMINARY MAIN ENGINEERING DATA OF RAW WATER SOURCES

Item	Alternative 1	Alternative 2	Alternative 3	Alternative 4
1) Raw Water Source	Khlong Raphiphat	Chao Phraya River (Bang Pa-In Site)	Chao Phraya River (Bang Sai Site)	Chao Phraya River (Samkoke Site)
2) Pump Size, kw HP	450 (603)	712 (955)	843 (1,130)	909 (1,219)
3) Transmission Pipe Line - Diameter, mm - Lenght, km	 700 17	 700 29	 700 35	 700 38
4) Max. Flow Rate, cu.m./h	2,280	2,280	2,280	2,280

TABLE 2-2
SUMMARY OF SITE SELECTION FOR COMBINED CYCLE POWER PLANT, CONDUCTED BY EGAT (1993)

Item	Categories	Total Score	Alt 1	Alt 2	Alt 3	Alt 4
1.	Investment Cost	30	30	19	16	14
2.	Water Quality	10	5	10	10	10
3.	Topography of Pumping Station	5	4	3	4	5
4.	Land Acquisition	15	15	15	15	10
5.	Environment	15	5	10	15	15
6.	Water Stability	20	5	20	20	20
7.	Construction Time	5	5	3	2	2
	Total	100	69	80	82	76

Remark : Alt 1 Khlong Raphiphat
Alt 2 Chao Phraya River at Bang Pa In
Alt 3 Chao Phraya River at Bang Sai
Alt 4 Chao Phraya River at Samkoke, Phathumthani

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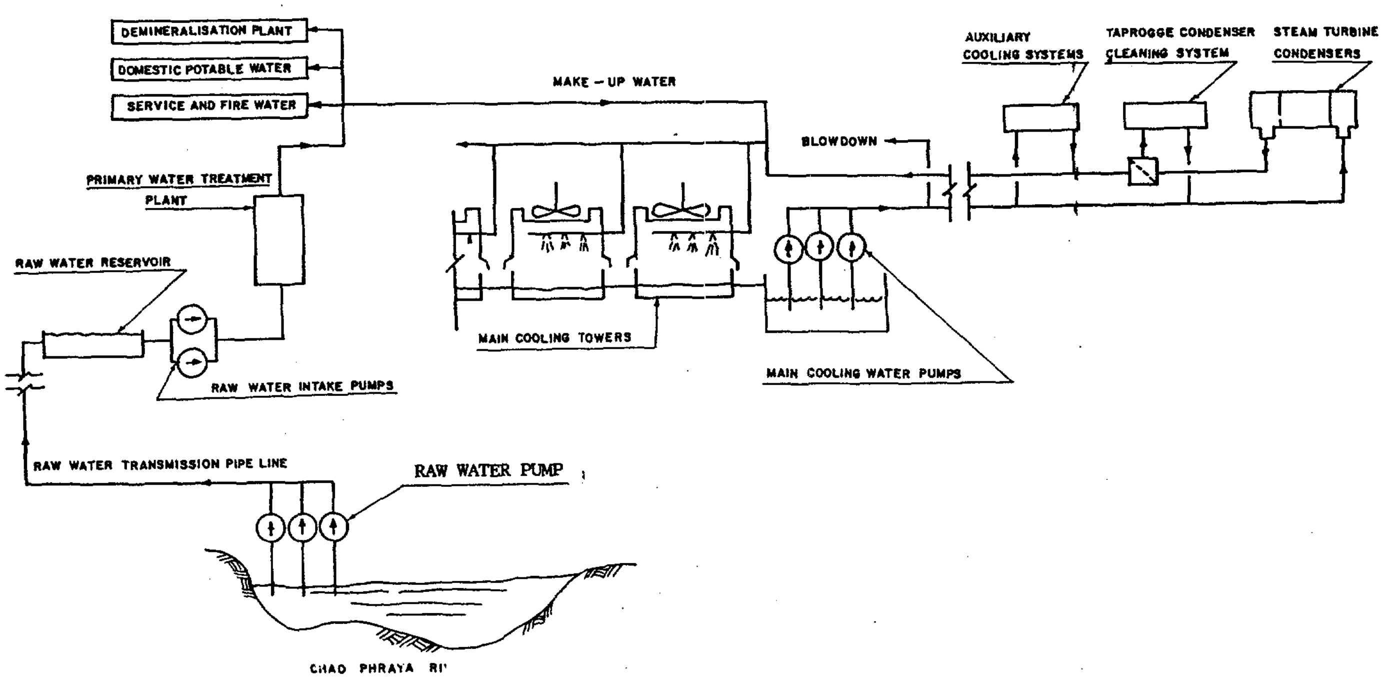
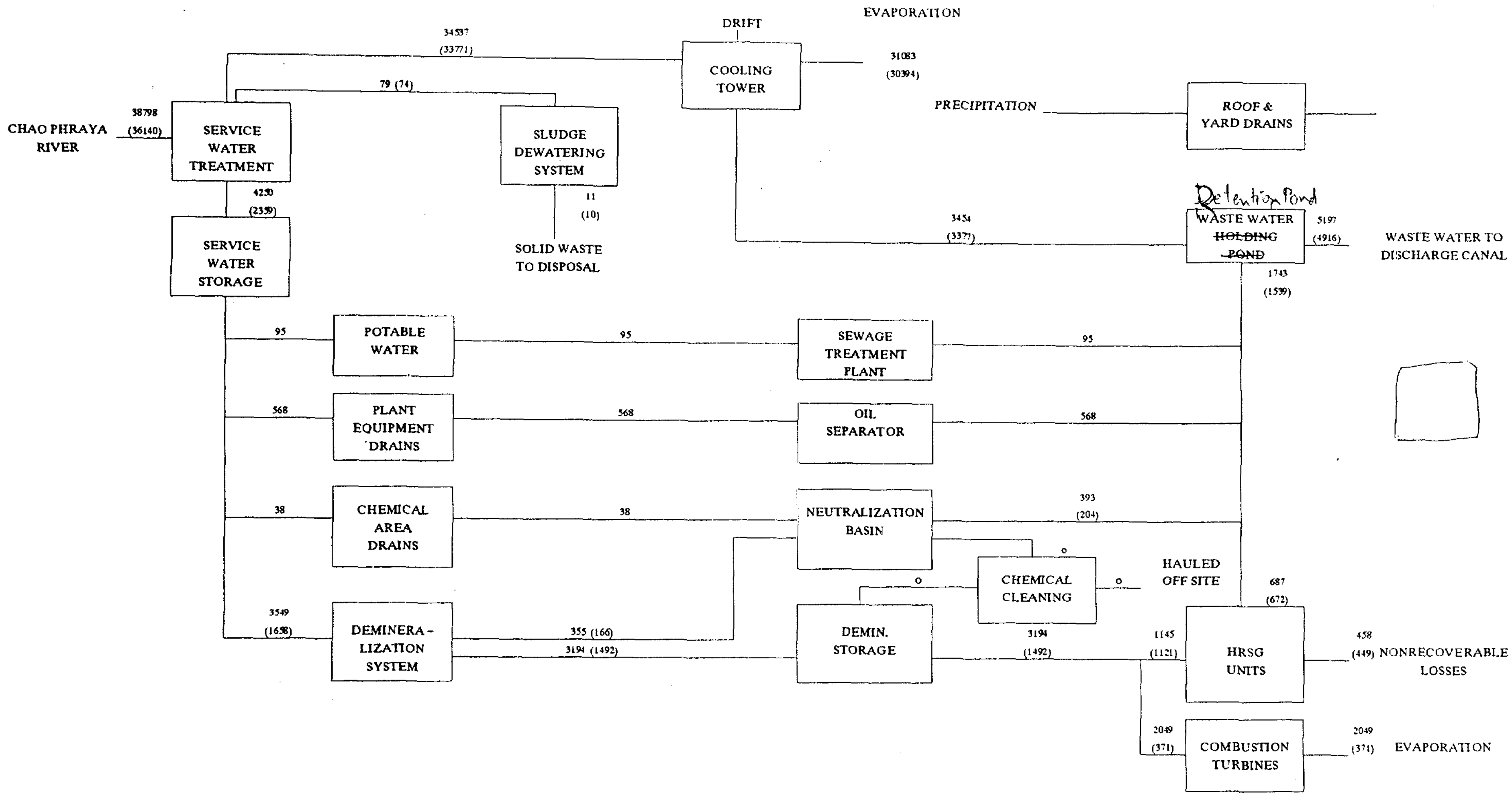


FIGURE 2-5 GENERAL FLOW DIAGRAM OF MAIN WATER USE



NOTES :

1. FLOWS ARE IN LITRES PER MINUTE.
2. FLOWS ARE BASED ON OIL FUEL. 100 PERCENT LOAD FACTOR. 3 PERCENT HRSG'S STEAM LOSSES, AND 75 PPMVD NO_x EMISSION LIMIT AT MEAN ANNUAL AMBIENT TEMPERATURE
3. FLOWS IN PARANTHESIS ARE BASED ON GAS FUEL. 100 PERCENT LOAD FACTOR. 3 PERCENT HRSG'S STEAM LOSSES, AND 75 PPMVD NO_x EMISSION LIMIT AT MEAN MINIMUM AMBIENT TEMPERATURE.
4. CIRCULATING WATER SYSTEM FLOWS ARE BASED ON OPERATION AT 10 CYCLE OF CONCENTRATION AND MEAN ANNUAL ENVIROMENTAL CONDITIONS

FIGURE 2-6 PRELIMINARY WATER MASS BALANCE

2.4.3 Water Treatment

According to different purposes of the demand sides, the raw water will be treated to meet such required qualities. The four categories of treated water are:

- water for cooling system
- water for steam cycle
- domestic water
- water for other purposes

2.4.3.1 Primary Water Treatment System

The raw water to be supplied to the Power Plant will be drawn from Khlong Raphiphat by means of the riverside pumping station. At the pumping station discharge pipe, the chlorination treatment using chlorine gas - water solution injection will be employed to control bacterial slime and algal growth in the raw water pipeline system.

The primary water treatment plant is located in the water treatment plant at site area. The treatment system effluent will be used as cooling tower make-up, service water, fire water, supply to the cycle make-up treatment system and supply to the potable water system.

The raw water will be clarified and stabilized with lime to minimise corrosion in the plant water distribution system. A portion of the clarified water will be filtered and will flow by gravity to the clearwell. The service water transfer pump will transfer the treated water from the clear well to the service/fire water storage tank. At the clear well, the filtered water will be disinfected by gas chlorination. The gas chlorination will also be applied at the influent of the solids contact unit (Clarifier), the SCU effluent. The coagulant solution will be fed into the primary mixing zone as well as aeration for iron oxidation in the raw water supply to the solids contact unit. The remainder of the clarified water will be used, unfiltered, as make-up water to the plant cooling water system.

The service water treatment system consists of a solids contact unit, a lime feeding system, a coagulant feeding system, a coagulant aid feeding system, a gas chlorination feeding system, dual media gravity filters, a back wash system, a sludge thickening system, a sludge dewatering system, controls and panels, pumps, and associated piping and valves. Figure 2-7 shows a flow diagram of the water pretreatment plant.

2.4.3.2 Demineralized Water Make-up for Steam Cycle

The cycle make-up treatment system will receive its supply from station service water which is pH stabilized, clarified, and filtered. The filtered water will be demineralized using a cation - anion mixed bed process in the cycle make-up treatment system. The cycle make-up treatment system influent water design criteria are as follows:-

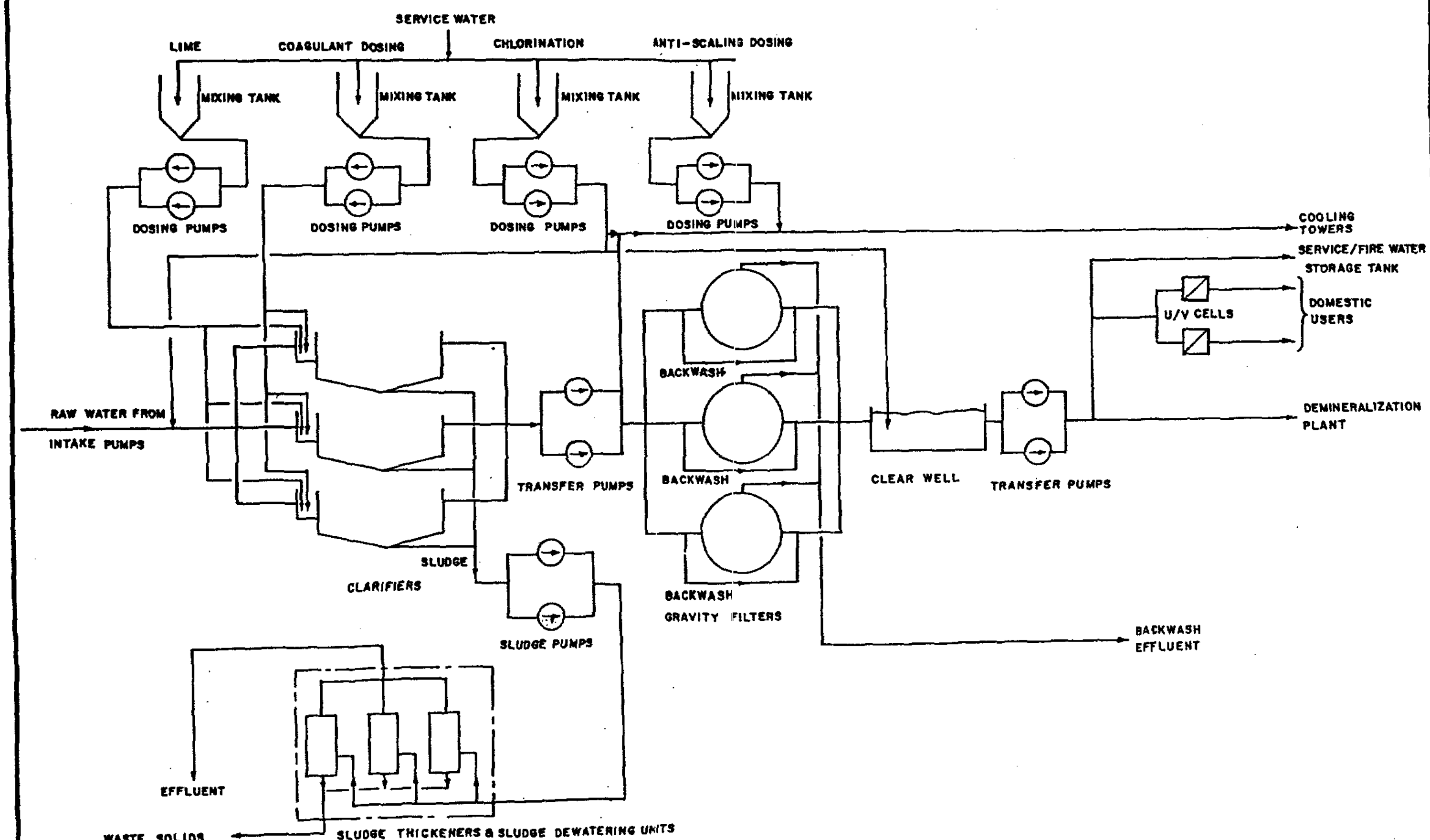


FIGURE 2-7 FLOW DIAGRAM OF WATER PRETREATMENT PLANT

Calcium as $CaCO_3$, mg/l	35
Magnesium as $CaCO_3$, mg/l	50
Sodium and potassium as $CaCo_3$, mg/l	21
M - Alkalinity as $CaCO_3$, mg/l	78
Sulphates as $CaCO_3$, mg/l	17
Chlorides as $CaCO_3$, mg/l	11
Nitrates as $CaCO_3$, mg/l	nil
Carbon Dioxide as CO_3, mg/l	nil
Silica as SiO_2, mg/l	15
pH, in pH units	8.0 - 10.0

Influent water temperature is expected to be in the range of 22 to 32 °C. The average demineralized effluent quality will not exceed the following limits.

Conductivity	0.2 μmho/cm.
Silica as SiO_2	0.01 mg/l
Oil	nil

2.5 COOLING WATER SYSTEM

There are two types of cooling water of the Power Plant, namely steam condenser circulating water and combustion turbine auxilliary equipment cooling water.

The steam turbine circulating water is forced to circulate by pumps and the water exchanges heat with the steam when it passes condenser. The hot water is sprayed down and exchanges the heat by contact with the counterflow, in terms of latent heat of the water. Therefore, a large amount of water is evaporated and a little amount of water is also carried over by air or drift loss, for technical term. The make up water compensation recover for evaporation, drift loss and cooling tower blowdown is filled at cooling tower basin.

The combustion turbine auxilliary equipment cooling water is utilized for cooling down the auxilliary equipment of the combustion turbine. The hot water releases the heat at the radiator by indirect contact with the air. In this case, the water is totally in a closed loop flow and the flow rate is much smaller than the above mentioned circulating water.

2.6 ENVIRONMENTAL DISCHARGES

The combustion turbine generators and auxilliary equipment are designed and constructed not only in accordance with the latest applicable requirements of the engineering codes and standards but also in accordance with the applicable requirements of the "Occupational Safety and Health Administration Standards," United States, Environmental Protection Agency (US.EPA.).

2.6.1 Air Pollution

2.6.1.1 Flue Gas Emission

The fuels of the Power Plant are natural gas as main fuel and distillate oil (no. 2) as back up fuel. The gas emitted from the stack of the Power Plant depends on several factors such as fuel properties, combustion efficiency and system performance. The remarkable pollutants will be NO_x, SO_2, CO, UHC and total suspended particulates (TSP).

Concentrations of air pollutants emitted from the Power Plant are specified as follows:

NO_x	not greater than 75 ppmvd
Soot	not greater than 20% opacity (Ringelmann)
CO	not greater than 10 ppmvd
UHC	not greater than 7 ppmvd

Description of air pollutants emitted from the Power Plant in case of diesel oil and natural gas is presented in Tables 2-3 and 2-4, respectively.

2.6.1.2 Air Pollution Control Equipment

a) Reduction of Nitrogen Oxides

In combustion chambers, occurrence of nitrogen oxides depends on combustion temperatures since ambient air is composed of nitrogen and oxygen. At combustion temperatures below 550°C, no nitrogen oxides occur but they do at temperatures above 1,650°C, as shown graphically in Figure 2-8. Therefore, combustion of different types of fuel gives rise to different portions of nitrogen oxides.

To control nitrogen oxides, demineralized water is sprayed into combustion chambers to keep combustion temperatures below the point that nitrogen oxides occur. This, therefore, reduces quantity of nitrogen oxides.

b) Control Equipments

Control equipments consist of the following:

(1) Water injection forwarding pump motor, 33 kW, 2,700 m^{-1}, 3 cycle, 350 Volt, 50 Hz.
(2) Relief valve for water pump disch
(3) Dual type water filter
(4) Flow meter
(5) Water injection flow control valve assembly

TABLE 2-3

FLUE GAS EMISSION FOR WANG NOI COMBINED CYCLE POWER PLANT

(Distillate Oil # 2)

UNIT	CT 1	CT 2
CAPACITY (MW)	100	100
OPERATION (Hr/day)	4	4
FUEL	Dist. Oil #2	Dist. Oil #2
. Type		
. Consumption Rate (l/hr)	36,000	36,000
. % S	1.0	1.0
STACK		
. Height (m)	60	60
. Diameter (m)	5.5	5.5
. Velocity (m/sec)	30.5	30.5
. Temperature (°C)	540	540
GAS EMISSION (g/sec)		
. NO_x*	47.2	47.2
. SO_2	162.8	162.8
EMISSION CONTROL SYSTEM		
. NO_x	S/W INJ	S/W INJ

Remark : * Express as NO_2, about 95 weight % of NO_x is NO (AP-42, US.EPA, 1985)

TABLE 2-4

FLUE GAS EMISSION FOR WANG NOI COMBINED CYCLE POWER PLANT

(NG : 300 MW)

UNIT	CT 1*	CT 2*	HRSG 1*	HRSG 2*
CAPACITY (MW)	100	100	-	-
OPERATION (Hr/day)	24	24	-	-
FUEL				
. Type	NG	NG	-	-
. Consumption Rate (MMSCFD)	27.5	27.5	-	-
STACK				
. Height (m)	(60)	(60)	60	60
. Diameter (m)	(5.5)	(5.5)	5.5	5.5
. Velocity (m/sec)	(30.5)	(30.5)	30.5	30.5
. Temperature (°C)	(540)	(540)	150	150
GAS EMISSION (g/sec)				
. NO_x**	-	-	45.8	45.8
EMISSION CONTROL SYSTEM				
. NO_x	S/W INJ	S/W INJ	-	-

Remark : * In case of open cycle or combined mode, flue gas is emitted through only 2 stacks

** Expressed as NO_2, about 95 weight % of NO_x is NO (AP-42, US.EPA, 1985)

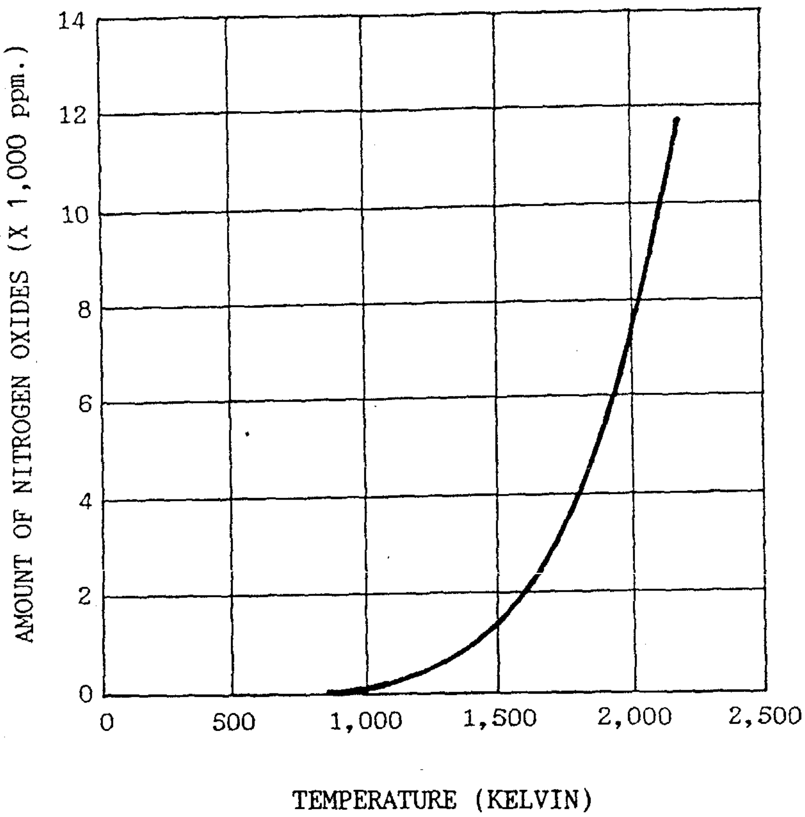


FIGURE 2-8 AMOUNT OF NITROGEN OXIDES AT VARIOUS COMBUSTION TEMPERATURES

(6) Accumulator-water injection for pressure precharging at 17 bar
(7) Water flow stop solenoid valve

c) Functions and Components

In combustion turbine operation, levels of oxides of nitrogen will be kept below 75 ppm by means of continuous water spraying.

Water which is used to control combustion temperatures will evaporate. However, quantity of spray water must be kept optimal since it affects turbine performance/efficiency (Figure 2-9).

In concludion, water injection with fuel burners will control combustion temperatures and thus limiting nitrogen oxides to be generated. Water will evaporate. Water is not used to treat nitrogen oxides which in turn will give rise to acid wastewater and require further treatment. By this method, nitrogen oxides are kept not to exceed 75 ppm.

d) Operation

Water from the storage tank is pumped via water injection forwarding pumps. The pumps are equipped with pressure switches to protect low suction pressure not to fall below 0.25 millibar. In order to prevent pump damage, relief valves and check valves are also installed to keep pressure in line disch not to exceed 60 bar. Also installed are pressure switches to prevent overload of pumps in case of excess flow rate. The pumps will be tripped when disch pressure falls below 15 bar. Spray water will be filtered through 2 dual type filters with a pore size of 5 micron. The filters are used alternately. Pressure switches are also installed to detect filter clogging. If pressure drop of one filter falls below 1.2 bar, it will automatically switch to the other filter. Filtered water then flows through 2 flow stop solenoid valves. Spray water is controlled by flow indicators by means of water injection flow control valve assembly which adjusts flow of spray water via water flow control valve actuators. Before spraying water into combustion chambers, there is a 0.5-l accumulator to pressurise spray water to 17 bar for better spraying.

e) Monitoring Equipments

Nitrogen oxides detectors will be installed at the edge of an exhaust duct where gases are emitted through bypass stacks or boilers (Figure 2-10). The main function of the detectors is to ensure high efficiency of gas turbines.

The detectors are not equipped at the top of bypass stacks and boiler stacks because gases must be emitted via exhaust duct before reaching bypass stacks or boiler stacks. Therefore, at this location, NO_x sensors will detect all emitted NO_x before exitting the atmosphere.

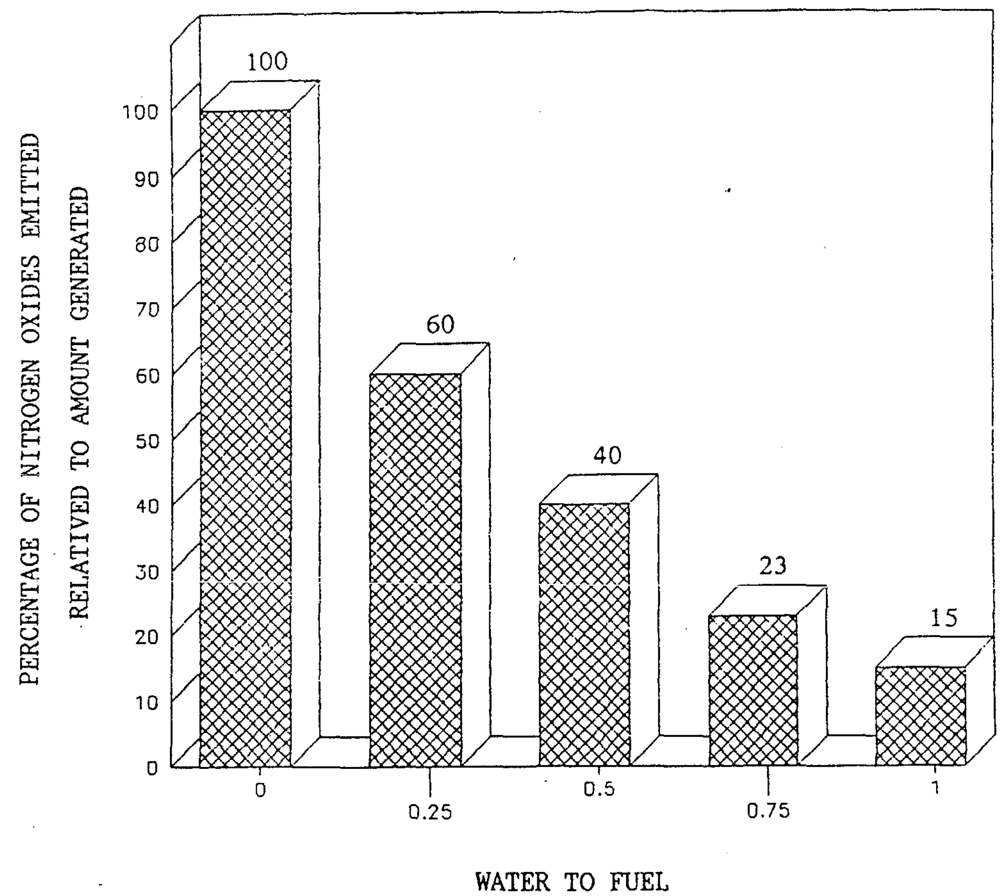


FIGURE 2-9 PERCENTAGE OF NITROGEN OXIDES EMITTED AT VARIOUS WATER TO FUEL RATIO

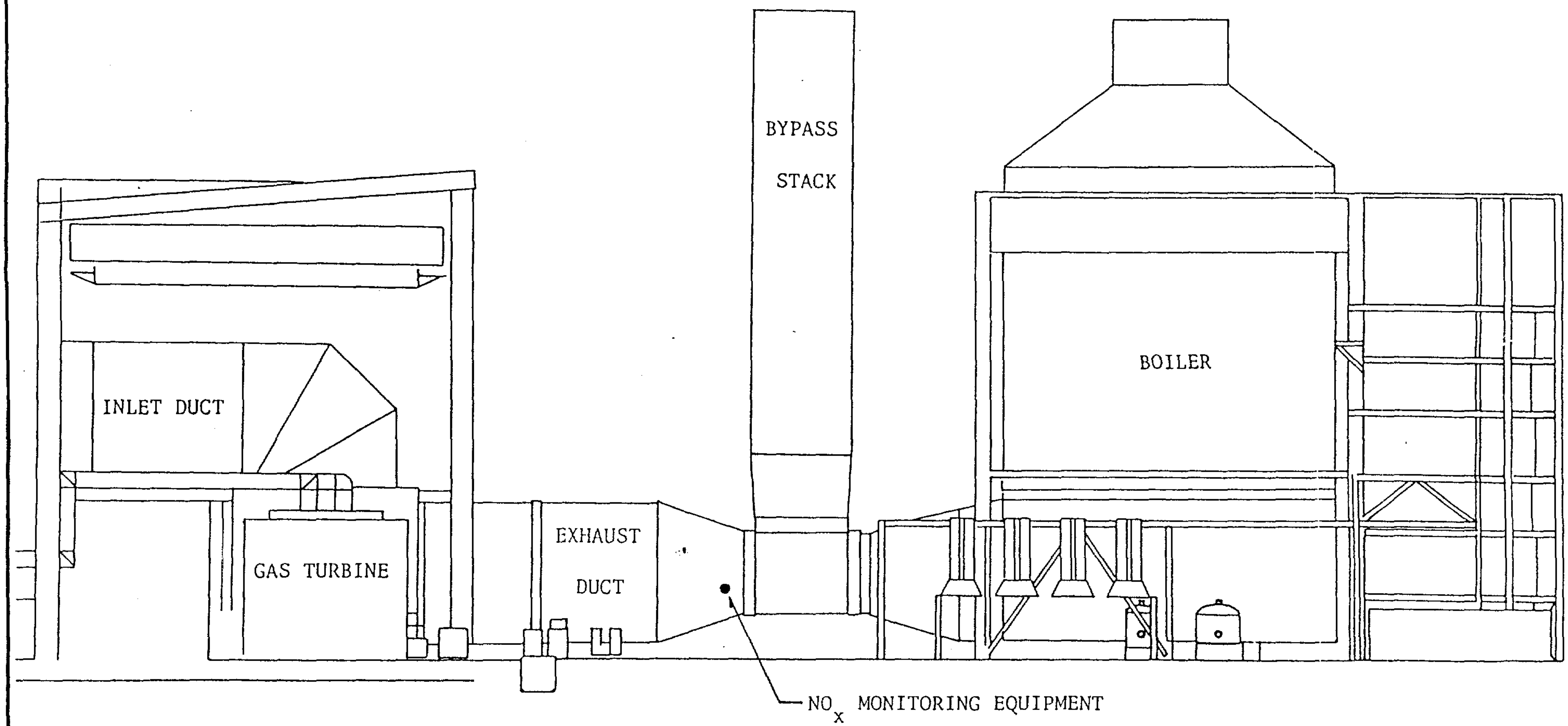


FIGURE 2-10 LOCATION OF NITROGEN OXIDES DETECTORS IN GENERATOR

2.6.2 Noise

The important noise sources are from combustion turbine and cooling tower. The noise limits are as follows:

2.6.2.1 Combustion Turbine Noise

With the combustion turbine generator unit operated at any capacity from 10 percent of continuous (base) site rated load capacity to full continuous (base) site rated load capacity, noise levels resulting from each combustion turbine generator will not exceed 54 dBA at 122 m or 85 dBA at 1 m average.

2.6.2.2 Cooling Tower Noise

Noise level of water, fans, gear reducers, and fan drive motors, measured at 1.5 m from the face of each cooling tower at 1.8 m above ground level will not exceed 85 dBA.

2.6.3 Wastewater Treatment

There are many kinds of wastewater from various sources of the proposed project during operation period. The wastewater from each source is treated accordingly to the acceptable values and is drained to collect in the holding pond before discharge to Khlong Raphiphat at the total flow rate of approx. 5,197 l/min for oil fuel and approx. 4,916 l/min for gas fuel.

The estimated quantity and parameters of each wastewater and their treatment methods are shown in Figure 2-11.

2.6.3.1 Chemical Wastewater

Chemical waste comes from several sources of water treatment building and chemical area.

a) Inside-Building Drains

Mezzanine floor drains (laboratory drains), including floor drain and overflow drain, feeders, tanks, test station sinks, chemical storage/access area of lime, coagulant and coagulant aid.

Ground floor drains including cycle make up treatment system, ion exchange regeneration wastes.

Primary exchangers backwash sump, secondary exchangers backwash sump, demineralizer regeneration trench, floor drain and overflow drain.

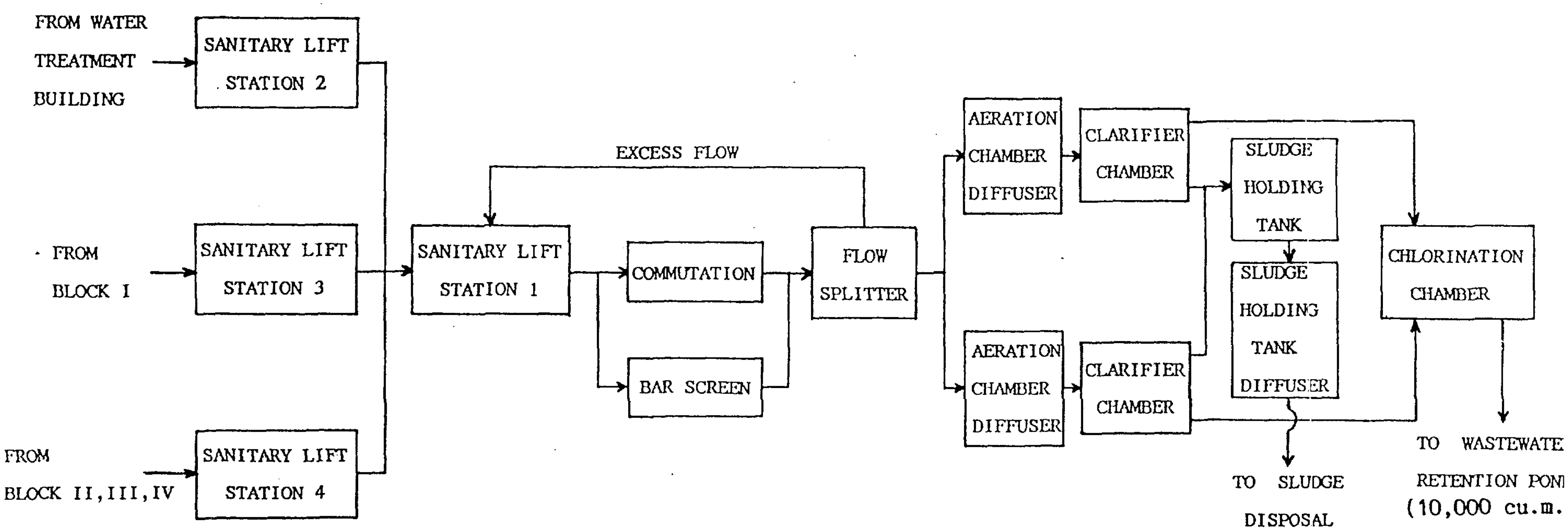


FIGURE 2-11 DIAGRAM OF WASTEWATER TREATMENT SYSTEM

b) Outside Chemical Building Area Drains

Including chemical tanks, metering stations, fill stations, equipment drain and safety showers floor drains.

The effluent flows by gravity to the neutralization basin (with bridge mounted mixer) for adjusting pH level to 6.5-8 by sulfuric acid and caustic soda before pumping to the holding pond. The total amount of chemical waste, for 6 blocks, is approx.393 l/min and 204 l/min in case of oil fuel or gas fuel, respectively. The treatment of chemically contaminated wastewater is shown diagramatically in Figure 2-12.

2.6.3.2 Cooling Tower Water Blowdown

The circulating water of steam turbine condenser is utilized to cool down the cycle steam at condenser and reject the heat at cooling tower. Sulphuric acid, chlorine and inhibitor is fed to the circulating water for controlling biological fouling, scale and corrosion in the cooling water piping. The acid is fed in proportion to the circulating water make up flow rate, biased by the circulating water pH. Inhibitor is fed in proportion to circulating water blowdown.

Periodically circulating water blowdown, manually or automatically, is necessary to control sludge, dissolved solids and concentrate in the circulating water to the acceptable values. The cooling water blowdown is approx. 3,454 l/min for oil fuel or 3,377 l/min in case of gas fuel.

2.6.3.3 Sanitary Drain and Treatment

The sewage treatment plant is built in a cast-in-place concrete basin. The influent to the sewage treatment plant is from sewage lift station 1 located adjacent to the sewage treatment plant. A minimum of 5 duplex lift pump stations is required to transfer area wastes to the sewage treatment plant. The sewage treatment plant is designed to receive wastewater of more than 9,000 l/d hydraulic load (The latest information for six blocks of electricity generating units is 95 l/min and EGAT personnel at the site is about 400 persons including workers) and 20 kg BOD_5/d of organic load. The sewage treatment plant is designed to accept a peak flow of a minimum 500 l/min.

The sewage treatment plant is guaranteed to perform as specified herein after. Effluent BOD_5 is not more than 20 mg/l for any consecutive 30-day average and total suspended solids is not more than 30 mg/l for any consecutive 30-day average.

2.6.3.4 HRSG Blowdown

A HRSG blowdown sump is designed for all six blocks, comprising two sump pumps, a sulphuric acid feed pump, an associated control and instrumentation. An acid feed pump has a capacity of approximately 1 l/h. The pump includes an automatic stroke positioner capable of

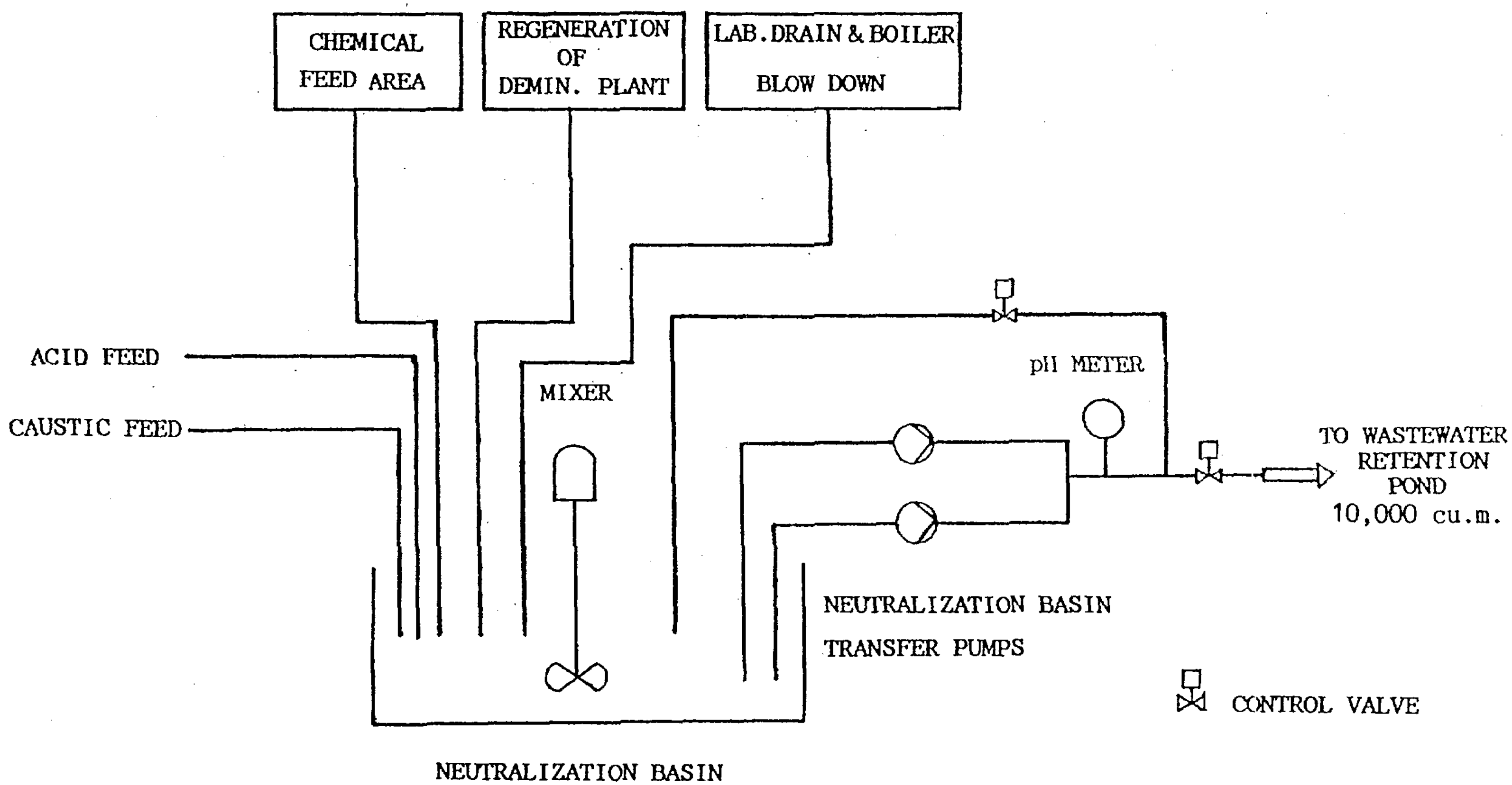


FIGURE 2-12 DIAGRAM OF CHEMICAL-CONTAMINATED WASTEWATER TREATMENT SYSTEM

receiving a 4-20 mA signal. Acid feed rate is proportional to blowdown flow with a bias on sump pH. The HRSG blowdown sump pumps transfer the cooled, neutralized, HRSG blowdown to wastewater holding pond. The flow rate is approx. 687 l/min for oil fuel and 672 l/min for gas fuel.

2.6.3.5 Plant Equipment Drains

General drainage of oily waste from plant equipment area such as combustion turbine areas, steam turbine areas, generator areas flows by gravity to collect and to separate oil in oil-water separator sump for each block, totalling of 6 sumps. Each sump contains 2 pumps. At normal load, one pump is on duty while the other is for standby. However two pumps are on duty at peak load. The pumps will transfer the plant equipment drains to the wastewater holding pond at a flowrate of approx. 568 l/min. The treatment system of oily contaminated wastewater is shown diagramatically in Figure 2-13.

2.6.4 Storm Drainage

Storm water collection system and drainage of the project site is designed based on the following assumptions. The 25 year one hour storm event is being used to determine peak runoff and the 25 year 24 hour storm event is being used for total volume. The drainage area used is 569,000 sq.m. and the runoff coeffienient, CN, is 93 (This is typical coefficient used for heavy industrial sites).

The surface runoff is collected by a series of concrete trenches and gutters. The trenches will serve a dual purpose, first to be used as a mechanical pipe corridor and second to route storm water. For areas in which mechanical pipe trenches are not located nearby, concrete gutters are constructed along roadways to collect runoff from both the roadways and surrounding plant areas. The water is routed to lift stations where water is pumped to Klong Lam Wang Chula and Khlong Raphiphat. However stormwater in some areas could possibly be drained by gravity directly off site near their respective locations.

2.6.5 Solid Wastes Handling

Major solid wastes to be generated at the Power Plant include domestic solid waste and sludge from the water treatment plant and sewage treatment plant.

2.6.5.1 Domestic Waste

Domestic solid waste for the Power Plant is estimated based on the operation staff number of 700 and rate of waste generation per person per day of 0.8 kg/person/d (TEAM and PAL, 1990) is 560 kg/day. Based on bulk density of solid waste of 0.3 t/cu.m., the estimated volume of the domestic waste is 1.87 cu.m. However, for conservative estimation of the domestic waste, a factor of 2 is adopted by TEAM and PAL (1990) for the Nam Phong power plant because there is no

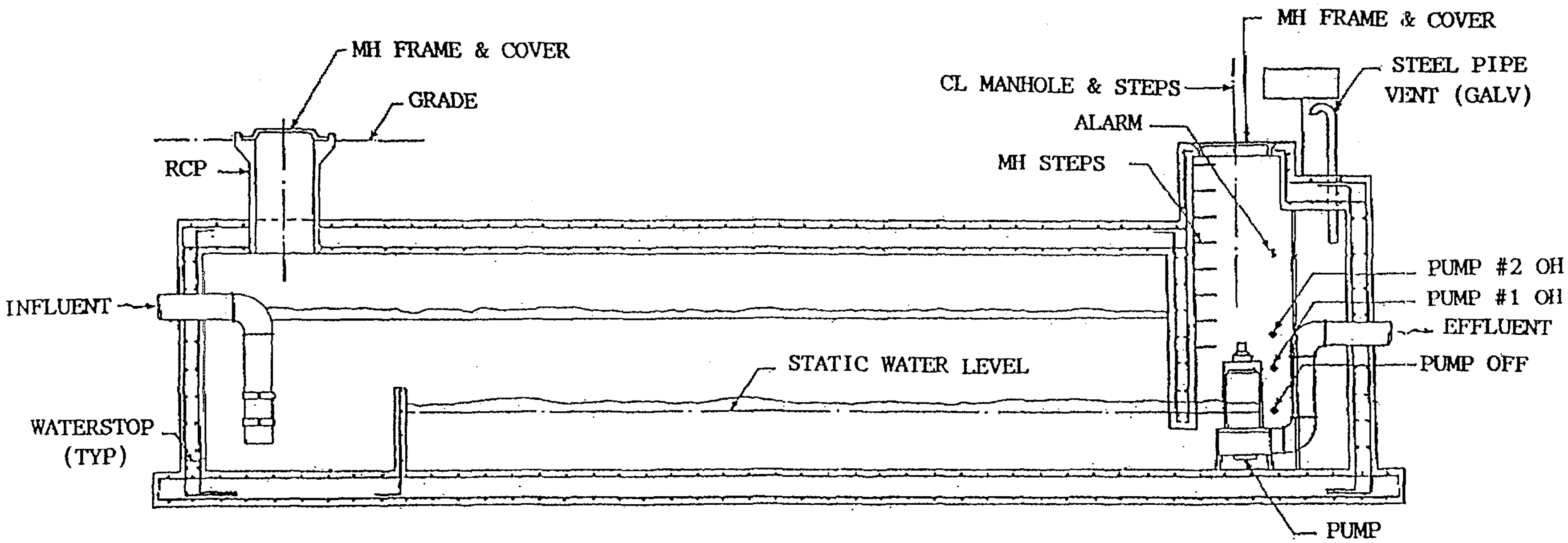


FIGURE 2-13 DIAGRAM OF OILY CONTAMINATED WASTEWATER TREATMENT SYSTEM

housing facilities available in the plant site. The factor of 2 is also adopted by this study for the Wang Noi power plant. Thus, for domestic waste handling, relatively large amount of 1.2 t or 4.0 cu.m./d is employed. For domestic waste disposal, EGAT will cooperate and request the existing Lam Ta Sao sanitary district in Amphoe Wang Noi to dispose of EGAT domestic waste to its solid waste dumping site.

2.6.5.2 Sludge

Two major sources of sludge are water treatment plant and sewage treatment plant. As regards to sludge from water treatment plant, TEAM and PAL (1990) had estimated the sludge amout of about 1.5-2.0 t/d for a 600 MW power plant. Based on such figure, the estimated sludge amout for the 1,800 MW Wang Noi power plant is about 4.5-6.0 t/d. For sludge from sewage treatment plant, the amout cannot be currently estimated because the treatment method is not yet identified. However, the sewage treatment plant is to be designed to accept a hydraulic load of not less than 9,000 l/d and a peak flow of a mininum of 500 l/min.

The sludge from water and sewage treatment plants need to be properly disposed of to prevent sanitation and public health problems. Sanitary landfill method is recommended as an appropriate treatment method. However, the disposal site is not yet identified and assessed by EGAT.

2.7 PROJECT IMPLEMENTATION SCHEDULE

A tentative implementation schedule for the Project is prepared by EGAT as shown in Figure 2-14. The schedule shows only major activities. The Project will be carried out under several contracts. However, the construction schedule of each contract is sequentialled, parallelled and related accordingly. The main items of the schedule are described as follows:-

2.7.1 Engineering and Economic Feasibility Study

The engineering and economic feasibility study of the Project was conducted during July 1993 upto January 1994.

2.7.2 Environmental Impact Assessment

The environmental impact assessment of the Project is carried out from November 1993 until February 1994.

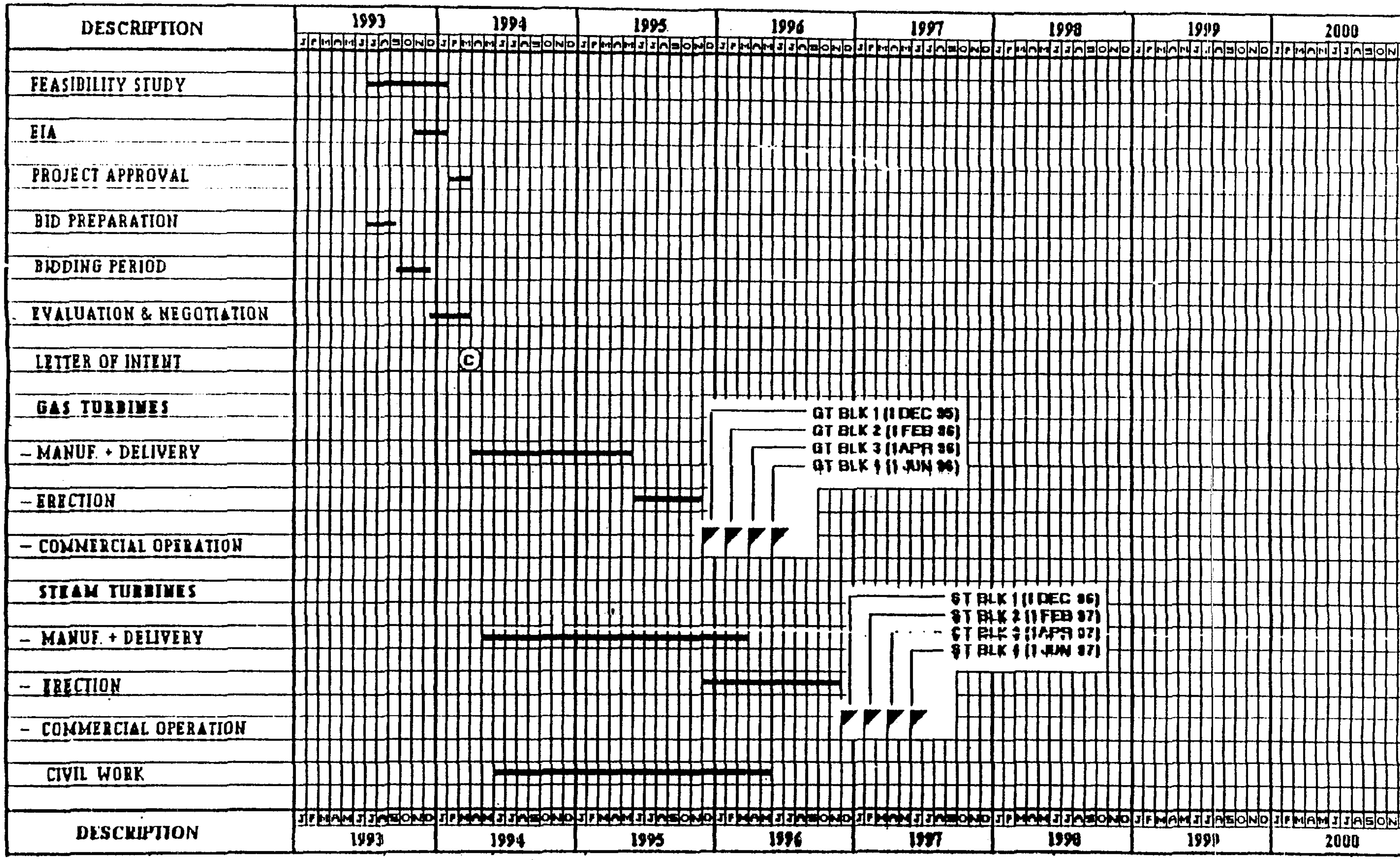


FIGURE 2-14 PROJECT IMPLEMENTATION SCHEDULE

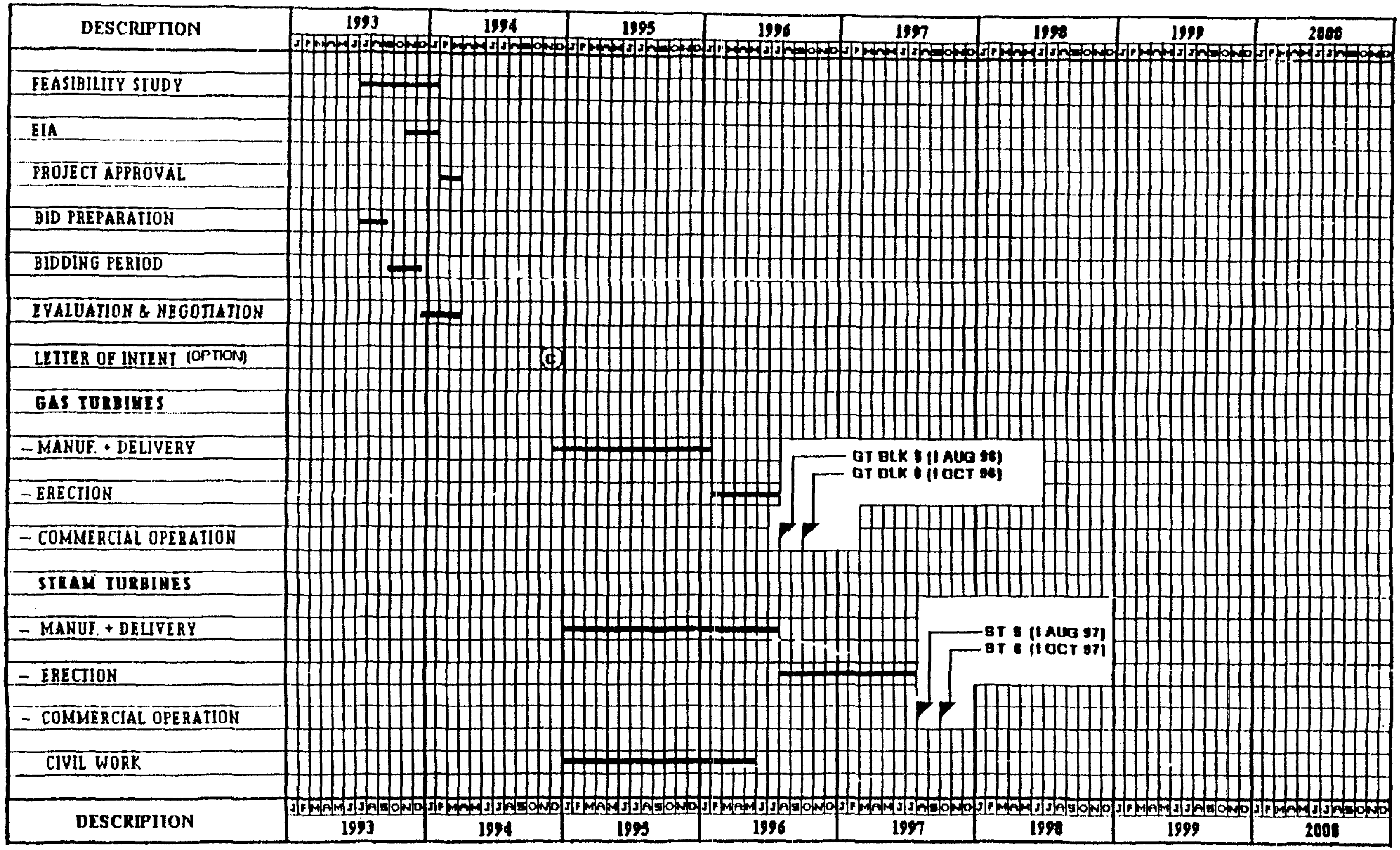


FIGURE 2-14 (CONT'D)

2.7.3 Construction of Combustion Turbines

The construction scheme includes manufacturing and testing at factories and shops, delivery to site and site erection. The construction of combustion turbines block 1-4 and block 5-6 will be made during April 1994 to November 1995 and from December 1994 to July 1996, respectively.

2.7.4 Commercial Operation of Combustion Turbine Generator Units

Commercial operation dates of combustion turbine generator units are planned to be:-

Block 1	December 1, 1995
Block 2	February 1, 1996
Block 3	April 1, 1996
Block 4	June 1, 1996
Block 5	August 1, 1996
Block 6	October 1, 1996

2.7.5 Construction of Steam Turbines

The construction scheme includes manufacturing and testing at factories and shops, delivery to site and site erection. The construction of steam turbines block 1-4 and block 5-6 will be made during May 1994 to November 1996 and from January 1995 to July 1997, respectively.

2.7.6 Commercial Operation of Steam Turbine Generator Units

Commercial operation dates of steam turbine generator units are planned to be:-

Block 1	December 1, 1996
Block 2	February 1, 1997
Block 3	April 1, 1997
Block 4	June 1, 1997
Block 5	August 1, 1997
Block 6	October 1, 1997

2.8 CIVIL WORKS

Civil works include land fill, site facilities and power plant structures. The construction period is from June 1995 to May 1996.

CHAPTER 3

EXISTING ENVIRONMENTAL CONDITIONS

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EXISTING ENVIRONMENTAL CONDITIONS

3.1 INTRODUCTION

The following chapter presents existing conditions of the environmental resources and values significantly available in the project area and directly and indirectly related to the establishment of the Wang Noi Combined Cycle Power Plant. The four major environmental categories according to the NEB guidelines, namely physical resources, ecological resources, human use values and quality of life values are included in this chapter. Each environmental category is further divided into individual environmental components. The presentation however is in the same order of the major environmental categories as just afore-mentioned.

The general study methodologies, sequences of individual studies, study area and priority of significantly environmental resources and values have been described in Chapter 1. However, the study methodologies in details of each individual environmental component are included in this chapter. The detailed activities were carried out according to the logical work plan and work schedule presented in the Inception Report which was already approved by EGAT.

The data and information obtained from various sources including those from the additional field surveys were analyzed, for the existing environmental conditions. For the possible components, past conditions and future trends were also studied. The presentations in this chapter are in the form of tables, graphs, maps and diagrams.

3.2 AIR QUALITY

3.2.1 Meteorology

The study of atmospheric motions and the transporting of air contaminants is important in evaluating the effects of air pollution. Atmospheric residence time for pollutants depends on types of pollutants (gaseous or particulates), their physical properties and the atmospheric conditions. Atmospheric motions determine extent to which the contaminants will be diluted, and dictate the paths followed by air-borne contamination.

Various degrees of air quality deterioration resulting from any power plant may be caused by different air pollutants. In nature there are many natural processes assisting in self-purification of air but the most important one is meteorological conditions of the area on both local and regional scales. Severity of pollutant impacts can be determined from weather parameters such as air temperature, wind speed and direction, cloud cover, insolation and stability conditions.

Climate in Thailand is generally hot with heavy rainfall, therefore it is classified as Tropical Rainy Climate. Subclimates can however be classified for different parts of the country, for example, the southern region including Chantaburi and Trad along the eastern coast has climate of Tropical Rain Forest Type with Monsoon Variety because there are heavy rains throughout the year but rain intensity changes according to seasons of monsoon. However, most parts of Thailand have climate of Tropical Savannah Type, comprising rainy and dry periods.

The Power Plant is located in a hot region on the central part of Thailand. The climate of the central part of Thailand is governed by the two tropical monsoons, i.e., the southwest and the northeast. The southwest monsoon prevails over the area during February to September, while the northeast monsoon prevails during October to January.

The rainy season usually starts following the outbreak of the southwest monsoon in May, when frontal systems pass the country towards the northern hemisphere. In October the frontal systems begin to move southwards, when the sun moves southwards towards the southern hemisphere. The relatively dry and cold season begins in November following the onset of the northeast monsoon. The cold air from Mainland China penetrates south as far as the northern Gulf of Thailand. The central area does not experience much cold weather and is characterized by slightly seasonal temperature variation.

To describe the climate of the project area and the surrounding area, Don Muang Airport weather station was selected. Climatological data for a 30-year period (1961-1990) recorded at this station are shown in Table 3.2-1.

(a) Atmospheric Pressure

The meteorological station is located at about the sea level so that the mean pressure is about 1,009.45 mbs with slightly diurnal or seasonal change, mean daily variation being about 4.50 mbs. Monthly means range from 1,006.6 to 1,012.7 mbs. Mean pressure, maximum pressure and minimum pressure are shown graphically in Figure 3.2-1.

(b) Air Temperature

Mean air temperature at Don Muang Airport is about 27.9 °C. The temperature is almost uniform throughout the year, with monthly means between 25.5 °C and 29.7 °C. Mean, mean maximum and mean minimum temperatures are shown graphically in Figure 3.2.-2. Diurnal variation between day and night is not significant.

TABLE 3.2-1 CLIMATOLOGICAL DATA FOR THE PERIOD 1961 - 1990

Station	DON MUANG AIRPORT	Elevation of station above MSL	4	meters
Index Station	48456	Height of barometer above MSL	12	meters
Latitude	13° 55' N	Height of thermometer above ground	8.75	meters
Longitude	100° 36' E	Height of wind vane above ground	5.00	meters
		Height of raingauge	2.00	meters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pressure (mbs.)													
Mean	1012.67	1011.28	1010.17	1008.61	1007.14	1006.64	1006.79	1006.86	1008.05	1010.06	1011.93	1013.20	1009.45
Ext. Max.	1023.71	1021.33	1022.69	1018.60	1014.20	1013.20	1015.90	1013.88	1015.24	1018.29	1021.00	1023.37	1023.71
Ext. Min.	1004.40	1002.37	1002.03	1000.00	999.66	998.30	998.60	999.32	999.00	1001.36	1004.70	1003.70	998.30
Mean daily range	4.97	5.01	5.02	4.94	4.49	3.84	3.79	3.98	4.45	4.51	4.37	4.66	4.50
Temperature (°C)													
Mean	25.9	27.4	28.7	29.7	29.1	28.8	28.4	28.3	27.9	27.9	27.1	25.5	27.9
Mean Max.	31.7	32.9	34.1	35.1	34.1	33.1	32.8	32.5	32.1	31.6	31.1	30.7	32.7
Mean Min.	20.7	22.6	24.1	25.4	25.5	25.5	25.1	25.1	24.9	24.9	23.6	20.8	24.0
Ext. Max.	35.7	37.4	40.0	39.9	40.8	38.1	37.0	37.2	37.1	35.7	35.6	34.9	40.8
Ext. Min.	11.7	16.0	14.9	19.6	20.0	21.2	21.9	19.0	21.2	20.6	15.0	10.0	10.0
Relative Humidity (%)													
Mean	68.0	72.0	72.0	73.0	76.0	75.0	76.0	76.0	79.0	78.0	74.0	69.0	74.0
Mean Max.	89.0	92.0	91.0	91.0	91.0	90.0	90.0	90.0	92.0	91.0	88.0	87.0	90.0
Mean Min.	45.0	48.0	49.0	51.0	56.0	57.0	58.0	60.0	62.0	62.0	57.0	50.0	55.0
Ext. Min.	20.0	20.0	20.0	23.0	30.0	30.0	38.0	40.0	38.0	28.0	25.0	26.0	20.0
Dew Point (°C)													
Mean	18.9	21.2	22.6	23.7	24.0	23.5	23.3	23.4	23.6	23.3	21.4	19.0	22.3
Evaporation (mm.)													
Mean – Pan	–	–	–	–	–	–	–	–	–	–	–	–	–
Cloudiness (0–10)													
Mean	5.1	5.6	5.9	6.7	7.9	8.4	8.5	8.8	8.6	7.7	6.3	5.2	7.1
Sunshine Duration (hr.)													
Mean						NO OBSERVATION							
Visibility (km.)													
0700 L.S.T.	5.2	4.5	5.8	8.2	11.0	11.3	11.4	11.3	11.3	11.1	10.6	8.4	9.2
Mean	9.3	8.6	9.1	10.4	12.5	12.8	12.9	12.7	12.7	13.0	12.9	11.8	11.6
Wind (knots)													
Mean wind speed	4.1	5.5	6.2	6.2	5.5	5.6	5.5	5.5	4.4	4.0	4.1	4.0	–
Prevailing wind	E	S	S	S	S	S,SW	SW	SW	S,SW	N	N	N	–
Max. wind speed	34.0	45.0	45.0	50.0	45.0	44.0	43.0	43.0	47.0	35.0	30.0	19.0	50.0
Rainfall (mm.)													
Mean	9.0	18.8	26.1	61.8	162.5	136.4	143.8	184.1	266.9	182.6	36.4	15.8	1244.2
Mean rainy days	1.1	1.9	2.2	5.9	14.3	13.8	16.1	17.9	19.5	14.3	5.3	1.4	113.7
Greatest in 24 hr.	34.3	48.4	58.1	106.2	122.2	67.0	74.1	117.5	148.4	207.7	53.8	48.8	207.7
Number of days with													
Haze	21.4	19.0	20.2	14.2	2.8	0.8	1.1	0.9	1.5	2.3	4.6	13.3	102.1
Fog	5.1	3.2	0.8	0.2	0.1	0.1	0.0	0.0	0.0	0.2	0.2	1.5	11.4
Hail	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thunderstorm	0.3	1.0	2.0	7.9	13.6	9.1	10.2	9.7	13.2	10.6	2.1	0.4	80.1
Squall	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2

SOURCE : METEOROLOGICAL DEPARTMENT

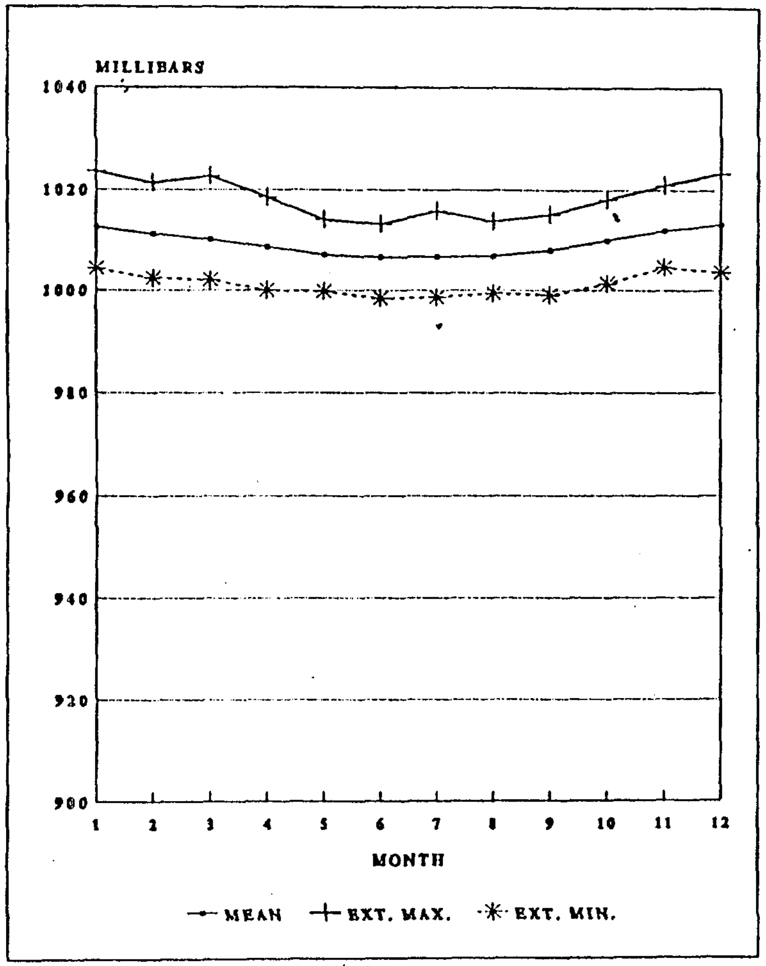


FIGURE 3.2-1 ATMOSPHERIC PRESSURE AT DON MUANG AIRPORT 30-YEAR PERIOD(1961-1990)

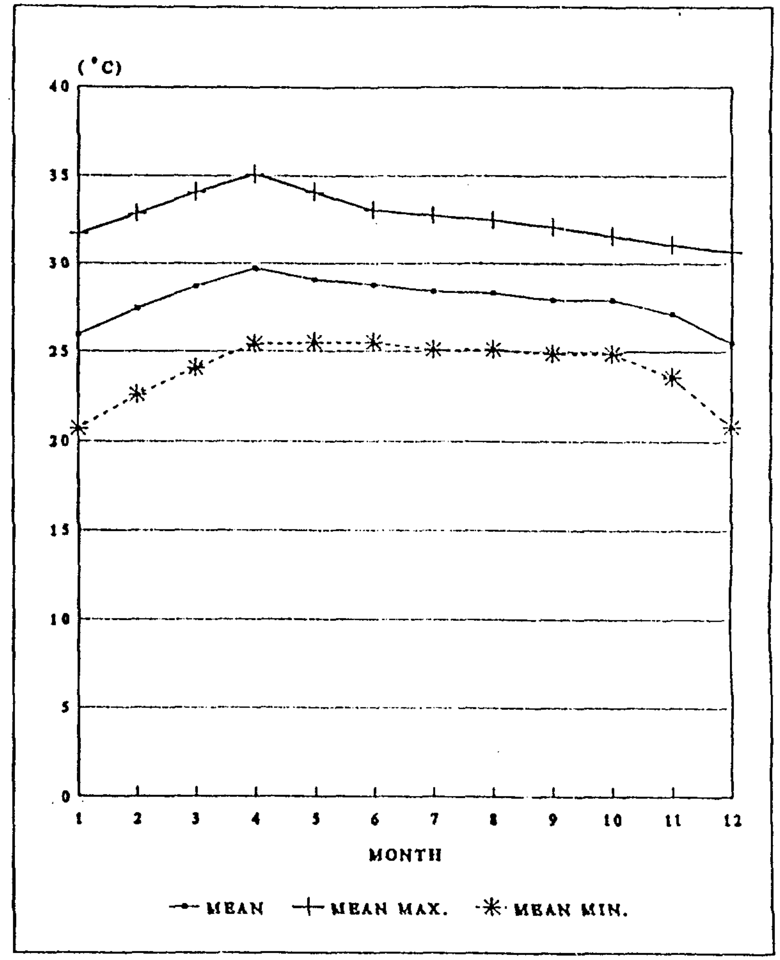


FIGURE 3.2-2 ATMOSPHERIC TEMPERATURE AT DON MUANG AIRPORT 30-YEAR PERIOD(1961-1990)

(c) Relative Humidity

The area is characterized by year-round high humidity around 74.0 percent. Humidity is highest with a monthly mean reaching 92.0 percent in rainy season and lowest with a monthly mean dropping to 45.0 percent in dry season. Mean, mean maximum and mean minimum relative humidity are shown graphically in Figure 3.2-3.

(d) Precipitation

The area receives abundant rainfall during the monsoon season. Total rainfall during 6-month period from May to October contributes about 85 percent of the annual rainfall which equals 1,244.2 mm. The mean and greatest rainfall in 24 h at Don Muang are shown graphically in Figure 3.2-4.

(e) Wind

Wind roses compiled by the Meteorological Department for a 30-year period (1951-1980) for the station is shown in Figure 3.2-5. Wind directions generally follow the monsoon pattern described previously. Wind recorded at Don Muang prevails from south or south-west for the months of February through September and from northeast or north during October through January. Calm conditions occur at about 6 to 16 percent in each month. Frequency occurrence of wind direction grouped in various wind speed intervals at Don Muang in 1992 is shown in Table 3.2-2 and is shown graphically in Figure 3.2-6.

(f) Stability Classes

Stability classes at Don Muang Station during the period of 5 years (1988-1992) were analyzed. The results are shown in Table 3.2-3. The most frequent stability class was found to be class D, which could occur during the day and nighttime. During the nighttime the most frequent stability class was found to be class F. Class A was found to occur with a small percentage. Percentage of stability classes at Don Muang in 1992 are shown in Figure 3.2-7. Similar results for 5-year data were obtained at this station.

3.2.2 Existing Air Quality

The area of the project site and the vicinity are plain areas clustered by various communities including temple and school in each community. Therefore, in this study, temple, school and house are representatives for air quality measurement. Six air quality measurement stations (Figure 3.2-8) are determined as follows:-

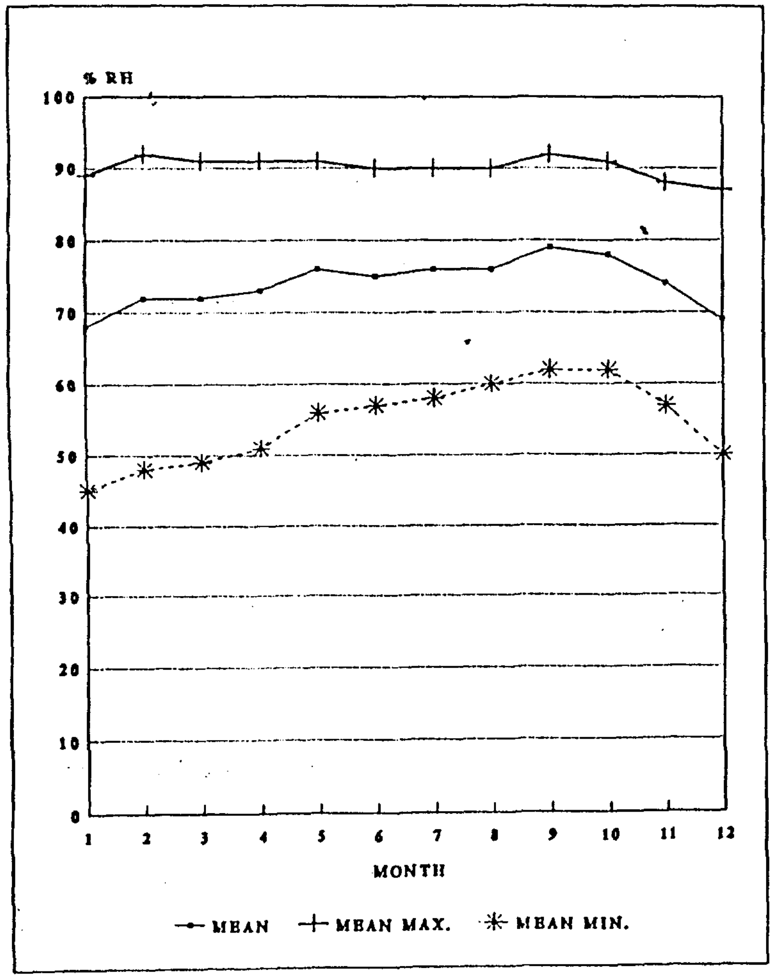


FIGURE 3.2-3 RELATIVE HUMIDITY AT DON MUANG AIRPORT 30-YEAR PERIOD(1961-1990)

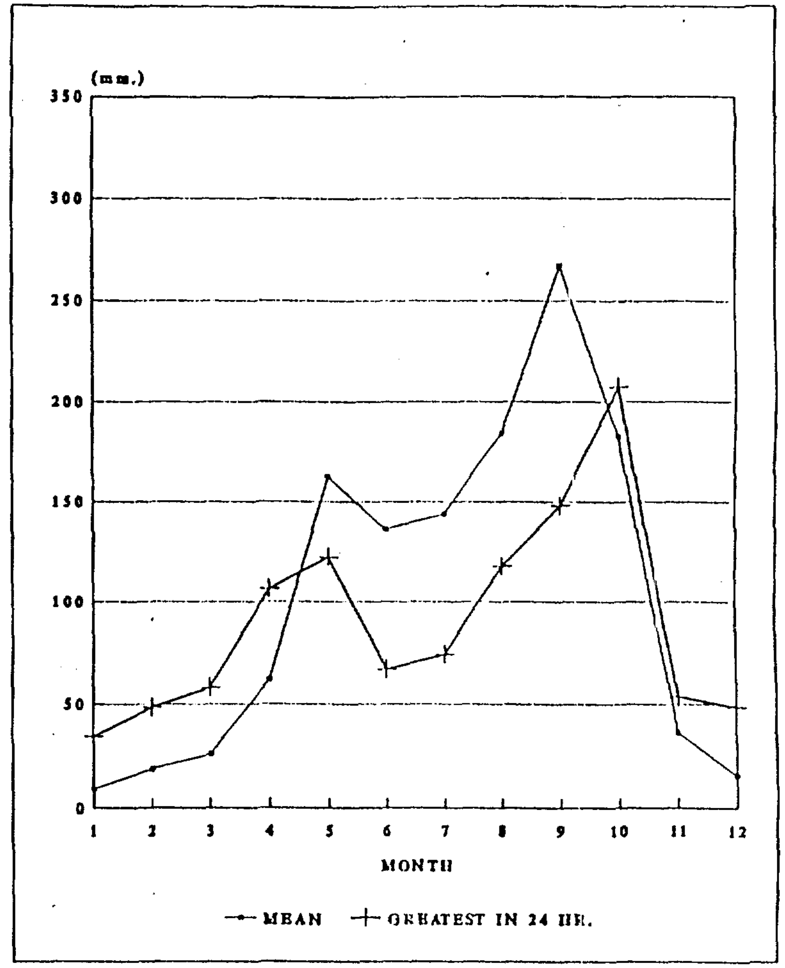
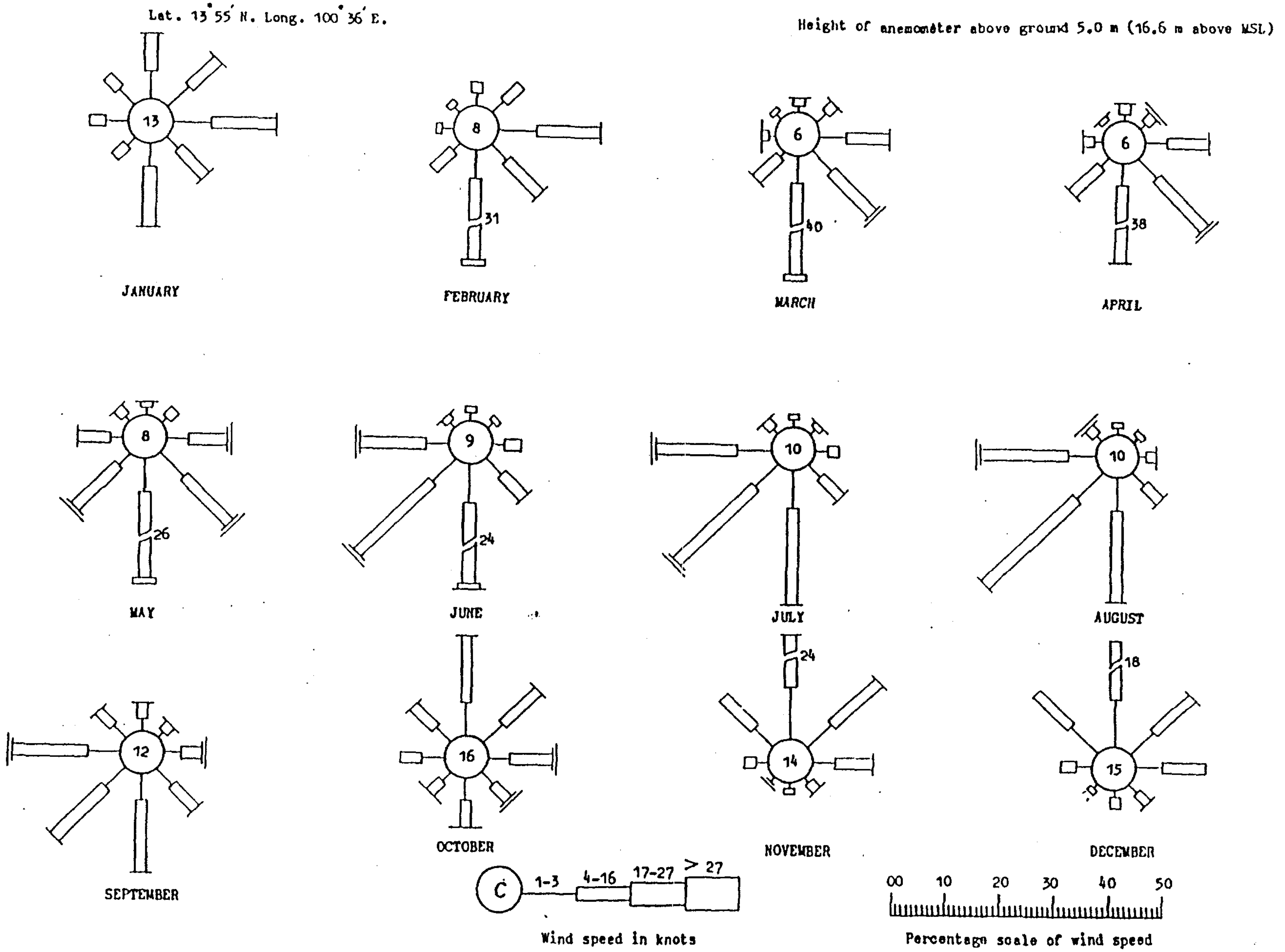


FIGURE 3.2-4 RAINFALL AT DON MUANG AIRPORT 30-YEAR PERIOD(1961-1990)



SOURCE : METEOROLOGICAL DEPARTMENT

TABLE 3.2-2 FREQUENCY OF OCCURRENCE OF WIND DIRECTION GROUPED IN VARIOUS WIND SPEED INTERVALS

STATION : DON MUANG, 1992

DIRECTION:SPEED	0-1	1-2	2-3	3-4	4-6	OVER 6	TOTAL
N	.0120	.0161	.0137	.0068	.0047	.0008	.0540
NNE	.0069	.0077	.0051	.0030	.0010	.0002	.0240
NE	.0085	.0080	.0022	.0005	.0003	.0000	.0195
ENE	.0080	.0056	.0020	.0003	.0003	.0001	.0164
E	.0108	.0092	.0058	.0026	.0024	.0002	.0311
ESE	.0124	.0133	.0063	.0018	.0009	.0001	.0348
SE	.0109	.0164	.0072	.0025	.0018	.0001	.0389
SSE	.0077	.0154	.0096	.0048	.0034	.0007	.0416
S	.0132	.0222	.0331	.0396	.0690	.0221	.1992
SSW	.0090	.0184	.0198	.0224	.0396	.0166	.1259
SW	.0046	.0096	.0110	.0109	.0180	.0052	.0593
WSW	.0038	.0100	.0229	.0191	.0137	.0039	.0733
W	.0064	.0174	.0170	.0196	.0219	.0055	.0877
WNW	.0084	.0098	.0064	.0026	.0030	.0006	.0307
NW	.0075	.0110	.0044	.0023	.0006	.0001	.0260
NNW	.0106	.0153	.0074	.0019	.0010	.0003	.0365
CALM	.1011						

NO. OF DATA OF CALM = 888

NO. OF TOTAL DATA = 8784

Source : SECOT, Met. Data from Meteorological Department analyzed by METPRO - PROGRAM

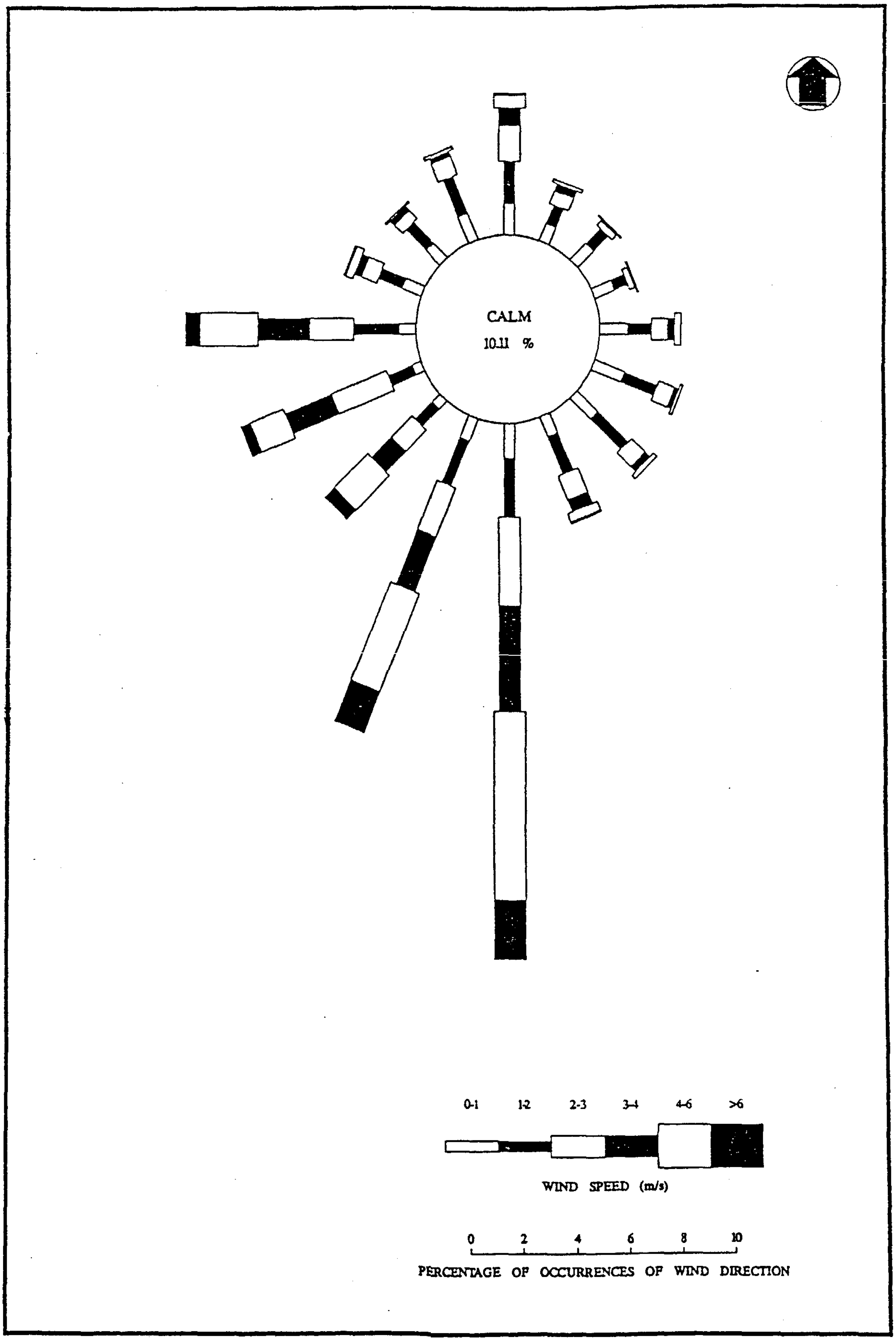


FIGURE 3.2-6 WIND ROSE AT DON MUANG STATION IN 1992

TABLE 3.2-3

COMPARISON OF PARCENTAGE OF STABILITY CLASS

AT DON MUANG AIRPORT DURING 1988 – 1992

Pasquill Categories		Percent Occurrence of Stability Class				
		1988	1989	1990	1991	1992
A	(Extremely Unstable)	0.52	0.30	0.24	0.42	1.97
B	(Moderately Unstable)	11.46	12.54	9.95	7.08	11.45
C	(Slightly Unstable)	16.69	16.03	15.08	13.19	15.80
D	(Neutral)	31.40	29.43	36.45	50.92	27.82
E	(Slightly Stable)	17.46	17.85	17.02	14.36	17.85
F	(Moderately Stable)	22.53	24.07	21.01	13.98	25.03

Source : SECOT, Met. Data from meteorological Department Analyzed by METPRO–Program

F:T32-3.WK1/37-B-0084

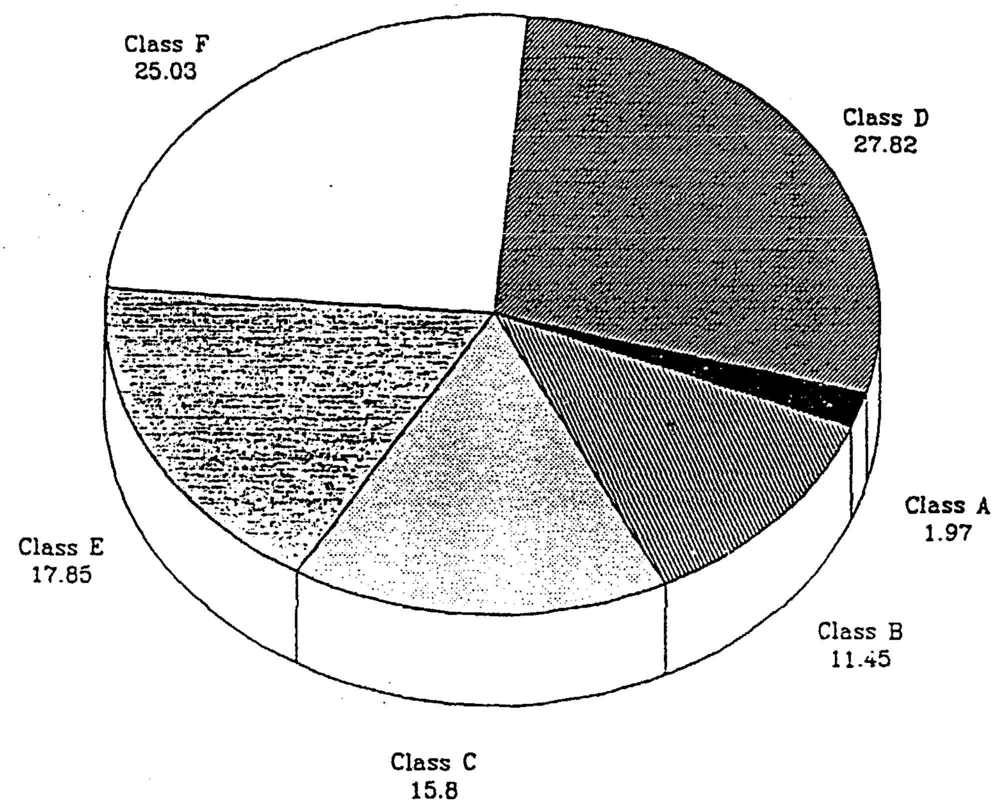


FIGURE 3.2-7 PERCENTAGE OF ATMOSPHERIC STABILITY CLASS AT DON MUANG AIRPORT IN 1992

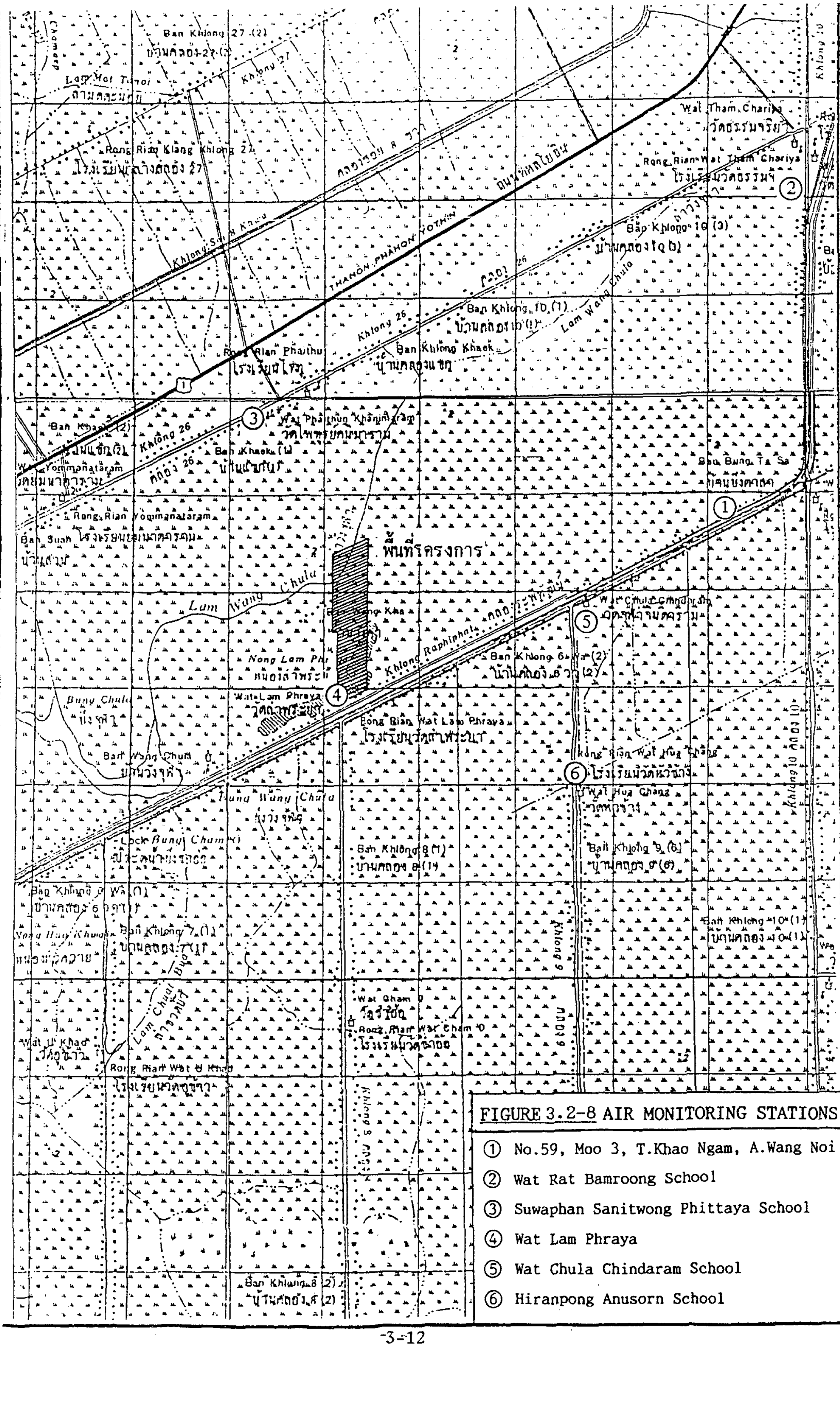


FIGURE 3.2-8 AIR MONITORING STATIONS

① No.59, Moo 3, T.Khao Ngam, A.Wang Noi

② Wat Rat Bamroong School

③ Suwaphan Sanitwong Phittaya School

④ Wat Lam Phraya

⑤ Wat Chula Chindaram School

⑥ Hiranpong Anusorn School

1. Moo 3, T.Khao Ngam, A. Wang Noi

2. Wat Rat Bamroong School

3. Suwaphan Sanitwong Phittaya School

4. Wat Lam Phraya

5. Wat Chula Chindaram School

6. Hiranpong Anusorn School

These communities are within the radius of 5-6 km from the project site.

In the light of air pollutants in this study, sulphur dioxide, nitrogen dioxide and total suspended particulates are the pollutants related to the Project, especially, sulphur dioxide and nitrogen dioxide.

The air quality measurement was conducted during 23-28 December 1993 by collecting air samples for three consecutive days. The sampling and analytical methods of air samples for each pollutant are shown in Table 3.2-4. The results of air sampling and analysis are shown in Table 3.2-5 which can be concluded as follows :-

Sulphur dioxide

From the measurement of sulphur dioxide from six stations around the project site during 23-28 December 1993, the concentrations are only non-detectable to 0.001 mg/cu.m. because there is seemingly no industry that emits sulphur dioxide.

Nitrogen dioxide

According to the results of nitrogen dioxide concentration from six stations around the project site, it is found that the range of concentrations is 0.042-0.101 mg/cu.m. which most of the concentrations are quite similar. At Suwaphan Sanitwong Phittaya School, the average concentration is higher than that of any other areas. That might be because the location of such a school is not far from Phahonyothin Road where emission of pollutants from the exhausts of vehicles exists.

TABLE 3.2–4
SAMPLING AND ANALYTICAL METHOD OF AMBIENT AIR QUALITY

Pollutants	Sampling Method	Analytical Method
TSP	Hi–Volume air sampler	Pre–post weight difference
SO_2	Impinger Absorption	Pararosaniline
NO_2	Impinger Absorption	Sodium arsenite

Remark : The result of NO_2 was multiplied by a factor for maximum value of one hour in order to be able to compare with the National Environment Board Standard.

TABLE 3.2-5

AMBIENT AIR QUALITY IN PROJECT AREA

Sampling Site	Sulphur Dioxide (mg/m^3)			Nitrogen Dioxide (mg/m^3)			Total Suspended Particulates (mg/m^3)		
	Dec. 23	Dec. 24	Dec. 25	Dec. 23	Dec. 24	Dec. 25	Dec. 23	Dec. 24	Dec. 25
1. No. 59, Moo 3, T. Khao Ngam, A. Wang Noi	N.D.	N.D.	N.D.	0.078	0.042	0.093	0.218	0.262	0.224
2. Wat Rat Bamroong School	0.001	N.D.	N.D.	0.062	0.053	0.101	0.189	0.198	0.196
3. Suwaphan Sanitwong Phittaya School	0.001	N.D.	N.D.	0.098	0.080	0.095	0.220	0.167	0.185
	Dec. 26	Dec. 27	Dec. 28	Dec. 26	Dec. 27	Dec. 28	Dec. 26	Dec. 27	Dec. 28
4. Wat Lam Phraya	N.D.	N.D.	N.D.	0.043	0.071	0.057	0.330	0.244	0.241
5. Wat Chula Chindaram School	N.D.	N.D.	N.D.	0.063	0.078	0.079	0.343	0.410	0.501
6. Hiranpong Anusorn School	N.D.	0.001	N.D.	0.059	0.057	0.058	0.222	0.296	0.337
Ambient Air Quality Standard	0.003 (24 - h)			0.320 (1 - h)			0.330 (24 - h)		

TSP

The concentrations of total suspended particulates from six stations are relatively high in some areas, that is, in the range of 0.167-0.501 mg/cu.m. The reasons might be because of dry weather in winter and most of the study areas consist of gravel roads that contribute to great dispersion of total suspended particulates. In addition, during the course of air sampling, the irrigation road along Khlong Raphiphat was under rehabilitation. From this measurement, 4 out of 18 samples of TSP exceeds MOSTE standard. It can be concluded that the existing concentrations of TSP in the vicinity of the project site is already high.

3.3 NOISE

The Power Plant , in general, might affect the noise level around the project site because of the noise caused by the machinery. In case of the big project site in which the machinery are used, it might affect noise level around the project site as well. Therefore, the study of noise impact to the community of the project site is necessary.

The noise impact to the community depends on the differences of the noise level in the community before and after the project completion. The study of noise impact, therefore, should start with the monitoring of noise levels in the existing condition of the community before project construction as a comparative data with those obtained during periods of project construction and operation.

3.3.1 Instrument and Noise Measurement Method

Noise measurement was conducted in the community around the project site by the instrument and measurement as follows:-

1. Instrument

Rion Integrating Sound Level Meter Model NL-10A capable of detecting noise levels in the range of 30-130 dBA at the frequencies of 20-12,500 Hz was used.

2. Noise Measurement

Noise measurement was conducted to comply with International Standard Organization (ISO) at the height of 1.5 m from the ground level in the spacious area in order to avoid the noise reflection from any construction sites. Noise measurement was conducted hourly through 24 hours for calculation of Leq (24) and noise level during day-night (Ldn) as per the following equations:-

$$Leq\ (24) = 10 \log \frac{1}{24} \left[\sum_{i=1}^{24} 10^{Li/10} \right]$$

$$Ldn = 10 \log \frac{1}{24} \left[(15 \times 10^{Ld/10}) + (9 \times 10^{(Ln+10)/10}) \right]$$

Li = Equivalent Noise Level for i^{th} hour

Ld = Equivalent Noise Level at day during 7 a.m. - 10 p.m.

Ln = Equivalent Noise Level at night during 10 p.m. - 7 a.m.

3.3.2 Monitoring Period

Noise measurement of the project was conducted during December 23-28, 1993.

3.3.3 Monitoring Sites

Six monitoring sites of noise measurement (Figure 3.3-1) were selected from the community around the project site and the intake pump station as follows:

1. Ban Bang Sai

In fact, the monitoring site represented area of the intake pump station which is located at Ban Bang Len. Unfortunately, during the study period, the area of intake pump station was under construction. Such condition might affect actual noise levels from the community activities. Therefore, Ban Bang Sai community with similar environment was selected for noise monitoring instead of Ban Bang Len.

2. Moo 3, T. Khao Ngam, A. Wang Noi

This area is sparsely populated at the distance of 4 km northeast to the Power Plant.

3. Suwaphan Sanitwong Phittaya School

It is sparsely populated area which is located about 3 km north to the project site and about 0.5 km away from Phahonyothin Road.

4. Wat Lam Phraya

This site is attached to the project site in the southern direction.

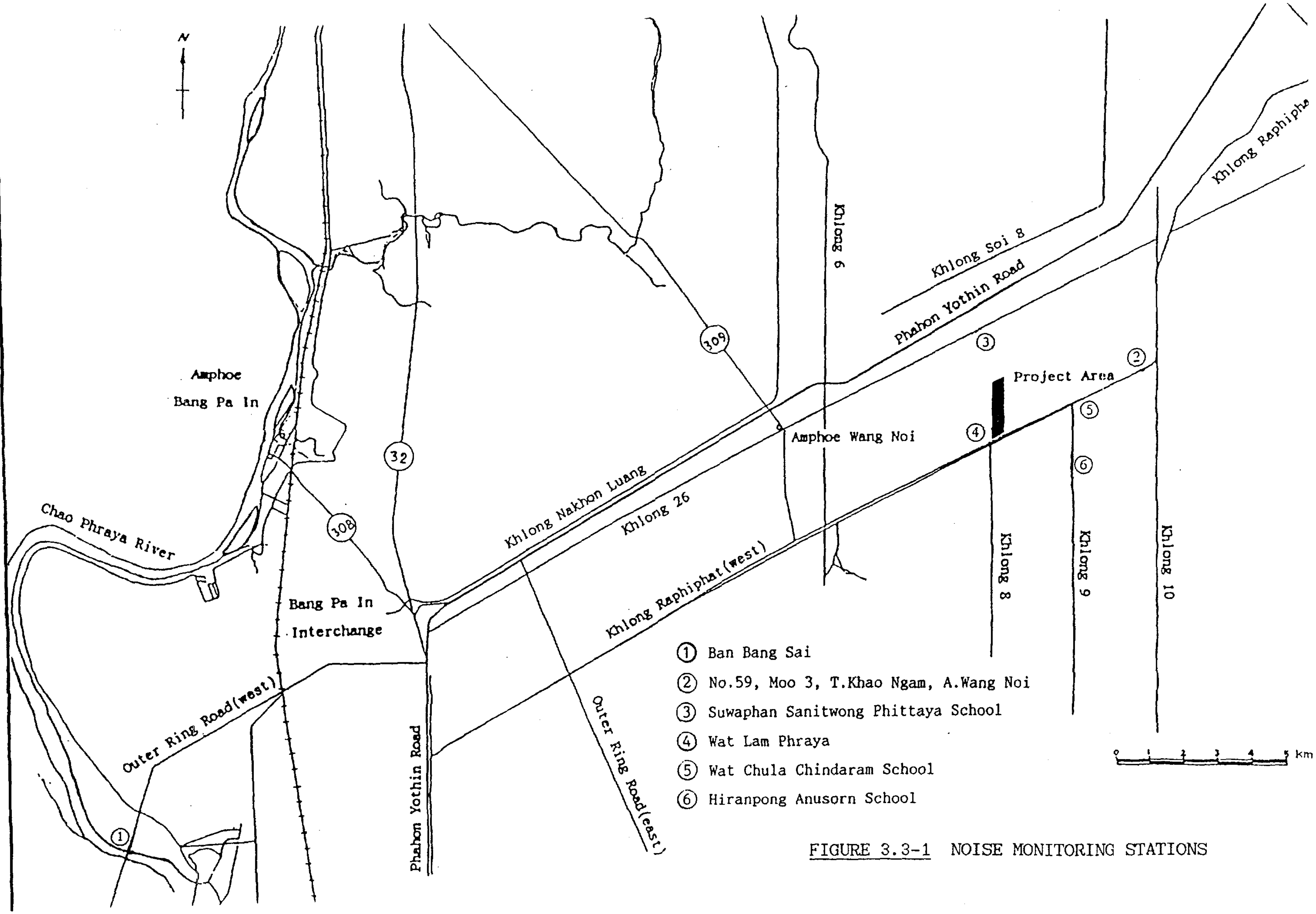


FIGURE 3.3-1 NOISE MONITORING STATIONS

5. Wat Chula Chindaram School

It is located about 2.5 km in the eastern direction of the project site.

6. Hiranpong Anusorn School

It is located about 2.5 km southeast to the project site.

3.3.4 Result

The result of noise level monitoring is shown in Table 3.3-1 and Figure 3.3-2. At the intake pump station at Ban Bang Len which was represented by Ban Bang Sai community, Leq (24) and Ldn were 61.6 and 65.2 dBA, respectively.

For the surrounding areas of the project site, Leq (24) and Ldn were found in the range of 55.4-60.8 and 59.6-68.1 dBA, respectively. The maximum noise level was detected at Suwaphan Sanitwong Phittaya School. The important reason is because the monitoring site at Suwaphan Sanitwong Phittaya School is near Phahonyothin Road. Hence, the noise from the traffic might increase more noise levels than any other monitoring sites.

From the noise measurement around the project site which was residential community as mentioned above, it could be said that the existing noise levels in those areas were in the range of 55-60 dBA. Compared with community noise standard of US.EPA. (70 dBA), Leq (24) from all monitoring sites were well below the standard.

3.4 SURFACE WATER HYDROLOGY

3.4.1 Introduction

The surface water hydrology is one of the first priority environmental components when considered together with the water resources management aspect. The Power Plant is planned to use water supply from the Chao Phraya River at Amphoe Bang Sai, Ayudhaya Province which is diverted from the Chao Phraya Dam at Chainat Province and Rama VI dam from Pasak River at Ayudhaya Province. The proposed water supply have planned to use for several purposes, e.g.; cooling system, boiler feed and domestic uses. Due to the multipurpose water demand for several activities e.g., for irrigation project, water supply project, transportation and for seawater intrustion protection. Therefore, the detailed analysis of water hydrology of Chao Phraya River is necessary to obtain a clear picture of water budget available for downstream developments including the Power Plant.

TABLE 3.3-1
NOISE LEVEL IN PROJECT AREA

Sampling Site	Date	Leq 24 (dB A)	Ldn (dB A)
Ban Bang Sai	Dec. 23, 93	61.6	65.2
No.59, Moo 3, T. Khao Ngam, A. Wang Noi	Dec. 24, 93	56.8	61.5
Suwaphan Sanitwong Phittaya School	Dec. 25, 93	60.8	68.1
Wat Lam Phraya	Dec. 26, 93	59.9	64.5
Wat Chula Chindaram School	Dec. 27, 93	59.3	60.7
Hiranpong Anusorn School	Dec. 28, 93	55.4	59.1

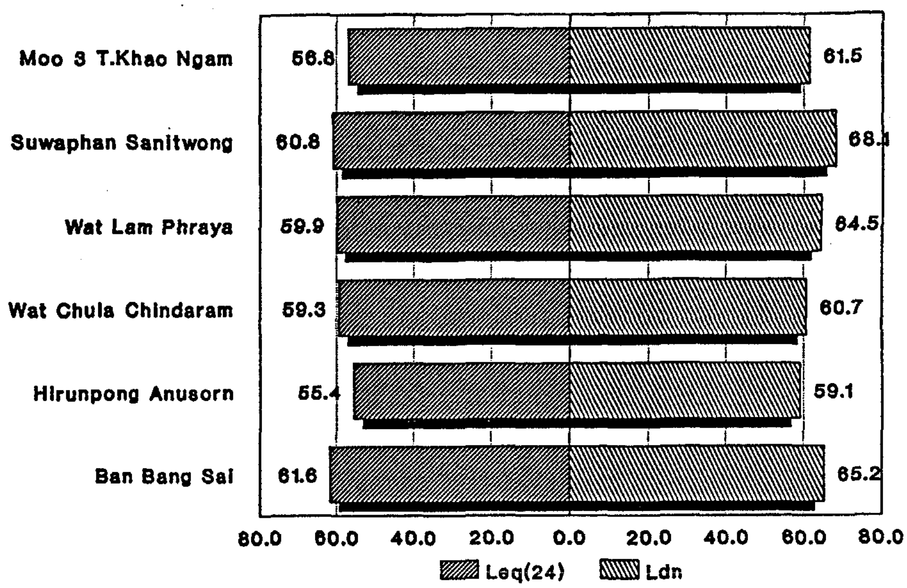


FIGURE 3.3-2 NOISE LEVEL IN STUDY AREA

3.4.2 Objective and Study Methodology

The objective of surface water hydrology aspect is to study the existing potential of surface water in and nearby the project area which are Chao Phraya River and Pasak River. The study of surface water hydrology will also consider Khlong Raphiphat, which is planned to be a water source for the Power Plant during both construction and operation periods.

The study methodology includes collection of stream flow record/data and field investigation.

3.4.3 Existing Surface Hydrology

3.4.3.1 Chao Phraya Basin

The Chao Phraya Basin is the largest basin in Thailand with the total catchment area of 178,000 sq.km. or approximately 38% of the country. Chao Phraya River originates from four rivers in the northern mountainous area, namely, Ping, Wang, Yom and Nan. The Ping joins the Wang at Tak and then merges with the other two rivers in Nakhon Sawan to form Chao Phraya River before flowing through the fertile central plain and finally joins the Gulf of Thailand at Samutprakarn. While flowing through the central plain, Chao Phraya River is divided into 3 rivers, namely, Suphanburi (or Tha Chin), Noi and Lopburi. Suphanburi River flows westwards from Chao Phraya River towards the Gulf of Thailand at Samutsakhon. While Noi river joins Chao Phraya River again at Amphoe Bang Sai, Ayudhaya Province and Lopburi River southeasterly departs Chao Phraya River at Singburi and joins Pasak River which later joins Chao Phraya River at Ayudhaya (Figure 3.4-1).

3.4.3.2 Water Resources Development in Chao Phraya Basin

Many small and large water resources development projects in the Chao Phraya Basin are to serve the irrigation and electricity production. These schemes change the hydrological pattern of many rivers in the Chao Phraya and lower Tha Chin Basins while flowing through the project area. Four major water resources development projects in the basin are:-

1) Bhumibol Dam Project

The Bhumibol Dam is a large scale dam constructed across the Ping River in the north of Tak. The construction phase was during 1957 to 1963. The dam creates a large reservoir with a storage capacity of 13,462 MCM and a surface area of 318 sq. km. The dam lies on the Ping river north to Amphoe Doi Tao in Chiang Mai with a total distance of 207 km from the dam. The dam can control the amount of water released from the catchment area of 26,400 sq. km. which equals to the runoff to the reservoir of about 6,580 MCM or 46% of the reservoir capacity. The water released from Bhumibol Dam can produce electricity, as well as serving the irrigation area of many provinces in the Chao Phraya Basin.

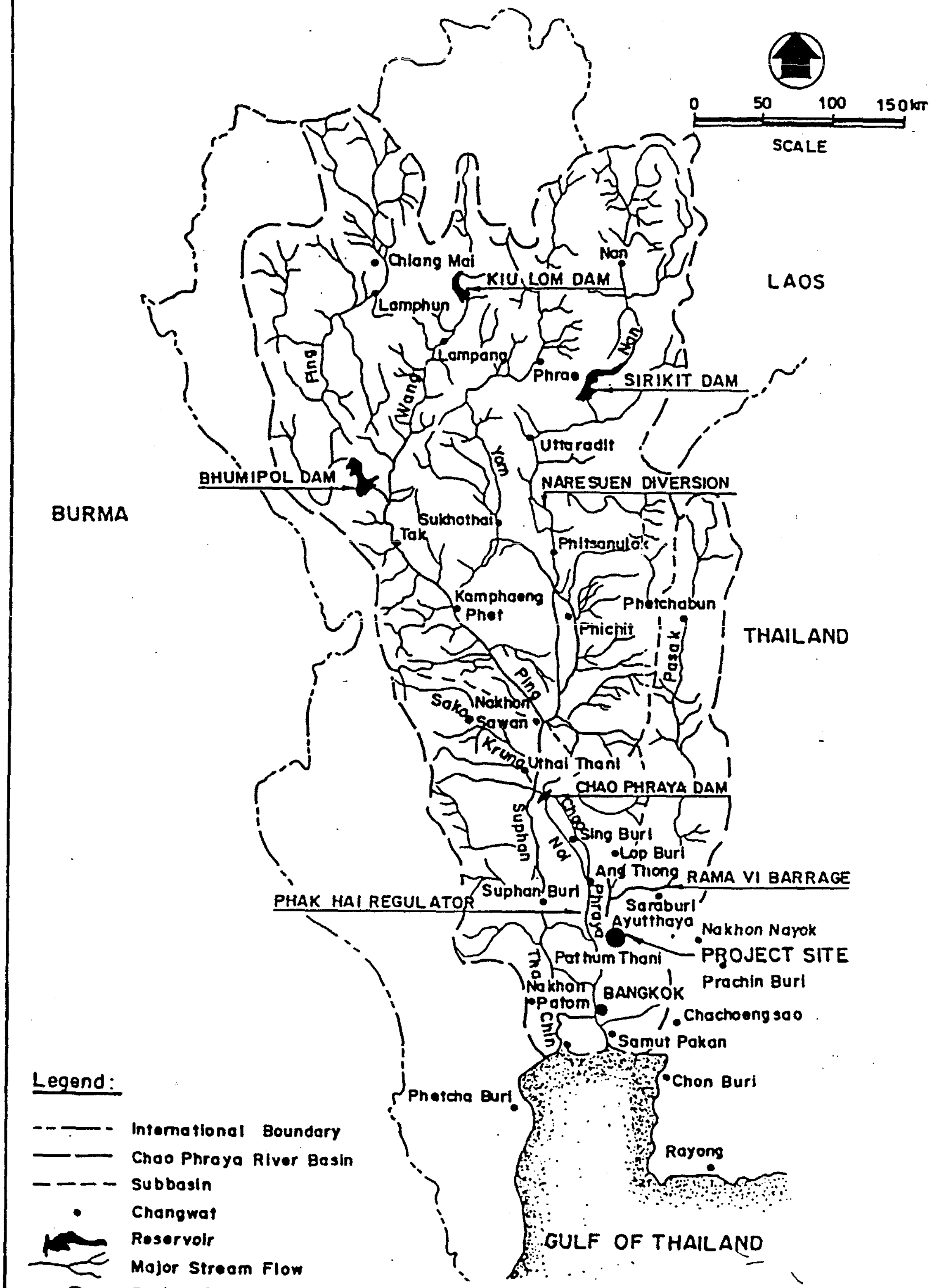


FIGURE 3.4-1 CHAO PHRAYA RIVER BASIN

2) Sirikit Dam Project

This is another large multipurpose earth dam constructed across the Nan River at Amphoe Tha Chin Pla, 58 km. towards the east of Uttraradit town. The construction phase was during 1967 to 1972. The dam creates a large reservoir with a storage capacity of 9,550 MCM and a surface area of 260 sq. km. The average annual runoff flows into the reservoir is about 5,973 MCM/year or 63% of the reservoir capacity. Apart from electricity generation the water released from the dam is also diverted to the irrigation area in the Nan and Chao Phraya Basins.

3) Great Chao Phraya Project

This project is composed of Chao Phraya Diversion Dam at Chainat. The dam was finished in 1957 while the irrigation canals on both sides of Chao Phraya River were finished in 1960. The project can serve both irrigation and flood protection purposes.

3.4.3.3 Chao Phraya Irrigation Project

The Chao Phraya River Basin Irrigation Project is an irrigation project after the completion of Chao Phraya Dam on Chao Phraya River at Chainat. The Chao Phraya Dam diverts water for irrigation areas on both the east bank and the west bank. The major purpose of the main irrigation canal for the west bank is to divert water from two natural canals, Mae Nam Suphan and Mae Nam Noi. In East bank, Khlong Chainat-Pasak which is 120 km long was constructed to divert water from Rama VI Dam on Pasak River to irrigation areas (Figure 3.4-2).

The Chao Phraya Irrigation Project is divided into 25 sub projects which can be classified into two main projects as follows:-

- Upper Chao Phraya Irrigation Project
- Lower Chao Phraya Irrigation Project

1) Upper Chao Phraya Irrigation Project

The Upper Chao Phraya Irrigation Project was planned to divert water to irrigation areas by both gravity flow and pumping. The project is composed of many sub projects e.g. Phonlathep, Maharaj, Manorom, Don Chedi, Phophraya, Barommathat, Chanasutr, Yangmanee, Thabote, Samchook, Chong Khae, Koke Kathiem and Rerng Rang. The total area of the whole project is approximately 3.75 million rai.

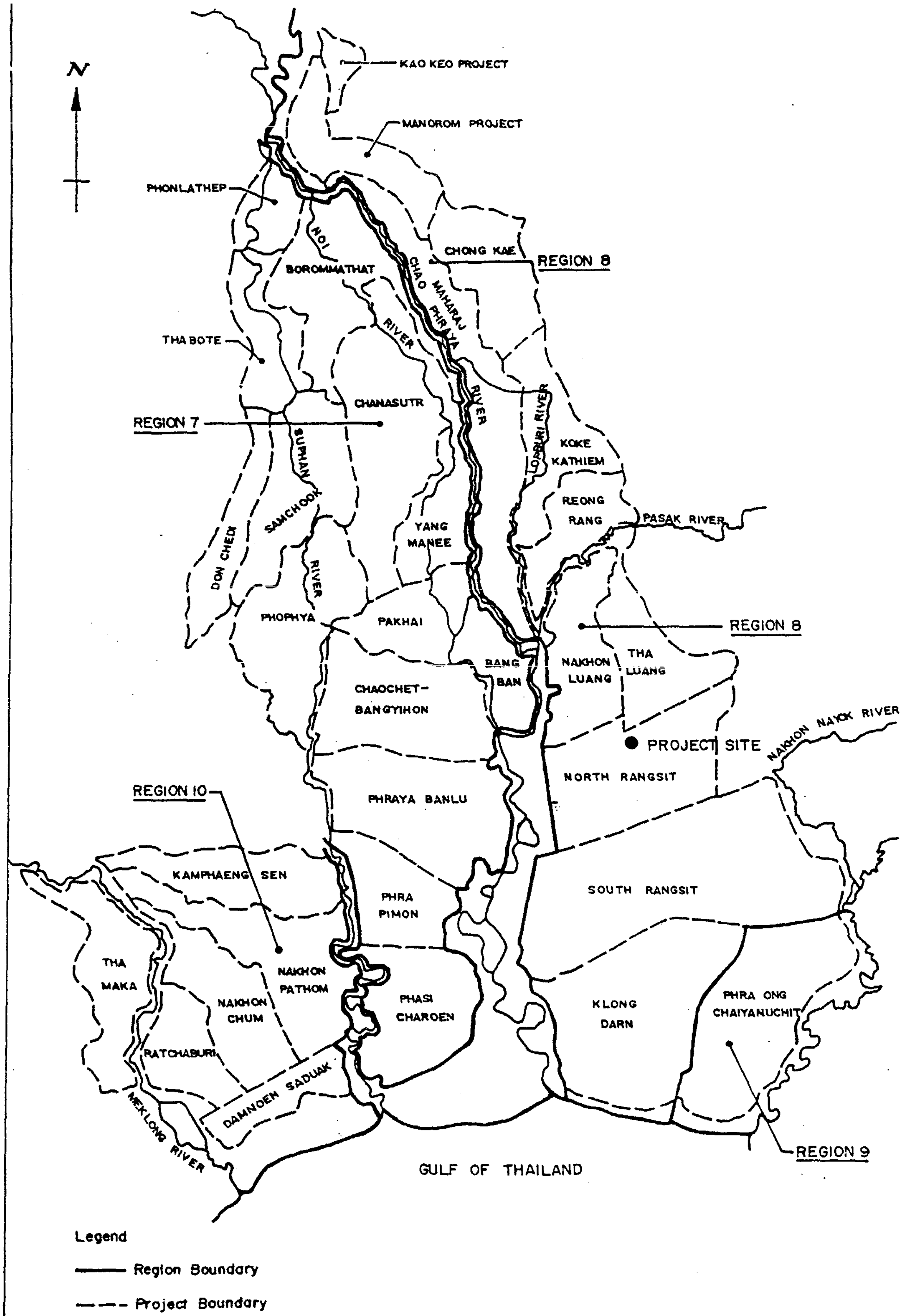


FIGURE 3.4-2 CHAO PHRAYA IRRIGATION PROJECT

2) Lower Chao Phraya Irrigation Project

The Lower Chao Phraya Irrigation Project is divided into two projects, Chao Phraya-West Bank Irrigation Project and Chao Phraya-East Bank Irrigation Project. This study emphasizes on the East Bank Project because the Power Plant is situated in this area (Figure 3.4-3).

2.1) Chao Phraya West Bank Irrigation Project

The project is composed of 6 sub-projects, namely, (i) Pakhai (ii) Bang Ban (iii) Chao Chet Bang Yihon (iv) Phraya Banlue (v) Phra Pimon and (vi) Phasi Charoen, having a total area of 1.65 million rai.

2.2) Chao Phraya East Bank Irrigation Project

The project site is located in the area of the Chao Phraya-East Bank Irrigation Project. The Chao Phraya-East Bank Irrigation Project is composed of 6 sub projects as follows:-

1) South Pasak Irrigation Project

The South Pasak Irrigation Project was initially designed to irrigate an area of 240,600 rai. However, at present, only 182,200 rai received water from Khlong Raphiphat. The water is aslo diverted into sub canals by 4 regulators, namely, Phramahin Regulator, Phra Ekathotsarot Regulator, Phra Sri Silp Regulator and Phra Srisaowaphak Regulator.

2) Nakhon Luang Irrigation Project

The Nakhon Luang Irrigation Project is planned to serve an irrigation area of 267,048 rai. However, at present, only 257,800 rai receives water which is diverted from Khlong Raphiphat via Khlong Nakhon Luang and also water from Khlong Prieo - Sao Hai Project and South Pasak Project which is diverted via Khlong Huai Ba and Khlong Nong Ru.

3) North Rangsit Irrigation Project

The North Rangsit Irrigation Project was planned to cover an irrigation area of 445,500 rai but only 373,640 rai actually receives water from West Raphiphat at the northern part of the project and from South Raphiphat which stretches to Khlong Rangsit at the southern part of Phra Thammaracha siphon. In dry season, the project irrigates water to an area of 121,000 rai by diverting water drained from the northern part at the end of season. The allocated water is sent through drainage canals instead of irrigation canals due to low water level in Khlong Raphiphat.

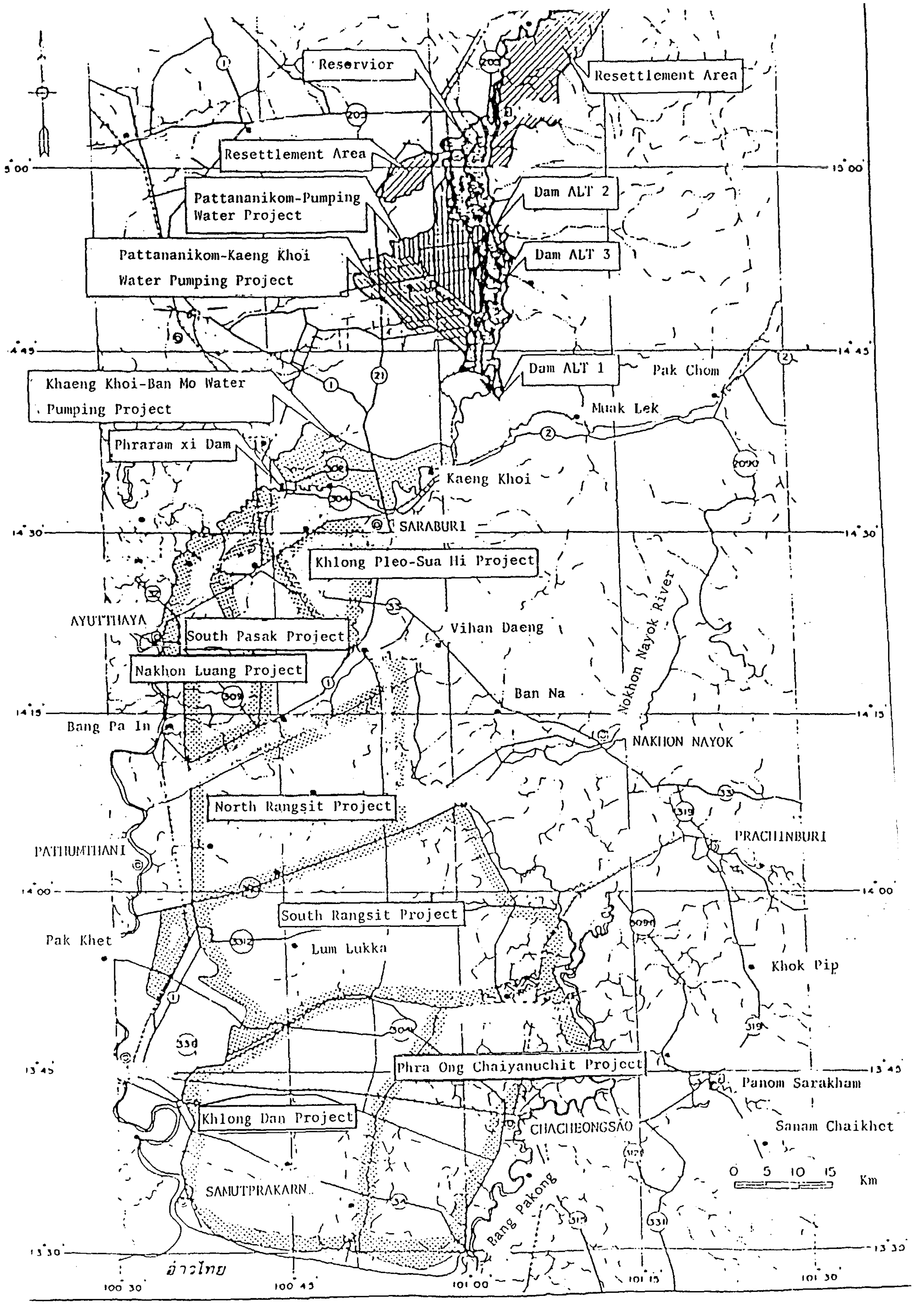


FIGURE 3.4-3 IRRIGATION AREA OF LOWER CHAO PHRAYA EAST BANK AND PASAK BASIN

4) South Rangsit Irrigation Project

The South Rangsit Irrigation Project covers an irrigation area of 529,974 rai. However, only 464,900 rai is used for cultivation. The irrigation area receives water from South Raphiphat (Khlong 13) and water drained from the North Rangsit Irrigation Project as well as water from Chao Phraya River via the pumping station at Chulalongkorn Regulator and from Nakhon Nayok River via Somboon Regulator. The Chulalongkorn Regulator Regulates water via Khlong Rangsit to areas between Khlong 1 and Khlong 7. The Somboon Regulator regulates water to the eastern part of the project area.

5) Khlong Dan Irrigation Project

The Khlong Dan Irrigation Project was planned to serve an irrigation area of 525,000 rai. At present, only 343,100 rai receives water for cultivation. Since the project area is located on the east bank of lower Chao Phraya River adjacent to the Gulf of Thailand. The project area is lower than other surrounding areas therefore there is water drained across the project area to the sea. The project area has thus always experienced flooding during rainy season. During dry season, very small amount of water is allocated to Khlong 13 for Chao Phraya river water has high salinity content. Therefore, water shortage generally occurs.

6) Phra Ong Chaiyanuchit Irrigation Project

The Phra Ong Chaiyanuchit Irrigation Project covers an irrigation area of 510,000 rai. However, at present, only 474,600 rai receives water from Khlong Saen Saeb which receives water drained from canals in the South Rangsit Irrigation Project. The eastern part of the project area receives water from Bang Pakong River.

Royal Irrigation Department has set up development/improvement plans for these afore-mentioned projects during 1993-1997 with a total budget of approximately 1,435 million baht.

3.4.3.4 Water Resources Development in Pasak River Basin

The Pasak River Basin is located on the east bank of Chao Phraya River. Pasak River is a main tributary joining Chao Phraya River at Ayudhaya. Presently, the development in Pasak River basin comprises Rama VI Dam across the river to divert water via Khlong Raphiphat to the lower Chao Phraya River Basin. However, from agricultural statistics of the country within the past 10-20 years, it is found that, during the past 4-5 years, expansion of agricultural land has decreased. This is due to lack of suitable land and shortage of water for plantation. Agricultural production rate decreased from 5% per annum to 3-4% per annum, presently.

RID has planned to develop the Pasak River Basin by aiming at storage of water in the river basin for various purposes. A dam will be constructed in Lopburi. It is expected that, in 1997, the project will be completed and thus can supply water to the eastern side of the Lower Chao Phraya Irrigation Project. The total irrigation area is approximately 2 million rai. At present, this project receives water diverted from Chao Phraya Dam of about 2,100 MCM/yr. Thus the Pasak Project will help reduce that portion of water which is presently diverted from Chao Phraya Dam.

The Pasak Project will also supply water for the following destinations:

(1) Khlong Prieo - Sao Hai, an area of 135,000 rai
(2) Kaeng Khoi - Ban Mo, an area of 80,000 rai
(3) Pumping projects under Community Development Department, Local Administration Department and Energy Development and Promotion Department, an area of 20,000 rai.
(4) Supply of water for domestic and industrial uses in Lopburi and Saraburi, an average of 48 MCM.
(5) Control of pollution from industrial and residential sources in Pasak River, approximately 78 MCM in dry season.

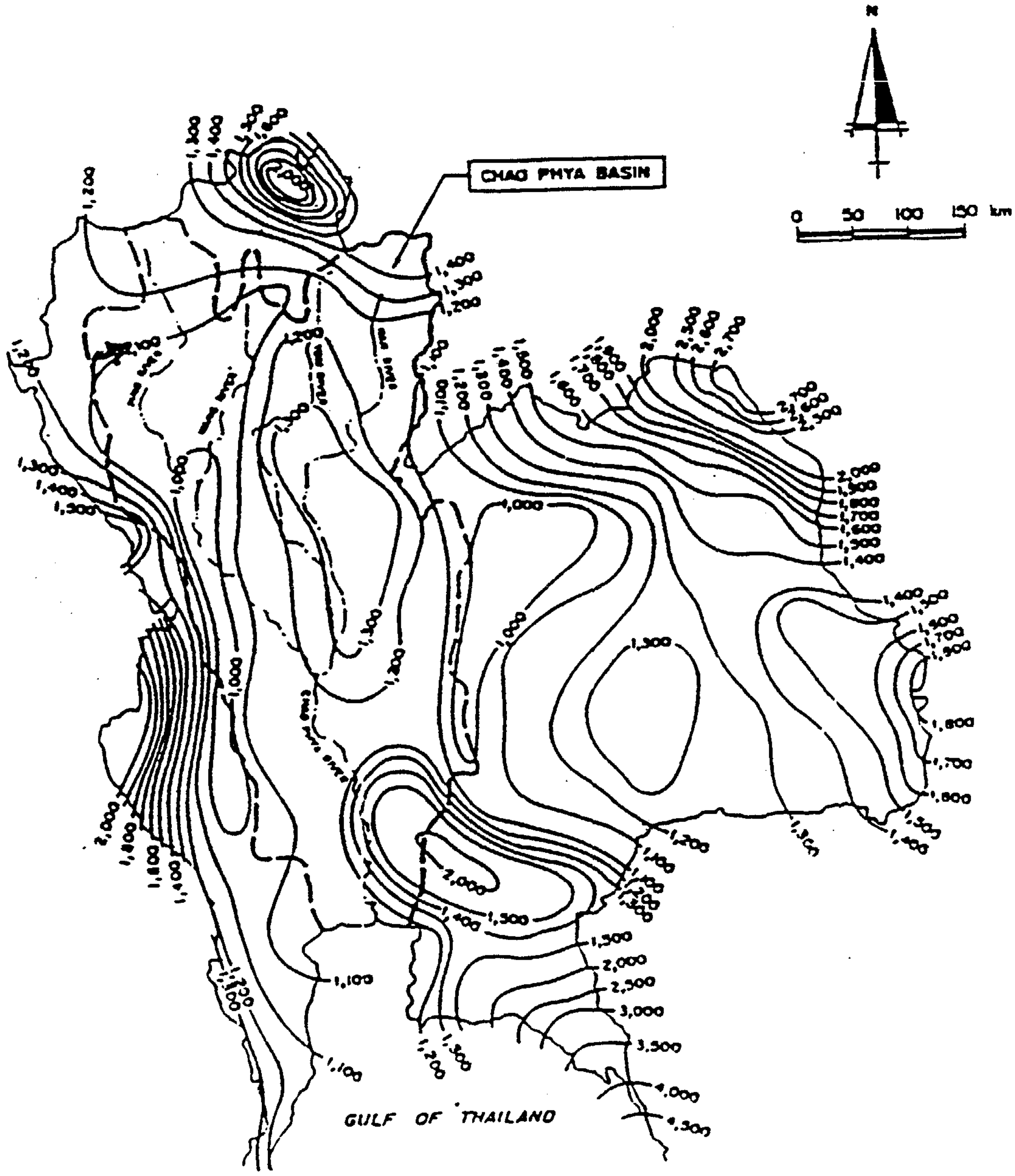
3.4.4 Rainfall and Runoff

3.4.4.1 Rainfall Characteristic

The climate of the Chao Phraya River Basin is influenced by the southwest monsoon which usually starts in May and ends in October. The depression storms from the South China Sea in September and October produce peak streamflows in the Chao Phraya River and its tributaries.

Average annual precipitation in the Chao Phraya River Basin varies from a minimum of 1,000 mm in the western part to about 1,400 mm in the headwater and to 2,000 mm in the eastern Chao Phraya Delta as presented in Figure 3.4-4. Variations from year to year which produce floods and droughts are important factors in determining the usefulness of water resources.

The information on rainfall characteristic of the project area is taken from RID rainfall measurement stations of Nakhon Luang, Tha Luang and North Rangsit Irrigation Projects. Details of the stations are shown in Table 3.4-1. Mean monthly rainfall data as shown in Tables 3.4-2 to 3.4-4 reveal that mean annual rainfall is approximately 1,270 mm with the maximum of 1,800 mm and the minimum of 790 mm.



Legends

--------- Watershed Boundary

—1,200— Isohytals in Millimetres

FIGURE 3.4-4 AVERAGE ANNUAL RAINFALL IN CHAO PHRAYA BASIN

TABLE 3.4-1
LIST OF RAINFALL GAUGING STATION IN STUDY AREA

Irrigation Project	Code	Name	Province
1. Nakhon Luang	43032	Tha Rua	Ayudhaya
	42122	Nakhon Luang	Ayudhaya
	42190	Khlong Khaomao Reg.	Ayudhaya
	42220	Khlong Chik Reg.	Ayudhaya
	42300	Upper 4R Canal	Ayudhaya
2. Tha Luang	32120	Raphiphat 3R Canal	Pathumthani
	32130	Raphiphat Regulator	Pathumthani
	42132	A. Phachi	Ayudhaya
	54052	A. Nong Khae	Saraburi
	54210	Phra Ekathotsarot Reg.	Saraburi
3. North Rangsit	32012	A. Muang	Pathumthani
	32052	A. Nong Sua	Pathumthani
	32082	Rangsit Rice Expt. St.	Pathumthani
	32110	Raphiphat 6R Canal	Pathumthani
	32120	Raphiphat 3R Canal	Pathumthani

TABLE 3.4-2
AVERAGE MONTHLY RAINFALL IN NAKHON LUANG IRRIGATION PROJECT AREA

oyal Irrigation Department, Thailand

ation – 42032 A. Tha Rua, Ayudhaya
– 42122 A. Nakhon Luang, Ayudhaya
– 42190 Klong Khao Mao Regulator (CAP. 13), Ayudhaya
– 42220 Klong Chik Reguator (CAP. 16), Ayudhaya
– 42300 Upper 4R Canal (NKG. 4), Ayudhaya

MM

Y/M	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
1965	92.3	156.0	212.3	90.7	236.7	369.5	150.9	36.1	13.9	4.7	60.3	37.6	1,462.0
1966	61.1	250.2	202.3	267.5	235.9	206.5	157.1	23.3	21.3	3.0	6.3	5.3	1,495.7
1967	77.8	113.5	89.2	135.7	81.3	248.3	42.4	19.9	0.0	7.9	73.7	4.7	949.7
1968	108.1	113.7	107.4	101.0	147.2	218.0	93.9	20.3	0.0	3.1	0.0	29.0	951.6
1969	23.9	77.7	160.2	300.2	130.1	437.7	129.7	53.9	0.6	13.5	32.5	44.0	1,403.9
1970	70.5	152.2	250.1	151.4	295.4	317.3	139.4	3.0	36.0	0.0	2.2	21.0	1,443.9
1971	61.2	126.2	136.6	112.6	217.0	163.8	164.9	3.1	5.2	0.0	2.4	43.4	1,091.5
1972	129.9	65.1	134.4	46.9	207.2	571.0	192.0	161.1	29.6	0.0	0.0	90.4	1,677.6
1973	10.3	147.3	134.1	212.0	206.0	229.6	77.1	25.3	4.9	1.1	3.6	30.3	1,132.2
1974	161.1	135.7	125.9	201.0	177.7	269.0	326.7	48.6	1.2	110.3	0.7	20.6	1,531.5
1975	56.7	130.3	213.0	209.3	232.2	225.1	163.9	80.5	14.7	0.0	25.2	56.2	1,412.0
1976	36.3	131.7	148.3	244.7	301.7	269.7	136.2	49.2	13.9	6.9	0.0	26.0	1,465.0
1977	122.8	141.3	120.3	119.9	186.6	290.5	118.0	21.4	16.1	11.6	95.9	1.3	1,246.8
1978	46.6	237.9	133.6	250.8	116.2	405.4	107.7	2.1	0.0	0.0	2.1	0.4	1,302.7
1979	49.4	218.3	130.8	191.8	224.6	279.9	3.2	0.0	0.0	0.0	2.3	22.4	1,127.7
1980	124.3	133.3	202.1	197.0	149.1	180.5	253.8	29.6	0.0	0.0	13.7	32.2	1,315.4
1981	36.1	128.4	168.3	161.5	213.5	223.9	70.9	86.2	0.0	0.0	0.5	23.2	1,162.5
.982	70.5	98.2	162.2	154.3	60.0	137.6	111.4	78.0	6.9	0.6	0.0	0.0	929.6
.983	0.1	147.0	137.9	97.6	283.2	198.0	286.7	47.2	8.3	3.6	36.8	15.0	1,261.3
984	73.2	138.4	99.7	174.5	176.7	167.4	161.0	26.8	0.3	1.6	0.0	28.0	1,097.5
985	83.0	132.4	72.4	146.5	123.4	303.9	150.9	34.2	0.0	0.0	0.0	0.0	1,046.7
986	123.7	185.0	108.7	178.2	134.6	352.7	161.9	0.0	5.0	3.2	0.0	3.2	1,256.3
987	59.6	128.4	85.5	130.7	86.4	279.0	117.7	90.9	0.0	0.0	28.5	3.3	1,010.0
988	99.3	106.3	133.3	150.4	232.8	240.4	195.4	0.0	0.0	28.6	6.3	16.8	1,210.2
989	15.6	144.4	66.8	77.5	211.6	194.6	170.6	21.3	0.0	9.8	0.0	63.4	980.6
990	11.1	223.5	38.2	102.8	35.5	263.6	472.1	30.2	0.0	6.2	0.6	12.1	1,250.7
'G =	71.6	149.1	143.3	163.7	134.7	272.3	162.1	38.4	6.9	3.7	15.3	24.6	1,241.1
,X =	161.1	250.2	250.1	300.2	301.7	571.0	472.1	161.1	36.0	110.3	95.9	90.4	1,677.6
N =	0.1	65.1	38.2	46.9	60.0	163.3	8.2	0.0	0.0	0.0	0.0	0.0	929.6

F:T34-2.WK1/37-B-0043

TABLE 3.4–3
AVERAGE MONTHLY RAINFALL IN SOUTH PASAK PROJECT AREA

Royal Irrigation Department, Thailand

Station – 32120 Raphiphat 3R Canal (NRS.4), Pathumthani
– 32130 Raphiphat Regulator (NRS.5), Pathumthani
– 42132 A. Phachi, Ayudhaya
– 54052 A. Nong Khae, Saraburi
– 54210 Phra Ekathotsarot Regulator (RPP.3), Saraburi

MM

Y/M	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
1965	38.3	223.6	150.8	126.7	237.4	490.7	153.0	43.0	18.7	6.8	56.5	55.3	1,601.1
1966	62.6	302.4	234.7	290.9	347.6	175.5	162.4	36.0	28.3	5.0	0.1	5.8	1,651.3
1967	90.3	222.4	103.6	222.8	132.5	279.4	59.1	28.2	0.0	6.0	105.4	11.1	1,260.8
1968	168.5	93.1	151.6	161.5	198.4	172.0	53.6	6.3	0.0	5.3	0.0	77.6	1,087.8
1969	55.3	33.9	131.0	287.6	138.3	481.5	125.8	65.4	0.0	17.1	49.3	53.3	1,493.5
1970	73.4	237.4	272.9	234.8	374.7	271.7	124.2	9.3	63.7	0.0	10.8	28.1	1,701.1
1971	56.6	123.6	149.5	148.8	295.7	231.9	140.0	0.4	1.8	0.0	0.8	18.7	1,167.8
1972	104.3	37.5	172.0	90.9	218.8	645.4	163.1	195.2	37.3	0.0	1.4	81.3	1,746.9
1973	35.4	124.3	179.5	203.2	215.3	139.3	74.4	33.5	1.2	3.2	20.0	52.3	1,132.1
1974	115.3	173.3	107.2	209.4	148.2	170.8	255.9	88.0	1.6	62.0	11.9	26.9	1,370.4
1975	45.9	106.5	235.3	236.4	198.9	215.3	121.1	57.8	6.5	0.0	35.4	29.1	1,288.4
1976	27.4	140.7	138.0	302.1	348.7	346.3	84.7	40.5	5.8	3.0	5.7	14.9	1,457.6
1977	31.7	86.1	83.6	82.2	169.2	225.3	83.3	57.0	4.0	1.8	39.9	0.0	864.1
1978	16.1	195.2	224.1	252.9	128.3	325.2	92.5	5.5	0.0	19.5	11.1	2.7	1,273.1
1979	18.9	121.9	60.1	176.4	195.0	196.3	67.8	0.0	0.0	0.0	3.6	28.7	868.9
1980	96.8	82.7	283.7	210.4	342.1	258.9	269.1	29.5	0.0	0.0	16.0	11.9	1,601.0
1981	36.0	214.5	197.0	160.0	247.0	261.8	137.5	166.3	0.0	0.0	0.0	53.7	1,524.2
1982	39.2	146.1	166.7	131.9	107.9	180.8	114.5	104.5	14.0	0.0	1.4	1.2	1,008.0
1983	1.4	142.6	137.3	131.6	332.7	204.1	372.7	55.1	14.1	10.3	60.8	9.4	1,521.9
1984	60.0	157.1	109.7	213.2	254.1	173.6	170.6	36.3	0.0	2.5	0.0	2.8	1,137.8
1985	39.4	114.3	81.8	173.6	179.7	298.5	147.4	24.3	0.0	0.0	0.0	0.0	1,109.1
1986	63.5	170.0	160.7	211.9	164.7	257.8	175.8	11.6	22.5	0.0	0.0	21.7	1,265.1
1987	75.6	104.9	100.8	128.8	83.5	301.3	96.7	62.5	0.0	0.5	22.9	0.0	977.4
1988	105.1	113.1	255.6	170.6	297.4	179.4	246.2	0.6	0.0	3.1	15.8	63.7	1,450.5
1989	7.6	115.7	68.6	106.7	258.4	253.3	134.1	28.2	0.0	1.8	0.0	32.7	1,007.0
1990	28.9	177.8	70.5	93.9	35.3	300.2	491.6	16.0	0.0	4.2	9.3	29.8	1,307.5
AVG =	61.5	146.8	156.8	183.0	219.2	272.5	158.6	46.2	8.4	5.8	18.4	27.4	1,304.8
MAX =	168.5	302.4	283.7	302.1	374.7	645.4	491.6	195.2	63.7	62.0	105.4	81.3	1,746.9
MIN =	1.4	37.5	60.1	32.2	83.5	170.8	53.6	0.0	0.0	0.0	0.0	0.0	364.1

TABLE 3.4–4
AVERAGE MONTHLY RAINFALL IN NORTH RANGSIT PROJECT AREA

Royal Irrigation Department, Thailand

tation – 32012 A. Muang, Pathumthani
– 32052 A. Nong Sua, Pathumthani
– 32082 Rangsit Rice Experimental Station, Pathumthani
– 32110 Raphiphat 6R Canal (NRS. 2), Pathumthani
– 32120 Raphiphat 3R Canal (NRS. 4), Pathumthani

MM

Y/M	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
1965	38.1	177.6	109.1	85.2	132.6	413.6	173.4	38.3	8.8	0.8	70.6	41.8	1,340.0
1966	64.9	300.8	142.4	221.3	260.6	193.0	197.0	17.0	47.6	12.8	0.0	0.0	1,457.4
1967	115.9	145.6	85.6	253.3	107.8	305.2	85.3	40.9	0.0	1.0	55.6	12.2	1,208.5
1968	82.0	126.5	172.5	163.6	208.4	293.5	164.5	41.1	0.0	9.6	0.0	43.9	1,305.6
1969	45.0	101.8	184.1	214.6	155.2	434.2	226.2	55.1	0.0	31.3	33.4	75.4	1,556.2
1970	61.5	200.3	312.3	256.2	340.8	308.3	203.6	25.8	68.6	0.0	12.3	16.0	1,305.3
1971	53.0	140.9	135.3	125.8	363.5	208.8	219.8	6.8	2.6	0.0	5.3	9.3	1,271.0
1972	158.8	41.8	176.9	103.0	149.5	625.7	162.5	200.7	60.2	0.0	0.0	67.0	1,746.0
1973	9.2	70.9	168.8	177.3	172.2	279.7	98.6	37.0	0.0	1.1	4.6	81.7	1,101.0
1974	145.2	166.3	64.3	216.7	101.8	157.9	365.0	71.7	0.0	30.4	1.8	66.6	1,437.5
1975	20.0	111.4	211.4	241.0	193.4	203.6	174.0	31.3	3.1	0.0	24.8	10.8	1,223.7
1976	49.1	139.3	118.7	267.5	331.0	288.9	149.9	37.5	3.4	19.6	29.0	1.5	1,435.3
1977	48.7	86.9	62.1	110.6	135.5	232.6	68.4	6.2	1.4	15.4	50.6	0.0	818.5
1978	9.6	215.1	136.3	200.7	95.8	230.0	127.7	9.1	0.0	1.6	4.7	0.0	1,030.6
1979	24.7	119.7	75.1	117.1	199.1	186.8	43.5	5.8	0.2	0.0	1.5	14.2	787.5
1980	38.9	82.3	355.5	202.5	271.7	259.8	232.5	21.5	0.0	0.0	41.7	3.2	1,509.5
1981	108.1	163.9	133.7	119.3	233.4	280.6	139.0	128.3	0.0	0.0	2.8	36.3	1,345.9
1982	66.7	122.4	198.5	136.9	135.5	263.0	146.7	57.8	3.8	0.0	1.5	0.0	1,182.7
1983	2.5	131.7	149.9	93.1	329.1	324.2	399.4	51.3	8.5	5.9	52.7	27.3	1,605.9
1984	61.7	40.7	132.7	177.0	224.3	234.2	158.8	2.7	0.0	13.6	0.0	7.4	1,053.1
1985	39.1	148.3	84.0	144.8	94.4	265.7	203.1	35.9	0.0	0.0	2.1	0.0	1,067.3
1986	66.2	258.1	151.5	193.5	166.6	301.4	203.6	11.4	24.7	0.0	0.0	8.9	1,386.0
1987	75.0	61.6	127.5	62.9	63.7	312.0	96.6	71.4	0.0	0.0	8.2	0.0	379.1
1988	77.2	127.4	185.5	133.6	225.2	379.7	252.0	0.6	0.0	24.3	0.0	45.0	1,450.7
1989	4.2	68.8	57.7	148.1	168.4	227.9	115.3	22.8	0.0	0.0	0.0	15.0	828.2
1990	17.9	177.3	51.6	96.3	103.7	261.1	532.7	36.1	0.0	5.2	22.0	7.2	1,311.6
VG =	59.0	135.7	145.5	165.9	192.8	287.4	190.0	42.1	9.0	8.6	16.4	22.8	1,274.8
AX =	158.3	300.8	355.5	267.5	363.5	625.7	532.7	200.7	68.6	80.4	70.6	31.7	1,805.8
IN =	2.5	40.7	51.6	62.9	63.7	157.9	43.5	0.6	0.0	0.0	0.0	0.0	787.5

F:T34-4.WK1/37-B-0043

3.4.4.2 Runoff Characteristic

1) Chao Phraya River

Table 3.4-5 summarises runoff data within 26-37 years of 6 stations within Chao Phraya River Basin. Locations of the stations are shown in Figure 3.4-5. Bhumibol and Sirikit reservoirs are also included in the 6 stations mentioned before. In addition, Station S.9 in Pasak River Basin is also taken into consideration. It can be seen from Table 3.4-5 that runoff in Chao Phraya River at Nakhon Sawan (C.2) is about 23,260 MCM and reduced to 11,666 MCM after passing Chao Phraya Dam. For Pasak River, runoff to Chao Phraya River is about 2,416 MCM. Table 3.4-6 shows variation of monthly runoff from various stations and indicates that high flow of runoff occurs between August and November.

2) Khlong Raphiphat

In Rama VI Reign, Rama VI Dam was constructed across Pasak River at Tambon Tha Luang, Amphoe Tha Rue, Ayudhaya province. Besides, Khlong Raphiphat was constructed to divert water from Rama VI Dam to plantation areas in the west bank of the lower Chao Phraya River Basin with a maximum capacity of 120 cms or 310 MCM/month Khlong Raphiphat is separated into 2 streams, namely West Raphiphat and South Raphiphat at Amphoe Nong Khae, Saraburi Province. The Power Plant is located on West Raphiphat. South Raphiphat leads water to the lower area Via Khlong 13 and Khlong Rangsit Prayoonsak. In order to efficiently regulate water in Khlong Raphiphat, RID constructed regulators across various sections of Khlong Raphiphat starting at the mouth near Rama VI Dam. Locations of regulators are shown in Figure 3.4-6. In the project area there are 2 regulators on West Raphiphat , namely Phra Sri Silp Regulator and Phra Intaracha Regulator.

Since the agricultural land on the east bank had increased, Chao Phraya Dam was built in 1953. RID dredged Khlong Chainat-Pasak to connect Chao Phraya River and Pasak River. This Khlong aims at diverting water from Chao Phraya Dam to Pasak River at Rama VI Dam at about 210 cms. This Khlong is 120 km long with regulators for allocating water to cultivation land.

RID has allocated water via regulators to cultivation land since 1965 upto present. Tables 3.4-7 and 3.4-8 and Figures 3.4-7 and 3.4-8 show volume of water diverted into Khlong Raphiphat between 1976-1993 at Phra Narai Regulator and Phra Sri Silp Regulator. It can be seen that volume of water released via Phra Narai Regulator is about 2,300 MCM/year with the minimum value of about 1,647 MCM/year in 1992. Monthly variation ranges between 97 and 277 MCM with values higher than 200

TABLE 3.4–5
LIST OF SELECTED STREAMFLOW GAUGING STATIONS

River and Station	Code	Location	Control Agency	Drainage Area (Sq.km)	Record Period	Mean Annual Flow (mcm)
1. Bhumibol Dam	–	TAK	EGAT	14,023	1952–1989	5,388
2. Sirikit Dam	–	NAN	EGAT	10,335	1952–1989	5,692
3. Chao Phraya	C.2	NAKHON SAWAN	RID	110,569	1978–1990	23,260
4. Chao Phraya	C.13	CHAINAT	RID	–	1960–1986	12,960
5. Chao Phraya	C.7	ANG THONG	RID	–	1960–1986	11,666
6. Pasak	S.9	SARABURI	RID	14,374	1973–1991	2,416

Remark: Side flow at Nakhon Sawan is about 12,768 MCM/yr (JICA, 1988)

Source:
1) Feasibility Study and Environmental Impact Assessment of Pasak Project, July 1991.
2) Lower Chao Phraya West Bank Area Development Project, 1982.
3) Master Plan Study on Water Management System and Monitoring Program in Chao Phraya River Basin, July 1988.

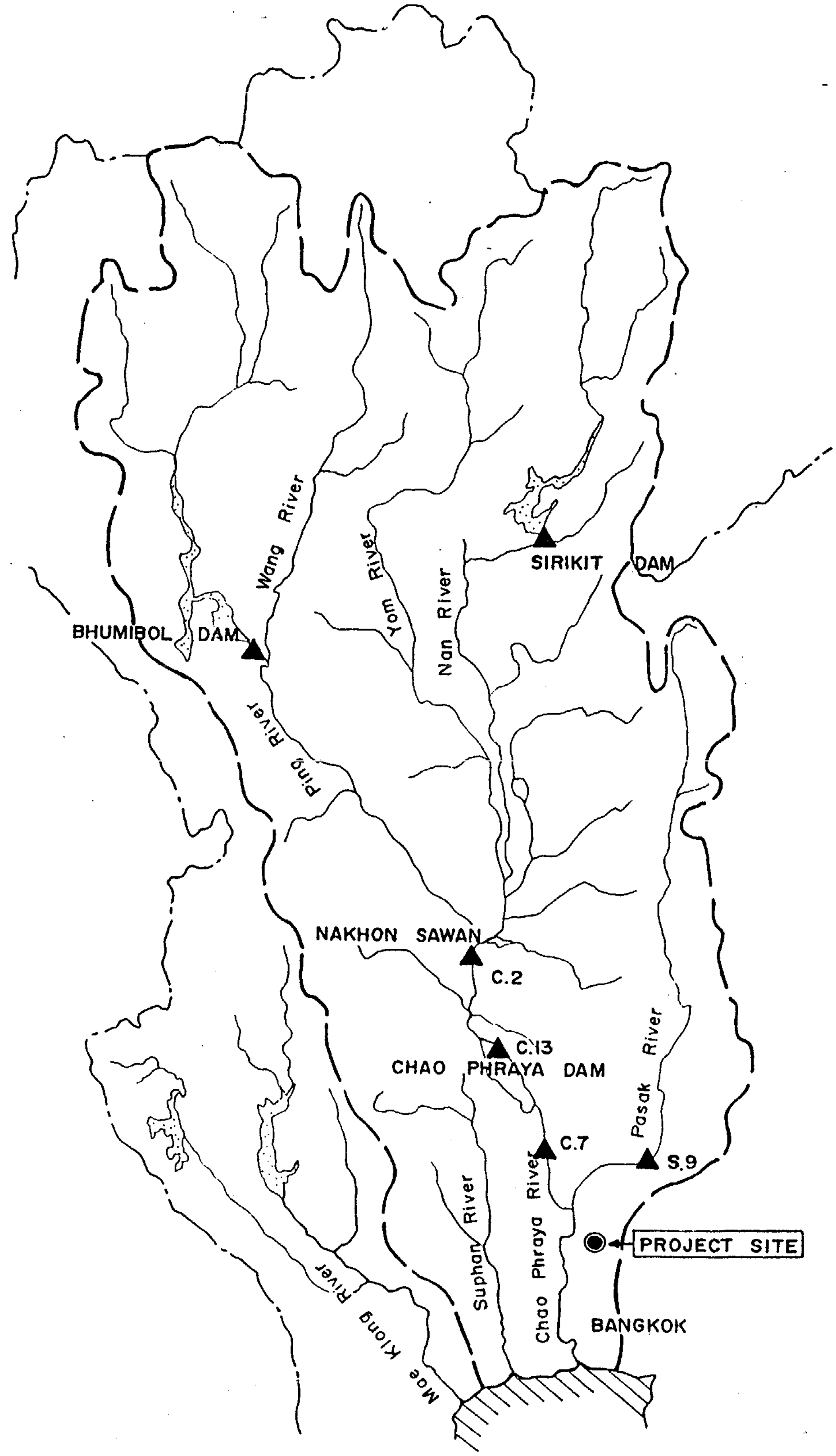


FIGURE 3.4-5 STREAM GAUGING STATIONS

TABLE 3.4–6
AVERAGE MONTHLY AND ANNUAL FLOW OF SELECTED STATIONS

Unit : MCM

River and Station	Code	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
1. Bhumibol Dam	–	41.32	166.09	274.65	321.60	805.50	1,445.70	1,220.70	611.19	285.80	131.55	57.62	27.15	5,388.90
2. Sirikit Dam	–	76.86	175.91	306.94	761.55	1,521.22	1,599.90	600.48	256.26	138.77	103.03	74.73	70.35	5,692.00
3. Chao Phraya	C.2	1,084.20	1,242.10	1,399.20	1,664.10	2,403.10	3,775.80	4,818.70	2,809.20	1,393.80	765.80	822.30	1,081.00	23,259.10
4. Chao Phraya	C.13	253.20	500.60	655.30	745.70	1,116.40	2,282.50	3,745.50	1,755.80	967.20	401.20	271.70	262.50	12,957.60
5. Chao Phraya	C.7	331.80	557.90	656.30	662.40	849.10	1,765.90	2,847.40	1,662.00	1,210.60	477.60	321.90	322.70	11,665.60
6. Pasak	S.9	18.51	50.27	93.98	117.00	234.52	673.80	920.80	183.50	58.98	30.34	17.31	17.04	2,416.00

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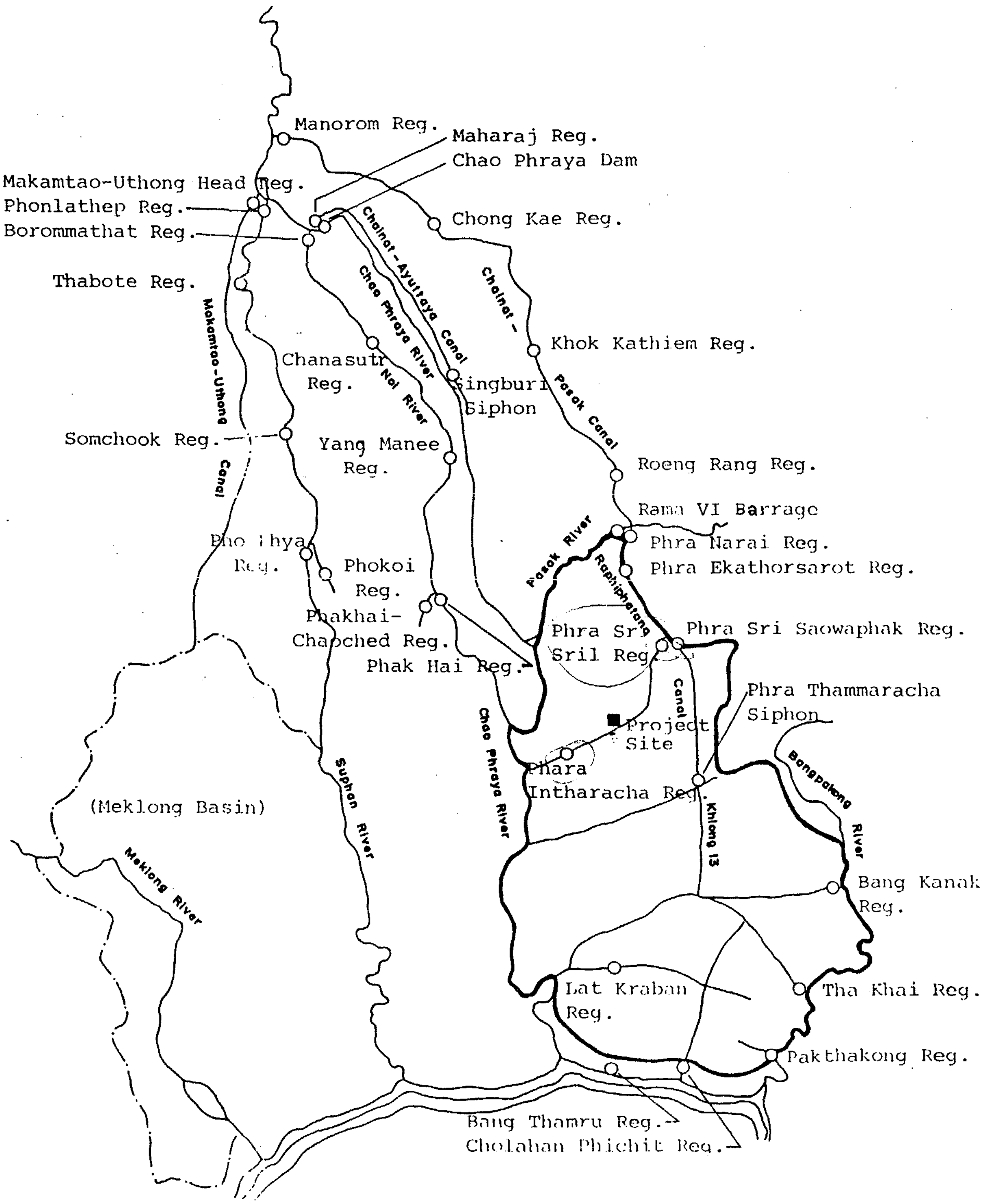


FIGURE 3.4-6 LOWER CHAO PHRAYA BASIN AND CHAO PHRAYA EAST BANK PROJECT

TABLE 3.4-7
WATER DIVERSION TO RAPHIPHAT CANAL AT PHRA NARAI REGURATOR
2519-2536 B.E.

YEAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	ANNUAL (MCM)
2519	322	225	259	242	212	151	343	236	41	74	138	335	2578
2520	304	332	239	205	145	329	278	129	81	80	107	184	2413
2521	215	149	110	166	207	252	157	244	119	157	131	245	2152
2522	294	241	261	255	271	278	305	174	100	106	37	63	2385
2523	65	171	204	274	273	300	94	193	39	128	145	172	2058
2524	196	198	177	165	279	203	292	224	63	202	235	272	2506
2525	241	150	130	116	178	319	286	215	26	214	264	245	2384
2526	263	239	174	105	130	156	162	102	23	69	203	335	1961
2527	226	157	167	137	190	295	467	324	84	197	218	265	2727
2528	229	185	203	225	274	196	350	290	66	130	191	280	2619
2529	274	171	202	225	219	218	267	179	154	94	239	303	2545
2530	247	159	146	82	132	317	465	323	123	84	89	182	2349
2531	166	246	218	217	143	248	252	261	105	139	139	185	2319
2532	182	238	286	185	150	232	344	289	113	110	98	237	2464
2533	204	186	255	267	262	277	95	181	188	126	72	145	2258
2534	203	101	181	61	111	196	233	163	187	104	71	115	1726
2535	110	89	55	21	232	150	325	205	144	99	83	136	1649
2536	149	122	123	90	150	203	164	48	75				
AVERAGE	216	187	188	169	198	240	271	210	96	124	145	218	2300
MAX	304	332	286	274	279	329	467	324	188	214	264	335	2727
MIN	65	89	55	21	111	150	94	48	23	69	37	63	1649

REMARK: 1) DURING DRY PERIOD IN 2517-2518, THE REGURATOR WAS UNDER REPAIR BY RID SO THE CALCULATION WAS ABANDONED FOR THESE YEARS.

2) SIRIKIT DAM WAS OPERATED IN 2517.

F:T34-7.WK1/37-B-0043

TABLE 3.4-8
WATER DIVERSION TO RAPHIPHAT CANAL AT PHRA SRI SILP REGURATOR
2519-2536 B.E.

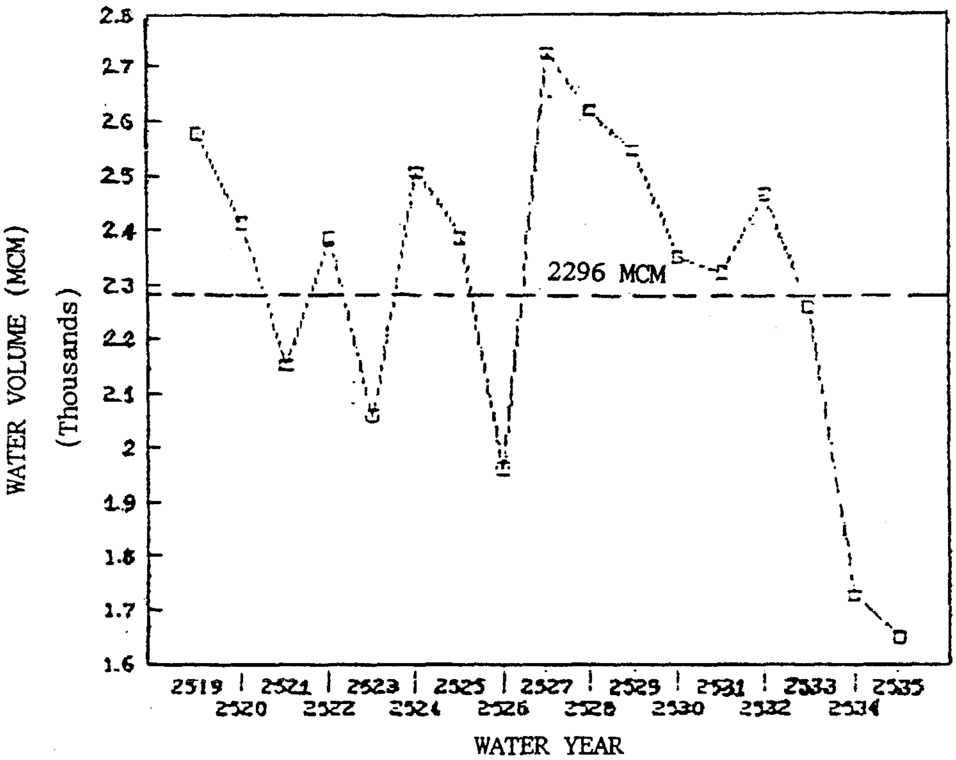
YEAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	ANNUAL (MCM)
2519	110	115	88	80	98	55	129	85	26	35	63	110	994
2520	98	128	82	65	44	125	94	59	59	47	62	90	953
2521	79	63	48	75	80	96	90	44	64	57	42	73	811
2522	94	100	85	67	69	75	66	42	55	32	8	2	695
2523	16	32	68	51	78	67	19	22	17	26	21	46	463
2524	71	77	65	38	75	69	63	53	22	82	85	111	811
2525	70	58	51	23	48	121	91	55	8	87	101	102	815
2526	109	89	76	27	37	23	56	11	4	20	70	101	623
2527	80	70	60	37	66	101	152	94	29	64	76	124	953
2528	93	98	90	90	99	73	101	78	39	47	56	70	934
2529	79	48	57	67	64	68	79	42	35	42	52	96	729
2530	88	55	38	34	32	93	177	93	57	39	33	40	779
2531	43	75	86	63	23	20	33	32	42	48	50	55	570
2532	48	50	60	48	30	64	75	58	32	33	38	58	594
2533	44	39	36	55	40	53	46	21	30	49	33	32	478
2534	40	35	37	22	24	39	41	31	26	20	26	35	376
2535	31	27	23	12	57	32	82	55	54	48	27	33	481
2536	38	32	26	30	28	60	39	4	15				272
AVERAGE	68	66	60	49	55	69	80	49	34	46	50	69	685
MAX	109	128	90	90	99	125	177	94	64	87	101	124	953
MIN	16	27	23	12	23	20	19	4	4	20	8	2	272

REMARK: 1) DURING DRY PERIOD IN 2517-2518, THE REGURATOR WAS UNDER REPAIR BY RID SO THE CALCULATION WAS ABANDONED FOR THESE YEARS.
2) SIRIKIT DAM WAS OPERATED IN 2517.

F:T34-8.WK1/37-B-0043

WATER DIVERSION TO RAPHIPHAT CANAL

AT PHRA NARAI REG (2515-2535 B.E.)



MONTHLY WATER DIVERSION TO RAPHIPHAT

AT PHRA NARAI REG (2505-2536 B.E.)

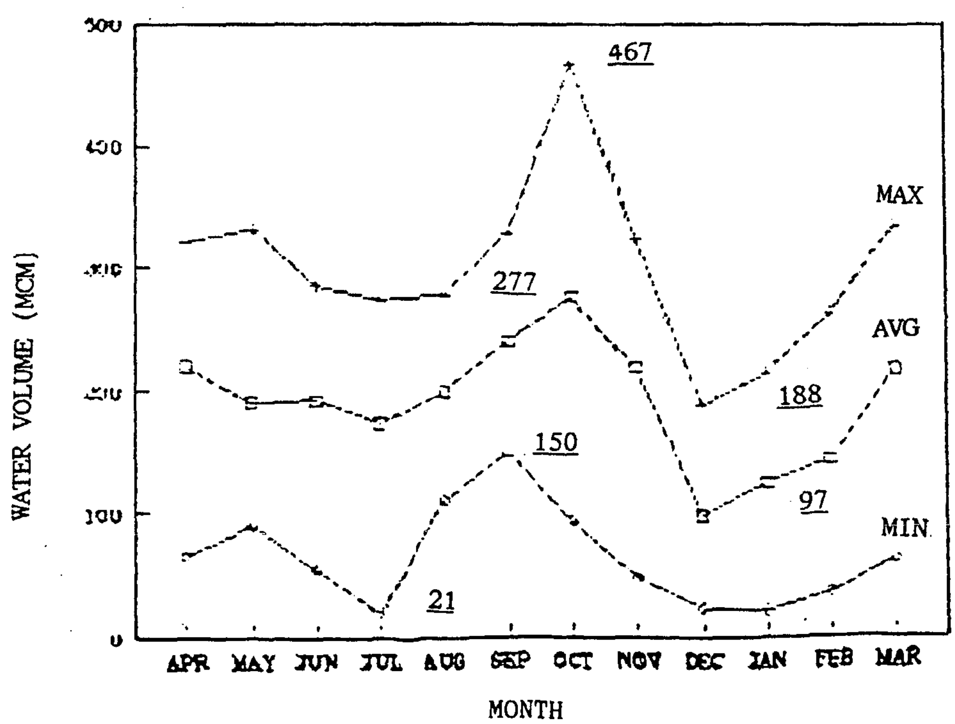
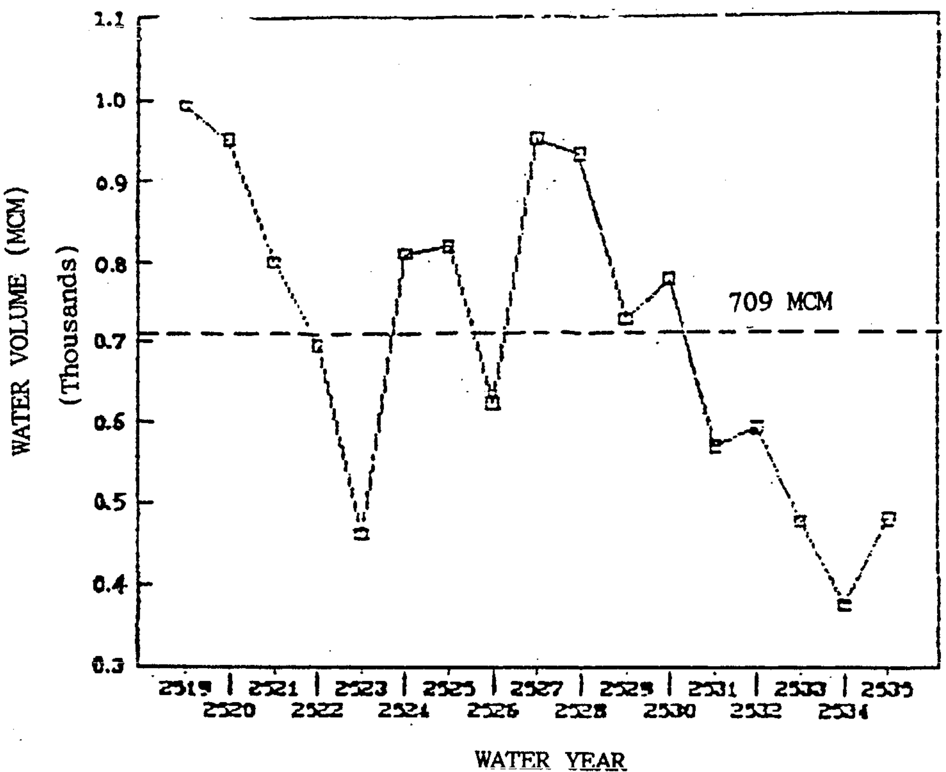


FIGURE 3.4-7 WATER DIVERSION TO RAPHIPHAT CANAL AT PHRA NARAI REGULATOR

WATER DIVERSION TO RAPHIPHAT CANAL

AT PHRA SRI SILP REGULATOR



WATER DIVERSION TO RAPHIPHAT CANAL

AT PHRA SRI SILP REGULATOR

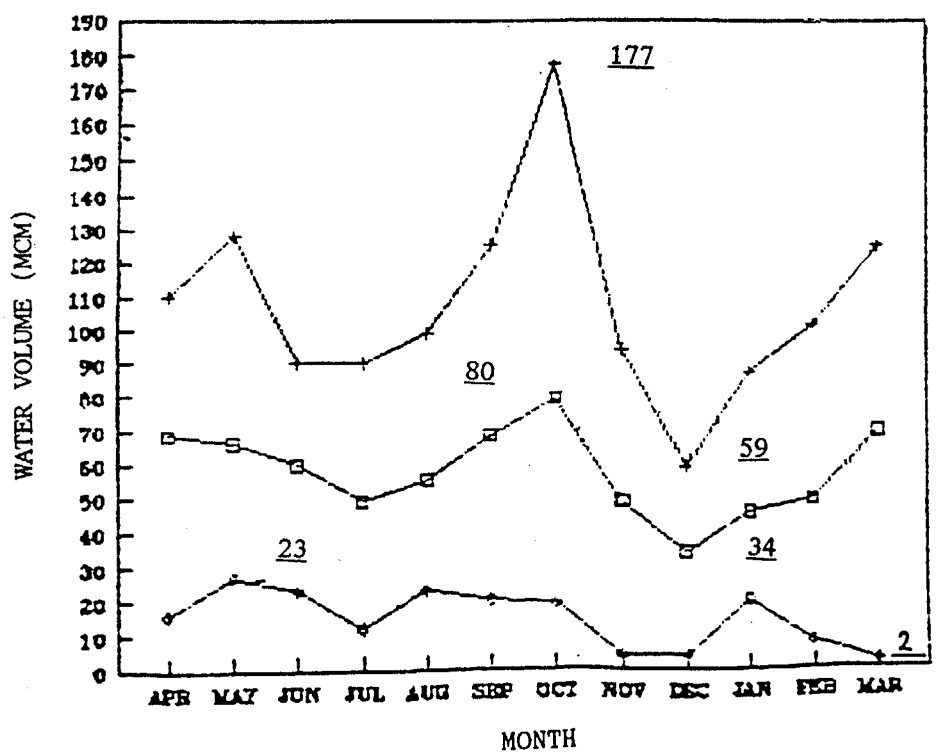


FIGURE 3.4-8 WATER DIVERSION TO RAPHIPHAT CANAL

AT PHRA SRI SILP REGULATOR

MCM during August to November. Minimum average monthly volume ranges between 22 and 150 MCM with the minimum of 21 MCM in July.

West Raphiphat downstream of Phra Sri Silp Regulator has an average annual volume of about 709 MCM with the minimum of 376 MCM. Monthly variation ranges between 35 and 82 MCM. Minimum monthly volume ranges between 2 and 23 MCM. The month with minimum volume is March of 2 MCM.

3.5 SURFACE WATER QUALITY

3.5.1 Introduction

Construction and operation of the Power Plant will certainly affect surface water quality, aquatic biology and fisheries in the receiving water body, i.e. the Raphiphat Irrigation Canal (Khlong Raphiphat). Significant source of the effects is power plant effluents generated by different sources and stored in effluent holding pond prior to discharge to Khlong Raphiphat. In addition, huge quantity of water withdrawal from Chao Phraya River at Bang Sai or Khlong Raphiphat for power plant uses will also affect adversely on aquatic organisms. Moreover, quality and biological composition of such water withdrawn from the river or the canal will affect raw-water intake structures, plant process structures and water treatment processes as well and should be taken into consideration too. Hence, existing conditions of surface water quality and aquatic biology at the raw-water intake site in Chao Phraya River and at the effluent receiving site in Khlong Raphiphat and its upstream and downstream have to be studied in details, so that the adverse impacts of the Project on water quality and vice versa will be reasonably assessed and mitigation measures to effectively minimize those adverse impacts will be appropriately recommended.

3.5.2 Objectives

The main objectives of the surface water quality study are as follows:

1. To determine existing water quality conditions in Chao Phraya River at the raw-water intake site and in Khlong Raphiphat.

2. To assess suitability of Chao Phraya water and Khlong Raphiphat as raw water source of power plant water supply for different using purposes.

3. To evaluate adverse effects of effluent discharge on Khlong Raphiphat water quality.

4. To recommend appropriate mitigation measures and monitoring program.

3.5.3 Study Methodology

3.5.3.1 Literature Review

Existing information, data and reports relevant to the present study on water quality were collected, reviewed and analyzed. These information, data and reports included laws and standards on pollution control in Thailand and water quality data in Chao Phraya River, 1985-1988 conducted by NEB; Water quality monitoring at the proposed raw water intake sites for the proposed project in Chao Phraya River and Khlong Raphiphat and in the proposed effluent receiving water body, Khlong Raphiphat conducted by EGAT; and water quality monitoring of effluent holding pond water and effluent receiving water in Huai Pong canal of the Rayong Combined Cycle Power Plant conducted by EGAT.

3.5.3.2 Field Investigation

In order to update the existing water quality data, an additional field investigation on surface water quality in Chao Phraya River and Khlong Raphiphat was conducted in December 1993. Sampling stations included one station at the proposed raw water intake site in Chao Phraya River and 4 stations in Khlong Raphiphat i.e. one upstream station of the project site, one station at the project site and 2 downstream stations of the project site (Figure 3.5-1).

At each sampling station, a water sample was collected from mid-depth layer and temperature, pH and conductivity were immediately measured. The collected water sample was then divided into 3 portions for further analyses at the SEATEC Chemistry Laboratory using the methods described in the Standard Methods for the Examination of Water and Wastewater (APHA, 1985). Water samples taken from Khlong Raphiphat were also analyzed for Na, K, Ca, Mg, SSP (Soluble Sodium Percentage) and RSC (Residual Sodium Carbonate) by the Division of Soil Analysis, Department of Land Development.

3.5.4 Existing Surface Water Quality

3.5.4.1 Chao Phraya River

Based on NEB water quality monitoring for Chao Phraya River from 1985 to 1988 (Figure 3.5-2) for the area from Pathumthani (Station 16) to Ayudhaya (Station 20) which covers the raw water intake site of the proposed project (Table 3.5-1 and Figure 3.5-2), the results indicated no salinity intrusion to the area with low conductivity and low concentrations of chloride. As regards to water quality indices including pH, DO, BOD, NO_3 , NH_3, phenols, cyanide and heavy metals, the results indicated that most values of those parameters were within the class 3 of the NEB surface water quality standards. In addition, the Department of Health had conducted a water quality monitoring survey in Chao Phraya River in 1990 and found low BOD values of less than 1.0 mg/l for the areas of Bang Sai, Bang Pa In and Ayudhaya (Department of Health,1991). The results comply

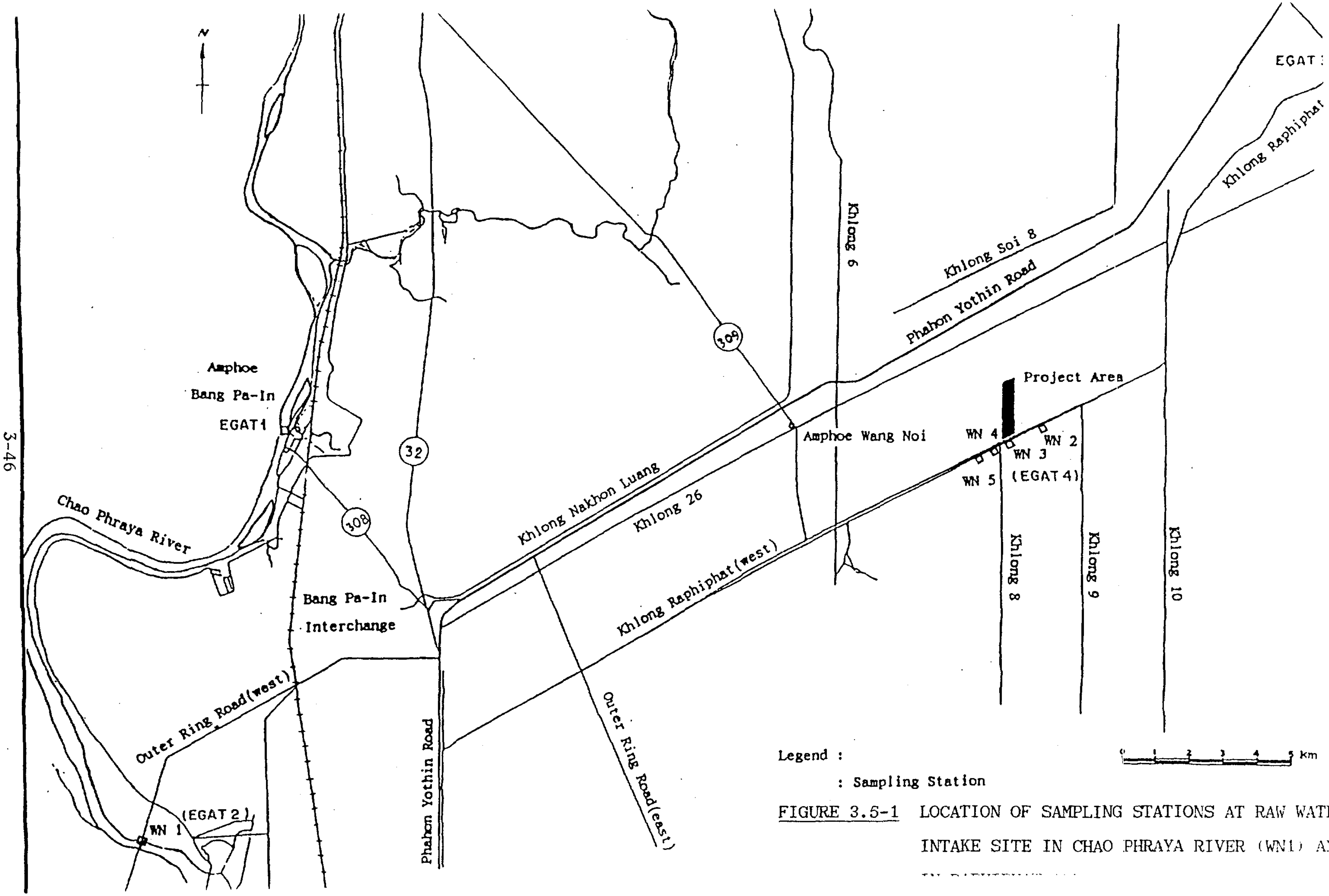


FIGURE 3.5-1 LOCATION OF SAMPLING STATIONS AT RAW WATI
INTAKE SITE IN CHAO PHRAYA RIVER (WN1) A

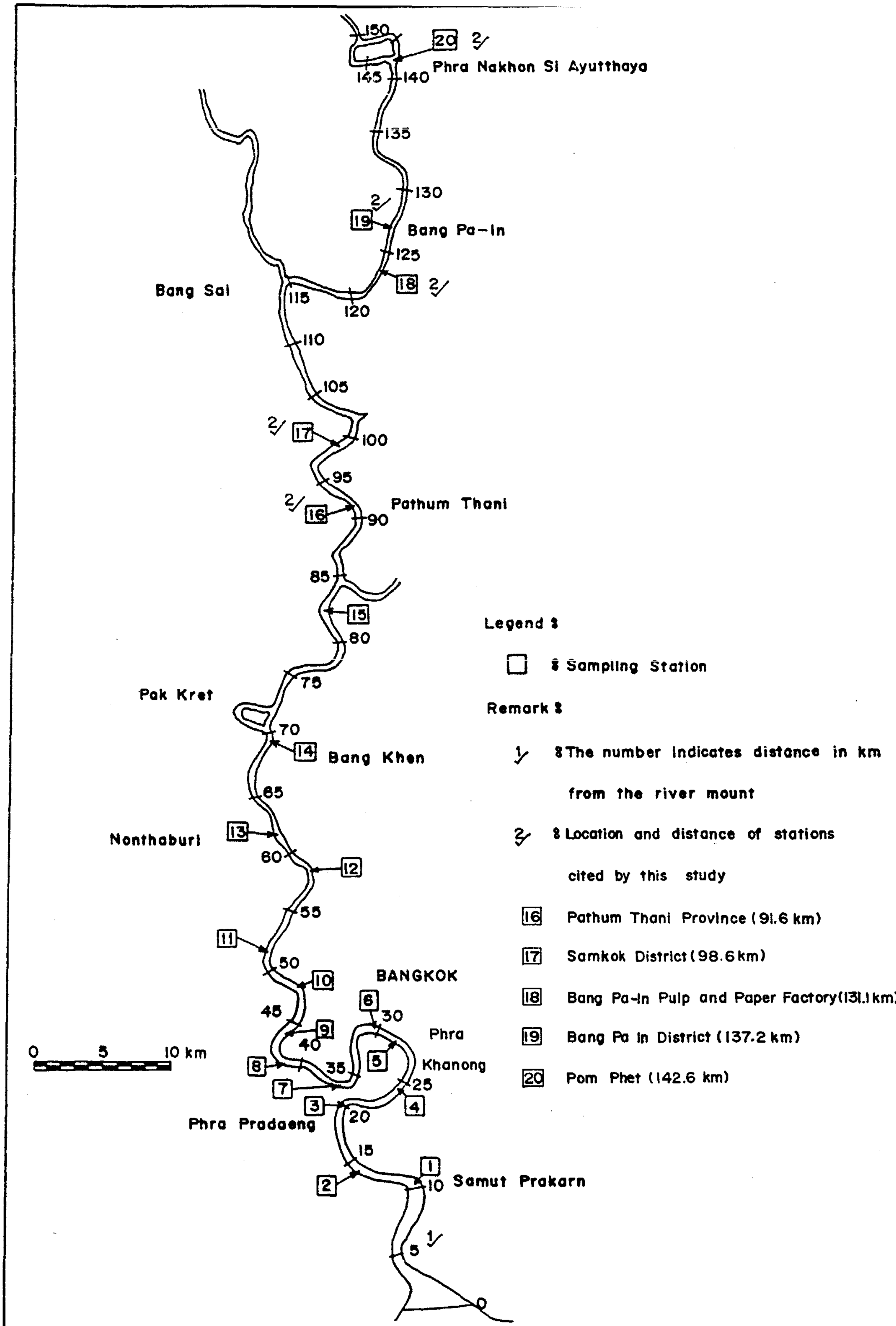


FIGURE 3.5-2 LOCATION OF NEB SAMPLING STATIONS FOR CHAO PHRAYA RIVER WATER

MEAN VALUES OF LOW TIDE WATER CHARACTERISTICS MEASURED BY NEB IN

CHAO PHRAYA RIVER FROM PATHUMTHANI TO AYADHAYA, 1985-1988[1/]

Station	16				17				18				19				20				Surface Water Quality Standards Class 3
Parameters / Year	85	86	87	88	85	86	87	88	85	86	87	88	85	86	87	88	85	86	87	88	
Air Temperature, °C	–	–	–	–	–	31.6	33.1	–	–	31.9	32.5	–	–	–	–	–	–	31.8	33.5	–	
Water Temperature, °C	29.6	–	–	–	29.7	29.6	30.5	–	30.7	29.1	30.4	–	30.7	–	–	–	31.1	29.3	30.5	–	
Conductivity, u mhos/cm	195	–	–	143	190	189	187	143	194	180	181	132	193	–	–	–	164	174	179	123	
Salinity, ppt	0	–	–	–	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	–	–	–	0.0	0.0	0.0	0.0	
Chloride, mg/l	10.9	–	–	–	11.2	10.4	10.1	14.5	13	9.2	45.8	12.7	12.4	–	–	–	7.4	9.1	45.6	13.1	
Suspended Solids, mg/l	16	–	–	53	13	48	44	59	15	42	24	57	25	–	–	–	34	36	26	114	
pH	7.4	–	–	7.5	7.3	7.7	7.2	7.5	7.4	7.5	7.3	7.5	7.5	–	–	–	7.6	7.5	7.4	7.4	5–9
Alkalinity, mg/l as CaCO3	–	–	–	94	–	73.3	65.5	90	–	75.5	63.8	82	–	–	–	–	–	76	62.5	87	
Dissoled Oxygen, mg/l	4.1	–	–	–	4.2	4.2	3.7	4.6	5	5.3	4	5	5.2	–	–	–	6.2	6	5.4	5.8	4.0
BOD, mg/l	1.4	–	–	1.3	2.1	1.7	1.6	1.5	1.8	1.4	1.5	2.8	1.4	–	–	–	1.5	1.5	1.7	1.1	2.0
COD, mg/l	12.1	–	–	12.5	16.2	13.5	12.1	12.5	13.6	12.2	12.4	18.8	10.5	–	–	–	16.4	8.8	16.4	12.7	
TOC, mg/l	–	–	–	9.63	–	5	6.93	11.73	–	4	6.25	9.43	–	–	–	–	–	3.91	6.48	9.78	
NO2–N, mg/l	0.004	–	–	–	0.004	0.01	0.00	0.00	0.006	0.01	0	0.01	0.005	–	–	–	0.002	0.00	0.00	0.00	
NO3–N, mg/l	0.172	–	–	0.24	0.165	0.18	0.16	0.03	0.185	0.26	0.11	0.19	0.134	–	–	–	0.108	0.15	0.09	0.19	5.0
NH3–N, mg/l	0.06	–	–	1.71	0.23	0.2	0.04	1.54	0.18	0.14	0.06	1.82	0.05	–	–	–	0.46	0.19	0.04	1.13	0.3
Kjeldahl–N, mg/l	3.2	–	–	–	4.3	1.65	0.5	0.70	6.4	0.64	0.4	0.32	4.5	–	–	–	4	1.53	1.1	0.87	
Total–P, mg/l	0.139	–	–	0.01	0.100	0.01	0.03	0.09	0.092	0.04	0.08	0.04	0.108	–	–	–	0.063	0.04	0.02	0.05	
Total Coliform, MPN/100 ml	18,900	–	–	4,800	6,900	3,125	2,325	6,650	9,900	12,975	10,900	14,955	14,900	–	–	–	23,800	7,975	33,250	9,500	20,000
Faecal Coliform, MPN/100 ml	–	–	–	–	–	2,150	1,125	1,400	–	2,000	5,075	8,300	–	–	–	–	–	2,000	8,433	2,967	4,000
Phenols, ug/l	–	–	–	–	1	0.05	0.0	0.0	–	0.0	0.0	0.0	1	–	–	–	–	1.4	0.0	0.0	5.0
Cyanide, ug/l	–	–	–	–	–	0.0	0.0	0.0	–	0.0	0.0	0.0	54.17	–	–	–	–	0.0	0.0	0.0	5
Zn, ug/l.	–	–	–	27.0	15.54	–	–	31	–	–	–	24	54.17	–	–	–	67.43	–	–	25.0	1,000
Cd, ug/l	–	–	–	0.59	0.5	–	–	0.22	–	–	–	0.17	0.15	–	–	–	0.18	–	–	0.1	5.0
Mn, ug/l	–	–	–	101.0	33.8	–	–	88	–	–	–	156	46.55	–	–	–	61.33	–	–	72	1,000
Hg, ug/l	–	–	–	0.15	–	–	–	0.28	–	–	–	0.08	–	–	–	–	–	–	–	0.56	2
Cr, ug/l	–	–	–	6.8	–	–	–	6.7	–	–	–	9.8	–	–	–	–	–	–	–	9.4	50
Ni, ug/l	–	–	–	1.0	–	–	–	2.2	–	–	–	6.9	–	–	–	–	–	–	–	3.9	100
Cu, ug/l	–	–	–	2.5	–	–	–	3	–	–	–	8.4	–	–	–	–	–	–	–	12	100
Pb, ug/l	–	–	–	3.6	–	–	–	2.2	–	–	–	3.2	–	–	–	–	–	–	–	3.1	50

Remark: [1/] NEB (1989)

F:T35–1.WK1/37–B–0043

with class 3 of the standard of water classification for Chao Phraya River notified by the NEB in 1986 (NEB, 1989). For faecal and total coliforms, however many values found in the area were higher than the standards of class 3, particularly in the Bang Pa In and Ayudhaya areas (Table 3.5-1). In 1990, the Department of Health found that the values of faecal and total coliforms in Muang and Sam Khok districts of Pathumthani were also higher than the standards of class 3. The water classification of class 3 means medium clean fresh surface water resources using for: 1) consumption but have to pass through an ordinary treatment process before
uses and 2) agriculture and class 4 means fairly clean fresh surface water resources using for : 1) consumption but require special water treatment process before uses, 2) industry, and 3) other activities (NEB, 1989).

3.5.4.2 Sites of Raw Water Intake

Water quality investigations at the Bang Sai raw water intake site and the Khlong Raphiphat raw water intake site at Nong Khae had been carried out by EGAT in November 1993 and this study in December 1993 and by EGAT in January 1994, respectively. Results of the investigations as shown in Table 3.5-2 illustrated that water quality indices found at the raw water intake sites were relatively within the standards of class 3 of the NEB surface water quality standards (Table 3.5-3). However, BOD value found at Khlong Raphiphat raw water intake site at Nong Khae was considerably high with the BOD value of 31 mg/l but values of total and faecal coliforms were relatively low. It is also noted that no salinity intrusion into the intake site with low concentration of chloride. The water quality is therefore suitable for different using purposes including make-up water for condenser cooling towers, service water such as auxilliary equipment cooling water and fire fighting water, domestic use water (potable water) and demineralized water make-up for steam cycle. However, water treatment to meet quality requirement is needed. Water treatment systems for different using purposes are expressed in Chapter 2.

3.5.4.3 Khlong Raphiphat

Water quality investigations in Khlong Raphiphat had been conducted by EGAT in November 1993 and by this study in December 1993. Besides BOD values, water quality in Khlong Raphiphat is classified to be class 3 of the NEB surface water quality standards (Tables 3.5-2 and 3.5-3). For BOD, the values found in all stations are higher than the standard of class 3 and some of them are higher than the standard of class 4. As regards to water quality criteria for aquaculture, the Khlong Raphiphat water quality is relatively suitable for aquaculture practices (Table 3.5-3). However, the calcium concentration is relatively low as compared with the criterion, while the concentrations of ammonia and suspended solids are relatively high. For irrigation purpose, SSP (Soluble Sodium Percentage), SAR (Sodium Absorption Ratio) and RSC (Residual Sodium Carbonate) had been analyzed as shown in Table 3.5-2. The determined values of 29-31% SSP, 0.6-0.7 SAR and 0.8-0.9 meq/l RSC are in the safe levels for irrigation. In order to avoid deleterious effects of irrigation water on soil, Mc Kee and Wolf (1976) recommended that the values of SSP, SAR and RSC should be not more than 50-60%, 10 and 1.25 meq/l, respectively. In addition, Mc Kee and Wolf had also

TABLE 3.5-2
WATER CHARACTERISTICS IN CHAO PHRAYA RIVER AND RAPHIPHAT IRRIGATION CANAL

Parameters	Chao Phraya River						Raphiphat Irrigation Canal				
	Bang Pa-In				Bang Sai						
	SEATEC 1	SEATEC 2	SEATEC 3	EGAT 2 2/	EGAT 3	WN 1 *	EGAT **	WN 2	WN 3 **	WN 4	WN 5
Air Temperature, °C				33	33	29.0	33	29.0	28.0	29.0	29.0
Water Temperature, °C	32.0	32.5	32.0	30.7	29.4	28.0	30.6	28.0	27.0	28.0	28.0
pH	7.6	7.7	7.6	7.0	7.0	7.6	7.5	7.7	7.6	7.6	7.6
Conductivity, µmho/cm	–	–	–	280	260	286.9	250	240.6	240.6	240.6	240.6
Turbidity, NTU	–	–	–	18	140 3/	37	30	57	57	67	55
Suspended Solids, mg/l	–	–	–	152	223 3/	34.4	137	61.8	39.2	26.2	30.9
Dissolved Solids, mg/l	–	–	–	50	180	146	71	116	132	142	120
Total Alkalinity, mg/l as Ca CO3	–	–	–	94	78	108.8	86	87.8	89.3	86.9	87.8
Total Hardness, mg/l as Ca CO3	–	–	–	94	78	95.2	94	59.7	58.8	56.8	71.1
Carbon Dioxide, mg/l	–	–	–	4	5	–	9.5	–	–	–	–
Dissolved Oxygen, mg/l	4.8	4.9	4.9	4.9	7.3	4.4	4	5.9	5.2	5.4	4.6
BOD, mg/l	1.4	0.6	1.1	1.7	1.1	2.4	2.6	2.3	4.8	5.3	3.3
Nitrite (NO2-N), mg/l	–	–	–	0.01	0.02	–	0.01	–	–	–	–
Nitrate (NO3-N), mg/l	0.15	0.16	0.17	0.86	0.48	0.2	1	0.1	0.1	0.1	0.1
Ammonia (NH3-N), mg/l	nd 4/	nd	nd	0.37	0.2	–	0.5	–	–	–	–
Phosphate (PO4-P), mg/l	–	–	–	5.4	0.85	2.2	1.4	0.2	3.4	5.6	3.3
Sulfate (SO4), mg/l	–	–	–	16.5	19.6	–	14.3	–	–	–	–
Chloride (Cl), mg/l	–	–	–	–	–	8.8	–	7.4	6.4	5.6	6.4
Sodium, mg/l	–	–	–	–	–	–	–	10.3	10.8	10.6	11.4
Potassium, mg/l	–	–	–	–	–	–	–	3.1	3	3	3.2
Calcium mg/l	–	–	–	–	–	–	–	15.9	15.7	15.2	15.5
Magnesium, mg/l	–	–	–	–	–	–	–	8.8	3.9	3.9	–
Iron (Fe), mg/l	–	–	–	0.94	1.5	–	1.5	–	–	–	–
Lead (Pb), mg/l	nd	nd	nd	–	–	–	–	–	–	–	–
Chromium (Cr), mg/l	nd	nd	nd	–	–	–	–	–	–	–	–
Cadmium (Cd), mg/l	–	–	–	tr 5/	tr	–	tr	–	–	–	–
Zinc (Zn), mg/l	–	–	–	tr	tr	–	tr	–	–	–	–
Copper (Cu), mg/l	–	–	–	tr	tr	–	tr	–	–	–	–
Nickel (Ni), mg/l	–	–	–	tr	tr	–	tr	–	–	–	–
Manganese (Mn), mg/l	–	–	–	0.2	1.1	–	0.4	–	–	–	–
Mercury (Hg), mg/l	<0.001	<0.001	<0.001	–	–	–	–	–	–	–	–
DDT, ug/l	0.043	0.038	0.008	–	–	–	–	–	–	–	–
Dieldrin, ug/l	–	0.084	0.311	–	–	–	–	–	–	–	–
Endrin, ug/l	–	0.005	0.022	–	–	–	–	–	–	–	–
Total Coliform, MPN/100 ml	1,100	>2,400	1,100	9,000	500	–	1,400	–	–	–	–
Faecal Coliform, MPN/100 ml	210	210	150	1600	300	–	80	–	–	–	–
Greases and Oils, mg/l	–	–	–	–	–	2.5	–	1.5	nd	nd	1.5
SSP, %	–	–	–	–	–	–	–	28.85	29.81	30.25	30.91
SAR	–	–	–	–	–	–	–	0.6	0.63	0.63	0.67
RSC, mg/l	–	–	–	–	–	–	–	0.84	0.87	0.91	0.85

Remarks
- * Raw water intake site at Bang Sai
- ** Wastewater receiving site in front of the Project Site
- 1/ SEATEC (1991)
- 2/ EGAT (2536)
- 3/ High value due to bridge construction
- 4/ Not-detectable
- 5/ Trace

SUMMARY OF WATER QUALITY IN CHAO PHRAYA RIVER AND KHLONG

RAPHIPHAT AND WATER QUALITY CRITERIA AND STANDARDS

Parameters	Chao Phraya River		Khlong Raphiphat	Water Quality Standards/Criteria									
				Surface Water 1/		Aquaculture 4/		Fisheries 5/	Irrigation Water Supply 6/			Public Water Supply 7/	
	Bang Pa–In	Bang Sai		Class 3	Class 4	USEPA	Suggested Level	Enhancement	No Problem	Moderate Problem	Significant Problem	Permissible Criteria	Desirable Criteria
Air Temperature, °C	33	29–33	28–33										
Water Temperature, °C	30.7–32.5	28.0–29.4	27.0–30.6	n 2/	n								
pH	7.0–7.7	7.0–7.6	7.5–7.5	5.0–9.0	5.0–9.0	6.5–9.0	6.5–9.0	6.0–9.0	6.5–8.4	–	–		
Conductivity, µ mho/cm	280	260–287	240–250						< 750	750–3,000	> 3,000		
Turbidity, NTU	18	37–140	30–67			–	< 60	< 50					
Suspended Solids, mg/l	152	34–223	26–137			–	< 25						
Dissolved Solids, mg/l	50	146–280	71–142			250	< 400					500	< 200
Total Alkalinity, mg/l as $CaCo_3$	94	78–109	86–89			20	20–200						
Total Hardness, mg/l as $CaCo_3$	94	78–95	56–94			–	< 300						
Carbon Dioxide, mg/l	4.0	5.0	9.5			–	< 2.0						
Dissolved Oxygen, mg/l	4.8–4.9	4.4–7.3	4.0–5.9	4.0	2.0	–	> 4.0					> 4.0	saturation
BOD, mg/l	0.6–1.7	1.1–2.4	2.3–5.3	2.0	4.0								
Nitrite (NO_2–N), mg/l	0.01	0.02	0.01			–	< 0.1						
Nitrate (NO_3–N), mg/l	0.15–0.86	0.20–0.48	0.1–1.0	5.0	5.0			0.3	< 5	5–30	> 30	10	absent
Ammonia (NH_3–N), mg/l	nd–0.37	0.20	0.50	0.5	0.5	0.02	< 0.02						
Phosphate (PO_4–P), mg/l	5.4	0.8–2.2	0.2–5.6					0.1	–	–	–		
Sulphate (SO_4), mg/l	16.5	19.6	14.3										
Chloride (Cl), mg/l	–	8.8	5.6–7.4						< 140	140–350	> 350		
Iron (Fe), mg/l	0.9	1.5	1.5			1.0	< 0.5		5.0			0.3	0.3
Lead (Pb), mg/l	nd	–	–	0.05	0.05	–	< 0.03	< 0.10	5.0			0.05	absent
Chromium (Cr), mg/l	nd	–	–	0.05	0.05	0.1	< 0.10	< 0.05	0.10			0.05	absent
Cadmium (Cd), mg/	tr	tr	tr	0.005, 0.05 3/	0.005, 0.05	–	0.2					0.01	absent
Zinc (Zn), mg/l	tr	tr	tr	1.0	1.0	–	< 0.03	< 0.10	2.0			5	absent
Copper (Cu), mg/l	tr	tr	tr	0.1	0.1	1.0	< 0.01	< 0.02	0.2				
Nickel (Ni), mg/l	tr	tr	tr	0.1	0.1								
Manganese (Mn), mg/l	0.2	1.1	0.4	1.0	1.0	–	< 100		0.2				
Mercury (Hg), mg/l	< 0.001	–	–	0.002	0.002	–	< 0.10	< 0.10					
DDT, mg/l	0.008–0.043	–	–	1.0	1.0							0.04	absent
Dieldrin mg/l	0.084–0.311	–	–	0.1	0.1							0.02	absent
Endrin, mg/l	0.005–0.022	–	–	none	none								
Total Coliform, MPN/100 ml	1,100–9,000	500	1,400	20,000	–								
Faecal Coliform, MPN/100 ml	150–1,600	300	80	4,000	–							2,000	< 20

Remarks

1/ NEB (1989)

2/ Naturally but changing not more than 3°C

3/ 0.005 and 0.05 mg/l for water with hardness not more than 100 mg/l and more than 100 mg/l respectively

4/ Aquacauture Engineering (1985) 4 : 137–138

5/ Committee on Water Quality Criteria (1972), cited by Team and Pal Consultant (1990)
Mackenthum (1969), cited by Team and Pal Consultant (1990)

6/ RID (1978), cited by Team and Pal Consultant (1990)

7/ [illegible]

classified irrigation water into 3 classes, class I : excellent to good or suitable under most conditions; Class II : good to injurious or harmful to some plants under certain conditions, and Class III : injurious to unsatisfactory or harmful to most plants under most conditions. The characteristic of water, which had been accepted as sufficient to determine its suitability for irrigation, are (a) the total concentration of salts, expressed as mg/l or the specific electrical conductivity in micromhos per centimeter, (b) the percentage of sodium which is equal to (Na x 100) / (Na + Ca + Mg + K) when the bases are expressed as milliequivalents per litre, and (c) boron, chloride, and sulfate concentrations. In addition, the Royal Irrigation Department has classified irrigation water into 4 classes, class I excellent, suitable for most plants under most conditions; Class II good to injurious, probably harmful to the most sensitive crops; Class III injurious for almost plant except some which have good tolerance; and Class IV unsuitable for most plants under most conditions. Criteria of irrigation water classification and current characteristics of Khlong Raphiphat water are summarized in Tables 3.5-4 and 3.5-5. Based on the irrigation water classification criteria, Khlong Raphiphat water is classified to be class I which is suitable to plants under most conditions.

TABLE 3.5-4
CLASSIFICATIONS OF IRRIGATION WATERS BY MC KEE AND WOLF (1974) AND CURRENT CHARACTERISTICS OF KHLONG RAPHIPHAT WATER

Water Class	% Na	Boron mg/l	Chloride meq/l	Sulfate meq/l	Specific Conductivity umho/cm	Total Salts mg/l
I	<30-60	<0.5	<2-5.5	<4-10	500-1,000	700
II	30-75	0.5-2.0	2-16	4-20	500-3,000	350-2,100
III	>70-75	>2.0	>6-16	>12-20	>2,500-3,000	>1,750-2,100
Khlong Raphiphat Water	29-31	-	0.16-0.18	0.30	240-250	71-142

TABLE 3.5-5

CLASSIFICATION OF IRRIGATION WATERS BY THE ROYAL IRRIGATION DEPARTMENT AND CURRENT CHARACTERISTICS OF KHLONG RAPHIPHAT WATER

Water Class	Specific Conductivity umho/cm	SAR	SSP	RSC
I	0-250	0-10	0-40	<<1.25
II	250-750	10-18	40-60	<1.25
III	750-2,250	18-26	60-80	1.25-2.50
IV	Over 2,250	Over 26	Over 80	Over 2.50
Khlong Raphiphat Water	240-250	0.6-0.7	28.8-30.9	0.8-0.9

3.6 GROUNDWATER HYDROLOGY AND QUALITY

3.6.1 Introduction

Since it is planned that groundwater will be withdrawn to supply for domestic purposes in the Power Plant during both construction and operation periods, the study on groundwater source is essential to determine availability and sufficiency of groundwater source and appropriateness of quality.

3.6.2 Objectives and Study Methodology

The objectives of the study are as follows:

(1) To study general hydrological conditions of groundwater in the study area.

(2) To study quality of groundwater in the study area from Department of Mineral Resources (DMR) records.

(3) To investigate existing conditions of groundwater quality in the vicinity of the project site.

(4) To evaluate impacts to groundwater quality and quantity due to project establishment.

The study on groundwater hydrology and quality is carried out according to the following steps:

(1) Collection of information on groundwater hydrology and quality in the study area from DMR records and relevant reports as background information.

(2) Field study on quality of groundwater in the study area.

(3) Evaluation of impacts to groundwater quality and quantity due to project establishment.

(4) Recommendation on mitigation measures and monitoring programs for groundwater hydrology and quality during project construction and operation.

3.6.3 Hydrogeological Background

According to the Hydrogeologic Map issued by Department of Mineral Resources (DMR) as shown in Figure 3.6-1, the project area is located within the zone of multiple aquifers of the Lower Central Plain (Upper Tertiary to Post-Pleistocene). The aquifers are fluviatile, deltaic and marine sediments which consisted of elasic sediments accumulated in the fault/flexture depression as deep as 2,000 m. ~~The groundwater system is concealed~~ under the Bangkok marine clay and is made up of multiple ~~aquifers formed~~ by alternating layers of sands or gravels and clays. To the depth of about 400 m. in Ayudhaya, 6 principal artesian aquifers have been distinguished according to their hydrogeo-electrical properties as follows:

(1) Bangkok Aquifer or 50 m zone,
(2) Phra Pradaeng Aquifer or 100 m zone,
(3) Nakhon Luang Aquifer or 150 m zone,
(4) Nonthaburi Aquifer or 200 m zone,
(5) Sam Khok Aquifer or 300 m zone,
(6) Phaya Thai Aquifer or 350 m zone.

Figure 3.6-2 portrays the profile of these aquifers in the north-south direction. All aquifers have similar water-bearing ~~characteristics and are~~ relatively very permeable. The groundwater flow within these aquifers is generally from the north to the south direction and with an approximate flow rate of 4 cm/year. Most of deep wells withdraw groundwater from the Phra Pradaeng and Nakhon Luang Aquifers at the depths of 100-150 m. The thickness of each layer of aquifers varies from 10-40 m. The static water level is about 5-12 m below the ground surface. The yield of a deep well generally varies from 40-200 gpm or 9-45 cu.m./h. However, a high pumping rate upto 440 gpm or 100 cu.m./h. may be obtained at some deep wells. The quality of well water was certified by DMR to fit for most consumptive use.

Figure 3.6-3 shows the soil layers found in the bored logs of some deep wells drilled around the vicinity of the project area. Table 3.6-1 provides some data on the well performance of selected deep wells. According to the obtained data, it was found that most of deep wells within this vicinity withdraw groundwater from the aquifer unit at the depth about 300-400 ft. or 90-120 m below the ground surface. The water quality was generally good. However, the maximum well yields (estimated values) vary largely from 20 to 500 gpm. or from 72 to 1,800 cu.m./day based on 16 hour pumping per day.

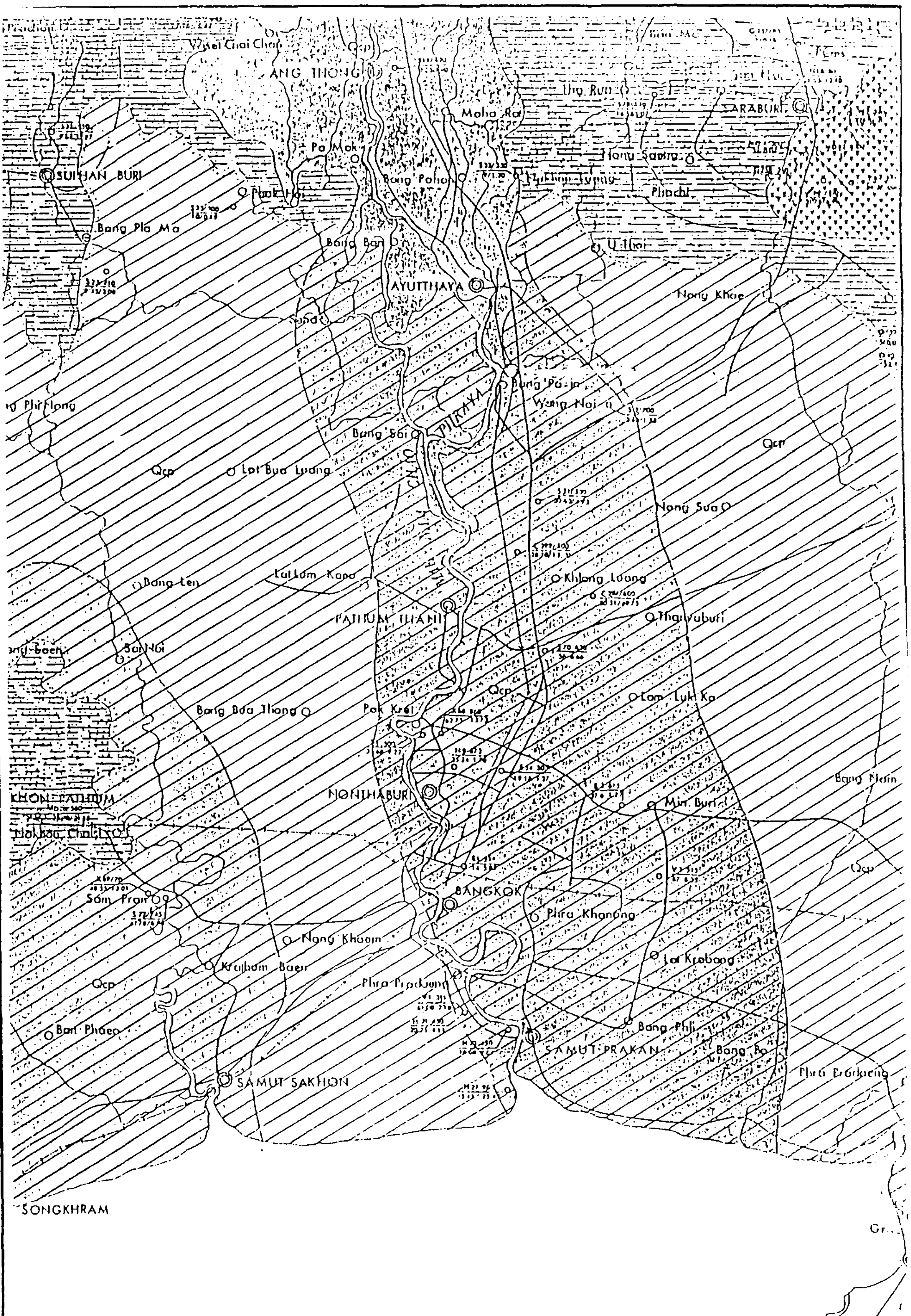


FIGURE 3.6-1 HYDROGEOLOGIC MAP OF LOWER CENTRAL PLAIN

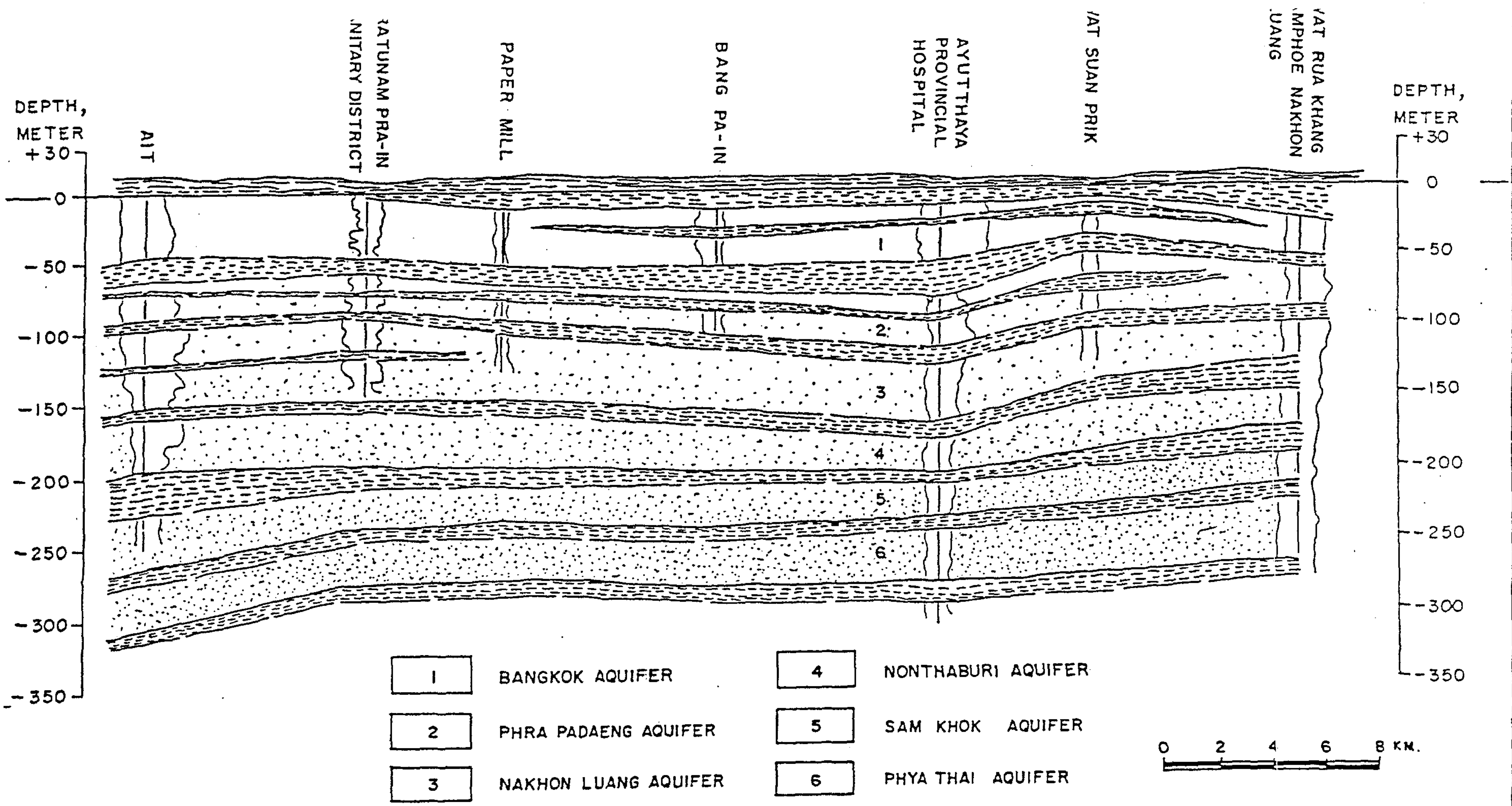


FIGURE 3.6-2 PROFILE OF AQUIFERS AT AYUDHAYA IN NORTH-SOUTH DIRECTION

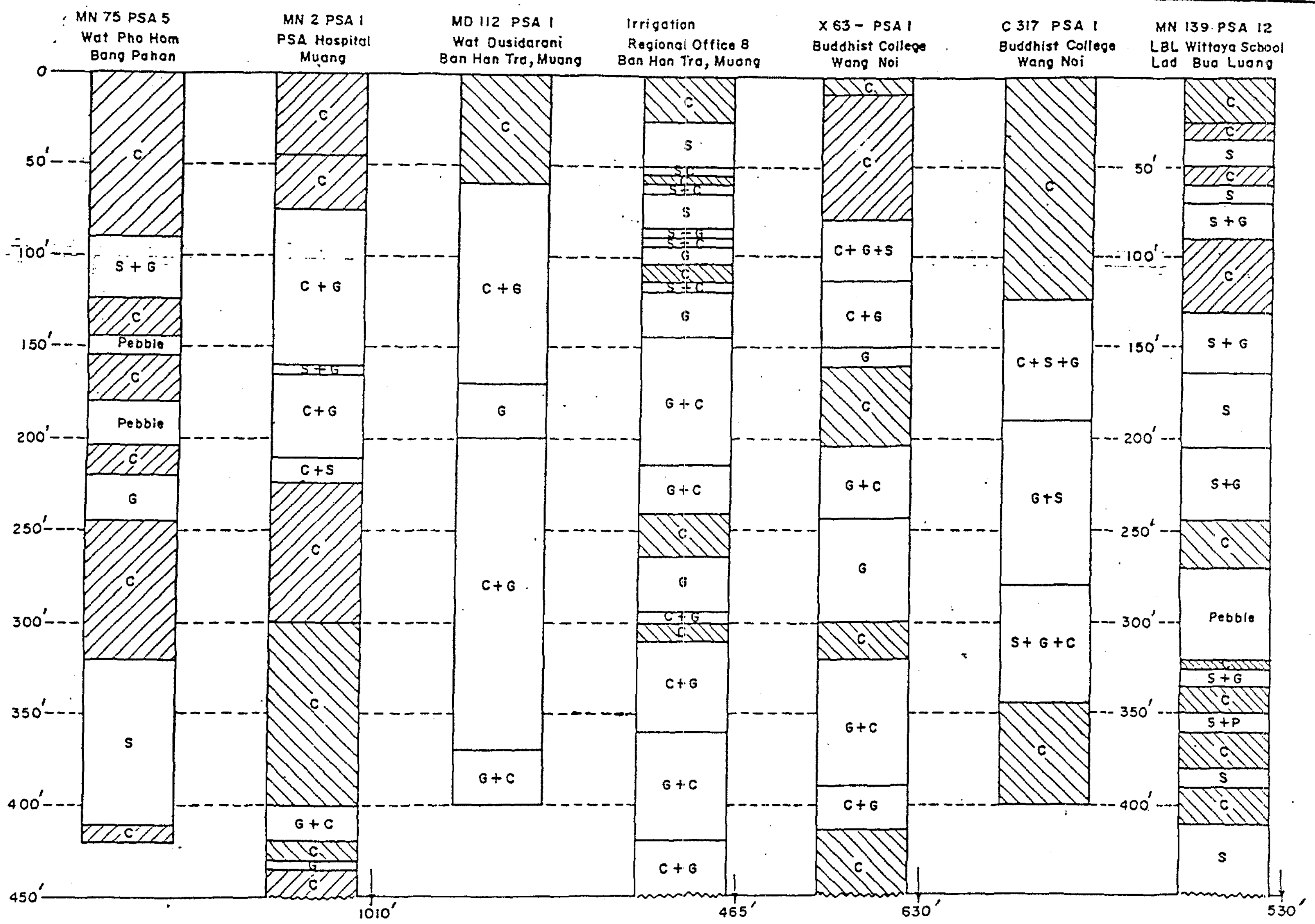


FIGURE 3.6-3 BORED LOGS OF EXISTING DEEP WELL IN STUDY AREA

<u>TABLE 3.6-1</u> LIST OF EXISTING DEEP WELLS IN STUDY AREA

Well No.	Date	Well Location Amphoe, Changwat	Drilled Depth m.	Well Size Depth m.	Well Size Dia. in	Aquifer Unit Depth m.	Aquifer Unit Type ppm	Pumping Test Q m^3/hr	Pumping Test SWL m.	Pumping Test Drawdom	Expected Max. Yield gpm	Expected Max. Yield m^3/day	Water Quality pH	Water Quality Iron	Water Quality Chloride ppm	Water Quality TDS ppm	Water Quality Hardness $CaCO_3$ ppm
C326PSA2	4/76	Wat Bot Maha Rat, PSA	113	73	6	64-70	G-C	44.2	2.65	2.64	-	-	-	-	-	-	-
MN3PSA2	1/79	Wat Rua Khaeng Nakhon Luang, PSA	294	149	8	114-158	S	57.2	7.48	5.70	500	1,800	7.5	0.20	7.2	537	135
MN4PSA3	1/79	Amphoe Pa Chi Hospital Pa Chi, PSA	137	78	6	73-76	C-S	6.6	4.80	29.27	50	180	7.80	0.45	32	537	124
DMR33PSA1	3/81	Wat Kai, Han Sang Bang Pahan, PSA	95	95	5	85-94	Pebble-C	11.9	5.94	2.09	120	432	7.70	0.17	39	484	155
P.1027	7/81	Irrigation Regional Office 8 Ban Han Tra, Muang, PSA	142	137	8	110-128	G	90.2	9.65	3.71	400	1,440	7.90	0.89	13	536	107
MD112PSA1	6/77	Wat Dusitaram, Ban Han Tra Muang, PSA	122	122	4	113-122	G	7.4	7.21	2.57	20	72	-	-	-	-	-
MN2PSA1	12/78	PAS Hospital Muang, PSA	303	123	8	111-117	C-G	113.2	7.80	20.57	500	1,800	7.50	0.3	9	462	90
-	7/78	Phra. In Racha Water Work Bang Pa-In, Ayutthaya	152	152	6	134-146	N/A	44.2	17.71	1.77	-	-	-	-	-	-	-
C317PSA1	4/75	WN Buddhist Training College Wang Noi, PSA	168	129	4	85-105	S-G-C	11.2	1.52	13.72	30	108	7.80	0	485	1,164	430
X63PSA1	7/73	Maha Mongkut Rat Witthayalai Wang Noi, PSA	192	79	6	76-79	N/A	47.5	0.91	5.18	-	-	7.20	0.22	1,850	3,949	1,770
MW74PSA1	1/81	Ban Sai HMG Training Center Bang Sai, PSA	242	229	6	189-225	C-G	4.39	14.29	2.94	220	792	7.80	0.66	92	566	86
C296PT6	10/72	Thai-German Training Center Muang, Pathum Thani	61	49	6	33-56	S-G-P	22.5	6.86	-	-	-	7.20	3.7	6,635	13,095	3,180
C297PT7	12/72	Buddhist Doctrinal Practice Center Khlong Luang, Pathum Thani	183 (after 5 drilled holes upto 150 m deep	155	6	146-152	C-G	10.2	15.40	0.91	-	-	7.60	1.1	14	506	90
C299PT8	2/73	Teacher Training College Khlong Luang, Pathum Thani	152	121	6	108-120	G-S	61.6	8.75	6.78	-	-	8.30	0.16	1	438	69

Beside the utilization of groundwater via deep wells, shallow wells of 3-5 m. deep is also a common source of water for household uses at those rural communities with some distance away from Chao Phraya River. Especially during the dry season, the shallow well becomes the only source of water because the vicinity areas of the Project are dry and no flow is available in the irrigation/drainage canals. The water level during the dry season normally varies from 1 to 3 m. below the ground surface and depends on the well location.

3.6.4 Groundwater Quality in Project Area

According to Table 3.6-2, quality of groundwater from Well No. C317PSA1 and X63PSA1 when compared with standards of groundwater for drinking purpose, is acceptable for pH and iron content. However, concentration of chloride and hardness of water from Well No. C317PSA1 exceeds the suitable allowance but still falling within the maximum allowance while that from Well No. X63PSA1 exceeds even the maximum allowance.

In order to obtain the most up-to-date data of groundwater quality in the study area, EGAT collected groundwater samples from 3 existing wells in the vicinity areas of the Power Plant on April 28, 1993. In addition, during the course of study, the study team collected groundwater samples from 2 existing wells on December 17, 1993 in conformity to those collected by EGAT.

The samples collected by the study team were analysed by the laboratory of SEATEC by the procedures given in "Standard Methods for Examination of Water and Wastewater".

The analytical results of groundwater quality are summarized in Table 3.6-3 together with the results from EGAT's sampling and standards of groundwater for drinking purpose.

The result of the study can be presented according to the standards as follows:

pH:

pH of groundwater from the 3 wells falls within the suitable level.

Turbidity:

Turbidity of groundwater from Ban K. Apinant and Wat Sawang Arom is within the suitable level but that from Wat Lam Phraya is even higher than the maximum level.

Total Solids:

Total solids of groundwater from Wat Sawang Arom and Ban K. Apinant are within the suitable level. However, total solids of groundwater from Wat Lam Phraya are much higher than the maximum level.

TABLE 3.6–2
QUALITY OF GROUNDWATER AS SURVEYED BY DMR

Parameters	Well No.		Standards of Groundwater for Drinking Purpose	
	C317PSA 1	X63PSA 1	Suitable	Maximum
pH	7.8	7.2	7.0–8.5	6.5–9.2
Fe, mg/l	nil	0.22	0.5	1.0
Cl, mg/l	485	1,850	200	600
TDS, mg/l	1,164	3,949	–	–
Hardness mg/l $CaCO_3$	430	1,770	300	500

Remarks: Locations of Wells

1. C317PSA 1 : Wang Noi Buddhist Training College
2. X63PSA 1 : Maha Mongkut Rat Witthayalai

Source: DMR

TABLE 3.6–3
QUALITY OF GROUNDWATER IN STUDY AREA

Parameter	Ban K. Apinant	Wat Lam Phraya		Wat Sawang Arom		Standards of Groundwater for Drinking Purpose 3/	
	1/	1/	2/	1/	2/	Suitable	Maximum
pH	7.1	7.2	7.2	7.7	7.7	7.0–8.5	6.5–9.2
Conductivity (umho/cm)	1,300	4,500	–	750	–	–	–
Turbidity (NTU)	4.8	24	24	1.2	3.5	5	20
TS (mg/l)	737	4,150	–	516	–	750	1,500
DS (mg/l)	–	3,921	3,230	–	564	–	–
SS (mg/l)	–	229	28.5	–	2.4	–	–
Alkalinity (mg/l CaCO3)	236	128	132.3	304	327.6	–	–
Hardness (mg/l CaCO3)	312	1,420	na	140	160	300	500
Ca (mg/l)	234	1,100	–	124	–	–	–
Mg (mg/l)	78	320	–	16	–	–	–
Fe (mg/l)	0.75	1.5	0.3	0.19	0.4	0.5	1.0
Mn (mg/l)	0.11	1.6	nd	0.04	nd	0.3	0.5
Cl (mg/l)	300	1450	1413.5	55	58.5	200	600
Sulfate (mg/l)	26.3	25.7	–	32.3	–	200	250
Nitrate (mg/l)	–	–	8.7	–	8	45	45

REMARKS: 1/ Samples collected by EGAT on Apirl 28, 1993

2/ Samples collected by study team on December 17, 1993

3/ Notification of the Ministry of Industry, No. 4.B.E. 2521, issued under Groundwater Act B.E. 2520, printed in the Royal Government Gazette, Vol. 95, Part 66, dated June 27 B.E. 2521 (1978)

4/ na = not available

5/ nd = non–detectable

Hardness:

Hardness of groundwater from Wat Sawang Arom is within the suitable level while that from Ban K. Apinant slightly exceeds the suitable level but still within the maximum level. However, hardness of groundwater from Wat Lam Phraya is very much higher than the maximum level.

Iron:

Groundwater from Wat Lam Phraya and Wat Sawang Arom contains iron concentration within the suitable level. However, result of EGAT's iron analysis of groundwater from Wat Lam Phraya shows that iron content exceeds the maximum level. Iron content of groundwater from Ban K. Apinant falls between the suitable and maximum levels.

Manganese:

Groundwater from the 3 wells contains manganese in the level conforming to the suitable level except for an EGAT's analysis of groundwater from Wat Lam Phraya.

Chloride:

Groundwater from Wat Sawang Arom contains chloride within the suitable level but groundwater from Ban K. Apinant and Wat Lam Phraya has high chloride concentration. Chloride in groundwater from Wat Lam Phraya even exceeds the maximum level.

Sulfate:

Groundwater from the 3 wells contains sulfate in the level much lower than the suitable level.

Nitrate:

Groundwater from Wat Lam Phraya and Wat Sawang Arom has nitrate content within the suitable level.

Presently, groundwater from Ban K. Apinant and Wat Sawang Arom is withdrawn for consumption. It is found from the analysis that quality of groundwater from these 2 wells is suitable for drinking purpose. The well at Wat Lam Phraya has not been in use for several years due to its high chloride content.

3.7 SOIL RESOURCES

3.7.1 Topography and Landform

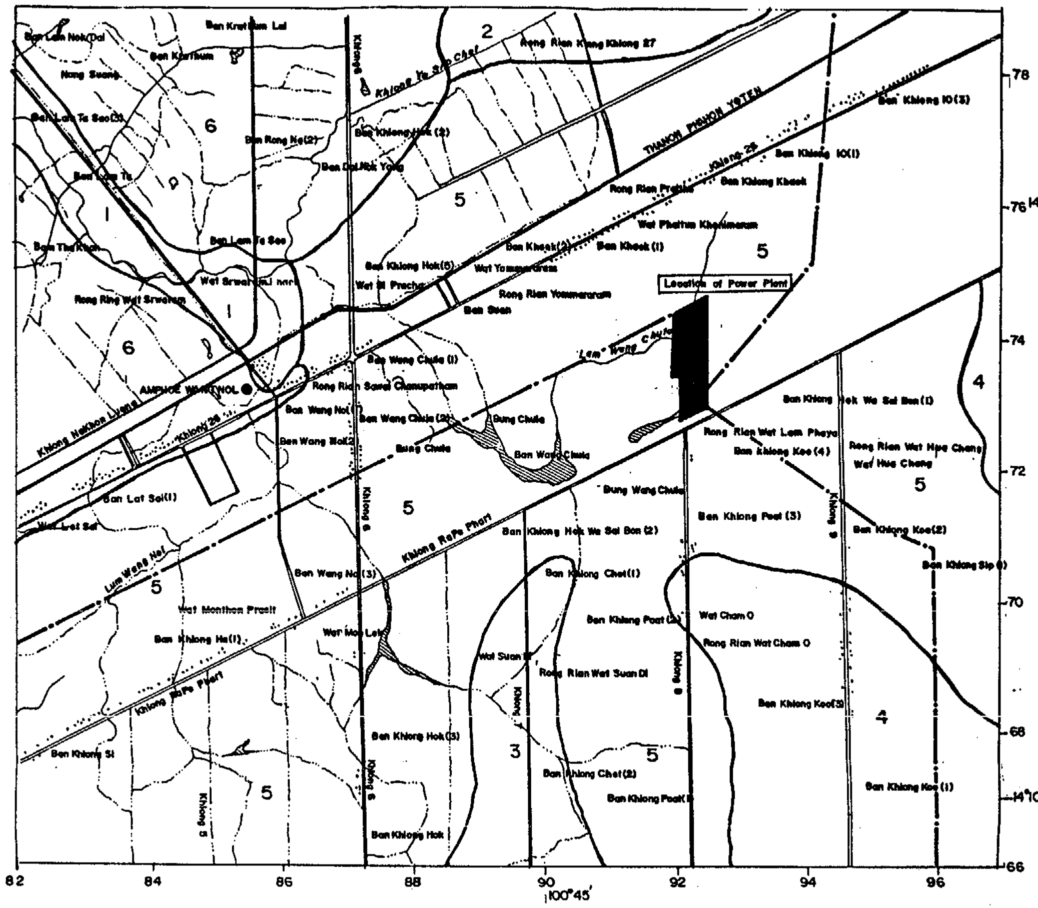
With elevation of about 2 m MSL, the general topography of the project area is flat, very gently inclined to the east (to Chao Phraya River). The slope of the surface, in general, is less than 1 percent. Geomorphologically, the area is inferred as the brackish deposit facies of the young deltaic plain (Takaya, 1987). This deposition is referred to take place during the period of the last transgression of sea level in Thailand which was about 4,000 years ago (Pramojanee et.al, 1984). The area has little microrelief. Along rivers and creeks the natural levee, if existing at all, are narrow and low. Faint remnant of tidal creeks, barely below the general level of land are observed. Since it is the lower reaches of the plain, in rainy season the area received not only in situ rainfall but also water flowing in from upstream. Because the slope gradient of the area is very gentle, the water cannot immediately drain away but accumulates steadily. By the height of rainy season most of the delta is flooded as high as 50-100 cm above the actual surface.

3.7.2 Soil Characteristic and Land Quality

Forming in the deltaic zone, therefore, properties and characteristic of the soil which, actually, derived mostly from the fluvial sediments, to certain extents, is influenced by the sea water. The sediments which are the parent material of the soil in the area were deposited under the brackish water environment. Under this circumstance, the so-called "Acid Sulphate Soil" is developed. As the definition, the Acid Sulphate Soils are the soil developed from parent material containing pyritic mud. The pyritic materials in the mud formed by the reduction of the sulphates of the seawater. Under moist aerobic condition the pyritic materials oxidizes essentially to sulphuric acid (although the actual changes are rather more complex). The acid produced reacts with soil minerals and bases. One result is the formation of basic sulphates such as <u>jarosite</u>, the basic ferric sulphate. This mineral appears as straw-yellow mottles in the transition horizon between the upper oxidized horizon and the totally reduced subsoil horizons. Due to the resemblance of this yellow mottle to cat faeces, thus, normally the term "cat clay" also applies for it.

For the soil in the area, depended on the degree of profile development and the position in the landform (the delta), at certain depth of its profile, this straw-yellow mottle is present. In the area (the area within 5 kms from power plant site) 6 soil mapping units which comprise 6 <u>soil series</u> were recognized (see attached soil map in Figure 3.7-1). All of these 6 soil series are generally known as the acid sulphate soil. Such 6 soil mapping units included: (see the legend in the soil map)

No.1 = the Ayutthaya Series
No.2 = the complex unit of Ayudhaya and Mahaphot Soil Series
No.3 = the Chachoengsao Series
No.4 = the Ongkarak Series



Legend

1 = Ayuttaya Series.

2 = Ayuttaya / Mahaphot Series Complex.

3 = Chachoengsao Series.

4 = Ongkarak Series.

5 = Rangsit Series.

6 = Sena / Rangsit Series Complex.

N

Scale 1 2 3 4 km.

Symbols

= Road

= irrigation Cannel

= Nafural Cannel

= Swamp

= Soil Boundary

= Locailon of Power Plant

= Transmission line

FIGURE 3.7-1 SOIL MAP OF STUDY AREA

No.5 = the Rangsit Series

No.6 = the complex unit of Sena and Rangsit Soil Series

The complex soil unit is a group of defined and named taxonomic soil units (in this case is the Soil Series) regularly geographically associated in a defined proportional pattern but this taxonomic member (the soil series) connot practically be separated and presented as the individual mapping unit even in the detailed soil survey. In the area there are two complex soil units, the mapping unit No.2 and No.6. Each unit is composed of two soil series. Unit No.2 is composed of Ayudhaya and Mahaphot series. The proportion of these two soil series in the unit is; Ayudhaya:Mahaphot = 60:40 percent of the total area of the mapping unit. The proportion of the Sena:Rangsit soil series in the mapping unit No.6 is also 60:40 percent.

The followings are the descriptions of properties, characteristic and quality of each soil series which is defined in terms of its suitability for agricultural and engineering purposes in the project area.

3.7.3 Properties Characteristic and Suitability of Each Soil Series in the Area.

3.7.3.1 Ayudhaya Series

a) General :

Ayudhaya soils are formed from surface layers of river alluvium which grade down to brackish water sediments. They occur in river basins in the northern part of the old tidal flats between the zone with riverine sediments and that with brackish water sediments. Relief is flat. Elevation ranges from 2 m. to 4 m. above sea level. Slopes are nearly level, less than 1%. The climate is Tropical Savannah (Koppen "Aw"). Annual precipitation ranges from 1,000 mm. to 1,400 mm.

b) Drainage and Permeability :

Poorly drained. Runoff and permeability are slow. Deep surface flooding to depths of between 80 mm. and 2 m. from river water, occurs for about five months during the rainy season. The soil remains wet for longer than five months, but the groundwater level falls to about 150 cm during the peak of the dry season and the soil cracks.

c) Vegetation and Land Use :

Mainly used for broadcast rice cultivation.

d) Characteristic Profile Features :

The Ayudhaya series is a member of the very fine, mixed, acid, isohyperthermic, Typic Tropaquepts. They are deep, strongly acid clay soils characterized by a thick dark A horizon overlying a pale, red mottled B horizon which contains jarosite mottles at some depth between 100 cm. and 150 cm. from the surface, overlying a reduced C horizon with a high sulphur content. Gypsum crystals occur in the lower A and B horizons, as do slickensides and pressure faces.

e) Range of Profile Features :

The A horizon is from 30 cm. to 50 cm. thick, has 10YR hue, values of 4 through 1 and a chroma of 1 with clay or silty clay textures. Structure is weak, medium to coarse blocky, with weak granular in the uppermost layer. Field pH values range from 4.5 to 7.0.

The B horizon has its lower boundary from 90 cm. to 160 cm. below the soil surface and has hues of 10YR or 7.5YR, values of 4 to 6 and chromas of 2 or 1. Structure is weak prismatic breaking to moderate or strong, fine blocky. Mottling colour is variable; but predominantly red in the upper B and brownish yellow and pale yellow (catclay) in the lower part, the latter appearing as coatings on pores, root channels and ped faces. Field pH values range from 4.0 to 5.0 and usually decrease with depth.

The C horizon consists of half ripe, very soft clay and has hues of 10YR to 5Y or 5GY, with values fo 4 or 5 and chromas of 1 or less. Field pH values increase with depth.

f) Suitability of Soil for Agricultural Purposes

Land Use Alternatives	Suitability Classes	Major Limitations
Paddy	Suitable	flooding
Upland crops	not suitable	flooding
Fruit trees	not suitable	flooding
Permanent pasture	not suitable	flooding

g) Suitability of Soil for Engineering Purposes

Type of Engineering Uses	Suitability Ratings	Major Limitaitons
Topsoil	poor	clayey
Sand and gravel	not suitable	-
Roadfill	poor	low supporting capacity, wetness

Degree of Limitations

Corrosivity-Uncoated Steel	very high	high total acidity, poorly drained
Corrosivity-Concrete	high	pH 5.0 or less in horizon
Irrigation and drainage	slightly	some need for drainage
Terraces and diversions	none	-
Highway and road construction	severe	low supporting capacity, wetness, flood hazard
Excavated ponds	none	-
Pond reservoir areas	none	-
Pond embankments	moderate	slope stability
Septic tanks	severe	high water table, flood hazard, slow permeability,
Light industries	severe	low loading capacity in the subsoil, high water table, flooding, high corrosivity of steel
Low building foundations	severe	high water table, flooding, low loading capacity in the subsoil.

The analytical data of certain properties of this soil are included in Appendix F.

3.7.3.2 <u>Chachoengsao Series</u>

a) General :

Chachoengsao soils are formed from brackish water sediments which overlie marine sediments and occur on former tidal flats which have not been flooded by sea water for some time. Relief is flat. Slopes are nearly flat, less than 1%. Elevation is usually about 1 m. above sea level. The climate is Tropical Savannah (Koppen "Aw"). Annual precipitation ranges from 1,000 mm. to 1,400 mm.

b) Drainage and Permeability :

Poorly drained. Runoff and permeability are slow. These soils are flooded by impocunded rainwater and river water to depths of between 30 and 40 cm. for four to five months during the wet season. Groundwater level falls below 1.5 m. during the peak of the dry season and the soils crack.

c) Vegetation and Land Use :

Mainly used for transplanted rice cultivation with broadcast rice in some places.

d) Characteristic Profile Features :

Chachoengsao series is a member of the fine, montmorillonitic, nonacid, isohyperthermic, Typic Tropaquepts. They are deep, medium acid to neutral soil characterized by a dark coloured A horizon overlying a paler coloured B horizon containing red mottles in the upper layers and brownish yellow and yellowish brown mottles in the lower layers. The B horizon overlies a reduced greenish grey marine clay which is low in sulphur. Pressure faces and slickensides are characteristic for the B horizon.

e) Range of Profile Feature :

The A horizon is from 20 to 40 cm. thick, has 10YR hue, values of 3 or less and chromas of 1 or 2 with clay or silty clay textures. Structure is weak coarse blocky and field pH values range from 4.5 to 5.5.

The B horizon has its lower boundary between 130 and 150 cm. of the soil surface and has hues of 10YR, 2.5Y or 5Y, values of 5 or 6 and chromas of 1 or 2. Structure is prismatic breaking to moderate blocky. Field pH values range from 5.0 to 8.0, increasing with depth. Few pale yellow jarosite mottles may occur in the lower B horizon.

The horizon is a reduced dark grey and greenish grey, soft clay. Shell fragments may occur very deep in the profile and field pH is usually 8.0.

f) Suitability of Soil for Agricultural Purposes

Land Use Alternatives	Suitability Classes	Major Limitations
Paddy	P-I (Highly Suitable)	-
Upland crops	P-V (Not suitable)	flooding
Fruit trees	F-V (Not suitable)	flooding
Permanent pasture	L-III (Not suitable)	flooding

g) Suitability of Soil for Engineering Purposes :

Type of Engineering Uses	Suitability Ratings	Major Limitations
Topsoil	poor	clayey
Sand and gravel	not suitable	-
Roadfill	poor	low supporting capcity, wetness

Degree of Limitations

Corrosivity-Uncoated Steel	moderate	mod. total acidity, poorly drained, high conductivity
Corrosivity-Concrete	moderate	high Na and Mg salts content
Irrigation and drainage	slightly	need for drainage
Terraces and diversions	none	-
Highway and road construction		low supporting capacity,wetness, flood hazard
Excavated ponds	none	-
Pond reservoir areas	none	-
Pond embankments	moderate	slope stability, compressibility
Septic tanks	severe	slow permeability, flood hazard, high water table

Light industries	severe	low supporting capacity, high water table.
Low building foundations	severe	low supporting capacity, high water table, flooding.

The analytical data of certain properties of this soil are included in Appendix F.

3.7.3.3 Mahaphot Series

a) General :

Mahaphot soils are formed from surface layers of river alluvium which grade down to brackish water sediments. They occur in river basins in northern part of the old tidal flats between the zone with riverine sediments and that with brackish water sediments. Relief is flat. Slopes are nearly level, less than 1%. Elevation ranges from 2 to 4 m. above sea level. Climate is Tropical Savannah (Koppen "Aw"). Mean annual precipitation ranges from 1,000 to to 1,400 mm. Mean annual temperature is 27° C.

b) Drainage and Permeability :

Poorly drained. Runoff and permeability are slow. These soils are flooded by river water to depths of 80 cm. to 2 m. for about five months during the rainy season. Groundwater level falls below 1.5 m. during the peak of the dry season.

c) Vegetation and Land Use :

Mainly used for broadcast rice cultivation.

d) Characteristic Profile Features :

Mahaphot series is a member of the very fine mixed, acid, isohyperthermic, Typic Tropaquepts. They are deep soils with extremely to very strongly acid reaction in the A and B horizon, and strongly to medium acid reaction in the C horizon. They are characterized by a very dark grey to black clay A horizon overlying a greyish brown or brown clay B horizon, which in turn overlies a reduced dark grey clay C horizon. These soils are mottled throughout with strong brown coatings in root channels and pores in the A horizon, and weak red, red and brownish yellow mottles in the B horizon. Yellow (catclay) jarosite mottles occur in the deeper subsoil, usually below 1 m. from the soil surface. Pressure faces and slickensides occur in the B horizon and the soil cracks at the surface when dry.

e) Range of Profile Features :

The A horizon is from 20 to 40 cm. thick, has 10YR hue, value of 1 or 2 and chromas of 1 or 2. Structure is weak coarse blocky and moderate crumb in the uppermost layer. Field pH values range from 4.5 to 5.5.

The B horizon has 10YR and 7.5YR hues, values of 4 or 5 and Chroma of 2. Structure is moderate medium, breaking to fine blocky, commonly arranged in weak prisms. Field pH values range from 4.0 to 4.5.

The C horizon is a dark grey or greyish brown reduced clay which may have few brown mottles in the upper layers and is half ripe. Field pH values are 4.5 rising to 6.0 or more below 2 m. from the soil surface.

f) Suitability of Soil for Agricultural Purposes :

Land Use Alternatives	Suitability Classes	Major Limitations
Paddy	suitable	acidity, flooding
Upland crops	not suitable	flooding, acidity
Fruit trees	not suitable	flooding, acidity
Permanent pasture	not suitable	flooding

g) Suitability of Soil for Engineering Purposes :

Type of Engineering Uses	Suitability Ratings	Major limitations
Topsoil	poor	clayey soil
Sand and gravel	not suitable	-
Roadfill	poor	low supporting capcity, wetness
	Degree of Limitations	
Corrosivity-Uncoated Steel	very high	high total acidity, poorly drained
Corrosivity-Concrete	high	pH 5.0 or less

Irrigation and drainage	moderate	susceptability to flooding
Terraces and diversions	-	need for drainage
Highway and road construction	severe	low supporting capacity, flood hazard, mod. shrink-swell
Excavated ponds	none to slightly	flooding
Pond reservoir areas	none to slightly	-
Pond embankments	moderate	slope stability, compressibility
Septic tanks	severe	slow permeability, high water table, flooding
Light industries	severe	low-loading capacity, high water table, flooding, very high corrosivity of uncoated steel
Low building foundations	severe	low-loading capacity, high water table, flooding, very high corrosivity of uncoated steel.

The analytical data of certain properties of this soil are included in Appendix F.

3.7.3.4 Ongkarak Series

a) General :

Ongkarak soils are formed from brackish water deposits and occur on former tidal flats. Relief is flat. Slope is less than 1%. Elevation ranges from 1 to 3 m. above sea level. The climate is Tropical Savannah (Koppen "Aw"). Mean annual precipitation is about 1,400 mm. Mean annual temperature is 27 °C.

b) Drainage and Permeability :

Poorly drained. Permeability and runoff are slow. These soils are flooded by river water to depths of 1 m. or more for six to seven months during the rainy season. Groundwater level falls below 1 m. during the peak of the dry season.

c) Vegetation and Land Use :

Mainly used for broadcast rice cultivation. Rushes and sedges occur in places where the soils are too acidic for cultivation.

d) Characteristic Profile Features :

Ongkarak series is a member of the very fine, mixed, acid, isohyperthermic, Sulfic Tropaquepts. They are deep, extremely acid soils and are characterized by a black or very dark grey clay A horizon overlying a greyish brown to brown clay B horizon, which in turn overlies a dark grey; reduced clay C horizon below approximately 150 cm. from the soil surface. The soils are mottled throughout with strong brown and yellowish red coatings along root channels in the A horizon, and prominent red, strong brown and yellow (catclay) jarosite mottles in the B horizon. Yellow jarosite mottles occur within 50 cm. of the soil surface and are diagnostic for the series. Pressure faces and slickensides occur in the B horizon and the soil cracks at the surface when dry.

e) Range of Profile Features :

The A horizon is from 10 to 25 cm. thick, has 10 YR hue, values of 2 or 3 and chroma of 1. Structure is moderate to weak, coarse blocky and crumb in places. Field pH values range from 4.0 to 4.5.

The B horizon has 10YR and 7.5YR hues, values of 4 or 5 and chroma of 2. Structure is moderate coarse, breaking to fine blocky and field pH values are usually less than 4.5.

The C horizon is clay often containing a high content of undecomposed organic material with dark grey colours and may contain few brown mottles in the upper layers. The soil is half ripe to nearly unripe and has field pH values of 4.5 rising to 6.0 or more below approximately 2 m. from the soil surface.

f) Suitability of Soil for Agricultural Purposes :

Land use Alternatives	Suitability Classes	Major Limitations
Paddy	marginally suitable	acidity, flooding
Upland crops	not suitable	flooding, acidity
Fruit trees	not suitable	flooding, (drainage)
Permanent pasture	not suitable	flooding

g) Suitability of Soil for Engineering Purposes :

Type of Engineering Uses	Suitability Ratings	Major Limitations
Topsoil	poor	clayey soils
Sand and Gravel	not suitable	-
Roadfill	poor	supporting capacity, wetness

Degree of Limitations

Corrosivity-Uncoated Steel	very high	high total acidity, poorly drained
Corrosivity-Concrete	high	pH 5.0 or less
Irrigation and drainage	moderate	susceptability to flooding, need for drainage
Terraces and diversions	-	
Highway and road construction	severe	low supporting capacity, flood hazard,
Excavated ponds	none to slightly	flooding
Pond reservoir areas	none to slightly	-
Pond embankments	moderate	slope stability
Septic tanks	severe	slow permeability, high water table, flooding
Light industries	severe	high water table, flooding, low loading capacity in the subsoil
Low building foundations	severe	high water table, flooding, low loading capacity in the subsoil

The analytical data of certain properties of this soil are included in Appendix F.

3.7.3.5 Rangsit Series

a) General :

Rangsit soils are formed from brackish water deposits and occur on former tidal flats. Relief is flat. Slopes are less than 1%. Elevation ranges from 2 to 3 m. above sea level. The climate is Tropical Savannah (Koppen 'Aw'). Mean annual precipitation is about 1,400 mm. Mean annual temperature is 27 °C.

b) Drainage and Permeability :

Poorly drained. Permeability and runoff are slow. These soils are flooded to depths of 1 m. or more by river water for four to five months during the rainy season. Groundwater level falls below 1 m. from the soil surface during the peak of the dry season.

c) Vegetation and Land Use :

Mainly used for broadcast rice cultivation.

d) Characteristic Profile Features :

Rangsit series is a member of the fine, mixed, acid, isohyperthermic, Sulfic Tropaquepts. They are deep, extremely acid soils which are characterized by a black or very dark grey clay A horizon overlying a brown, greyish brown or dark greyish brown clay B horizon, which in turn overlies a dark grey reduced clay C horizon with an upper boundary approximately 150 cm. from the soil surface. These soils are mottled throughout with yellowish brown mottles as coatings along root channels in the A horizon, and with red, yellowish red and yellow (catclay) jarosite mottles in the B horizon. The yellow jarosite mottles occur below 50 cm. and within 100 cm. of the soil surface and are diagnostic for the series. Slickensides and pressure faces occur in the B horizon and the soil cracks at the surface when dry.

e) Range of Profile Features :

The A horizon is from 20 to 40 cm. thick, has 10YR hue, values of 2 or 3 and chroma of 1. Structure is weak coarse blocky to massive and field pH values range from 4.0 to 5.0. A thin broken E horizon may be present but is not diagnostic for the series.

Septic tanks	severe	slow permeability, high water table, flooding
Light industries	severe	high water table, flooding, low loading capacity
Low building foundations	severe	high water table, flooding, low loading capacity.

For the analytical data of certain properties of this soil are included in Appendix B.

3.7.3.6 Sena Series

a) General :

Sena soils are formed from brackish water deposits and occur on the former tidal flats. Relief is flat. Slopes are less than 1%. Elevation ranges from 2 to 3 m. above sea level. The climate is Tripical Savannah (Koppen 'A'). Mean annual precipitation is about 1,400 mm. Mean annual temperature is 27°C.

b) Drainage and Permeability :

Poorly drained. Permeability and runoff are slow. These soils are flooded by river water to depths of 1 m. or more for four to five months during the rainy season. Groundwater level falls below 1 m. from the soil surface during the peak of the dry season.

c) Vegetation and Land Use :

Mainly used for broadcast rice cultivation.

d) Characteristic Profile Features :

Sena series is a member of the very fine, mixed, acid, isohyperthermic, Sulfic Tropaquepts. They are deep, strongly to medium acid over extremely acid soils. They are characterized by a very dark grey or black clay A horizon overlying a greyish brown or brown clay B horizon, which in turn overlies a reduced dark grey clay C horizon. These soils are mottled throughout with strong brown coating on root channels in the A horizon, and brownish yellow, yellow and red (mainly in the upper B) mottles in the B horizon. The presence of yellow (cat clay) jarosite mottles below 50 cm. and within 1 m. of the soil surface and gypsum crystals in the B and

The B horizon has 10YR and 7.5YR hues, values of 4 or 5 and Chroma of 2. Structure is moderate, medium prismatic breaking to blocky and pH values are 4.5 or less.

The C horizon is usually dark grey (10YR4/1 or 5Y4/1) and may contain few brown mottles in the upper part; is nearly unripe and has pH values of 4.5 rising to 6.0 below 2 m.

f) Suitability of Soil for Agricultural Purposes :

Land Use Alternatives	Suitability Classes	Major Limitations
Paddy	moderately suitable	acidity, flooding
Upland crops	not suitable	flooding, acidity
Fruit trees	not suitable	flooding, (drainage)
Permanent pasture	not suitable	flooding

g) Suitability of Soil for Engineering Purposes :

Type of Engineering Uses	Suitability Ratings	Major Limitations
Topsoil	poor	clayey soil
Sand and gravel	not suitable	-
Roadfill	poor	low supporting capacity, wetness

	Degree of Limitations	
Corrosivity-Uncoated Steel	very high	high total acidity, poorly drained
Corrosivity-Concrete	high	pH 5.0 or less
Irrigation and drainage	moderate	susceptability to flooding, need for drainage
Terraces and diversions	-	
Highway and road construction	severe	low supporting capacity, wetness, flood hazard,
Excavated ponds	none to slightly	flooding
Pond reservoir areas	none to slightly	-
Pond embankments	moderate	slope stability

lower A horizon is diagnostic for the series. Pressure faces and slickensides occur on the B horizon and the soil cracks at the surface when dry.

e) Range of Profile Features :

The A horizon is from 20 to 40 cm. thick, has 10YR hue, values of 2 or 3 and chromas of 1 or 2. Structure is weak medium and coarse blocky. Field pH values range from 4.0 to 4.5.

The B horizon has 10YR and 7.5YR hues, values of 5 and chroma of 2. Structure is weak, medium and coarse primatic, breaking to fine blocky. Field pH values range from 4.0 to 4.5.

The C horizon is half ripe to nearly and has predominantly dark grey colours with few brown mottles in the upper part. Field pH values are 4.5 rising to 6.0 or more below approximately 2 m. from the soil surface.

f) Suitability of Soil for Agricultural Purposes

Land Use Alternatives	Suitability Classes	Major Limitations
Paddy		suitable acidity, flooding
Upland crops	not suitable	flooding, acidity
Fruit trees	not suitable	flooding
Permanent pasture	not suitable	flooding

g) Suitability of Soil for Engineering Purposes

Type of Engineering Uses	Suitability Ratings	Major Limitations
Topsoil	poor	clayey soils
Sand and gravel	not suitable	-
Roadfill	poor	low supporting capacity, wetness

Degree of Limitations

Corrosivity-Uncoated Steel	very high poorly drained	high total acidity
Corrosivity-Concrete	high	pH 5.0 or less
Irrigation and drainage	slightly to moderate	susceptability to flooding, need for drainage
Terraces and diversions	-	-
Highway and road construction	severe	low supporting capacity, wetness, flood hazard
Excavated ponds	none to slightly	flooding
Pond reservoir areas	none to slightly	-
Pond embankments	moderate	slope stability
Septic tanks		severeslow permeability, high water table, flooding
Light industries	severe	high water table, flooding, low loading capacity
Low building foundations	severe	high water table, flooding, low loading capacity

The analytical data of certain properties of this soil are included in Appendix F.

3.7.4 Conclusion of Quality of Soil Resources

Quality of soil resources in the area is assessed in terms of its suitability for agricultural and engineering purposes.

For agricultural purposes four types of use for paddy, upland crop, fruit tree and permanent pasture are considered. For paddy field, the suitability of the soil varies from highly suitable to marginally suitable. The highly suitable one is the soil of Chachoengsao Series whilst the well to moderately suitable are the soil of Ayutthaya, Mahaphot, Sena and Rangsit Series. Except the Rangsit series the major limitation for the others is the flooding which is usually high and lasts rather well long in rainy season. For the Rangsit soil series other than flooding, the strongly acid reaction is also included. In this series the so-called "cat clay" which is the source of the acidity presents at rather shallow depth in the profile (about 50 cm from the soil surface: see the description of the series). Only one soil series which is considered as marginally suitable is Ongkarak soil series. The major limitations of this soil series for paddy field are both flooding and strongly acid reaction. In the profile of this soil series, the cat clay is present at very shallow depth, about 30 cm. from the soil surface (also see the description of the profile of this soil). For other agricultural uses (upland crops, fruit tree and permanent pasture), under natural circumstance, all of the soils in the area are not suitable. The major limitations are either flooding or strongly acid reaction or both. However, under irrigation system, in many locations are of the area, such limitations especially flooding, have been eliminated by ditching, and bunding up the soil surface. With such measures and other intensive managements, many areas have been used for growing fruit tree, vegetable and other cash crop. Naturally, except acidity, the soil in the area is relatively fertile. When such limitation factors as flooding and acidity have been eliminated, the good and reasonable crop yields are obtained.

For engineering purposes, the soils in the area are suitable for only certain kinds of use such as for excavated pond, pond reservoir area, irrigation and drainage network. For the other uses, there are a number of limitations such as too heavy texture, high total acidity, high to moderately shrink swell, high water table, very high corrosivity of uncoated steel, etc., (for the details of kind and degree of limitation, see the description of each soil unit).

3.8 AQUATIC BIOLOGY AND FISHERIES

3.8.1 Introduction

Generally, the water body is now receiving a lot of organic and inorganic materials from various sources. The water quality in the river varies greatly due to seasonal changes. The aquatic organisms as plankton and benthos also vary in their species composition and abundance due to the changes of water characteristics, particularly temperature and nutrient concentration. The power plant construction will more or less affect these organisms to some extent. Aquatic biology is one out of many aspects that must be studied. The data obtained from the study are useful for assessing impacts of the power plant construction and operation on aquatic communities. Recommendations on factors, i.e. plankton, benthos, and other aquatic organisms including other related aspects will be drawn out as guideline for solving problems and setting a management program of the Project in the operation phase.

3.8.2 Objectives

The objectives of the study on the aquatic biology are as followed:

(1) To collect, review and analyze information on aquatic ecology of project area and the vicinity.

(2) To conduct field sampling survey on aquatic ecology (phytoplankton, zooplankton and benthic animals) in the project area.

(3) To describe possible ecological changes and probable impacts of the Power Plant on aquatic communities.

(4) To recommend appropriate mitigation/monitoring measures.

3.8.3 Study Methodology

A field sampling program consisting of five sampling sites as the water quality sampling stations has been set up. At each sampling site, plankton organisms and benthic animals were collected. During field surveys, observation on aquatic weeds along both edges of the sampling area were conducted.

In addition, data on fisheries resources in the study area were also collected by an interview with local residents in the project area and its vicinity. Moreover, an interview with the inhabitants found fishing in Khlong Raphiphat were also made. Efforts were also made to determine fish species composition in receiving water bodies.

3.8.3.1 Sampling Stations

Samples were collected in five sampling stations (Figure 3.5-1), one station located at the proposed water intake site for cooling system and the other four sampling stations were at Khlong Raphiphat including the site of wastewater discharged from the Power Plant and its upstream and downstream. Field sampling for the existing condition was conducted on December 17, 1993.

3.8.3.2 Method of Field Data Collection

At each selected sampling station, plankton organisms and benthic invertebrates were collected by using 60 microns mesh size plankton net and 0.5 sq.ft. Ekman Dredge, respectively.

To determine plankton abundance, 30 litres of water was taken from the surface (at a depth of about 30 cm.) and then poured through the plankton net. The plankton retained in the net were transferred into a glass bottle, then preserved in 4% formalin solution for further identification and determination of abundance at the laboratory.

At each sampling site for plankton as mentioned, benthic animals were also collected from the bottom of the river. For each grab of sediment, quick observation was made of the texture of the mud including its cohesiveness and composition of the sediment (sand, gravel, debris, mud, clay, etc.). The sediment was then sorted through a series of wire sieve to separate benthic animals and the animals found were preserved in 7% formalin solution for further identification in the laboratory.

3.8.4 Existing Condition of Aquatic Organisms

3.8.4.1 Plankton Organisms

The survey of plankton organism in 1989 was conducted by National Inland Fisheries Institute in Chao Phraya River between Pak Kret, Nonthaburi and Samutprakarn. The results of study for 4 times during February to December 1989 showed the species composition and the abundant of plankton organisms. Plankton types found consisted of 33 species of phytoplankton and 23 species of zooplankton with a density of 16.18×10^3 ind/cu.m. Blue green algae was found abundantly at all sampling time with the average of 11.18×10^3 ind./cu.m. The dominate zooplankton species are the arthropod nauplii with an average density of 5.0×10^3 ind./cu.m.

Analysis of plankton samples collected from the 5 sampling stations on December 16,1993 showed low productivity of the area in terms of both plankton density and species number. As shown in Table 3.8-1, a total of 37 genera of plankton comprising 44 species were identified. They belonged to 8 phyla and the number of species in each phylum was as follows; Cyanophyta (Blue green algae), 7; Chlorophyta (green algae), 8; Bacillariophyta (Diatom), 11; Chrysophyta (yellow algae), 1; Euglenophyta (euglenoid), 1; Protozoa, 3; Rotifera, 7; and Arthropod, 4. Zooplankton of Phylum Arthropoda consist of some unidentified species which were mostly in larval form of the following groups, cyclopoid copepoda, copepoda nauplii and insect larvae.

Phytoplankton which regularly found at all stations in Khlong Raphiphat and Chao Phraya River were Amphithrix, Lyngbya, Oscillatoria, Cymbella, Gomphonema, and Gyrosigma. In comparison with plankton distribution at 4 sampling stations of Khlong Raphiphat, the distribution was rather uniform.

Number of zooplankton found in this study at Chao Phraya River was quite low. The dominant species were protozoan Centrophyxis ecornis with density of 12,000 ind./cu.m. and arthropod, cyclopoid copepod group, with the density of 24,000 ind./cu.m. Zooplankton found in Chao Phraya River in this study was 16.5% of total plankton density.

In Khlong Raphiphat which will be the wastewater receiving canal, the percentage of zooplankton were moderately high at stations 2 and 5. The results also ndicate the non uniform distribution of zooplankton. There are many factors that influence the dominance of zooplankton such as organic matter, suspended particles and water flow.

Table 3.8-2 shows densities of phytoplankton and zooplankton including their percentages at each station. Station 5 contained the highest density of 640,250 ind./cu.m, consisting of 64.5% zooplankton. The numerous zooplankton species were rotifer of genus Hexarthra and arthropod of genus Bosmina. The highest percentage of phytoplankton was found at station 4 with high density of Oscillatoria.

TABLE 3.8-1

SPECIES COMPOSITION AND ABUNDANCE OF PLANKTON ORGANISMS

Scientific Name	Station				
	1	2	3	4	5
PHYTOPLANKTON					
Phylum Cyanophyta (Blue-green algae)					
Amphithrix sp.	–	18,000	12,000	68,000	65,000
Anabaena sp.	–	–	–	2,000	2,000
Chroococcus sp.	–	–	18,000	10,000	6,500
Lyngbya sp.	18,000	6,500	31,500	18,000	2,600
Microcystis aeruqinosa Kuetzing	–	–	10,000	–	–
M. incerta Lemmermann	–	–	2,000	2,250	4,000
Oscillatoria sp.	9,000	–	31,500	234,000	52,000
Phylum Chlorophyta (Green algae)					
Closterium ehrenbergi Meneghini	9,600	–	–	10,000	–
C. lanceolatum Kuetzing	–	2,000	2,000	2,600	18,000
Eudorina elegans Ehrenberg	–	2,250	2,600	31,500	19,500
Oedogonium sp.	2,000	–	–	–	–
Radiofilum conjunctivan Schmidle	6,750	–	–	–	–
Scenedesmus bijuga (Turp.) Lagerh.	–	26,500	18,000	39,000	31,500
Sc. dimorphus (Turp.) Kuetzing	–	–	–	78,000	–
Spirogyra sp.	–	2,250	–	10,000	1,300
Phylum Bacillariophyta (Diatom)					
Cymbella sp.	31,500	–	–	–	–
C. ventricosa Kuetz	2,500	25,000	2,600	2,000	4,500
Diatoma elongatum Agardh	4,600	–	–	–	–
Fragilaria sp.	19,200	–	–	–	–
Gomphonema gracile Ehr.	2,250	4,000	38,000	2,000	1,250
Gyrosigma kutzingii Cleve.	234,000	20,000	8,000	4,000	9,100
Melosira varians C.A.Ag.	6,750	–	–	–	–
Nitzschia sp.	10,000	–	4,000	9,000	4,000
N. amphibia Grunow	4,500	–	–	–	–
Surirella robusta Ehrenberg	–	2,000	2,200	3,600	–
Synedra ulna (Nitzsch) Ehrenberg	–	4,000	–	–	–
Phylum Chrysophyta (Yellow algae)					
Dinobryon sertularia Ehrenberg	–	30,000	–	2,500	–
Phylum Pyrrophyta (Dinoflagellate)	–				
Ceratium hirundinella (O.F.Muell.)	–	–	64,000	4,000	–
Glenodinium sp.	–	–	–	30,000	–
Phylum Euglenophyta (Euglenoid)					
Euglena sp.	–	–	–	10,000	6,500
SUBTOTAL PHYTOPLANKTON	360,650	142,500	246,400	572,450	227,750

TABLE 3.8-1 (Cont'd)

Scientific Name	Station				
	1	2	3	4	5
ZOOPLANKTON					
'hylum Protozoa (protozoan)					
Centropyxis ecornis (Ehr.) Leidy	12,000	65,000	3,000	2,000	4,500
Difflugia tuberculata Wallich	2,200	–	12,000	–	2,000
D. urceolata Carter	6,750	–	–	–	25,000
'hylum Rotifera (Rotifer)					
Brachionus angularis Gosse	2,500	3,000	2,000	12,000	23,000
Br. forficula Wierzejshi	–	–	–	–	–
Conochilus sp.	6,000	2,500	–	10,000	–
Hexarthra mira (Hudson)	–	–	–	6,000	124,000
Keratella tropica	11,000	–	–	–	–
Lecome (M.) bulla (Gosse)	–	2,650	–	24,000	–
Trichocerca similis (Wierzejshi)	6,750	–	–	–	–
hylum Arthropoda (Arthropod)					
Bosmina longirostris (O.F.Muller)	2,200	–	–	–	124,000
Bosminopsis deitersi Richard	–	12,000	2,000	–	56,000
Ceriodaphnia cornuta Sars	–	5,000	–	–	23,000
Macrothrix laticornis (Jurine)	–	–	–	1,200	10,000
Unidentified cyclopoid copepods	24,000	5,600	4,000	–	15,000
Copepod nauplii	–	85,000	12,000	–	12,000
Insect larvae	–	12,000	–	–	–
SUBTOTAL ZOOPLANKTON	73,400	105,450	35,000	54,120	418,500
GRAND TOTAL	434,050	247,950	281,400	626,570	646,250

mark : Unit expressed in individual/cu.m.

The sampling date is December 17, 1993

F:T38-LWK1/37-B-0043

TABLE 3.8-2
ABUNDANCE AND PERCENTAGE OF PLANKTON ORGANISMS

Organisms	Station 1		Station 2		Station 3		Station 4		Station 5	
	Abundance	%	Abundance	%	Abundance	%	Abundance	%	Abundance	%
Phytoplankton	360,650	83.5	142,500	43.7	246,400	85.7	572,450	92.0	227,750	35.5
Zooplankton	71,200	16.5	183,750	56.3	41,000	14.3	49,200	8.0	412,500	64.5
Total	431,850	100	326,250	100	287,400	100	621,650	100	640,250	100

Remark : Unit expressed in organisms or cells per cu.m. of water

The sampling date is December 17, 1993

F:T38-2.WK1/37-B-0043

Species diversity indices of phytoplankton and zooplankton were analyzed by Shanon-Weiner index (Patrick, 1973). At Chao Phraya River, the diversity indices of phytoplankton and zooplankton were 2.2 and 1.8, respectively. At station 2-5 which are the stations located in Khlong Raphiphat, the species diversity indices for phytoplankton and zooplankton were 2.0 and 1.5-2.0 respectively. The diversity indices are relatively high which indicate that no highly dominant plankton species exists.

3.8.4.2 Benthic Animals

The result of benthic animals collected from the five sampling stations is shown in Table 3.8-3. Three phyla of benthic animals were found i.e., Annelida, Arthropoda, and Mollusca.

The aquatic earthworm Family Naididae was found at stations 1 and 3 with the density of 132 and 44 ind/sq.m. respectively. The insect larvae of Family Chironomidae were found at stations 2, 3 and 4 while larvae of Family Chaoboridae were found only at station 5. The number and species found at all sampling stations showed considerably low production of benthic animals of the study area. The density was in range 44-220 organisms/sq.m.

3.8.4.3 Aquatic Weeds

There are 10 to 20 species of aquatic macrophytes found in Thai water bodies, (NIFI, 1976). Generally, most water weeds are found close to shore, at a depth of 1 m. or less.

Chao Phraya River : The study on the aquatic weed at the proposed water intake site for set up the intake structure of water supply for cooling system, only floating weed was found at the sampling site (Table 3.8-4). The floating weed, water hyacinth or Pak Tob Java Echiornia crassipes was present densely at some locations along the river bank.

Khlong Raphiphat : At the sampling station 2-5 which are the stations in Khlong Raphiphat, water hyacinth are also found at all stations especially in front of the water gate of diversion canal (Table 3.8-4) The submerged weed, namely Sarai Hang Karok Hydrilla verticillata and Sarai Pung Chado Ceratophylum demersum were also found at all stations at the edges of banks. Kra Jab Trapa sp. was found only at station 5. Station 4 was the station where there are highest species number of aquatic weed. Five types of aquatic weed were found. Aquatic weed in Khlong Raphiphat was not high in density except Chawk Hunu at station 5. This might be that station 5 has some shallow area and the water was stagnant during sampling period.

3.8.4.4 Fisheries

Fish sampling could not be carried out during the study period due to the location was not suitable for fish sampling. Therefore, the informations on fish in Chao Phraya River and Khlong Raphiphat are obtained from the literature reviews and through interviews with local people.

TABLE 3.8–3
ABUNDANCE OF BENTHIC ORGANISMS

Organisms	Abundance (Ind./sq.m)				
	Station				
	1	2	3	4	5
Phylum Annelida					
Class Oligochaete					
Family Naedidae	–	–	88	–	264
Family Tubificidae	–	88	–	220	132
Phylum Arthropoda					
Class Insecta					
Order Diptera	–	352	88	–	44
Fam. Chironomidae					
Phylum Mollusca					
Class Gastropoda					
Fam.Marginellidae Rivomarinella sp.	–	–	44	–	–
Class Bivalvia					
Fam. Corbiculidae Corbicula sp.	–	–	–	–	88
TOTAL	–	440	220	220	528

TABLE 3.8-4
SPECIES OF AQUATIC WEEDS FOUND IN CHAO PHRAYA RIVER
AND KHLONG RAPHIPHAT ON DECEMBER 17, 1993

Aquatic Weeds		Abundance				
Thai Common Name	Scientific Name	Station				
		1	2	3	4	5
Family Oragraceae						
Kra Jab	Trapa sp.	–	–	–	–	+
Family Salviniaceae						
Chawk Hunu	Salvinia cucullata	–	–	–	–	+++
Family Pontederaceae						
Pak Tob Java	Echiornia crassipes	+++	+	+	+	+
Family Lemnaceae						
Nae Ped	Lemna perpusille	–	–	–	+	–
Family Azollaceae						
Nae Daeng	Azolla pinnata	–	–	–	+	–
Family Hydrocharidaceae						
Sarai Hangkarok	Hydrilla verticillata	–	+	+	+	+
Family Ceratophyllaceae						
Sarai Pung Chado	Ceratophyllum demersum	–	+	+	+	+

* Relative Abundance

– = absent

\+ = less

++ = moderate abundant

+++ = abundant

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Fisheries in Chao Phraya River

A few studies of fisheries in Chao Phraya River have been under taken and not much information is available for the study area at Amphoe Bang Sai.

Table 3.8-5 summarizes fish species found in Lower Chao Phraya River by Chukajorn, et. al. (1980) and Kittivorachate (1992). There were 36 fish species found in Lower Chao Phraya River, from Ang Thong to Nonthaburi.

In 1990, the annual catch was about 38.9 tonnes, valued at approximately 2.0 million baht per year. Of such catch, 28.2 tonnes were sold in the local fish market. The popular fishing gears found were cast-net, gill-net and hook. The record on the catch per unit effort of these three fishing gears collected by Chukajorn et al. in 1980 were 2.18, 2.13 and 0.98 kg/man/day. There is no information available on the catch per unit effort after that. However, it appears that the Chao Phraya River at present is less productive than that was found in the past.

The results of the fish sampling in Chao Phraya River at Nonthaburi and Pathumthani showed also the unknown species of fish eggs ranging from 47-14,519 eggs/cu.m. during December 1990 but not found during sampling period of June-September.

Fisheries resources in Khlong Raphiphat

The informations on fisheries resources in Khlong Raphiphat was obtained through interviews with local people, officials and fish trader in the local market.

The fish species composition found in Khlong Raphiphat was shown in Table 3.8-6. There are totally 13 fish species, and this number did not count on frogs and shrimps which are rarely found in this canal. However, some frogs and shrimps can be caught during dry season. These fish species are the common fish species found in the central part of Thailand. The fish production in Khlong Raphiphat cannot be estimated but very low production is suggested by local people, due to the fluctuation of water volume in the canal and use of illegal fishing methods. Most of the fishing practices are sports fishing. Very few people fish for their household consumption. The amount of fish caught per day is relatively small.

The fresh fish sold in the market are obtained from the aquaculture activity in nearby areas and other provinces. There are some catfish (hybrid catfish) farms and integrated chick-n-fish farms which take water from Khlong Raphiphat. The limitation of aquaculture activities in this area was also the same as aquaculture practices elsewhere. They are competition use of land, water quality and water supply. Most of the fish farms close to Khlong Raphiphat cannot be operated during dry season.

TABLE 3.8-5
FRESHWATER FISH SPECIES REPORTED TO BE PRESENT IN LOWER CHAO PHRAYA RIVER, ANG THONG PROVINCE TO NONTHABURI PROVINCE (DURING 1980 – 1990)

Thai Name	Scientific Name
Lin Ma	Cynoglossus sp
Uk	Hemipimelodus sp.
Kamank	Puntius proctozysron
Nuaerd Phram	Polynemus sp.
Nua on	Kryptopterus sp.
Ma	Bosamenia micropeltes
Ka thing	Metacembelus armatus
Ta kok	Cyclocheilichthys enoplos
Tapien Khao	Puntius gonionotus
Mael	Setipinna sp.
Kod ruang	Mystus nemurus
Mor Chang Yeap	Pristolepis fasciatus
Mor Thai	Anabas testudineus
Sua Pon Nam	Toxotes sp.
Kayang Khang Lie	Mystus vittatus
Tapian Thong	Puntius altus
Sa	Labiobarbus spilopleurs
Kod Nuan	Osteogeneiosus sp
Pab	Paralaubuca sp.
Salard	Notopterus notopterus
Bu	Oxyeleotris marmoratus
Sank Ka Vard	Pangasius siamensis
Siew Hang Luang	Rasbora dusomesis
Sawai	Pangasius sutchi
Soi	Cirrhinus jullieni
Cha on	Ompok bimaculatus
Daeng	Kryptopterus bleekeri
Te Pho	Pangasius larnaudi
Duk Dan	Clarias batrachus
Chon	Channa striatus
Sai Yu	Pangasius nasutus

ources; Chu Kajorn et al (1980) , Kittivorachate et al (1992)

TABLE 3.8-6

SPECIES OF FISH RECORDED TO BE PRESENT IN KHLONG RAPHIPHAT

Thai Name	Scientific Name
Tapien Khao	Puntius gonionotus
Siew	Esomus sp.
Krim	Tricopsis vittatus
Kadi Mo	Trichogaster trichopterus
Mor Thai	Anabas testudineus
Chon	Chana striata
Duk Uae	Clarias macrocephalus
Duk Dan	Clarias batranchus
Lai Na	Fluta alba
Nil	Orechromis niloticus
Salad	Notopterus notopterus
Bu	Oxyyeleotris marmoratus

3.9 TERRESTRIAL ECOLOGY

3.9.1 Introduction

The main ecological land use of the study area is rice field, swamp and flooding land which is good habitat for birds, reptiles and amphibians. This project area is similar to the other site of central plain of Thailand. Birds eat cereal, insects and mollusks while reptiles and amphibians eat all of living insects, fishes and small animals. This area is quite fertile in terms of food for birds, amphibians and reptiles.

3.9.2 Objectives

1. Review of secondary data on birds, reptiles and amphibians in the study area.
2. Field check of existing status and abundance of birds, reptiles and amphibians in the study area.
3. Assessment of effects of the Power Plant on birds, reptiles and amphibians.
4. Recommendation on mitigation measures and monitoring programs for ecological impacts during construction and operation phases.

3.9.3 Methodology

- Field check and survey in the study area to gather secondary data.
- Identification of the impact of the Power Plant on birds, reptiles and amphibians.
- Analysis of the advantage and disadvantage of the Power Plant on birds, reptiles and amphibians.
- Recommendation on mitigation measures and monitoring programs for alleviating ecological impacts during construction and operation periods.

3.9.4 Results

Birds are classified by their status and abundance. Status are categorized into resident, winter visitor, passage migrant and breeding visitor. Abundance are classified as very rare, rare, uncommon, fairly common, common and very common.

Birds investigation was carried out during the field surveys. Table 3.9-1 contains a list of birds found in the study area.

According to the information above, the status of birds at this site is 62.2 percent of resident, 32.4 percent of winter visit, 2.7 percent of breeding visit and 2.7 percent of passage migrant (Table 3.9-2).

TABLE 3.9-1
LIST OF BIRDS FOUND IN STUDY AREA

NAME	SCIENTIFIC NAME	STATUS	ABUNDANCE
นกเป็ดผีเล็ก	Tachybaptus ruficollis	R	VC
นกกาน้ำเล็ก	Phalacrocorax niger	R	C
นกกาน้ำปากยาว	Phalacrocorax fuscicollis	R	UC
นกอ้ายงั่ว	Anhinga melanogaster	R	R
นกยางกรอกพันธุ์ชวา	Ardeola speciosa	R	VC
นกยางกรอกพันธุ์จีน	Ardeola bacchus	WV	VC
นกยางเขียว	Butorides striatus	R	C
นกยางควาย	Bubulcus ibis	R	FC
นกยางเปีย	Egretta garzetta	R	C
นกยางโทนน้อย	Egretta intermedia	WV	FC
นกยางโทนใหญ่	Egretta alba	R	C
นกยางไฟหัวดำ	Ixobrychus sinensis	R	VC
นกยางไฟหัวเทา	Ixobrychus eurhythmus	M	R
นกยางไฟธรรมดา	Ixobrychus cinnamomeus	R	VC
นกยางดำ	Dupetor flavicollis	BV	VC
นกแขวก	Nycticorax nycticorax	R	C
นกกระสานวล	Ardea cinerea	R	UC
นกกระสาแดง	Ardea purpurea	R	C
นกปากห่าง	Anastomus oscitans	BV	C
นกช้อนหอยขาว, นกกุลา	Threskiornis melanocephalus	WV	UC
เป็ดหางแหลม	Anas acuta	WV	C
เป็ดลาย	Anas querquedula	WV	C
เป็ดเปีย	Aythya fuligula	WV	R
เป็ดแดง	Dendrocygna javanica	R	C
เป็ดคับแค	Nettapus coromandelianus	R	C
นกเขาชวา	Geopelia striata	R	C
นกอีวาบตั๊กแตน	Cacomantis merulinus	R	VC
นกกาเหว่า	Eudynamys scolopacea	R	C
นกกระปูดใหญ่	Centropus sinensis	R	VC
นกกระปูดเล็ก	Centropus bengalensis	R	C
นกแสก	Tyto alba	R	C

TABLE 3.9–1 (Cont'd)

NAME	SCIENTIFIC NAME	STATUS	ABUNDANCE
นกเค้าแมว	Glaucidium cuculoides	R	VC
นกกะเต็นน้อยธรรมดา	Alcedo atthis	WV	VC
นกกะเต็นใหญ่ธรรมดา	Halcyon capensis	R	UC
นกกะเต็นอกขาว	Halcyon smyrnensis	R	VC
นกกะเต็นหัวดำ	Halcyon pileata	WV,M	C
กระจาบคาหัวเขียว	Merops philippinus	R	C
นกจาบคาเล็ก	Merops orientalis	R	VC
นกตะขาบทุ่ง	Coracias benghalensis	R	VC
นกโพระดกธรรมดา	Megalaima lineata	R	C
นกตีทอง	Megalaima haemacephala	R	VC
นกแอ่นตาล	Cypsiurus balasiensis	R	VC
นกแอ่นบ้าน	Apus affinis	R	C
นกนางแอ่นบ้าน	Hirundo rustica	WV	VC
นกแอ่นพง	Artamus fuscus	R	C
นกจาบฝนปีกแดง	Mirafra assamica	R	C
นกเด้าดินทุ่ง	Anthus novaeseelandiae	R,WV	VC
นกเด้าดินสวน	Anthus hodgsoni	WV	C
นกอุ้มบาตร	Motacilla alba	WV	C
นกเด้าลมหลังเทา	Motacilla cinerea	WV	VC
นกเด้าลมเหลือง	Motacilla flava	WV	VC
นกอีเสือสีน้ำตาล	Lanius cristatus	WV	VC
นกอีเสือหัวดำ	Lanius schach	R	VC
นกปรอดหัวสีเขม่า	Pycnonotus aurigaster	R	VC
นกปรอดสวน	Pycnonotus blanfordi	R	VC
นกแซงแซวหางปลา	Dicrurus macrocercus	R	C
นกแซงแซวหางบ่วงใหญ่	Dicrurus paradiseus	R	C
นกแซงแซวเล็กเหลือบ	Dicrurus aeneus	–	
นกเอี้ยงด่าง	Sturnus contra	R	VC
นกกิ้งโครงคอดำ	Sturnus nigricollis	R	VC
นกเอี้ยงสาริกา	Acridotheres tristis	R	VC
นกเอี้ยงหงอน	Acridotheres javanicus	R	VC
นกกาแวน	Crypsirina temia	R	C
อีกา	Corvus macrorhynchos	R	C

TABLE 3.9–1 (Cont'd)

NAME	SCIENTIFIC NAME	STATUS	ABUNDANCE
นกคอทับทิม	Luscinia calliope	WV	VC
นกคอมรกต	Luscinia svecica	WV	VC
นกกางเขนบ้าน	Copsychus saularis	R	C
นกยอดหญ้าหัวดำ	Saxicola torquata	WV	VC
นกพงปากหนา	Acrocephalus aedon	WV	C
นกพงใหญ่พันธุ์ญี่ปุ่น	Acrocephalus arundinaceus	WV	VC
นกพงคิ้วดำ	Acrocephalus bistrigiceps	WV	VC
นกพงตั๊กแตนอกลาย	Locustella lanceolata	WV	VC
นกหางนาค	Megalurus palustris	R	C
นกกระจิบหญ้าสีเรียบ	Prinia inornata	R	VC
นกยอดข้าวหางแพนลาย	Cisticola juncidis	R	VC
นกยอดข้าวหางแพนหัวแดง	Cisticola exilis	R	C
เหยี่ยวขาว	Elanus caeruleus	R	C
เหยี่ยวดำ	Milvus migrans	WV	C
เหยี่ยวด่างดำขาว	Circus melanoleucos	WV	UC
เหยี่ยวทุ่ง	Circus spilonotus	WV	C
เหยี่ยวออสเปร	Pandion haliactus	WV	UC
นกอัญชันเล็ก	Porzana pusilla	WV	C
นกหนูแดง	Porzana fusca	R,M	C
นกกวัก	Amaurornis phoenicurus	R	VC
นกอัญชันคิ้วขาว	Porzana cinerea	R	UC
นกอีล้ำ	Gallinula chloropus	R	C
นกอีโก้ง	Porphyrio porphyrio	R	FC
นกคูท	Fulica atra	WV	UC
นกอีแจว	Hydrophasianus chirurgus	R,WV	C
นกพริก	Metopidius indicus	R	C
นกกระแตหงอน	Vanellus vanellus	WV	R
นกกระแตแต้แว้ด	Vanellus indicus	R	VC
นกหัวโตหลังจุดสีทอง	Pluvialis fulra	WV	VC
นกชายเลนน้ำจืด	Tringa glareola	WV	VC
นกปากซ่อมหางพัด	Gallinago gallinago	WV	VC
นกกระแตผีชายหาด	Esacus magnirostris	R	R
นกแอ่นทุ่งใหญ่	Glareola maldivarum	BV	VC

TABLE 3.9-1 (Cont'd)

NAME	SCIENTIFIC NAME	STATUS	ABUNDANCE
นกนางนวลธรรมดา	Larus brunnicephalus	WV	VC
นกนางนวลขอบปีกขาว	Larus ridibundus	WV	FC
นกนางนวลแกลบเคราขาว	Chlidonias hybridas	WV	VC
นกนางนวลแกลบดำปีกขาว	Chlidonias leucopterus	WV	C
นกนางนวลแกลบปากหนา	Gelochelidon nilotica	WV	FC
นกเขาไฟ	Streptopelia tranquebarica	R	VC
นกอีแพรดแถบอกดำ	Rhipidura javanica	R	VC
นกกระจอกบ้าน	Passer montanus	R	VC
นกกระจอกตาล	Passer flaveolus	R	VC
นกกระจาบธรรมดา	Ploceus philippinus	R	FC
นกกระจาบอกลาย	Ploceus manyar	R	UC
นกกระติ๊ดตะโพกขาว	Lonchura striata	R	VC

หมายเหตุ

R = นกประจำถิ่น (Resident)
WV = นกที่อพยพมาในช่วงฤดูหนาว (Winter visitor)
M = นกที่อพยพผ่านมา (Passage migrant)
BV = นกที่อพยพมาเพื่อผสมพันธุ์ (Breeding visitor)
VR = หายากมาก (very rare)
R = หายาก (rare)
UC = ไม่ชุกชุม (uncommon)
FC = ชุกชุมพอควร (fairly common)
C = ชุกชุม (common)
VC = ชุกชุมมาก (very common)

TABLE 3.9-2

PERCENT OF BIRD STATUS

Status	Number	Percent
R	69	62.2
WV	36	32.4
M	3	2.7
BV	3	2.7

TABLE 3.9-3

PERCENT OF BIRD ABUNDANCE

Abundance	Number	Percent
VR	nil	nil
R	5	4.6
UC	9	8.2
FC	6	5.5
C	40	36.7
VC	49	45.0

Birds abundance are: 45.0 percent very common, 36.7 percent common, 5.5 percent fairly common, 8.2 percent uncommon and 4.6 percent rare. There is no very rare bird in this study area (Table 3.9-3).

Amphibians and reptiles are very common in this area. A list of amphibians and reptiles is included in Table 3.9-4.

3.10 LAND USE

3.10.1 Introduction

The study on land use pattern around the project site was investigated using aerial photographs and field survey. It is realized that the developments may cause impacts on environment, natural resources, farming system, birds, animals, plants, economics and society. Like some other modern factories with thousands of employees, the Power Plant will induce rapid changes of land use and land utilization. The subsequent impacts upon the land use after the construction may be positive and/or negative. Hence, the study illustrates the existing land use, forecasts impacts, gives some mitigation measures and suggests appropriate environmental development plan for the future.

3.10.2 Objectives

1. To illustrate the existing land use in terms of their definition, shape, area and distribution.
2. To survey the patterns of land use and compile up-to-date land use map.
3. To find out the impacts (positive and/or negative) of the construction on land use.
4. To minimize the negative impacts on land use during and after the construction.
5. To propose appropriate environmental development plan.

3.10.3 Scope of Work

- The study on land use was focussed in a 5-km radius of the Plant.
- The land use patterns are based on aerial photograph interpretation, field checking and compilation on 1:15,000 base map.
- Mitigation measures will be suggested when positive/negative impacts are identified.
- Proper environmental development plan on land use is broadly overviewed to keep the environment sustainable to meet the requirement of ONEB regulation.
- Possible monitoring program for future is also suggested.

TABLE 3.9-4
LIST OF AMPHIBIANS AND REPTILES

Name	Scientific Name
คางคกบ้าน	Bufo melanostictus
กบนา	Rana tigerina
เขียดบัว, เขียดหนอง	Rana limnocharis
อึ่งอ่างบ้าน, อึ่งอ่างข้างลาย	Kaloula pulchra
ตะพาบธรรมดา	Trionyx cartilageneus
จิ้งจกบ้านหางแบน	Platyurus platyurus
ตุ๊กแกบ้าน	Gekko gekko
กิ้งก่ารั้ว, กิ้งก่าหัวแดง	Calotes cristacellus
กิ้งก่าสวน	Calotes mystaceus
เต่านา	Damonis subtrijuga
จิ้งเหลนบ้าน	Mabuya mulfifasciata
งูทางมะพร้าว	Elaphe radiata
งูสิง	Ptyas korros
งูเขียวหัวจิ้งจก	Ahaetulla prasina
งูสามเหลี่ยม	Bungarus faciatus
งูเห่า	Naja naja
งูกะปะ	Agkistrodon rhodostoma
งูเขียวหางไหม้ท้องเหลือง	Trimeresurus albolabris
งูเขียวหางไหม้ท้องเขียว	Trimeresurus popeorum
งูก้นขบ	Cylindrophis rufus
งูดินบ้าน	Kamphotyphlops braminus
งูเหลือม	Python reticulatus

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3.10.4 Methodology of Land Use Classification

3.10.4.1 Photo Interpretation

The study area covers the flat land of central Chao Phraya plain or about 79 sq. km. It is a circle of 5-km in radius, where the Power Plant is located at the center. Black and white aerial photographs of 1: 15,000 scale taken in December 1992 (9 by 9 inch in size) were utilized to classify and identify the use of land through photogrammetric instruments. More details on land activities and land use were also investigated through 3-dimension vision which governs by 60 percent forward overlap. Delineation of land use boundary was conducted directly on aerial photograph.

3.10.4.2 Field Checking

Four field visits were carried out during November and December 1993 to eliminate mis-classification and ensure the accuracy.

3.10.4.3 Map Rectification

To raise more accuracy on mapping, the 1:50,000 topographic map was enlarged as control map. All details appeared on aerial photographs were transferred to the reference map using vertical sketch master, the instrument that makes the details coincide with control points.

3.10.4.4 Map Compilation

The procedure included detailed symbolization and area measurement.

3.10.5 Impact Assessment

Since the Project consists of the Plant, intake pipeline, cooling tower, etc., the study was mainly aimed at the impacts on land use that may be caused by the construction and polluted waste drained from the Power Plant. Impacts of pipeline on land use were determined by extensive field investigation. Trend of land use change caused by expansion of residential area was also forecast.

3.10.6 Environmental Development Plan

The study also gives an overview of green area which must occupy at least 15 percent of the total area. It is recommended that some suitable tree species be possibly introduced to the site as green belt. It also suggested some ideas to monitor the effects on land use in long term basis.

3.10.7 Results

The total area of 78.54 sq. km. was classified into 4 major land use classes, namely, agricultural area; urban and built-up land; water bodies and idle land as shown in Figure 3.10-1.

3.10.7.1 Agricultural Land

This land use type occupied the vast area of 69.18 sq. km. or 88.09 percent of the total area. The utilization of land are rice field, orchard, cash crop cultivation and perennial plantation which covered the area of 55.77, 12.46 and 0.95 sq. km., respectively (Table 3.10-1). Rice field is high productive area where the production can be cultivated 2 or 3 times annually. Those lands are in the irrigation development area.

The popular fruit trees are orange, mango, palmeo, banana, cashew nut, and mixed crops. Due to the effect of fast expansion in economy since 1990-1991, the land development companies developed land for sales. Some perennial trees such as Casuarina equisetifolia were planted on arid zone. The cash crop cultivation needs intensive farming system such as good irrigation system, planting technique, soil preparation technique, insecticide and fertilizer application, etc. Temporary crops are various kinds of vegetables, bamboo and cassava. The list of horticultural crops are illustrated in Table 3.10-2.

3.10.7.2 Urban and Built-up Land

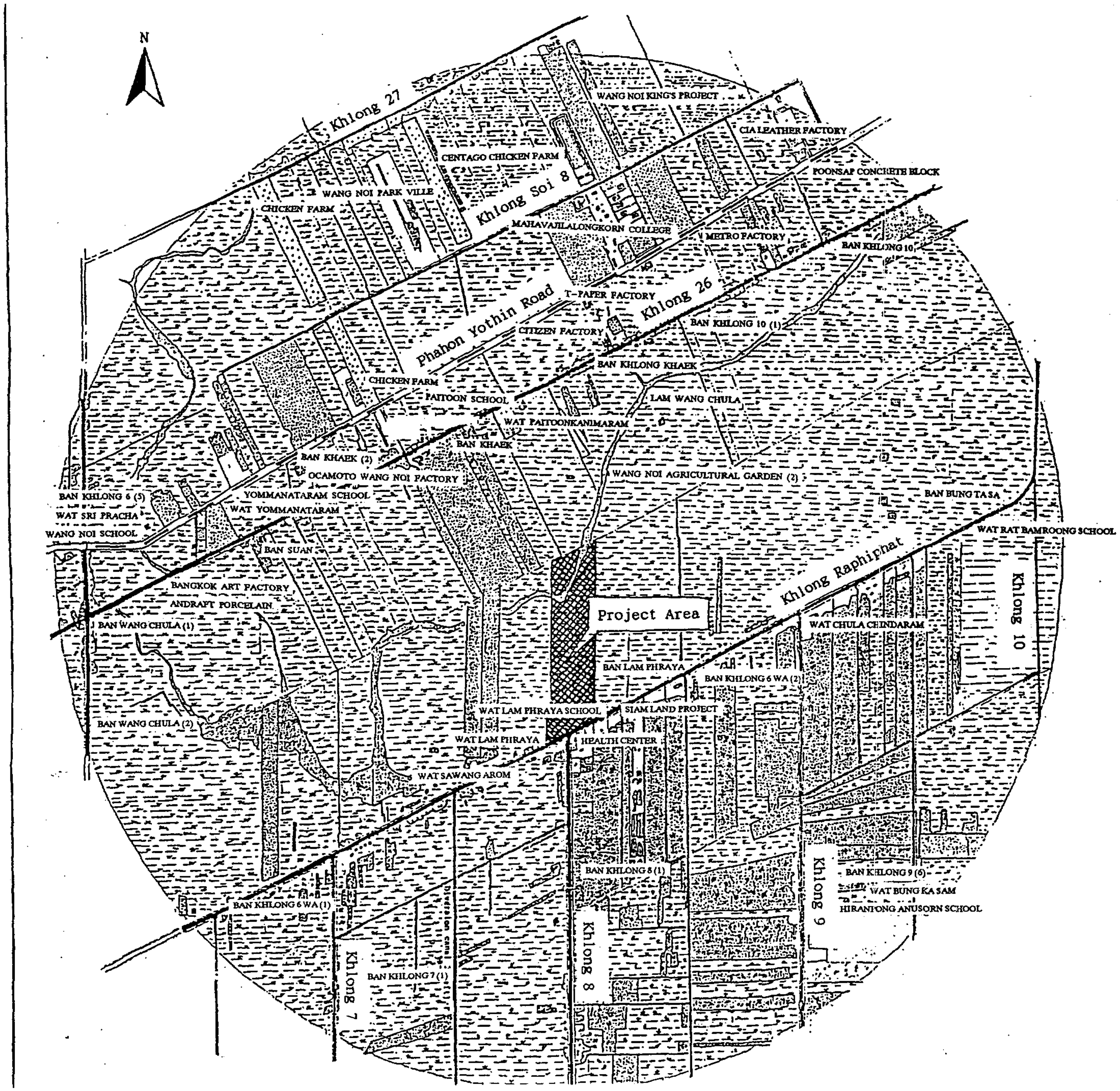
The clusters of housing are usually located on land and along the road or canal. Some houses are isolated and surrounded by field plots. Typical housing area normally consists of edible trees and forest trees (Tables 3.10-3 and 3.10-4). The residential area occupied an area of 1.768 sq. km. or 2.26 percent of the total area.

3.10.7.3 Water Bodies

This classification of land includes river, canal, and pond. Khlong Raphiphat and secondary or subcanal system are important for economic aquatic vegetable cultivation, home garden water supply, fruit tree water supply, fishing, bathing and washing. Artificial ponds were prepared for water storage and some are for fish farming. Water resources occupies the total surface area of 4.13 sq. km. or 5.28 percent of the study area.

3.10.7.4 Idle Land

This term implies bare land and water log area. The activities in this land use pattern are not identified. Almost of the land is left so that grass and aquatic weeds are common. The area of baren area and marsh are 3.45 sq. km. or 4.39 percent of the study area.



LEGENDS:

- HIGHWAY
- ROAD
- STREAM
- CANAL (KHLONG)
- SUBCANAL
- WATER BODIES
- PADDY FIELD
- MIXED ORCHARDS
- RESIDENTIAL AREA
- INDUSTRIAL AREA
- ANIMAL FARM
- IDLE LAND

FIGURE 3.10-1 LAND USE PATTERN WITHIN 5 KM. RADIUS OF POWER PLANT

TABLE 3.10-1

LAND USE CLASSIFICATION OF STUDY AREA

Land Use Pattern Level I	Level II	Level III	Area sq. km.	%
AGRICULTURAL LAND			69.18	88.09
	– Rice field		(55.77)	(71.01)
	– Orchard		(12.46)	(15.88)
		= Orange	8.28	10.54
		= Mango	2.03	2.53
		= Palmeo	0.39	0.50
		= Banana	0.13	0.17
		= Cashew Nut	0.06	0.08
		= Mixed Crop	0.22	0.28
		= Agricultural Estate	0.31	0.40
		= Casuarina sp.	1.04	1.32
	– Cash crop		(0.95)	(1.20)
		= Vegetables	0.92	1.17
		= Bamboo	0.02	0.02
		= Cassava	0.01	0.01
URBAN AND BUILT UP AREA			1.78	2.26
	– Residential area		(0.64)	(0.81)
	– Road		(0.63)	(0.80)
	– Factory		(0.19)	(0.24)
	– Farm		(0.32)	(0.41)
WATER BODIES			4.13	5.26
	– River		(1.46)	(1.86)
	– Canal		(1.67)	(2.13)
	– Pond		(0.85)	(1.08)
IDLE LAND			3.45	4.39
	– Bare land		(1.21)	(1.54)
	– Marsh land		(2.24)	(2.85)
TOTAL AREA			78.54	

Note : Figures in bracket are total area of sub–categories.

Table 3.10-2

LIST OF FIELD CROPS AND HORTICULTURAL CROPS IN STUDY AREA (1993-1994)

Thai Name	Botanical	Name	Type	Utilization
ข้าวจ้าว	Oryza	Sativa	GR	F
ส้มเขียวหวาน	Citrus	reticulata	FT	F
มะม่วง	Mangifera	indica	FT	F
ส้มโอ	Citrus	maxinta	FT	F
มะม่วงหิมพานต์	Anacardium	ocidentale	ST	F
กล้วย	Musa	sapientum	HB	F
ไผ่ตง	Dendrocalamus	asper	BB	F
มันสำปะหลัง	Manihot	esculenta	SB	F
ผักกาด	Brassica	chinensis	VG	F
สนทะเล	Casuarina	equisetifolia	ET	W, FR, B

Abbreviation : Type

GR	= Grass	FT	=	Fruit tree	P	=	Palm
ST	= Shrubby tree	HB	=	Herb			
BB	= Bamboo	SB	=	Shrub			
ET	= Exotic tree	VG	=	Vegetable			
CL	= Climber	AQ	=	Aquatic			

Utilization:

F = Food

W = Wood

FR = Fuelwood

B = Boundary

S = Shade

TABLE 3.10-3
LIST OF MULTI-PURPOSE TREES FOUND IN RESIDENTIAL AREA OF STUDY AREA (1993-1994)

	Thai Name	Botanical	Name	Type	Utilization
1.	ตาล	Borassus	Flabellifer	P	F, B
2.	มะพร้าว	Cocus	nucifera	P	F, B
3.	หมาก	Areca	catechu	P	F, B
4.	มะขาม	Tamarindus	indica	T	F, S
5.	มะขามเทศ	Pithecellobium	ducle	T	F, S
6.	สะเดา	Azadirachta	indica	T	FR, B, W
7.	ขี้เหล็กบ้าน	Cassia	siamea	T	F, FR
8.	มะรุม	Moringa	oleifera	ST	F
9.	ยอบ้าน	Morinda	citrifolia	ST	F, FR
10.	แคบ้าน	Sesbania	grandiflora	ST	F
11.	ชะอม	Acacia	pennata	T	F
12.	กุ่มบก	Crateva	religiosa	T	FR
13.	สะแกนา	Combretum	quardrangulare	T	FR
14.	ทองหลาง	Erythrina	subumbrans	T	F, S, FR
15.	นุ่น	Ceiba	pentandra	T	S
16.	ก้ามปู	Samanea	saman	T	S, FR
17.	ไทร	Ficus sp.		T	S
18.	คูน	Cassia	fistule	T	S, FR
19.	กระถินณรงค์	Acacia	auriculaeformis	T	FR, B, W
20.	ยูคาลิปตัส	Eucalyptus	camaldulensis	T	FR, B, W
21.	ไผ่รวก	Thysostachys	siamensis	BB	F, B

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Table 3.10-4

LIST OF TREE, HERB, VEGETABLE AND GRAIN FOUND IN HOME PLOT OF STUDY AREA (1993-1994)

	Thai Name	Botanical	Name	Type	Utilization
	Fruit Tree				
1	สาเก	Artocarpus	communis	FT	F,S
2	ขนุน	A.	heterophyllus	FT	F,S
3	ชมพู่	Eugenia	siamensis	FT	F,S
4	น้อยหน่า	Annona	squamosa	ST	F
5	มะละกอ	Carica	papaya	ST	F
6	ฝรั่ง	Psidium	guajava	ST	F
7	มะยม	Phyllanthus	indica	ST	F
8	มะนาว	Citrus	aurantifolia	ST	F
9	มะกรูด	C.	hystrix	ST	F
	Herbal Vegetable				
10	ข่า	Alpinia	galanga	VG	F
11	ขิง	Zingiber	officinale	VG	F
12	กระชาย	Boesenbergia	pandulata	VG	F
13	ตะไคร้	Cymbopogon	citratus	VG	F
14	กะเพรา	Ocimum	sanctum	VG	F
15	โหระพา	O.	basilicum	VG	F
16	มะเขือ	Solanum	xanthocarpum	VG	F
17	พริก	Capsicum	minimum	HB	F
18	สะระแหน่	Manthae	piperita	VG	F
19	ผักชี	Petrosselinum	hortense	VG	F
20	ผักบุ้ง	Ipomoea	reptans	CL, VG	F
21	ถั่วฝักยาว	Vigna	sesquipedalis	CL, VG	F
22	ฟักทอง	Cucurbitia	moschata	CL, VG	F
23	ผักแว่น	Marsilea	crenata	AQ	F
	Others				
24	อ้อย	Saccharum	officinarum	GR	F
25	ข้าวโพด	Zea	mays	GR	F

3.11 TRANSPORTATION

3.11.1 Introduction

The Project will be located on Highway No. 1 approximately 6 km from Amphoe Wang Noi and 75 km from Bangkok Metropolis.

3.11.2 Objectives of Study

The main purposes of this study are as follows:

(1) To study road network and traffic conditions in the vicinity of the project area emphasizing the proposed power plant site.
(2) To review traffic to be generated by the Project and assess impacts on traffic condition in the area.
(3) To recommend necessary measures to alleviate such effects.

3.11.3 Presentation of Results

3.11.3.1 Road Network and Traffic Conditions in Project Area

(1) Road Network :

Figure 3.11-1 illustrates the main road network in the middle part of the central region and for the study area. Roads under the control of Department of Highway (DOH) are divided into three categories; national highways, provincial highways and other roads. The provincial highway and other categories include many minor roads, for example, all weathered laterite or dirt roads, which are not shown in Figure 3.11-1. The following roads leading to and/or influenced by the Project are as follows: (Figure 3.11-2).

(i) Route No. 1 (Phahonyothin) : This road ran from Bangkok Metropolis to most provinces in the northern part of the country. The total distance is approximately 1,000 km. The section related to the Power Plant, starts from Bangkok Metropolis passing through Nonthaburi, Pathumthani and turns eastwards to Amphoe Wang Noi, about 75 km from Bangkok Metropolis. Route No.1, Rangsit-Saraburi section, was expanded to 10 traffic lanes by DOH and the construction was completed in January 1994. The project site is located on Route 1, 6 km far away from Amphoe Wang Noi. The section from Bangkok Metropolis to Saraburi is the busiest section in the area, where the Power Plant is located.

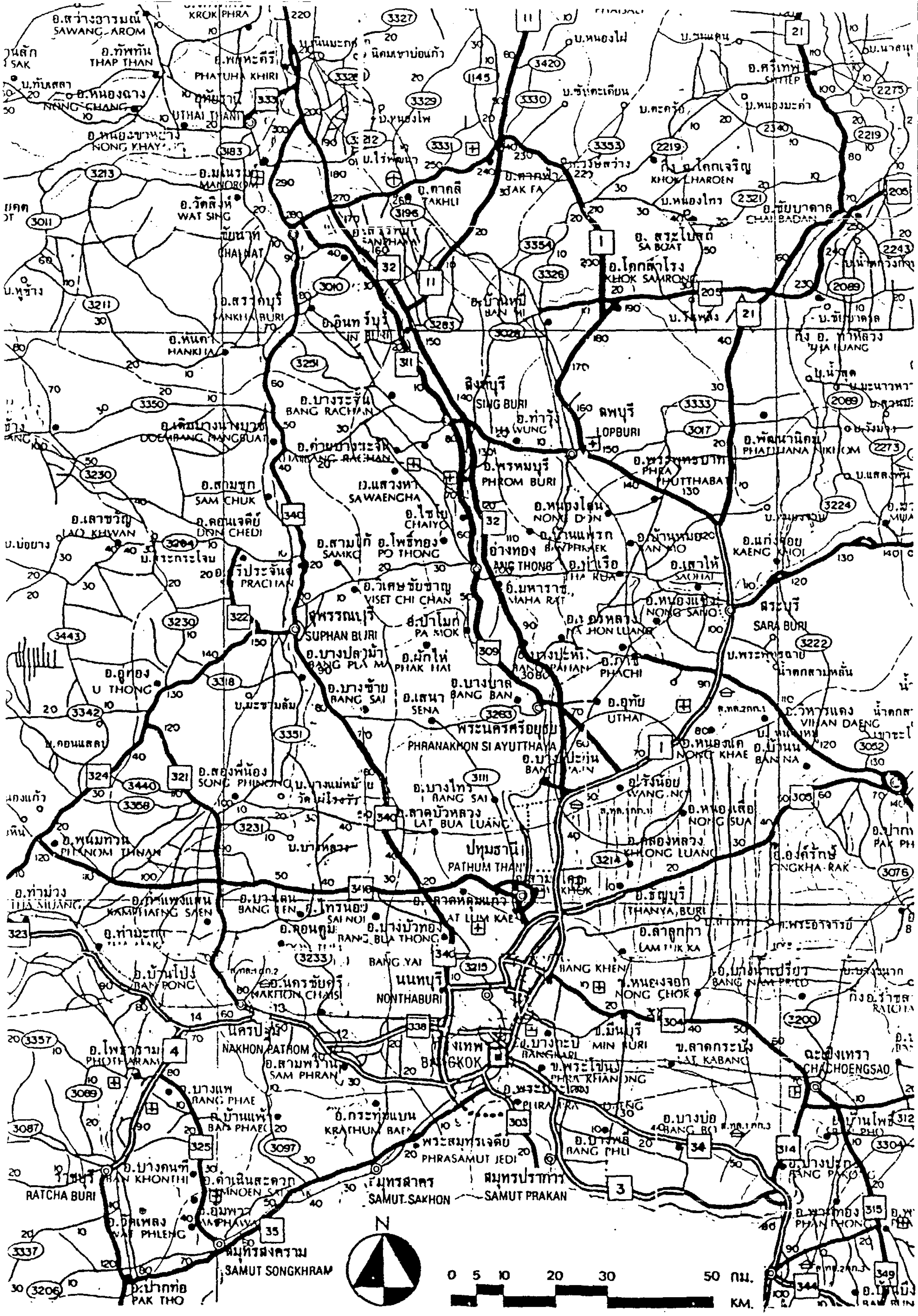

FIGURE 3.11-1 MAIN ROAD NETWORK IN THE MIDDLE PART OF CENTRAL REGION AND STUDY AREA

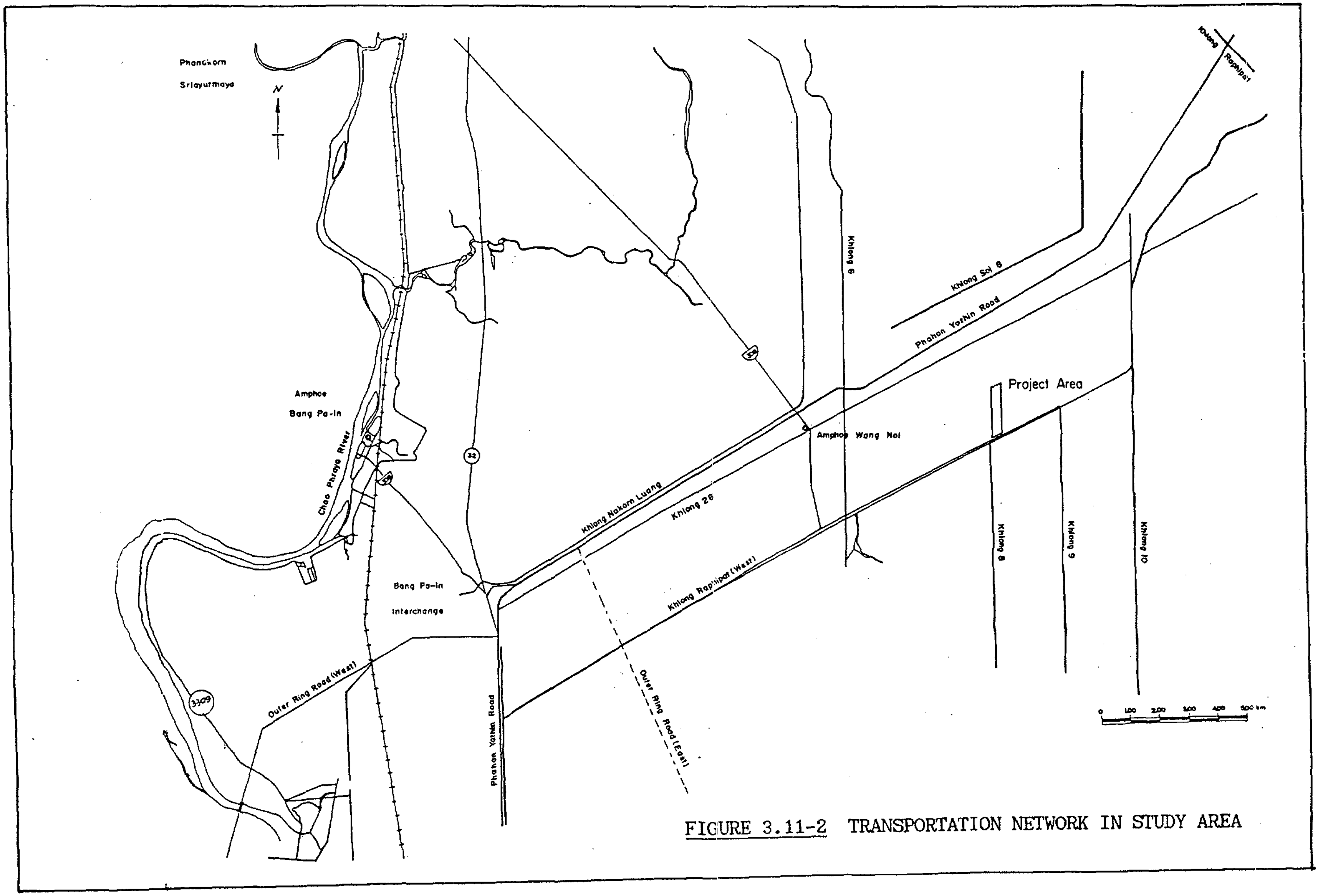

FIGURE 3.11-2 TRANSPORTATION NETWORK IN STUDY AREA

(ii) Route No. 32 : This road is an extension from Route No. 1 at the east-turn section to Bang Pa In, Ayudhaya and Ang Thong.

(iii) Route No. 308 : This route is a main provincial highway within the project area and is extended from Route 32 at Ayudhaya (close to the intersection of Route No. 32 and Route No. 1) to Amphoe Bang Pa In.

(iv) Route No. 309 : This route is extended from Route No. 1 at Amphoe Wang Noi and approximately 12 km from Amphoe Wang Noi to Ayudhaya. Route No. 309 leads to Ang Thong and Central region.

(v) Route No. 3309 : This route is the branch of Route No. 309 leading to Amphoe Bang Sai where a proposed intake raw water pumping station will be located at Ban Chiang Rak Noi of Amphoe Bang Sai.

(2) Existing Road Development

(i) Vibhavadi-Rangsit Elevated Toll Way Project : This new highway, which is already under construction, has 6 traffic lanes elevated on a concrete via duct 14 m above the existing Vibhavadi-Rangsit road. The total width of the highway is 25.30 m and the via duct piers are located within the central median of the existing road. A new flyover will be constructed to cross over both the Vibhavadi-Rangsit highway and the railway tracks at Bang Khen and Lak Si intersections. The Don Muang Tollway Company is the concessionaire for the whole project which is expected to be completed during 1993. Once the elevated highway is opened, it will relieve the chronic traffic congestion on the existing Vibhavadi-Rangsit road where the present traffic volume is about 200,000 vehicles per day and, is increasing at an annual rate of more than 8 percent.

(ii) Rangsit-Saraburi Rehabilitation Project : The existing highway No.1 between Rangsit and Saraburi is the primary route for traffic travelling between Bangkok Metropolis and the northern and northeastern provinces. The existing divided highways from 4 lanes to 10 lanes, and a new concrete road pavement is being provided in both directions. Each traffic lane will be 3.5 m wide and both carriageway will be provided with asphalt surfaced shoulders. Frontage roads are to be constructed as an integral part of the project. In addition, there are 5 interchanges to be constructed at : Bang Khan, Bang Pa In, Wang Noi, Hin Kong and Saraburi Bypass, in order to facilitate free and safe flow of interconnecting traffic. Once the whole project is completed, the capacity will be sufficient to meet the anticipated future increase in traffic volume.

(iii) Saraburi-Nakhon Ratchasima Widening and Rehabilitation Project : The highway from Saraburi to Nakhon Ratchasima is already being widened into a 4-lane divided highway. The existing 2-lane asphalt road is being rehabilitated with a concrete road pavement and, a new 2-lane carriageway built alongside the existing one. Both directions will have 7 m wide carriageways with 2.5 m wide asphalt surfaced shoulders and frontage roads are to be provided wherever the highway passes through heavily populated urban communities. In addition, seven interchanges will be provided at : Saraburi, Muak Lek, Kaeng Khoi, Pak Chong (East and West) , Sikhiu and Pak Thong Chai. The total length of the road is 142.8 km. Once the whole project is completed in 1994, it will be operated as a toll highway, providing a much quicker and very much safer journey for vehicles travelling between Bangkok Metropolis and the northeastern provinces.

(iv) Bang Pa In - Nakhon Sawan Widening and Rehabilitation Project : This section of highway No.32 which is the major access to the Northern Region of Thailand is already widened into a 4-lane divided highways. The existing heavily congested 2-lane asphalt road is being rehabilitated with a concrete road pavement and, a new carriageway is being built alongside the existing one. Both directions will have 7 m wide carriageways with 2.5 m wide asphalt surfaced shoulders. In addition, there are eight interchanges to be constructed at : Bang Pa In, Ayudhaya, Ang Thong, Singburi (North and South) , In Buri, Chainat and Uthai Thani. The total length of the road is 182.6 Km. Some sections were completed in 1993 but the project will not be finished until 1994. Upon completion, it will be operated as a toll highway.

(3) <u>New Highway Construction</u> (Figure 3.11-3)

(i) Eastern Bangkok Outer Ring Road : This new highway will start in Bang Pa In at the intersection of Route 1 and Route 32 from where it follows a new alignment around the eastern extremities of the capital before joining Route 34 (Bang Na-Bang Pakong) at Bang Phli. The road has 2-lanes of 3.50 m wide each with 2.5 m wide carriageway. Total length will be about 62 km. The construction will begin in 1994. Once completed, the project will facilitate the free movement of traffic around Bangkok Metropolis thus relieving congestion in the central zone of the capital.

(ii) Western Bangkok Outer Ring Road : This new highway will start in Bang Sai at the intersection of Route 1 and Route 308 and Route 3309 from where it follows a new alignment around the western extremities of the capital. The route will stand from Bang Sai to Bang Bua Thong. In addition, two interchanges and one bridge across Chao Phraya River will be aligned on. This route is a 4-lane asphalt concrete road pavement and under construction. It is expected that the new highway will be completed in 1994.

(4) <u>Traffic Volume</u>

Department of Highway (DOH) measured and computed average daily traffic on five important roads which are expected to be influenced from the Project as given in Tables 3.11-1 and 3.11-2 and can be described as follows :

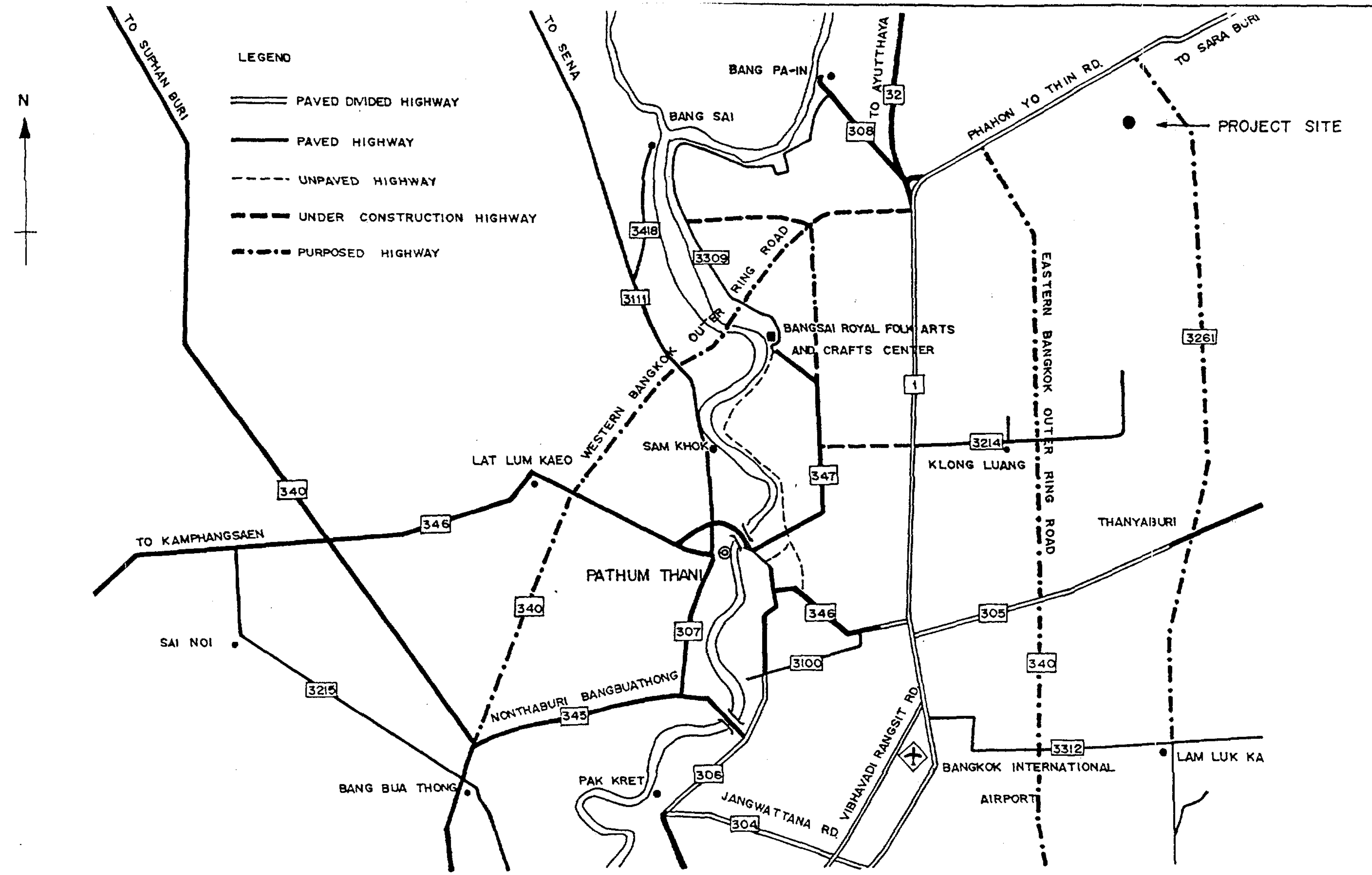

FIGURE 3.11-3 NEWLY PROPOSED AND UNDER CONSTRUCTION HIGHWAYS IN STUDY AREA

TABLE 3.11-1

ANNUAL AVERAGE TRAFFIC VOLUME ON FIVE MAJOR ROUTES DURING 1988 - 1992

Route No.	Control Section	Station Km.	Year														
			1988			1989			1990			1991			1992		
			LV	HV	Total	LV	HV	Total	LV	HV	Total	LV	HV	Total	LV	HV	Total
1	100	19+100	31799	5983	37782	33428	7786	41214	33339	9277	42616	56209	10868	67077	34585	5828	40413
	100	24+685	18947	7770	26717	17980	8944	26924	23545	7679	31224	20875	7186	28061	24911	17051	41962
	201	35+000	29235	24584	53819	29521	16779	46300	27425	16651	44076	22206	14308	36514	25408	17065	42473
	202	48+100	20789	19352	40141	26882	26099	52981	26658	25901	52559	36984	35817	72801	30785	16952	47737
	302	60+800	8424	12374	20798	10942	17237	28179	18470	12469	30939	17427	24262	41689	16865	14358	31223
	302	67+900	12254	18418	30672	12625	1809	14434	13312	18556	31868	16213	25296	41509	21078	20353	41431
	400	102+000	16591	13958	30549	19511	19892	39403	13028	12481	25509	15275	20948	36223	14529	11876	26405
32	401	55+850	8417	5097	13514	9047	5759	14806	9543	4891	14434	12879	6166	19045	12049	5819	17868
	500	96+800	5232	4291	9523	6626	5260	11886	6640	5138	11778	8918	6832	15750	9445	5515	14960
308	100	1+609	2380	1693	4073	3238	2511	5749	1999	1876	3875	4245	2949	7194	6435	4520	10955
309	100	10+337	981	416	1397	1085	538	1623	1357	744	2101	1759	1157	2916	4095	2001	6096
	100	18+000	4209	1766	5975	6321	2332	8653	6271	1662	7933	11223	3238	14461	13878	8632	22510
3309	200	7+000	544	710	1254	677	921	1598	888	810	1698	1409	1648	3057	2614	2335	4949
	300	3+000	696	792	1488	1267	1236	2503	955	1074	2029	2384	2556	4940	4776	3971	8747

Remarks: LV = Light Vehicles
HV = Heavy Vehicles

Source : Department of Highway

TABLE 3.11-2

PERCENTAGE OF ANNUAL AVERAGE DAILY TRAFFIC VOLUME BETWEEN LIGHT VEHICLES AND HEAVY VEHICLES ON MAJOR ROUTES

Route No.	Control Section	Station Km.	Year									
			1988		1989		1990		1991		1992	
			LV	HV	LV	HV	LV	HV	LV	HV	LV	HV
1	100	19+100	84.2	15.8	81.1	18.9	78.2	21.8	83.8	16.2	85.6	14.4
	100	24+685	70.9	29.1	66.7	33.3	75.4	24.6	74.4	25.6	59.4	40.6
	201	35+000	54.3	45.7	63.8	36.2	62.2	37.8	60.8	39.2	59.8	40.2
	202	48+100	51.8	48.2	50.7	49.3	50.7	49.3	50.8	49.2	64.5	35.5
	302	60+800	40.5	59.5	38.8	61.2	59.7	40.3	41.8	58.2	54.0	46.0
	302	67+900	39.9	60.1	41.1	58.9	41.8	58.2	39.0	61.0	50.9	49.1
	400	102+000	54.3	45.7	49.5	50.5	51.1	48.9	42.2	57.8	55.0	45.0
32	401	55+850	62.3	37.7	61.1	38.9	66.1	33.9	67.6	32.4	67.4	32.6
	500	96+800	54.9	45.1	55.7	44.3	56.4	43.6	56.7	43.3	63.1	36.9
308	100	1+609	58.4	41.6	56.3	43.7	51.6	48.4	59.0	41.0	58.7	41.2
309	100	10+337	70.2	70.2	29.8	66.8	33.1	64.6	35.4	60.3	39.7	32.8
	100	18+000	70.4	70.4	29.6	73.0	27.0	12.9	87.1	77.6	22.4	38.4
3309	200	7+000	43.4	43.4	56.6	42.4	57.6	36.5	63.5	46.1	52.8	47.2
	300	3+000	46.8	46.8	53.2	50.6	49.4	31.6	69.0	48.2	54.6	45.4

Source : Department of Highway

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(i) Route No.1 : On Route 1 (Phahonyothin), there were 7 observed stations from km 19-km 102 as follows:

(1) Km 19+000 Km 16+441 - Rangsit
(2) Km 24+645 Km 16+441 - Rangsit
(3) Km 35+000 Rangsit - Bang Pa In
(4) Km 48+100 Bang Pa In - Junction Wang Noi
(5) Km 60+800 Bang Pa In - Junction Wang Noi
(6) Km 67+900 Junction Wang Noi - Km 80+000 (Ayudhaya)
(7) Km 102+000 Km 80+000 (Ayudhaya) - Saraburi

Station (6), km 67+900 Junction Wang Noi - Km 80+000 Ayudhaya is in the proposed power plant site. The total vehicle number was within a range of 30,000 - 40,000 vehicles per day during 1988 - 1992. In 1988 - 1990, the number was within 30,000 - 32,000 vehicles per day and increased to 41,000 vehicles per day in 1991 - 1992. This was because of the new investment programs and the road improvement were accelerated in the area such as in Rangsit, Bang Pa In and Wang Noi to Saraburi. On Route 1 (67+900) in 1988 - 1989 light vehicles occupied a proportion of 40% while heavy vehicles were about 60%. However in 1990, light vehicles became a proportion of 60% while heavy vehicles were about 40% (Table 3.11-2).

(ii) Route No.32 : There were 2 (DOH) observed stations as follows:

Km 55+850 Junction Route 1 - Junction Ayudhaya
Km 96+800 Junction Route 32 - Junction Ayudhaya

The traffic volume on Route 32 was within a range of 9,000 - 19,000 vehicles per day during 1988 - 1992. In 1988 - 1989, a total vehicle number was in a range of 9,000 - 14,000 vehicles per day but in 1990 - 1992 increased to a range of 14,000 - 19,000 vehicles per day. Light vehicles and heavy vehicle on Route 32 was a proportion of 40 and 60%, respectively.

(iii) Route No.308 : Route 308 at station (1+609) Junction Route No.32 - Bang Pa In had a total traffic volume within a range of 4,000 - 7,000 vehicles per day during 1988 - 1991 and increased slightly in 1992.

(iv) Route No.309 : Route 309 at Station (18+000) Junction Wang Noi - Ayudhaya had a total traffic volume within a range of 5,000 - 7,000 vehicles per day during 1988 - 1990 and increased to 14,000 - 20,000 vehicles per day in 1991 - 1992.

(V) Route 3309 : Route 3309 at station 7+000 Bang Sai - Silapachip Phiset had a total traffic volume within a range of 1,200 - 1,600 vehicles per day during 1988 - 1990 and increased to 3,000 - 5,000 vehicles per day during 1991 - 1992.

(5) Existing Road at Power Plant Site Areas

The Power Plant is situated near Phahonyothin Road of the distance of 6 km from Amphoe Wang Noi. The entrance of the power plant site will use a lateritic road about 1 km from Phahonyothin Road to Khlong 26 and then using an EGAT's road, which was built from Khlong 26 to the power plant area near Wat Lam Phraya about 1.7 km asphalt pavement. The entrance of the power plant area can use two entrances : first, the road close to Wat Lam Phraya and second, a lateritic road from Khlong 7 running along irrigation canal. The existing road along Khlong Raphiphat will be improved to asphalt surface by RID.

The traffic volume in the power plant site found from the field investigation showed that, there was a low traffic volume which was generated from the community activities. Most of the vehicles were motorcycles, light trucks and some heavy trucks from the road construction along Khlong Raphiphat. Figure 3.11-4 illustrates the existing road of the proposed power plant site.

3.11.3.2 Other Networks

Within the vicinity of the study area, there are two other modes of transport available for goods and passenger movement, namely, rail and water transport. Railing was one of the most important modes of cargo transport in lower central region. The tracks ran to Bang Pa In. At Bang Pa In, the State Railway of Thailand (SRT) ran approximately 20 passenger trains daily, in each direction. Most of the passenger trains would stop at the Bang Pa In station. However, none of the cargo train stopped at Bang Pa In. Cargo services at Bang Pa In were not recorded, and it was expected that, cargo services are very low for two main reasons, short haul to Bangkok Metropolis and better service on road system.

Water transport was also available and close to the project site. Chao Phraya River was approximately 37 km. west to the site. Water transport was an attracting alternative for the industrial products. However, the mode was for a large amount of goods only.

3.12 WATER USE

Patterns of water use related to the Project are water use in East Bank Chao Phraya irrigation area and areas between downstream of Chao Phraya Dam to Chao Phraya river mouth. The description is as follows:

a) East Bank-Chao Phraya Irrigation Area

Water use pattern and management in the East Bank Chao Phraya irrigation area is quite complicated and not clear since the project area is large together with a large number of irrigation canals and main canals. The water comes from many sources such as Pasak River, Chao Phraya

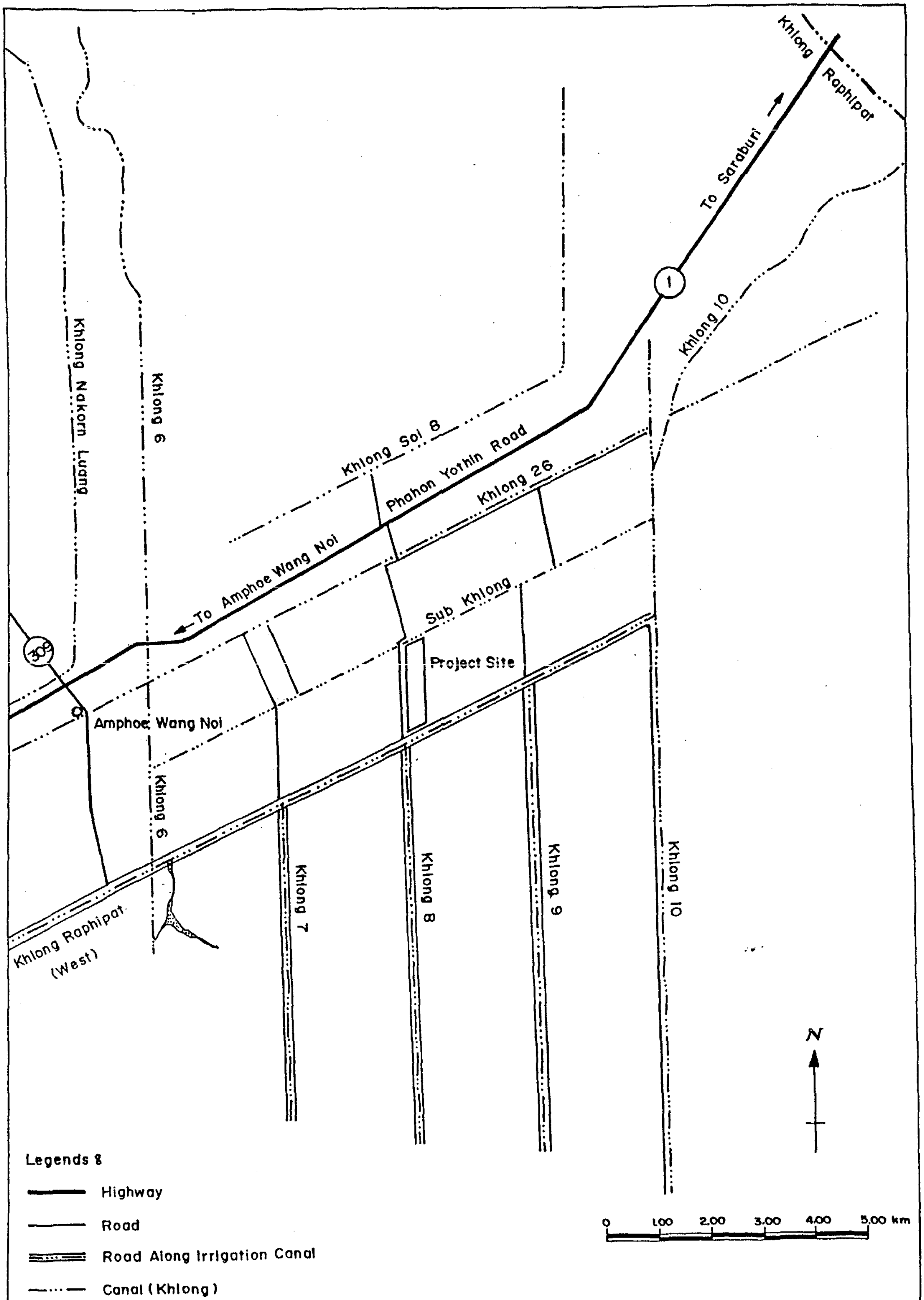

FIGURE 3.11-4 EXISTING ROAD NETWORK IN STUDY AREA

River, Nakhon Nayok River and Bang Pakong River. Since there are various types of land use and water use activities, estimation of water requirement is quite difficult.

Land characteristics and main irrigation canals of the East Bank-Chao Phraya irrigation area is shown in Figure 3.12-1. Figure 3.12-2 shows water use management and average runoff released through regulators at major control points in the area. Table 3.12-1 shows available data of average runoff.

Volume of water diverted from Chao Phraya Dam to Khlong Chainat-Pasak via Rerng Rang Regulator is about 2,454 MCM/year. The water is partly allocated to the Rerng Rang Project at about 245 MCM/year and diverted to Pasak River at Rama VI Dam at 2,209 MCM/year.

Rama VI Dam receives water from Pasak River at 2,305 MCM/year (station S.9) and from Khlong Chainat-Pasak at 2,209 MCM/year. Then the water is allocated to the East Bank-Chao Phraya Project via Phra Narai Regulator at 2,296 MCM/year and the rest is diverted into downstream of Pasak River at 2,354 MCM/year.

About 2,296 MCM/year which is diverted into Khlong Raphiphat via Phra Narai Regulator is allocated to the Nakhon Luang Project via Nakhon Luang Canal (235 MCM/year) and to the South Pasak Project or Tha Luang (450 MCM/year). At the section where Khlong Raphiphat passes the South Pasak Project, part of water (794 MCM/year) is diverted to West Raphiphat via Phra Sri Silp Regulator to irrigate the North Rangsit Project, while the other part (817 MCM/year) is diverted to South Raphiphat via Phra Sri Saowaphak to some parts of the North Rangsit Project, South Rangsit Project, Khlong Dan Project and Chaiyanuchit Project. The description is presented in Table 3.12-2.

According to the feasibility study and environmental impact assessment of Pasak Dam, water requirement in the East Bank-Chao Phraya Project was analysed using 30-year climatological data (1961-1990) and mean rainfall data for the project areas of the corresponding projects. The analysis was performed by identifying agricultural land according to mean statistical data during 1987 to 1991. Table 3.12-3 presents mean water requirement for irrigation from the existing irrigation projects. It is concluded that the computed water requirement is higher than the actual value of Rama VI Dam. This is because return flow of irrigation projects upstream to the site and additional quantity from Bang Pakong and Chao Phraya Rivers were substracted.

b) Water Use Downstream of Chao Phraya Dam

Chao Phraya Dam at Chainat diverts water through irrigation system into agricultural land along both banks of Chao Phraya River from Chainat down to the river mouth. If proper release from Bhumibol and Sirikit reservoirs is achieved, cultivation can be done both in dry and rainy seasons. Besides, irrigation water requirement, water is released to downstream of Chao Phraya Dam to fulfill downstream requirement.

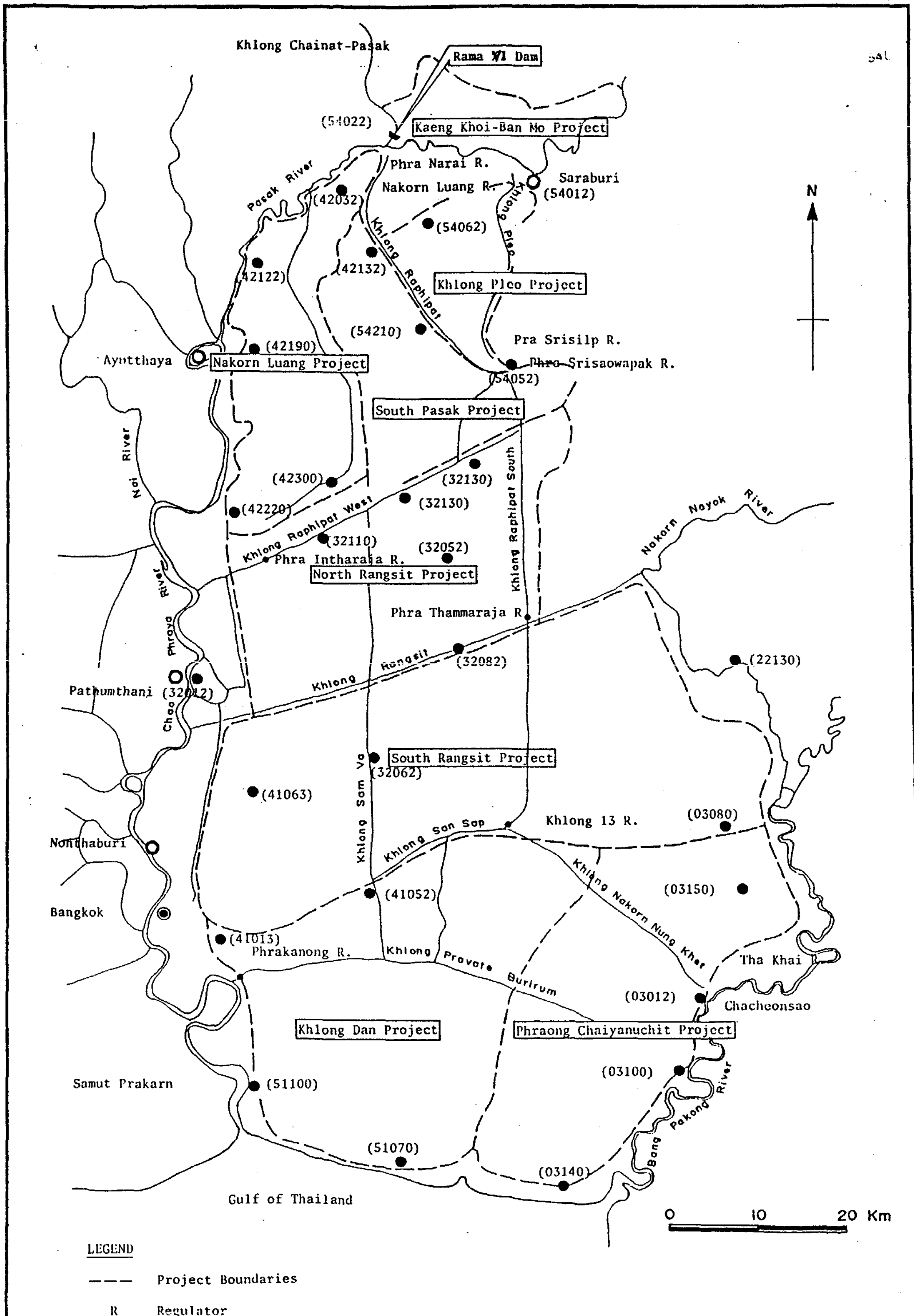

FIGURE 3.12-1 LOWER CHAO PHRAYA EAST BANK IRRIGATION PROJECT

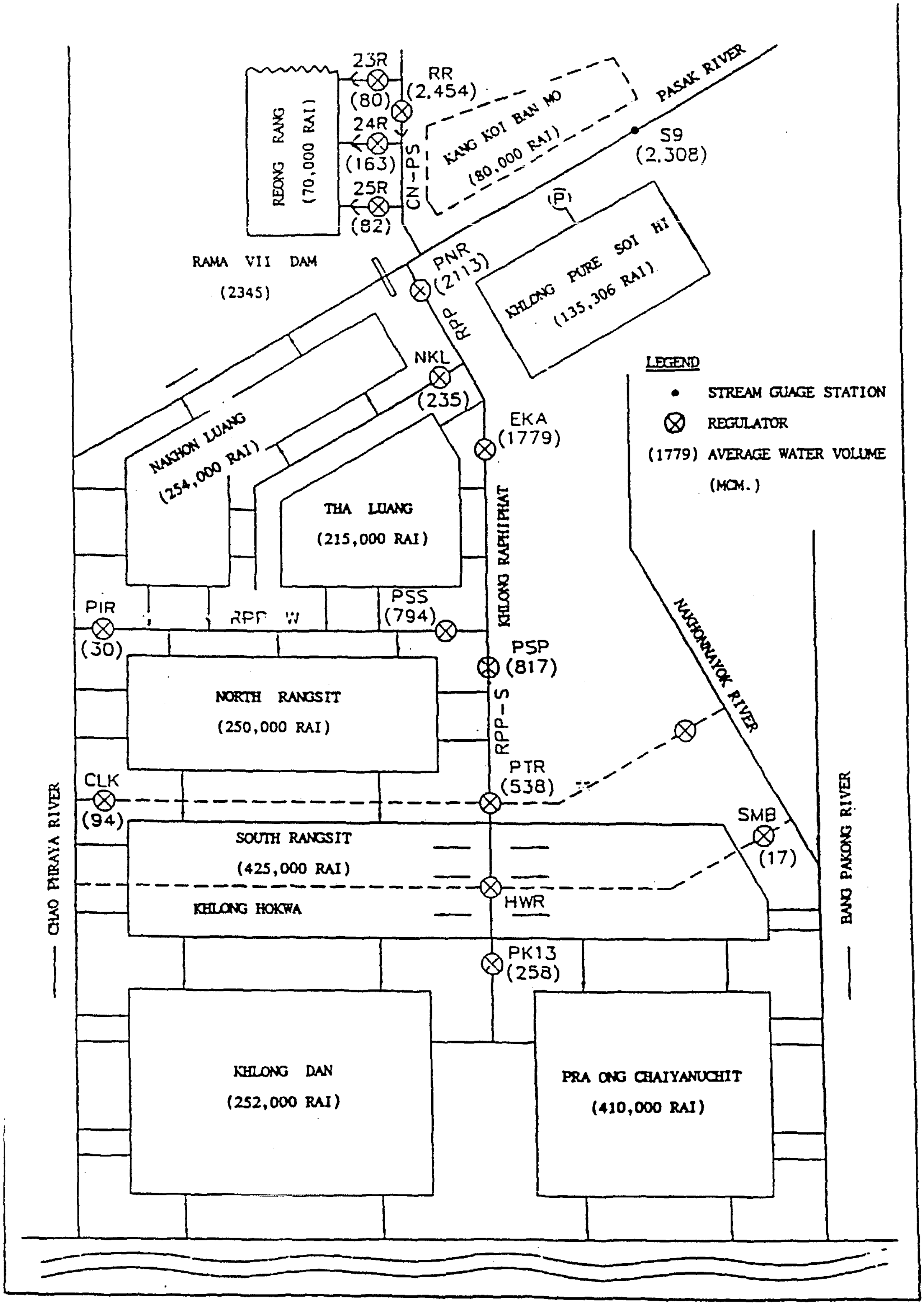

FIGURE 3.12-2 WATER MANAGEMENT IN LOWER CHAO PHRAYA EAST BANK IRRIGATION PROJECT

TABLE 3.12-1
WATER ALLOCATION IN LOWER CHAO PHRAYA-EAST BANK
(AVERAGE YEAR)

UNIT : MCM

'ear	Data Period	Apr. 30	May 31	Jun. 30	Jul. 31	Aug. 31	Sep. 30	Oct. 31	Nov. 30	Dec. 31	Jan. 31	Feb. 28	Mar. 31	Annual 365
VERAGE CONDITION														
23R Canal	29-34	2.7	2.1	1.3	9.7	11.3	14.1	16.7	12.2	1.1	1.5	2.1	4.9	79.8
erng Rang Reg.	08-34	197	188	213	212	215	256	259	240	182	145	146	201	2454
24R Canal	18-34	5.9	5.3	9.0	19.5	25.5	28.6	28.4	20.6	6.7	1.8	5.0	7.1	163.3
25R Canal (1)	n/a	3.0	2.7	4.5	9.8	12.8	14.3	14.2	10.3	3.4	0.9	2.5	3.5	81.6
Rama VI Dam	calc.	188	180	200	183	177	213	216	209	172	142	138	190	2209
ama VI Diversion Dam														
Pasak at S9	08-34	18	56	85	99	230	638	869	185	61	33	18	16	2308
RR at Rama VI	calc.	188	180	200	183	177	213	216	209	172	142	138	190	2209
Sum Inflow	calc.	206	236	285	282	407	851	1085	394	233	175	156	206	4517
Phra Narai Reg.	08-34	177	161	179	177	211	251	289	215	71	89	120	173	2113
D/S Rama VI	08-34	5	38	76	119	199	738	824	139	129	63	11	5	2345
Sum outflow	calc.	182	199	255	296	410	989	1113	354	200	152	131	178	4458
ıphiphat Canal														
Phra Narai Reg.	19-34	220	190	192	175	200	237	277	220	97	124	145	218	2295
Nakhon Luang Reg.	10-34	6	6	17	26	38	46	48	34	4	1	3	5	235
Ekathotsarot Reg.	22-34	181	160	162	127	132	163	167	137	87	121	147	194	1779
Phra Srisaowapak Reg.	10-34	92	75	71	55	55	66	79	61	39	57	71	96	817
Phra Sri Silp Reg.	19-34	70	68	62	50	57	67	91	51	35	46	50	60	709
Phra Intra Reg.	15-35	1.3	0.8	1.1	0.6	1.2	3.4	7.7	5.3	4.0	2.1	1.7	1.0	30.1
Phra Thammaracha Reg.	28-31	50	45	41	36	33	45	50	43	25	37	68	67	538
Phra Thammaracha Syphon	n/a	-	-	-	-	-	-	-	-	-	-	-	-	-
Hok Wa Syphon	n/a	-	-	-	-	-	-	-	-	-	-	-	-	-
Plai Khlong 13 Reg.	30-35	29	30	27	24	15	18	19	20	19	20	14	23	258
Chulalongkorn Reg.	30-34	15	9.0	8.0	5.0	0.0	0.0	1.0	2.0	2.0	7.0	22.0	23.0	94.0
Somboon Reg.	30-35	-1.0	1.0	0.0	-2.0	1.0	0.0	-1.0	1.0	2.0	10.0	7.0	-1.0	17.0

te: (1) No data was available at 25R. The diversion was estimated as half of that at 24R.

(2) "calc." means the values were calculated.

TABLE 3.12–2
AVERAGE WATER DEMAND FOR IRRIGATION PURPOSE

Area	Average (MCM)
To Khlong Raphiphat	2,113
Nakhon Luang Project	235
South Pasak/Tha Luang Project	267
North Rangsit Project	1,073
South Rangsit Project	280
Khlong Dan/Chaiyanuchit Project	258

TABLE 3.12-3
WATER MANAGEMENT FOR CHAO PHRAYA-EAST BANK AREA

PROJECT	AREA CROP														ANNUAL	JUL - DEC		JAN - JUN	
	WET	DRY	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	(MCM.)	MCM	%	MCM	%
A) IRRIGATION DEMAND																			
1. NAKHON LUANG	257234	7607	5	0	8	52	63	70	137	23	0	2	5	7	372	345	92.7	27	7.3
2. THA LUANG	184900	60678	18	2	3	24	28	23	34	7	0	7	22	30	198	116	58.5	82	41.4
3. NORTH RANGSIT	373649	246640	53	54	39	3	2	8	48	91	86	26	19	45	474	238	50.2	236	49.8
4. SOUTH RANGSIT	462881	232629	55	21	5	31	58	40	78	53	11	13	44	75	484	271	55.9	213	44
5. KHLONG DAN	344602	109874	19	7	1	2	12	15	42	38	8	4	15	25	188	117	62.2	71	37.8
6. PHRA ONG CHAIYANUCHIT	474609	348866	77	23	5	35	68	49	75	52	24	88	139	137	772	303	39.2	469	60.8
TOTAL WATER DEMAND	2E+06	1E+06	227	107	61	147	231	205	414	264	129	140	244	319	2488	1390	358.7	1098	44.1
B) WATER DIVERSION AT AVERAGE YEAR																			
1. AVG.FLOW AT PHRA NARAI REG. (08-34)			220	190	192	175	200	237	277	220	97	124	145	218	2295	1206	52.5	1089	47.5
2. AVG.FLOW AT RERNG RANG REG. (08-34)			188	180	200	183	177	213	216	209	172	142	138	190	2208	1170	52.9	1038	47

NOTE ; THE ACTUAL DEMAND FROM RAMA VI DAM IS LOWER DUE TO THE FACT THAT SOME PARTS OF DEMAND ARE SATISFIED BY THE RETURN FLOW FROM THE UPSTEAM IRRIGATION AREAS AND PUMPING FROM CHAO PHRAYA AND BANGPAKONG RIVERS.

SOURCE : FEASIBILITY STUDY AND ENVIRONMENTAL IMPACT ASSESSMENT OF PASAK PROJECT

Components of water use along Chao Phraya River downstream of the Dam are depicted in Figure 3.12-3.

- Irrigation water : Bang Ban, Chao Chet Bang Yi Hon, Phraya Ban Lue, Phra Pimol and South Rangsit,

- Domestic use and water supply,
- Industrial use, and
- Salinity intrusion control and navigation.

The computation of water requirement was performed considering dry season during March to April which is a critical period. The result from the MWA study reveals that existing water apart from navigation varies from 48.8 to 100.24 cms (1,538.9 to 3,161.2 MCM/yr) with mean value of 68.2 cms (2,150 MCM/year) (Table 3.12-4).

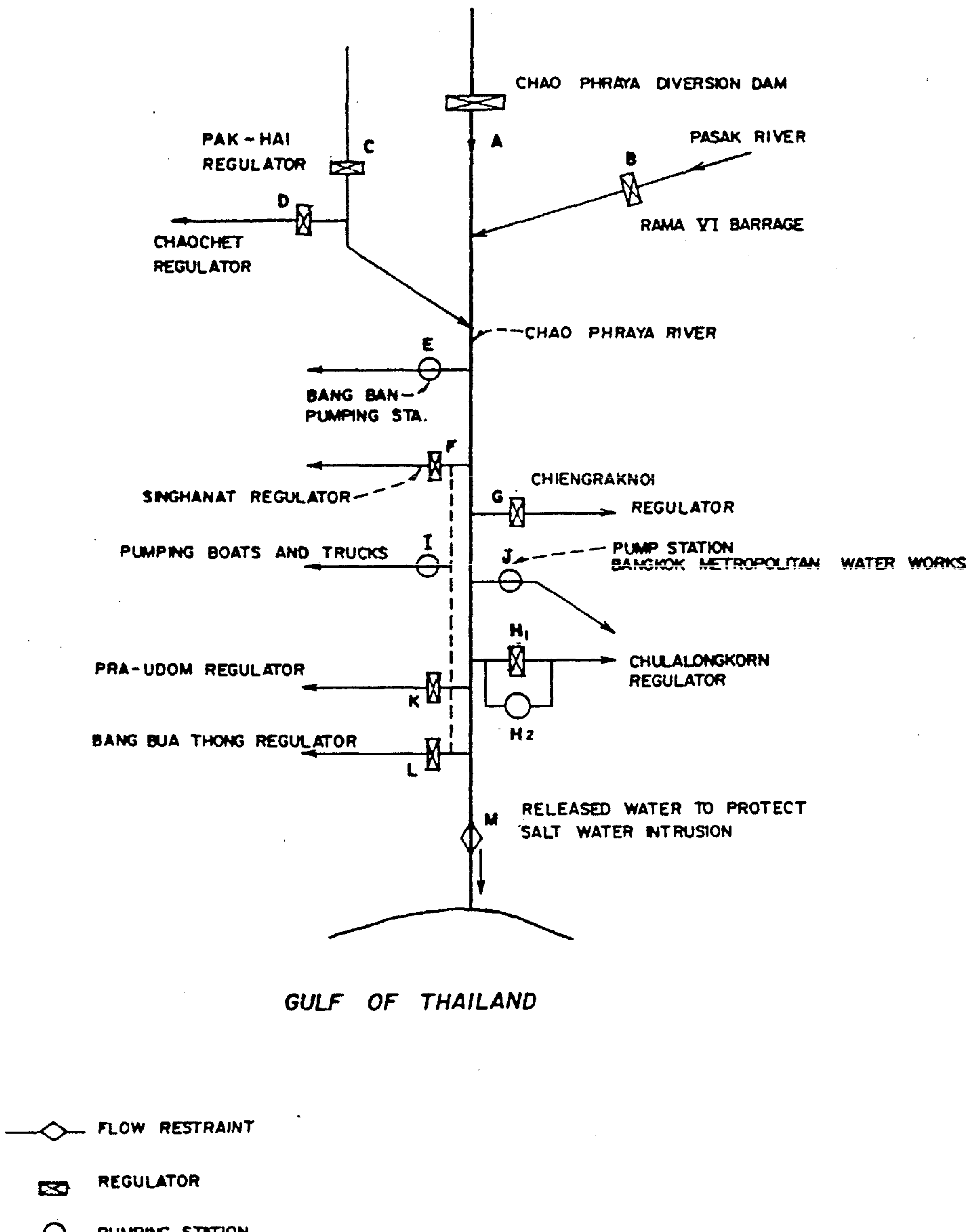

FIGURE 3.12-3 SCHEMATIC DIAGRAM OF WATER USE ALONG CHAO PHRAYA MAIN STREAM

TABLE 3.12–4
WATER DISCHARGE AT MEMORIAL BRIDGE FOR SALT WATER INTRUSION AND WATER POLLUTION CONTROL (1982–1988)

DATE		WATER DISCHARGE	
		CMS.	MCM/YR.
2525	MAR.	79.53	2,508.10
	APR.	100.24	3,161.20
2526	MAR.	67.97	2,143.50
	APR.	69.55	2,202.80
2527	MAR.	63.82	2,012.60
	APR.	69.14	2,180.40
2529	MAR.	66.60	2,100.30
	APR.	73.30	2,311.60
2530	MAR.	50.50	1,592.60
	APR.	62.30	1,964.70
2531	MAR.	66.20	2,087.70
	APR.	45.80	1,538.90
	AVG.	68.20	2,150.40

3.13 SOCIO - ECONOMICS

3.13.1 General

The power plant is located in Tambon Khao Ngam and Tambon Wang Chula of Amphoe Wang Noi, Ayudhaya Province. It is obvious that the establishment of the Power Plant will affect the whole community of Amphoe Wang Noi in terms of economy and social impact. Therefore, the existing conditions of Amphoe Wang Noi are presented herein to describe characteristics of its people.

Amphoe Wang Noi is one among 16 amphoes of Ayutthaya (Figure 3.13-1). It has an area of 224.0 sq.km. with 10 Tambons and 68 villages(Information from Central Population Registration, July 1, 1992). In 1992, There was a population of 44,703 in Amphoe Wang Noi comprising 22,304 males and 22,399 females. The total number of households was 9,352 in the same year. According to the population data of National Statistical Office, population of Amphoe Wang Noi has increased steadily during the past 10 year (1983-1992) between 0.16 upto 3.38 percent per annum (Table 3.13-1). The average annual increasing rate during the past 10 years is 2.03 percent. People in Amphoe Wang Noi earn their living from agriculture such as rice growing, fruit tree plantation, etc.

3.13.2 Population and Sample

To know socio-economic characteristics and attitudes of the villagers towards the Project, the 50 households were randomly drawn as a sample of the study by sampling technique of cluster. The villagers who lived in the area of 5 kilometers from site of the project of all direction were considered as a population who will be affected by the Project. Name of villages are listed in Table 3.13-1A. Those population was approximately 300 households. The population was divided into 5 groups by distance from the project site, 1, 2, 3, 4, and 5 km. The sample sizes were proportionally decreased with the distance, 10, 8, 6, 4 and 2 percent of population, respectively, or approximately 6 percent of population, as shown in Figure 3.13-2.

3.13.3 Social Characteristics

1. It was found that 41 of 50 households or 82 percent were living in the area for a long time and the rest of 9 households were still moving form the outside. Even before married, most of them were born and living in this area, and married to the couples living in the area. These were supported by the data that 40 respondents or 80 percent were born and living in this area before married and 31 respondents or 62 percent married to their couple who were born and living in this area. And 40 household or 80 percent of them wanted to migrate to other places. These indicated that this community was very old. People were connected to homogeneous group but theoretically less integration (Table 3.13-2).

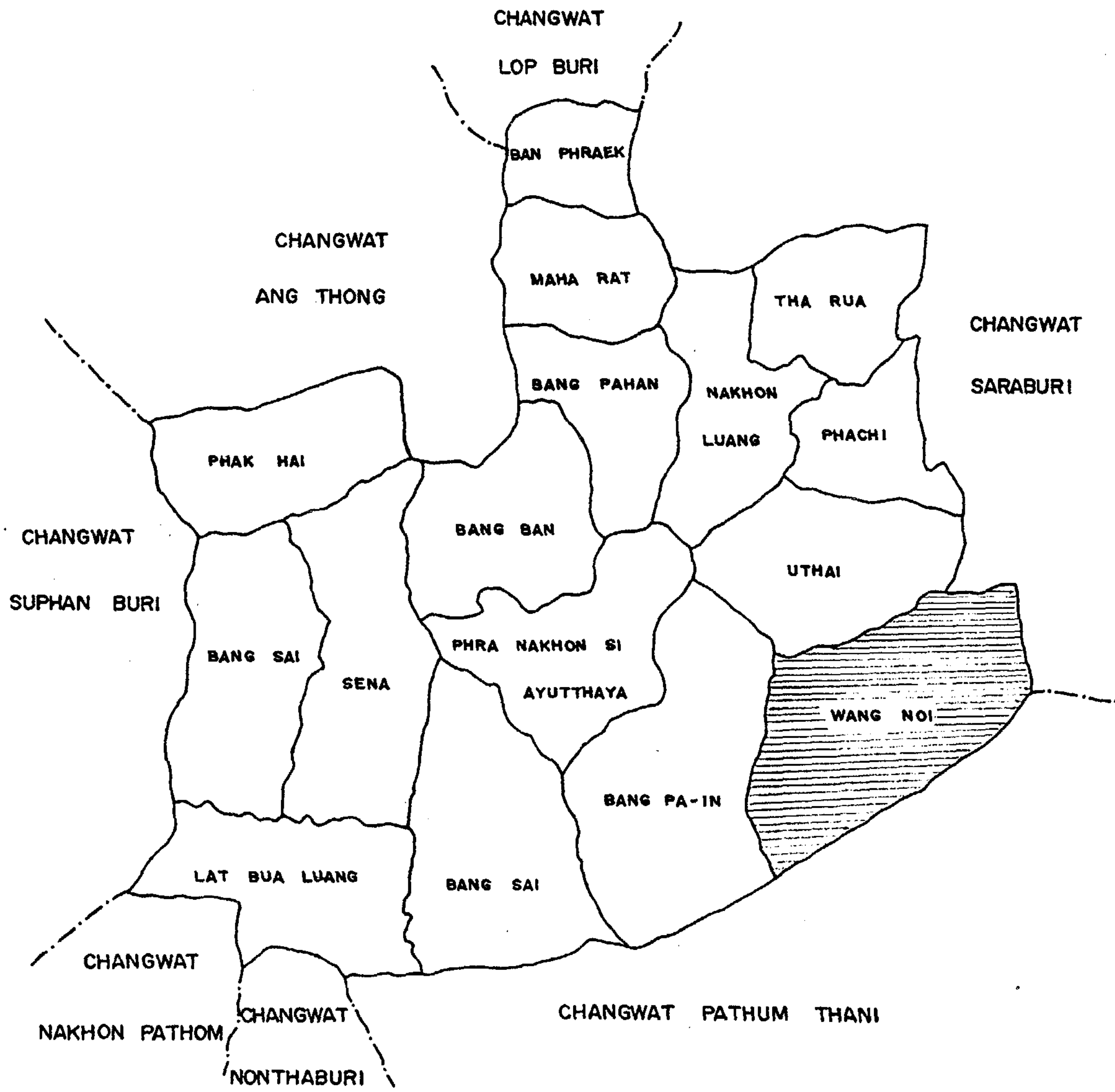

FIGURE 3.13-1 AMPHOES BOUNDARIES OF AYUDHAYA PROVINCE

TABLE 3.13-1

NUMBER OF POPULATION OF WANG NOI BY SEX AND NUMBER OF HOUSEHOLD

(1993 - 1992)

Year	No. of Population				No. of Household
	Male	Female	Total	% Increase per Annum	
1983	18,359	18,952	37,311	–	6,249
1984	18,250	19,121	37,371	0.2	6,436
1985	18,508	19,440	37,948	1.5	6,613
1986	19,154	19,814	38,968	2.7	6,734
1987	19,684	20,262	39,946	2.5	7,005
1988	20,421	20,874	41,295	3.4	7,548
1989	20,631	21,180	41,811	1.2	7,929
1990	20,996	21,653	42,649	2.0	8,285
1991	21,516	22,139	43,655	2.4	8,410
1992	22,304	22,399	44,703	2.4	9,352
Average				1.8	

TABLE 3.13-1A

LIST OF VILLAGES SAMPLED FOR SOCIO-ECONOMIC SURVEY

Distance from Power Plant (km)	Name of Village
0-1	Ban Wang Kham
1-2	Ban Khlong 8, Ban Wang Chula, Ban Khlong 6 Wah
2-3	Ban Khlong 7, Ban Suan, Ban Khaek, Ban Khlong Khaek, Ban Khlong 9
3-4	Ban Khlong 10, Ban Bung Ta Sa
4-5	Ban Bung Ta Kien, Ban Wang Noi, Ban Khlong 10, Ban Khlong 11

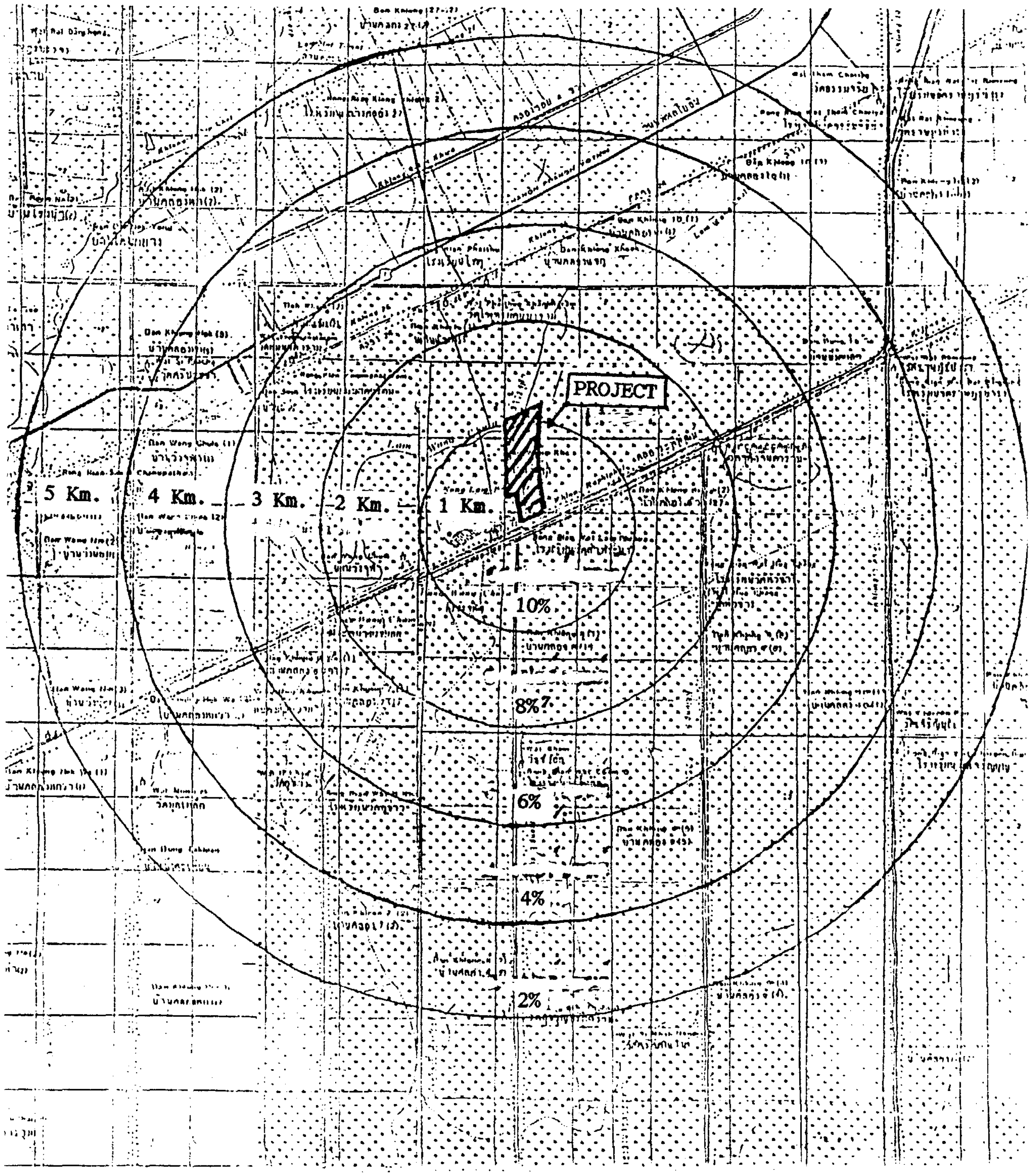

FIGURE 3.13-2 ILLUSTRATION OF SAMPLING FRAME OF SOCIO-ECONOMIC IMPACT STUDY

TABLE 3.13-2
SOME LIVING CHARACTERISTICS OF VILLAGERS

Living Characteristics	No. of Households	Percent
Living of household in the area		
Living for a long time	41	82.00
New migrant	9	18.00
Living area of respondents before marry		
In this area	40	80.00
Outside the area	10	20.00
Living area of couple before marry		
In this area	31	62.00
Outside the area	19	38.00
Migration of family		
Thought to migrate	10	20.00
No migration	40	80.00

2. Considering local organization, 16 households or 32 percent of the sample had their household's members in local organizations such as people scout, women group, village committee, tambon council, etc. while the rest of 34 households or 68 percent had no household member in local organization. It seemed that the villagers were not active in participating the local organizations but the they were rather involved in social activities. This indicated by the data that 33 households or 66 percent of the sample had their household members attending in every social and cultural festival conducted in the village or some where near the village and 14 households or 28 percent had their household members went to some festivals.

3. Although the village is near the district center and near Bangkok Metropolis, there were only 9 household heads or 18 percent of the sample reading newspapers everyday, 9 household heads or 18 percent reading newspapers some days and 32 household heads or 64 percent had seldom, a little, and never in reading newspapers since there were no newspapers, no time to read newspaper and one of them was illiterate. However they were able to get news and information from TV because 40 household heads or 80 percent of the sample watched TV everyday. However, radios seemed not popular in getting news and information. This was only 15 household heads or 30 percent of the sample listened to radios everyday and 30 household heads or 70 percent were seldom and never listening to radios (See Table 3.13-3).

4. According to public health, household heads told that their household members and themselves usually had general fever; headache, bodyache, etc. (86%) whereas other diseases including respiratory tract diseases, digestion channel diseases, and skin diseases were found not significant. When the villagers were sick, they usually went to any health services near their houses such as health care center, hospital, clinic, including buying medicine by themselves. It was convenient for them to reach any health services because the village was located near the district center where several health services were available (Table 3.13-4).

5. Asked about history of health in past 5 years, the household heads had the biggest problem of air allergies such as dust and other pollutions (46.00%). The second was skin diseases (22.00%) and short breathing, bronchitis and ear cripple (12.00% of each), as shown in Table 3.13-5.

3.13.4 Economic characteristics:

1. An average of household income of the sample was 116,615.20 baht/year, whereas the maximum was 350,280.00 baht and 20,000 baht as a minimum. It meant that the maximum was greater than the minimum approximately 17.5 times. Considering the distribution of household incomes it was found that the household incomes distributed relatively normal among five groups of income as seen in Table 3.13-6. It meant that there were continuously distribution of income.

TABLE 3.13-3
SOME SOCIAL CHARACTERISTICS OF SAMPLE

Social Characteristics	No. of Households	Percent
Living in social activities	(50)	(100.00)
Every activity	33	66.00
Some activities	14	28.00
Seldom	1	2.00
Little	1	2.00
Never	1	2.00
Reading newspaper	(50)	(100.00)
Everyday	9	18.00
Somtimes	9	18.00
Seldom	3	6.00
Little	11	22.00
Never	18	36.00
Watching TV	(50)	(100.00)
Everyday	40	80.00
Somtimes	4	8.00
Seldom	3	6.00
Never	3	6.00
Listening to Radio	(50)	(100.00)
Everyday	15	30.00
Somtimes	5	10.00
Seldom	11	22.00
Never	19	38.00

TABLE 3.13-4
DISTRIBUTION OF HEALTH SERVICES USED BY VILLAGERS

Health Services	No. of Households	Percent
Health Care Center	27	35.06
Hospital	16	20.78
Clinic	20	25.97
Drug Store	11	14.29
Others	3	3.90
Total	77	100.00

TABLE 3.13-5
5 YEAR HEALTH HISTORY OF HOUSEHOLD HEADS

Diseases	No. of Household Head			
	Having	None	Percent	Checked by Doctor
1. Allergies	23	24	46.00	5
2. Skin disease	11	39	22.00	3
3. Epilepsy	3	47	6.00	3
4. Heart disease	2	48	4.00	2
5. High blood pressure	1	48	2.00	1
6. Turberculosis	0	50	-	0
7. Diabetes	0	50	-	0
8. Short breathing	6	44	12.00	6
9. Anaemia	2	48	4.00	2
10. Bronchitis	6	44	12.00	6
11. Pneumonia	2	48	4.00	2
12. Sinus inflammable	1	49	2.00	1
13. Ear cripple	6	44	12.00	1
Total	62	583	9.54	

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TABLE 3.13-6

DISTRIBUTION OF HOUSEHOLD INCOME OF SAMPLE

Group of Income (per year)	No. of Households	Percent
50,000 baht and under	10	20.00
50,000 - 80,000 baht	9	18.00
80,001 - 110,000 baht	8	16.00
110,001 - 140,000 baht	8	16.00
140,001 - 170,000 baht	6	12.00
170,001 baht and above	9	18.00
Total	50	100.00

Max 350,280.00 baht/year
Min 20,000.00 baht/year
Ave 116,615.20 baht/year

2. Considering sources of household income, it was found that wage in private sectors was the biggest group. The second one was plant farming (rice and fruit) and wage in government sector (including public enterprise) as the third. These meant that the villagers earned their living mainly by to be hired in private industries and business. However, most of them were still growing rice and gardening fruit, especially orange (See Table 3.13-7). Most of them (74.00%) felt that their household incomes were sufficient for living whereas 10 households or 20.00 percent were still insufficient and 3 households or 6.00 percent were exceeded. And most of them (70.00%) felt that they might be able to increase their household income by adding some economic activities. Whereas 30.00 percent of them might not be able to increase their household income.

TABLE 3.13-7
SOURCES OF HOUSEHOLD INCOME

Source of Income	No. of Households	Income (Baht/year)	Percent
Plant farming	23	729,210	12.46
Animal farming	6	395,000	6.75
Trading and business	2	395,000	3.68
Wage in private sector	39	3,448,300	58.91
Wage in government sector (and public enterprise)	11	604,400	10.34
Others	10	461,600	7.86
Total	93	5,853,510	100.00

3. Considering an expense, the villagers paid about 2/3 of their household income as expenses. And it seemed that amount of expenses agreed with the household income. These were the greater for household income and the greater the expenses (See Tables 3.13-6 and 3.13-8).

TABLE 3.13-8
DISTRIBUTION OF HOUSEHOLD EXPENSE

Group of Expense	No. of Households	Percent
30,000 baht and under	8	16.00
30,001 - 50,000 baht	16	32.00
50,001 - 70,000 baht	9	18.00
70,001 - 90,000 baht	8	16.00
90,001 baht and above	9	18.00
Total	50	100.00

Whereas sources of household expenses were mainly in food and necessities (70.75%) and education of children (17.61%), and other sources were small, such as hobbies and leisure, charities, etc. (See Table 3.13-9). Most of them (66.60%) felt that their household expenses might not be increased in 1993 and 32.00 percent thought to be decreased. It meant that most of the villagers thought that they were able to maintain their expenses in 1993.

TABLE 3.13-9

SOURCES OF HOUSEHOLD EXPENSE

Source	No. of Households	Expense (Baht/year)	Percent
Food and necessities	50	2,888,440	70.75
Education of children	32	719,160	17.61
Hobbies and leisure	10	49,600	1.21
Charities	46	209,800	5.14
Repayment of debt	5	93,720	2.30
Insurance	28	112,100	2.75
Others	1	10,000	0.24
Total	172	4,082,820	100.00

4. Considering debt, 32 from 50 households or 64.00 percent were debted. An average debt was 95,280 baht. The biggest amount of debt was 10,001-40,000 baht (37.50%). The followings were 100,001 baht and above (25.00%) and 40,001-70,000 baht (25.00%) (See Table 3.13-10).

TABLE 3.13-10

DISTRIBUTION OF DEBT

Group of Debt	No. of Households	Percent
10,000 baht and under	3	9.38
10,001 - 40,000 baht	12	37.50
40,001 - 70,000 baht	8	25.00
70,001 - 100,000 baht	1	3.12
100,001 baht and above	8	25.00
Total	32	100.00

In terms of amount of money, the biggest source of loan was commercial banks, and the second was friends and relatives. It meant that the loan was mainly paid on trading and business or big farm not small farmers. Small farmers usually borrowed from Thai Farmers Bank. See Table 3.13-11.

TABLE 3.13-11
SOURCES OF LOAN

Source	No. of Households	Loan (Baht)	Percent
Thai Farmers Bank	20	608,000	12.25
Other Banks	4	2,600,000	52.40
Monetary Institute	2	120,000	2.42
Personal Loan Owner	3	90,000	1.81
Friend and relatives	9	1,494,000	30.11
Other	1	50,000	1.01
Total	39	4,962,000	100.00

And the traditional loan was still significantly remained in the villages. Among the debtors, at about 62.0 percent of them thought that their debt might not be increased and might be decreased in 1993. It meant that the amount of debt was large compared to income (84.77% of income) but not serious because the debt was mainly for investment that was able to be repaid.

5. Considering saving, there were only 17 households or 34.00 percent having saving. An average saving was 29,040.20 baht, 7,000 baht as minimum and 1,000,000 baht was maximum. Amount of all saving was 1,452,000 baht (24.81% of income). The saving were mainly in 10,000 baht and under (35.30%) and 25,001 - 40,000 baht. (See Table 3.13-12) These meant that there were small saving and the saving were still in the group of upper class of income. However, 16 of 17 households who had saving thought that they might have more saving in the future.

TABLE 3.13.12
DISTRIBUTION OF SAVING

Group	No. of Households	Percent
10,000 baht and under	6	35.30
10,001 - 25,000 baht	3	17.65
25,001 - 40,000 baht	4	23.53
40,001 - 55,000 baht	2	11.76
55,001 baht and above	2	11.76
Total	17	100.00

Maximum	1,000,000.00	Baht
Maximum	7,000.00	Baht
Average	29,040.20	Baht

6. An economic character of the villagers, in general, were relatively poor with an average household income of 116,615.20 baht/year and very wide disparity of income from 20,000 baht/year as minimum to 350,280. baht as maximum 17.5 times of difference. Most of the villagers earned of leaving by working as labor in private sector including industries and businesses and some of them were still doing plant farming including rice and orange. The use of water in agriculture, therefore, was still very needed. Total household income of the sample (50 households) was 5,853,510 baht, whereas all expense was 4,082,820 baht or about 70 percent of income used as expense. Most of expense was on food and necessities and education of children. While about 64 percent of the sample were debting with and average of 95,280 baht/household, 2,000 baht as minimum and 1,000,000 baht as maximum. All debt was 4,962,000 baht or about 84 percent of household income. The amount of debt therefore was large big compared to income. However, the debt was mainly used for an investment that was able to be repaid. Only 17 of 50 households were having saving with an average of 2,904 baht/household. All saving was 1,452,000 baht or about 24 percent of income that was relatively small.

3.13.5 Attitudes towards Wang Noi Combined Cycle Power Plant

1. On an awareness on the Project, the 37 household heads or 74.00 percent knew that the Power Plant will be located at Wang Noi, and the rest of 13 household heads did not know it. In addition it was observed that the awareness on the Project varied against distance of site of the Project to household location, reversely. It was the longer the distance, the more the awareness. These showed weak communication of the Project to the villagers who lived relatively far from the project location. It was confirmed by the fact that 21 household heads or 42.00 percent knew the

Project by being told from someone, and only 3 household heads or 6.00 percent knew by direct public relations made by the Project.

2. After details of the Project were described by the interviewers, most of household heads or 146 household heads or 92.00 percent thought that the Project might bring development to the village; such as better road, electricity, telephone, better job opportunities. higher income, and better economic condition of the village, in general. And 27 household heads or 54.00 percent thought that the Project would make them get more income. Whereas 22 household heads or 44.00 percent thought that the Project would not help increase their income.

3. About air pollution, the villagers had been always disturbed by dust from the reconstruction of road in the village. The construction of the Project might cause dust disturbance. It was confirmed by the fact that 47 household heads or 94.00 percent reported dust disturbance from reconstruction of road in the village and 26 household heads or 52.00 percent thought that construction of the project might produce dust disturbance. If the villagers were to be disturbed by dust from the Project, the villagers suggested the Project should use appropriate methods to control dust such as spraying by water, covering routes by asphalt and filtering dust of the Plant, as shown in Table 3.13-13.

4. About noise pollution, it was reported that there is existing low noise pollution in this village. Only 6 household heads or 12.00 percent reported that there was existing "high noise pollution" in the village, 22 of them or 44.00 percent reported "low noise pollution" and the rest of 22 household heads or 44.00 percent reported "very low noise pollution". In addition the Project might produce low noise pollution. However, some of them (8.00%) did not know or were not able to imagine. If the Project produced high noise pollution, some villagers suggested to control speed limit of trucks and avoid any noisy activities at night, as shown in Table 3.13-13.

TABLE 3.13–13
ATTITUDES OF VILLAGERS TOWARDS PROJECT

Environmental Impact Caused by Project	No. of Household Head	Percent
Village development		
Yes	46	92.00
Ne	4	8.00
Increase of income		
Yes	27	54.00
Ne	23	46.00
Existing dust disturbance		
High	47	94.00
Low	3	6.00
Dust disturbance by project		
Yes	25	50.00
No	24	48.00
Do not know	1	2.00
Existing noise pollution		
High	6	12.00
Low	22	44.00
Very Low	22	44.00
Noise pollution by project		
High	5	10.00
Low	20	40.00
Very Low	19	37.00
Do not know	6	12.00
Existing water in agriculture		
Sufficient	37	74.00
Seldom sufficient	10	20.00
Not sufficient	3	6.00

F:T3–13–13.WK1/37–B–0043

TABLE 3.13-13
(CONT'D)

Environmental Impact Made by Project	No. of Household Head	Percent
Cleanliness of water sources		
Most of them clean	43	86.00
Some of them clean	4	8.00
Most of them dirty	3	6.00
Water pollution generated by Project		
High	1	2.00
Moderate	2	4.00
Low	40	80.00
None	7	14.00

5. On water sources in agriculture, the villagers usually utilized water from irrigation canals passing through the villages for plantation, animal feeding and other purposes and the quantity was sufficient. It was confirmed by the data that 37 household heads or 74.00 percent had sufficient water in agriculture while 10 household heads or 20.00 percent and 3 household heads or 6.00 percent reported seldom sufficient and not sufficient, respectively. An existing water source in the village was still clean. These were reported by 43 household heads or 86.00 percent. The Project was imagined to produce "low" level of water pollution. It was reported by 40 household heads or 80.00 percent (see the details in Table 3.13-13). If the Project produced water pollution, some villagers suggested that the polluted water should be treated before discharge to natural water sources. And importantly, if polluted water appeared in villager's water sources, the villagers had to complain and request the Project to solve the problem.

6. Considering all factors affecting an environment of the village, most of villagers, thought that the project might produce more positive effects than negative effects and most of them accepted the Power Plant, as shown in Table 3.13-14.

TABLE 3.13-14
GENERAL EFFECTS OF PROJECT TO COMMUNITIES

General Effect	No. of Household Head	Percent
Positive and negative effects		
Positive effect more than negative one	43	86.00
Positive effect equal to negative one	4	8.00
Positive effect less than negative one	3	6.00
Decision on establishment of Project		
To be built	42	84.00
Not to be built	3	6.00
Not clear/no answer	5	10.00

F:T3-13-14.WK1/37-B-0043

3.14 PUBLIC HEALTH

3.14.1 Introduction

Public health is a main concern involved in any development of a project. The development of the Power Plant is expected to bring benefits to the country economy as a whole, even if the problems on public health persist. However, the health status of people residing and working in the project vicinity should still be considered.

3.14.2 Objective

The objective of the study is to assess impact of the Power Plant on health of people who live in and nearby the project area.

3.14.3 Study Methodology

Activities conducted for the public health study include literature review of related documents and reports available from various sources, and data collection in the project area. The collected information and data were analyzed to predict future trend of public health conditions. Impact assessment was based on the existing conditions, and trends, project description and operation plans, results of air quality modelling, and results of related studies. Recommendations for mitigation measures and monitoring programs were drawn from the result of the impact assessment.

For existing condition, emphasis is given to those of Ayudhaya. The data may be compared with those of the country or central region of Thailand. Most of tables or figures of this section are presented in Appendix D.

3.14.4 Existing Conditions

3.14.4.1 General Public Health Conditions

Wang Noi is an amphoe located south-east to Ayudhaya where borders on Pathumthani and Saraburi. The area of Wang Noi is approximately 224 sq.km. Population is 46,070 (1 July 1992) and population density is 206 persons/sq.km. (Ayudhaya Provincial Health Office, 1992). According to the annual report of Provincial Health Office in 1992, environmental and food sanitation in Wang Noi was quite good. That is; 94.14% of households have sanitary latrines; 91.18% have sanitary waste disposal containers; and 88.52% have clean water for use and drink.

Since the ancient time, Thai used to live along rivers and canals. Even nowadays in Wang Noi, there are a lot of people living along and nearby rivers and canals. Although most of households in Wong Noi have sanitary water supply, rain water is still be used as drinking water and water from the river or canals is taken for household consumption. Quality of water in Ayudhaya, using number of bacteria as an index, is not so good. That is 67.11% of rainwater, 50.61% of water from water supply system and 23.07% of canal water are qualified.

Furthermore, a report from food sanitation section in Provincial Health Office shows that only 54 restaurants out of 119 in Ayudhaya reach qualified standard.

These show that food and environmental sanitation is a big problem and it turns to be major cause of disease in this asea.

3.14.4.2 Public Health Statistics

Since Ayudhaya is located in central region of Thailand, north of Bangkok Metropolis, most public health statistics would be presented parallel to those of the central region which consists of 25 provinces. However, some statistics would be compared to those of the country depending on which is available and suitable.

1) Vital Statistics

Livebirth rates, death and natural increasing rate in Ayudhaya slightly fluctuate comparing to those of the whole country. The country's rates trend to be increasing. The number and death rates of infant slightly increase in the last two years (1992-1993) which seem to be the same pattern as that of the country. Vital statistics of Ayudhaya is presented in Table D-1, Appendix D.

2) Major Causes of Morbidity and Mortality

The first ten leading causes of morbidity and mortality as presented in Table D-2, Appendix D show that, for the whole country, non-infectious diseases and accidents are the major causes of death. These are similar to those of Ayudhaya (Table D-3). However, surveillance system of the Ministry of Public Health, Table D-4 and D-5 Appendix D shows that among top ten morbidity rate and mortality rate of diseases, the illness due to poor environmental sanitation such as acute diarrhea, dysentery, food poisoning, T.B. and hepatitis are still in this group. Among 25 provinces located in central region, Ayudhaya is in the top rank for these kinds of illness, e.g. it is in 3rd rank (1991 and 1993) for food poisoning, 4th (1991) and 7th (1992) for dysentery and 7th (1992) and 9th (1991) for acute diarrhea (Table D-6 and D-7 Appendix D). Table D-8, Appendix D, presents number and morbidity rate of the diseases due to poor environmental sanitation, diseases transmitted by food and water, in Ayudhaya.

Furthermore, concentrate on the report of the first ten causes of out-patients in Ayudhaya (Table D-9, Appendix D) during 1990-1992 disease of respiratory system is in the first rank for all these three years and diseases of skin and subcutaneous tissue is in the fifth rank. Causes of illness among in-patients (Table D-10, Appendix D), bronchitis, emphysema and asthma, the diseases of respiratory system are in the fourth rank and pneumonia is in the eighth. The number of cases and morbidity rate of three respiratory diseases : influenza, pneumonia and T.B. in Ayudhaya (1990-1992) is presented in Table D-11, Appendix D. Especially, pneumonia is one of the important infectious diseases in Ayudhaya. The risk group for pneumonia is child age under 5 years old. It is in the 2nd rank for cause of death among children.

Specifically, according to major causes of morbidity and mortality in Wang Noi, reports of out-patient in Wang Noi hospital (10-bed community hospital) show that diseases of respiratory system is in the first rank and diseases of skin and subcutaneous tissue is in the seventh in 1992 and ninth in 1993 (Table 3.14-1).

3) Health Facilities and Personnel

Ayudhaya is composed of 16 amphoes, 208 tambons within an area of approximately 2,560 sq. km. It is located in the central region, 75 km. from Bangkok Metropolis. Population is 762,716 (Dec. 1993, Provincial Public Health Office) and the population density is about 270 persons/sq.km. Most of land in Ayudhaya is used for agriculture (80%). About seventy percent of population are agriculturists. However, there are 538 factories (1992) with the workers of about 407,892 most of which migrate from other provinces.

Health facilities provided by the government are one general hospital (322 beds), eleven community hospitals (one 90-bed, one 60-bed, four 30-bed and five 10-bed) and 206 health centers including government specialized health agencies serving in this province such as Venereal Disease and AIDS Center. In addition, there are also some private health facilities. There are 59 clinics and four hospitals (2-not more than 10 beds, 1-not more than 50 beds and 1-more than 100 beds). Summary of available health facilities in Ayudhaya is presented in Table 3.14-2.

Serious shortage of physicians and all kind of health personnels affects almost the whole country especially provinces other than Bangkok Metropolis. Eventhough Ayudhaya is not too far away from Bangkok Metropolis, the problem still exists. The number of physicians in Ayudhaya in 1991 was 72 which made up the ratio of population per physician to be 9,380 which is about twice of that of the whole country. In 1992, two physicians added up in this province but population per physician was still higher than the average of the country. The ratio of population per other health personnel is in the same pattern, as presented in Table 3.14-3.

TABLE 3.14-1

NUMBER AND CAUSE OF ILLNESS OF OUT-PATIENTS OF

WANG NOI HOSPITAL OCT'91 - SEP'92 (1992) AND

OCT'92 - SEP'93 (1993)

Illness	1992		1993	
	Rank	Number	Rank	Number
Respiratory System	1	3,110	1	6,063
Accident and Poisoning	2	2,750	2	5,481
Digestive System	3	1,928	4	3,341
Symptoms and Ill-defined Condition	4	1,653	3	3,367
Infectious and Parasitic Diseases	5	800	6	1820
Musculoskeletal System and Connective Tissue	6	718	7	1364
Skin and Subcutaneous Disease	7	503	9	954
Mental Disorder	8	475	10	844
Blood Circulation System	9	438	5	1928
Nervous System and Sense Organs	10	416	11	744
Genital-Urinary System	11	368	12	666
Endocrine and Metabolic Diseases	12	222	8	1200
Complication of Pregnancy and Childbirth	13	168	13	333

Source : Wang Noi Hospital, Ayudhaya

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TABLE 3.14-2

HEALTH FACILITIES IN AYUDHAYA

Government		Private	
Category of Facilities	**Number**	**Category of Facilities**	**Number**
General Hospital	1	Hospitals	4
Community Hospitals	11	Clinics	59
General Hospital Branch	4	Dental Clinic	17
Health Center	206	Obstetrical Clinic	13
Provincial Health Office Clinics	1		
Venereal Disease & AIDS Center	1		
Community Medical Center	1		

Source : **Ayudhaya Provincial Health Office (1992).**

TABLE 3.14-3

HEALTH PERSONNEL AND POPULATION PER PERSONNEL IN AYUDHAYA (ONLY GOVERNMENTAL SECTOR) AND THE WHOLE COUNTRY

Category of Personnel	*Ayudhaya		**Country	
	Number	Pop[a]/Personnel	Number	Pop[a]/Personnel
Physician	74	9,282	12,808	4,425
Dentist	18	38,158	2,408	23,530
Pharmacist	22	31,220	4,333	13,076
Nurse	552	1,244	40,685	855
Public Health Technical Staff	40	17,171		
Nurse Aid	49	14,017		
Dental Assistant	39	17,611		
Assistant Pharmacist	20	34,342		
Technician	34	20,201		
Radiographer	20	34,342		
Health Worker	102	6,734		

Source : * Ayudhaya Provincial Health Office (1992)

** Public Health Statistics, 1991, Health Statistics Division, Office of the Permanent Secretary, Ministry of Public Health

F:T3-14-3.WK1/37-B-0043

This points out that number of health personnel in Ayudhaya is not sufficient. However, since Wang Noi is located next to Saraburi and Pathumthani, it is likely that people in Wang Noi or other parts of Ayudhaya would come to receive health service in both provinces or either Bangkok Metropolis. Furthermore, private sector was taken into account when number of population per health personnel was calculated. Thus, private hospitals and health facilities in Ayudhaya itself would be able to relieve a crisis to some levels.

4) <u>Health Services</u>

Health services in government sector are executed through the line under the Office of the Permanent Secretary of the Ministry of Public Health. The Provincial Health Office is responsible for providing health services in the area under its jurisdiction.

Health services may be divided into three areas, i.e. cure, prevention and control, and promotion of health. Curative work under the responsibility of the Provincial Health Office goes through general hospitals, community hospitals, etc. as mentioned in health facilities section. Prevention and control and promotion of health are conducted by the Provincial Health Office itself and also in cooperation with other organizations.

For prevention and control of diseases, 34 diseases are in surveillance system under epidemiology job. To prevent and control general communicable diseases, Provincial Health Office deals with the diseases which are spread out via water and food and mosquito and those which can be prevented by vaccination and infectious disease while health promotion section's work includes family planning, mather and child health, school health and nutrition.

3.15 OCCUPATIONAL HEALTH AND SAFETY

Poor management on occupational health and safety can cause total loss which includes injury, property, and manufacturing time loss. Therefore, adequate preventive measures must be planned and implemented. The prevention measures will be specified during the operation of the Project.

3.15.1 Heat

The ambient design temperatures used as design and performance criteria are:-

- For combustion turbine performance, °C

  Dry bulb32.6°
  Wet bulb28.9°
  Hg76%

- For auxilliary equipment design, °C

  Dry bulb43°
  Wet bulb38.1°
  Hg76%

Each combustion turbine generator is capable of operating across the full range of specified conditions.

In such condition, the heat stress exposed by the employees should be considered. The factors that should be taken into account are the workload, the exposure period, wind velocity, etc.

3.15.2 Noise

The combustion turbine generator, electrical equipment and controls will be located in enclosures with acoustic insulation for control of noise level.

At any capacity of each combustion turbine generator, the noise level should not exceed 54 dBA at 122 m away or 85 dB A at a distance of 1 m.

3.15.3 Fire Detection and Protection System

The entire combustion turbine generator installation, including all auxilliary enclosures, will be protected from fire with a complete automatic carbon dioxide fire protection system. The system includes cylinders, cylinder racks, piping, valves, nozzles, detectors, fire alarm actuating system, and all other equipment necessary for the safe and efficient operation of the units. Actuation of the fire protection system will be indicated at the remote control station, and by an audible alarm to warn any personnel in the turbine area of imminent danger. The sound alarm will be activated inside and outside the enclosures prior to release of carbon dioxide, allowing sufficient time for personnel to exit. The detection systems will also detect high concentrations of gas and alarm this condition.

The fire protection system will be suitable for units which will normally be unattended, will be fully automatic, and will be designed and installed in accordance with applicable codes of the National Fire Protection Association. The fire detection and protection system will be subject to the review of the authority having jurisdiction and be approved by EGAT's insurer.

A separate detector system and alarm will be provided for each enclosure. A minimum of two detectors will be located in each area particularly susceptible to fire and/or areas which would sustain costly fire damage. The bidder will state which authorities have approved the fire detectors.

The detector system will be arranged so that the normal operation and maintenance of the Power Plant can be carried out without dismantling the detector system.

Individual fire alarm annunciator equipment for each compartment or enclosure will be provided for the central control station and the alarms will also be displayed on the local control panel. A signal to indicate actuation of each compartment's fire protection system will be sent to the fire protection panel.

Each compartment or enclosure will be protected as a separate risk and the discharge of extinguishing agent into one compartment or enclosure will not affect the other compartments or enclosures.

The enclosure ventilating fans will be stopped and openings closed automatically in any enclosure in which the fire protection system comes into operation.

Equipment will also be provided to enable the initial discharge for each compartment or enclosure to be manually released in the event of failure of the automatic release mechanism. The location of the manual actuator for each compartment or enclosure will be in a position acceptable to EGAT.

Actuating devices will be arranged so that their operation can be checked by simulating fire conditions as nearly as possible. Reliability and avoidance of spurious alarms is of prime importance.

Full reserve cylinders of the fire extinguishing agent will be supplied, installed, and connected for use should a second fire occur before the initial battery of cylinders can be recharged.

Fire protection piping and components will be located in such a manner as to not impede the dismantling or removal of the unit housings.

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Full reserve cylinders of the fire extinguishing agent will be supplied, installed, and connected for use should a second fire occur before the initial battery of cylinders can be recharged.

Fire protection piping and components will be located in such a manner as to not impede the dismantling or removal of the unit housings.

A gas measurement instruments will be furnished to monitor and alarm hazardous levels of flammable gases within the combustion turbine enclosure. Each section of the enclosure will be provided with a detector head. The control module, located in the control room, will monitor and alarm each detector head. Failure of the detection elements or their associated wiring will be detected and displayed by a fault detection system.

3.15.4 Fire Protection Equipment

The following fire protection equipment will be furnished completely with accessories as specified.

16 - Fire hydrants, each with an operating wrench and a nonrising stem type secondary gate valve.
4 - Yard hydrants, each with a nonrising stem type isolating gate valve.
24 - Header shut-off valves with indicator posts.
16 - Hose houses.
40 - Hose cabinets, each with hose rack, hose valves, and couplings (10 per combined cycle block).
101 - Portable fire extinguishers (25 per combined cycle block plus 1 at the intake structure).
9 - Wheeled portable extinguishers (2 per combined cycle block plus 1 at the intake structure).
24 - Fire protection systems consisting of five fog nozzle systems for electric transformers for each combined cycle block and one foam water system for the steam turbine lube oil reservoir, lube oil conditioner, lube oil centrifuge and steam turbine EHC unit for each combined cycle block (6 per combined cycle block).
4 - Fire protection system designed to cool the outer surfaces of the outside fuel oil storage tanks (1 per fuel oil storage tank).
4 - Foam fire protection system designed to introduce a foam mixture into the center of the fuel oil storage tanks near the bottom (1 per fuel oil storage tank).

3.16 AESTHETIC VALUES AND TOURISM

3.16.1 Introduction

The architectural structure design of a power plant is related to environmental aesthetic quality around the plant site and its vicinity. Aesthetic quality of a power plant site can be changed significantly if the site is located near a major road. Generally, effects will depend on architectural design, landscape, topography, and vegetative around the site.

The objectives of the aesthetic values and tourism study were:

(1) To describe general existing aesthetic and tourism quality of the plant site and its vicinity within a 5 km radius.
(2) To assess impacts of project development on aesthetic and tourism quality in the vicinity of the site.
(3) To recommend measures to alleviate adverse effects on aesthetic values and tourism.

3.16.2 Aesthetic Quality of the Power Plant Site

Amphoe Wang Noi is located in an area mostly of a flat plain topography in the quaternary period. The recent flood plain of Wang Noi area is alluvial, sand, silt and back swamp deposits. Major land use pattern is of paddy fields. The irrigation canal found significant in the project area called Khlong Raphiphat is used for crop cultivation. The Power Plant occupies an area of 718 rai in the flat land. The vegetation within a 5 km radius area around the Power Plant are 34,856 rai of rice field and 8,381 of rai fruit orchards. The land use of urban and built up land of 1,112 rai, water body of 2,581 rai, idle land of 756 rai and flooding land of 1,400 rai (Figure 3.10-1 in section 3.10). Land use pattern in the surrounding areas, within a 5 km radius from the power plant site, is dominated by rice fields followed by fruit orchards. The scene is quite typical of rural agricultural areas in the central region, and is relatively quiet and serene.

None of the significant historical value or old ancient building appears in the areas except the buddhist monasteries (Wat). There are a number of about 20 monasteries around the Project and vicinity. Some monasteries were of old buildings such as Wat Lam Phraya and Wat Sawang Arom. Wat Lam phraya is the monastary near the power plant site, approximately 80 years of age. The monastary is now in a state of disrepair and new temples will be built instead of old temples. Figure 3.16-1 illustrates the distribution of buddhist monasteries around the Power Plant.

Along Phahonyothin Road near the entrance of the proposed project site, there are some industries settled along the route, e.g. electronics factory, watch factory and machinery factory. Some developments of Wang Noi area can be easily seen from Phahonyothin Road, including a high tension power transmission line near the proposed power plant site.

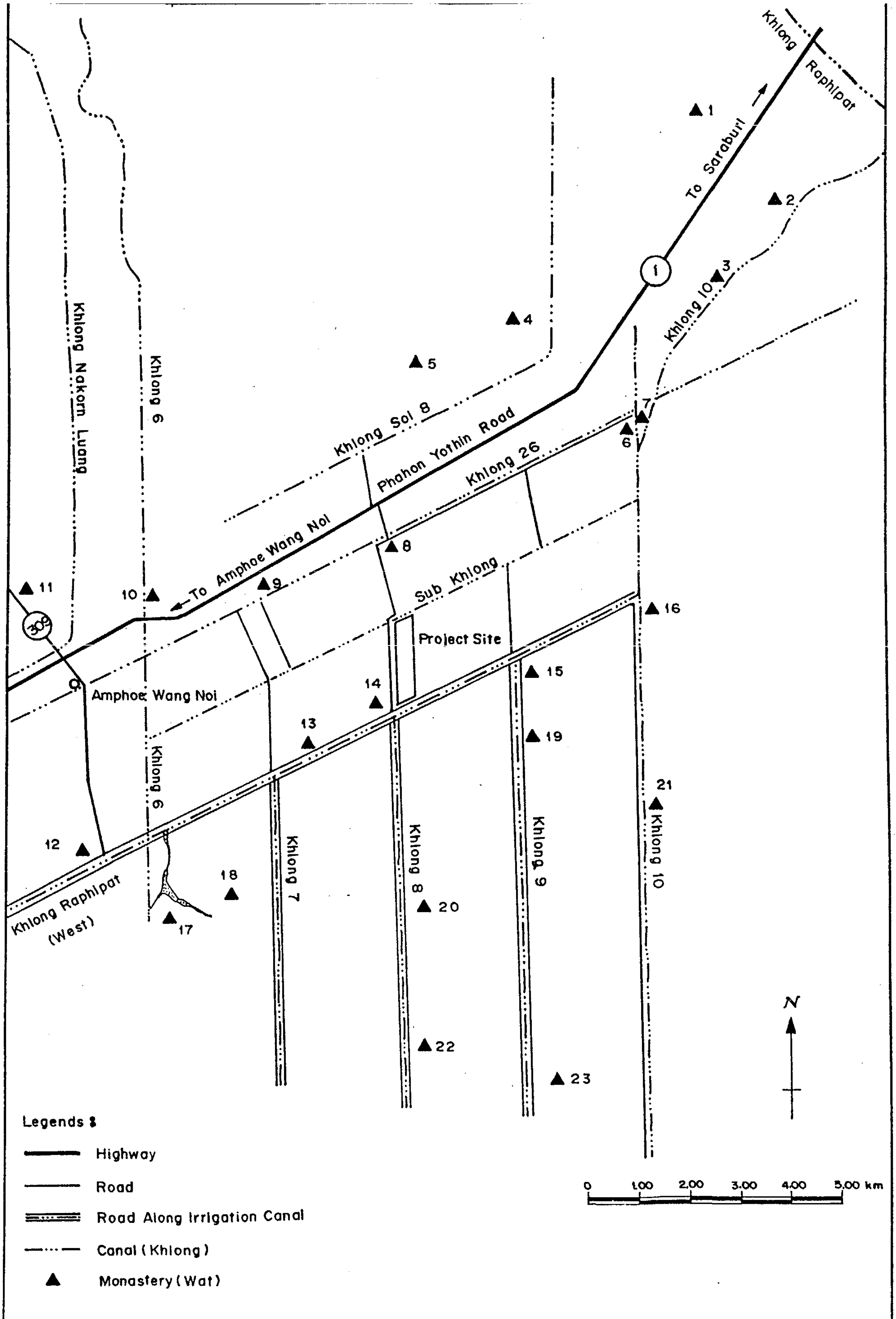

FIGURE 3.16-1 DISTRIBUTION OF MONASTERIES AROUND THE POWER PLANT

List of Monastery (Wat) of the proposed project and vicinity

1. Wat Phai Tam
2. Wat Khok Khi Lek
3. Wat Suan Kluai
4. Wat Thammaram
5. Wat Wong Sawan
6. Wat Thamchariya
7. Wat Rat Bamrung 1
8. Wat Phaithun Khanimaram
9. Wat Yommanataram
10. Wat Si Pracha
11. Wat Siwaram
12. Wat Monthon Prasit
13. Wat Sawang Arom
14. Wat Lam Phraya
15. Wat Chula Chindaram
16. Wat Rat Bamrung 2
17. Wat Mun Lek
18. Wat U Khao Lek
19. Wat Hua Chang
20. Wat Cham O
21. Wat Charoen Bun
22. Wat Suk Bun Tharikaram
23. Wat Si Khat Nang

FIGURE 3.16-1 (CONTINUED)

From the above discussion, it is concluded that aesthetic quality in the vicinity of the proposed power plant site is typical of rural agricultural areas in the central region. It is still good, calm and serene, but there are some adverse effects from developments such as the existing industries, residential buildings, and transmission lines in the project area and its vicinity.

3.16.3 Present Status of Tourism

Main Tourist Attractions

There is no famous tourist spot attraction Amphoe Wang Noi but there are some in the vicinity areas such as Amphoe Bang Pa In.

Amphoe Bang Pa In is one of the Ayudhaya's districts, situated 55 km north to Bangkok Metropolis by rail, or 55 km by road. Bang Pa In is famous for its royal palace which attracts many tourists.

The palaces which attract many tourists in Bang Pa In are:-

1. Bang Pa In Palace.

Bang Pa In Palace is a famous place for its royal palace, which comprises five important buildings:-

a) Phra Thinang Aisawan Thippa-at stands in the middle of the lake, replacing a former building of the same name erected by King Prasart Thong

b) Phra Thinang Warophat Piman to the north of the Royal Ladies Landing Place, occupies the original site of the Pavilion built during King Mongkut's reign. It has two storeys. One was used as the King's apartment, and the other as a reception hall. When the court was transferred to another building, the decaying pavilion was demolished and replaced by the new one which now serves as a hall for state ceremonies.

c) Phra Thinang Utthayan Phumisathian was almost totally destroyed by fire in 1938. Formerly, it was used as a highwater season residence but now only a few bricks remained.

d) Phra Thinang Wheat Chamroon is a Chinese-style building where the court followers generally resided during the rainy and cool seasons.

e) Phra Thinang Withun Thatsana is an observatory standing on a small island between Phra Thinang Utthayan Phumisathian and Phra Thinang Wheat Chamroon from which a commanding view of surrounding countryside can be enjoyed.

2. King Prasart Thong Shrine erected during King Chulalongkorn's reign stands on the edge of the lake.

3. Wat Nivet Thammaprawat is a remarkable building constructed during King Chulalongkorn's reign on the outer island, south of the Royal Palace. The temple was built in gothic style, resembling a christian church.

4. Wat Choompol Nikayaram is located by the bridge on the way from the railway station. It was built by King Prasart Thong and subsequently restored. The two Phra Chedis (relic shrines) in this temple are considered to be very beautiful.

5. Silapachip Phiset Bang Sai is on the route 3309 about 24 km from Amphoe Bang Pa In located at Tampon Chang Yai, Amphoe Bang Sai. Silapachip Phiset Bang Sai is a training center under the patronage of the Queen in order to conserve local culture and handicraft of the country.

CHAPTER 4

ASSESSMENT OF ENVIRONMENTAL IMPACTS

CHAPTER 4
ASSESSMENT OF ENVIRONMENTAL IMPACTS

4.1 INTRODUCTION

In order to assess the environmental impacts of the Wang Noi Combined Cycle Power Plant, present conditions and trends of the significant environmental resources and values existing in the project area as well as project features and plan of developmental stages must be known. Chapter II presents the major project features and processes as well as plan for developmental stages in the future. Environmental discharges in forms of gaseous emission, wastewater discharges and solid waste disposals are also included in this Chapter. Existing conditions and future trends of significant environmental resources and values in the project area have been qualitatively and quantitatively described and discussed in details in Chapter III.

The proposed installed capacity of the Wang Noi Combined Cycle Power Plant is 1,800 MW, consisting of 6 blocks of generators. The main components of each block include 2 units of combustion turbine, 2 units of turbine generator, 2 units of heat recover steam generator, 1 unit of steam turbine and 1 unit of steam turbine generator. The water demand for the Power Plant is estimated to be 15 MCM/year. Significant gases emitted from the stack of the Power Plant are NOx, SO_2, CO, UHC and TSP. Combustion turbine and cooling tower are the important sources of noise emitted from the Power Plant. Solid wastes generated from the Power Plant include domestic solid wastes and sludges from water treatment process and from sewage treatment process. As regards to wastewaters, different effluent from various sources, i.e. sewage treatment plant, oil separator and neutralization basin, are collected in the holding pond, prior to discharge to Khlong 26. The average flow rate is approximately 5,000 l/min.

Probable impacts of the Power Plant on environmental resources and values are assessed for both construction phase and operation phase. The impacts which will occur in the construction phase are normally short-term, whereas in the operation phase, the impacts are usually long-term.

Qualitative analyses are generally adopted for the environmental impact assessment of this study. However, efforts have been made to quantify environmental impacts to possible extent. Mathematical modelling is also employed to estimate the impacts on air quality and noise level.

4.2 AIR QUALITY

4.2.1 Construction Phase

The main air pollutant during construction phase is TSP due to ground level adjustment, equipment handling, construction including transportation. Therefore, the project should provide the TSP control measures to the contractors, such as spraying water on the adjusted ground level or TSP dispersion control from the truck during transportation.

4.2.2 Operation Phase

4.2.2.1 Model Selection

The US.EPA.'s Industrial Source Complex Model (ISC) was selected for estimating ground level concentrations (GLC) of air pollutants resulting from the Wang Noi Combined Cycle Power Plant. The ISC is a steady-state gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial source complex. This model can account for settling and dry deposition of particulate, downwash, area, line and volume sources, plume rise as a function of downwind distance, separation of point sources, and limited terrain adjustment. It operates in both long-term and short-term modes. ISC is appropriate for:

1. Industrial source complexes,
2. Rural or urban areas,
3. Flat or rolling terrain,
4. Short transport distances (<50 km), and
5. One hour to annual averaging times.

4.2.2.2 Data Preparation

a) Meteorological Data

In assessing the air quality impacts, by modeling the meteorological data are the most important inputs. Reliable results could be obtained if the data are accurate and abundant. In this study, the meteorological data used were those recorded at Don Muang Airport. The data were hourly recorded for the year 1992 (366 days or 8,784 hours), and were analyzed as mentioned in Chapter 3.

b) Topographical Data

The project site is located on the central area of Thailand and about 6 km northwest of Amphoe Wang Noi. The topographic feature of the site is flat terrain.

In assessing the air quality impacts of the Project by modeling, the ground level concentrations (GLC) of air pollutants were determined about 700 receptor points in various areas within 7 km radius from the proposed site.

c) Emission Source Data

The Power Plant consists of 6 blocks of electricity generator. Each block has a generating capacity of 300 MW, total of 1,800 MW. The main components comprising in each block are 2 units of combustion turbine, 2 units of combustion turbine generator, 2 units of heat recovery steam generator, 1 unit of steam turbine and 1 unit of steam turbine generator.

In the first phase of the Project, only combustion turbine generators will be operated. Distillate oil No.2 will be used as the main fuel for this phase. After completion of the Project which comprises installation of steam turbine generator, natural gas will be used as the main fuel. Therefore, air quality impact assessment of the Project is classified into 2 cases as following:

a) At the first stage of the Project, only combustion turbine generators are operated and distillate oil No.2 is used. The major pollutants for this case are NO_x and SO_2. Both normal and the worst cases of operating condition are considered. In the normal condition, the operation will take about 4 hour a day during 6 PM-10PM. Whereas, in the worst case, the 24-h operation of the Power Plant will be taken into consideration. In case of CT unit, the operation throughout 24 hours hardly occurs. Emission rates of NO_x and SO_2 found in each stack are 47.2 and 162.8 g/s, respectively. The details are shown in Table 4.2-1.

b) At the final stage, steam turbine generators will be put into operation. The major fuel at this stage is natural gas. Because of very low content of sulphur in natural gas, SO_2 will be considered as an insignificant pollutant. Therefore, only NO_x will be considered as the main air pollutant from the Project. The emission rate of NO_x from each stack as shown in Table 4.2-2 is 45.8 g/s.

   For the assessment of NO_x emitted from the Project, the conservative method will be considered because most of NO_x (about 95% by weight) emitted from the power plant stack are NO (AP-42, US.EPA, 1985), for NO_2 will be formed later. However, in the assessment of GLC, NO_2 concentration will be considered based on the assumption that NO_x will be completely changed into NO_2 form. In such case, it is supposed to be the worst case. If GLC of NO_2 in the ambient air derived from the modelling does not exceed the ambient air quality standard, it can be said that the impact will be within acceptable levels.

TABLE 4.2-1

FLUE GAS EMISSION FOR WANG NOI COMBINED CYCLE POWER PLANT

(DISTILLATE OIL # 2)

UNIT	CT 1	CT 2
CAPACITY (MW)	100	100
OPERATION (Hr/day)	4	4
FUEL	Dist. Oil #2	Dist. Oil #2
. Type		
. Consumption Rate (l/hr)	36,000	36,000
. % S	1.0	1.0
STACK		
. Height (m)	60	60
. Diameter (m)	5.5	5.5
. Velocity (m/sec)	30.5	30.5
. Temperature (°C)	540	540
GAS EMISSION (g/sec)		
. NO_x*	47.2	47.2
. SO_2	162.8	162.8
EMISSION CONTROL SYSTEM		
. NO_x	S/W INJ	S/W INJ

Remark : * Express as NO_2, about 95 weight % of NO_x is NO (AP-42, US.EPA, 1985)

TABLE 4.2-2

FLUE GAS EMISSION FOR WANG NOI COMBINED CYCLE POWER PLANT

(NG : 300 MW)

UNIT	CT 1*	CT 2*	HRSG 1*	HRSG 2*
CAPACITY (MW)	100	100	-	-
OPERATION (Hr/day)	24	24	-	-
FUEL				
. Type	NG	NG	-	-
. Consumption Rate (MMSCFD)	27.5	27.5	-	-
STACK				
. Height (m)	(60)	(60)	60	60
. Diameter (m)	(5.5)	(5.5)	5.5	5.5
. Velocity (m/sec)	(30.5)	(30.5)	30.5	30.5
. Temperature (°C)	(540)	(540)	150	150
GAS EMISSION (g/sec)				
. NO_x**	-	-	45.8	45.8
EMISSION CONTROL SYSTEM				
. NO_x	S/W INJ	S/W INJ	-	-

Remark : * In case of open cycle or combined mode, flue gas is emitted through only 2 stacks

** Expressed as NO_2, about 95 weight % of NO_x is NO (AP-42, US.EPA, 1985)

4.2.3 Modelling Result

The assessment of air quality impact from the Project was simulated in two cases.

a) First Stage

During the first stage, the maximum capacity of combustion turbines was considered, that is, the emission of pollutants from twelve stacks was estimated. The major pollutants in this case were NO_x and SO_2 emitted from distillate oil No.2 combustion. Both normal case (4 h/d operation) and worst case (24 h/d operation) were simulated.

Nitrogen Dioxide

From the simulation result as shown in Table 4.2-3, it was found that 1-hr maximum concentration of NO_2 in the normal case (4 h/day operation) was 29.3 ug/cu.m at the distance of 10.5 km northeast from the Project. In the worst case condition (24 hr/day operation), 1-h maximum concentration increased to be 142.7 ug/cu.m at the distance of 1.7 km east from the Project. It was seen that the maximum concentration of NO_2 of both normal and worst cases were well below the ambient air quality standard proposed by MOSTE. The results of 1-h maximum concentration of NO_2 for 4 h/d and 24 h/d operation of CT are shown graphically in Figures 4.2-1 and 4.2-2.

Three-hour maximum concentration of NO_2 from the simulation was also predicted. Maximum concentration for the normal case was found to be 20.4 ug/cu.m. at the distance of 7.6 km North from the Project. For the worst case condition, the maximum concentration was found to be 74.2 ug/cu.m at the distance of 2.2 km East-Northeast from the Project.

Sulphur Dioxide

Sulphur dioxide from the combustion turbine was also the major pollutant due to sulphur content in distillate oil No.2 itself. The simulation of air quality in the normal case showed that 1-h maximum, 24-h maximum and annual concentrations were 101.0, 11.9 and 1.1 ug/cu.m., respectively. Higher concentrations of SO_2 were found in the worst case condition. The 1-h maximum, 24-h maximum and annual concentrations were found to be 492.1, 41.5 and 5.6 ug/cu.m., respectively. The simulation result of SO_2 for 24-h and annual concentration were well below the ambient air quality standard proposed by MOSTE.

TABLE 4.2-3

MAXIMUM CONCENTRATION OF AMBIENT AIR FROM THE PROJECT

(COMBUSTION TURBINE)

Parameter	Normal case (4-hr operation)			Worst case* (24-hr operation)			Ambient Standard (ug/cu.m)
	Concentration (ug/cu.m)	Dist. (Km)	Dir	Concentration (ug/cu.m)	Dist. (Km)	Dir	
NO_2 : 1 hr	29.3	10.5	NE	142.7	1.7	E	320
: 3 hr	20.4	7.6	N	74.2	2.2	ENE	-
SO_2 : 1 hr	101.0	10.5	NE	492.1	1.7	E	-
: 24 hr	11.9	10.5	SW	41.5	4.5	N	300
: 1 year	1.1	8.1	N	5.6	7.6	N	100

Remark : * Hardly occur

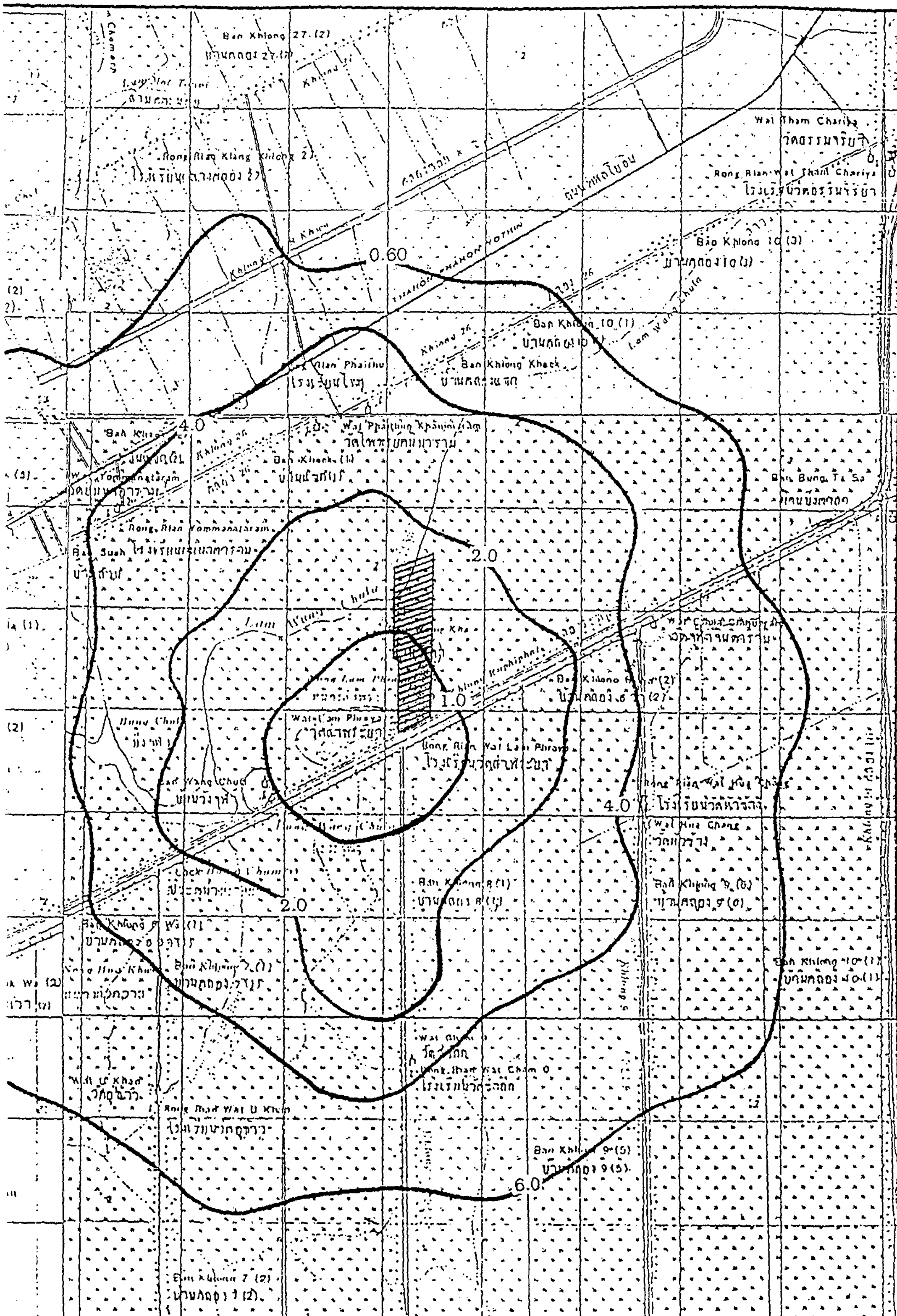

FIGURE 4.2-1 MAX 1 HR CONCENTRATION AT GLC OF NO_2 FROM THE PROJECT: 4 HR OPERATION FOR CT ONLY (ug/cu.m.)

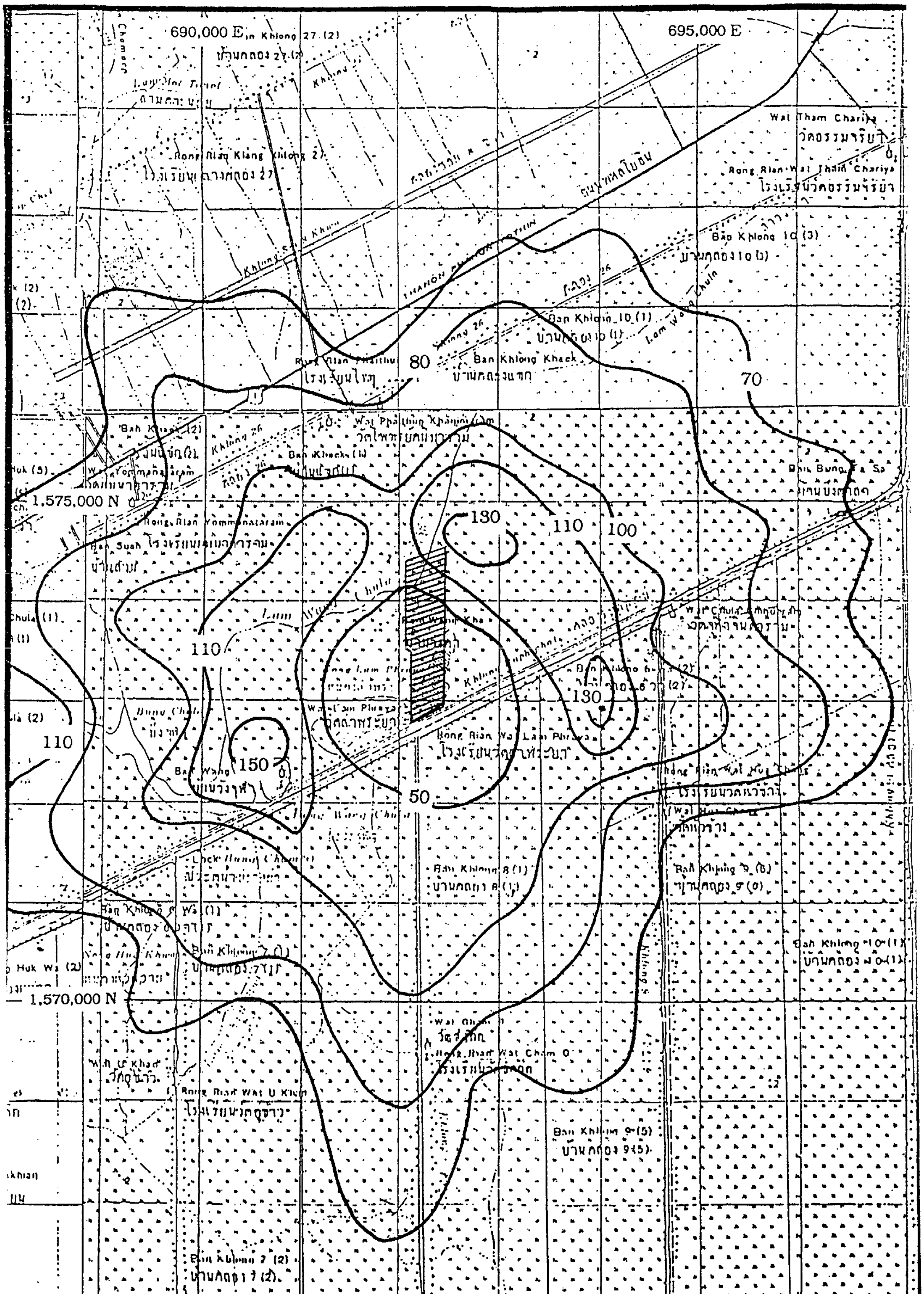

FIGURE 4.2-2 MAX 1 HR CONCENTRATION AT GLC OF NO_2 FROM THE PROJECT : 24 HR OPERATION FOR CT ONLY($\mu g/cu.m$)

The results of 24-h maximum concentration of SO_2 for 4 h/d and 24 h/d operation of CT are shown graphically in Figures 4.2-3 and 4.2-4.

b) Final Stage Operation

In this stage, six blocks of combined cycle power plant were completely operated. Maximum capacity of 6 x 300 MW of the Project were considered for air quality modelling. Nitrogen dioxide was only major pollutant emitted from exhaust stacks.

The assessment based on NO_x concentration emitted (in Table 4.2-2) is to determine maximum GLC of NO_x in the ambient air around the Project. The result can be summarized in Table 4.2-4 and the isoplethes is shown in Figure 4.2-5. It is found that the maximum 1-h concentration of NO_2 at GLC in the ambient air is 190.3 ug/m^3 in the north at the distance of about 1 km away from the project. In such area, the maximum concentration found is 120 ug/m^3 at about 3-km radius from the Project. Whereas, the further areas, the concentrations are lower. Compared with the ambient standard established by MOSTE (320 ug/m^3), the maximum concentration from the assessment (190.3 ug/m^3) is well below.

In addition, the maximum 3-h concentration from the assessment is 103.5 ug/m^3 at about 2.6 km in the north-northeast from the Project.

In conclusion, the operation of the Project during both CT operation and full range operation are not supposed to cause any adverse effect to ambient air quality around the Project due to NO_2 and SO_2. Furthermore, the fuel used and system design contributing to maintain the environment of the Project.

However, in order to follow-up the operation of the Project, the ambient air quality and emission from the power plant stack should be monitored.

4.3 NOISE

From the implementation of the Project, the noise impacts can be classified into 2 periods as follows:-

4.3.1 Construction Phase

Noise occurs during construction period from these main activities, that is, site preparation step, surface area leveling and traffic of the trucks. In each step, it will cause noise of various levels. Noise levels which will occur depend on the equipment used as shown in Table 4.3-1. At the distance of 15 m., the maximum noise level will be in the range of 76-101 dBA.

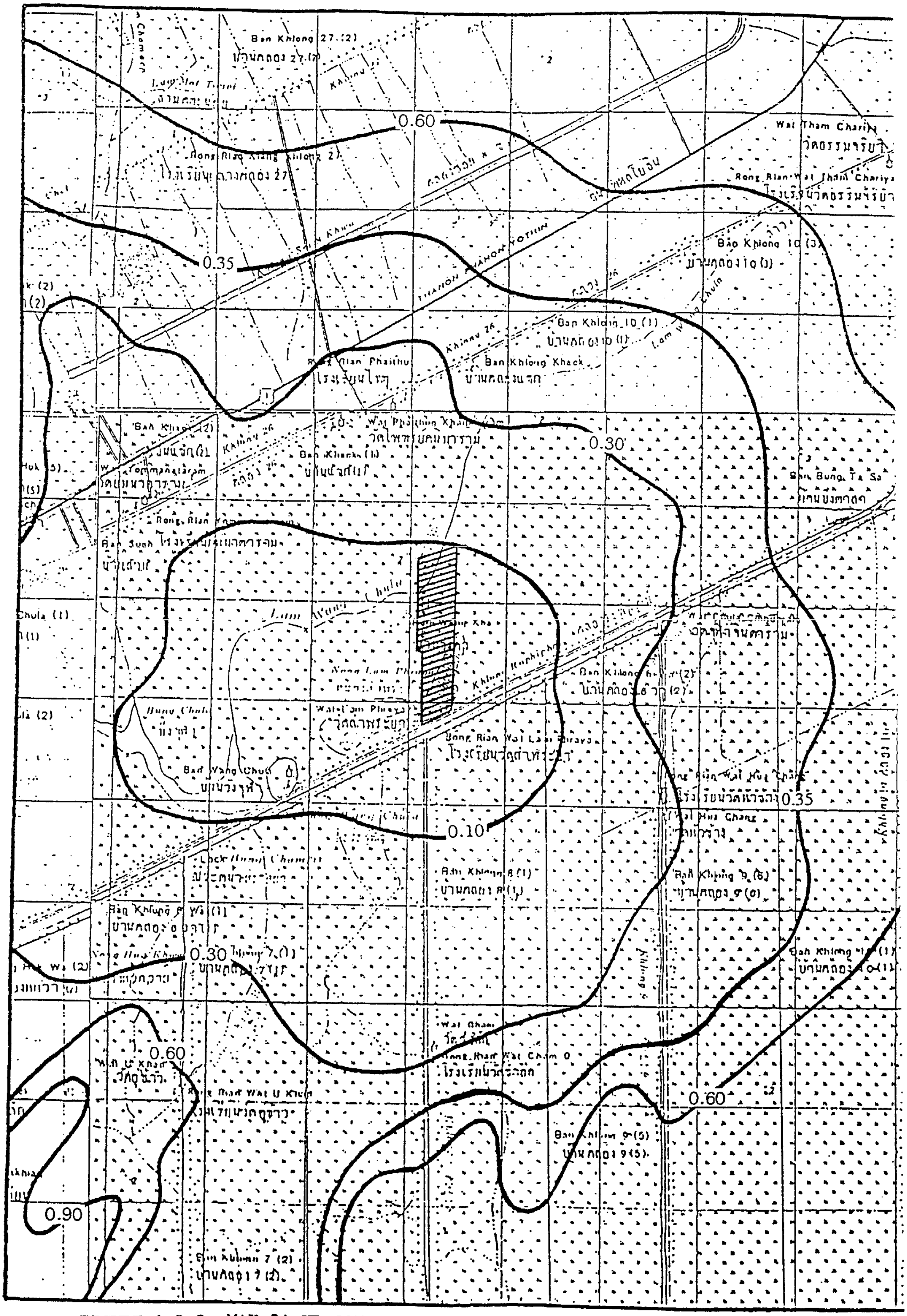

FIGURE 4.2-3 MAX 24 HR CONCENTRATION AT GLC OF SO_2 FROM THE PROJECT : 4 HR OPERATION FOR CT ONLY (ug/cu.m.)

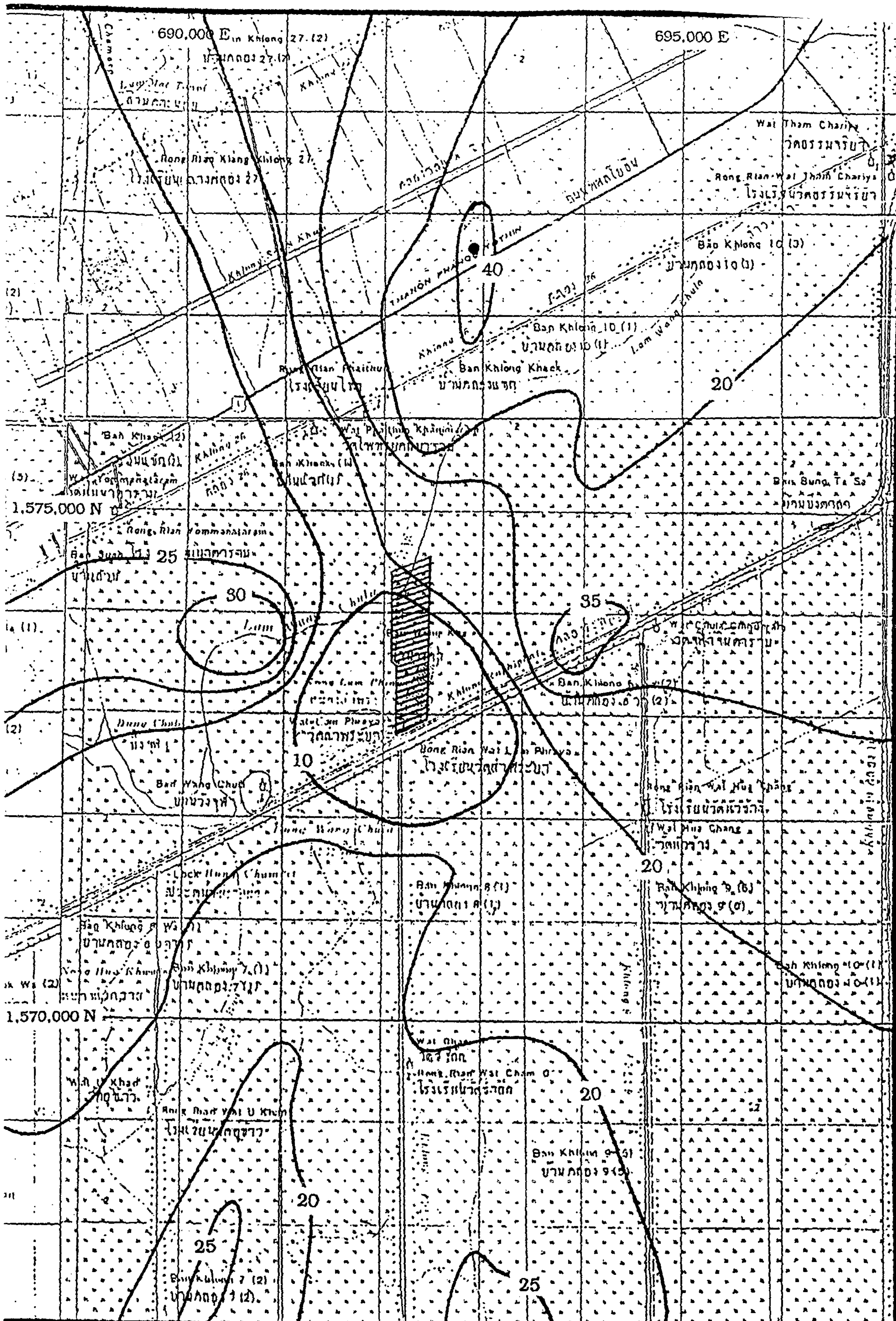

FIGURE 4.2-4 MAX 24 HR CONCENTRATION AT GLC OF SO_2 FROM THE PROJECT : 24 HR OPERATION FOR CT ONLY($\mu g/cu.m$)

TABLE 4.2-4

MAXIMUM CONCENTRATION AT GLC OF NO_2 FROM HRSG*

Hr	Conc. (ug/cu.m)	Dist. (km	Dir	Ambient Standard
1	190.3	1.1	N	320
3	103.5	2.6	NNE	-

Remark : * Complete operation

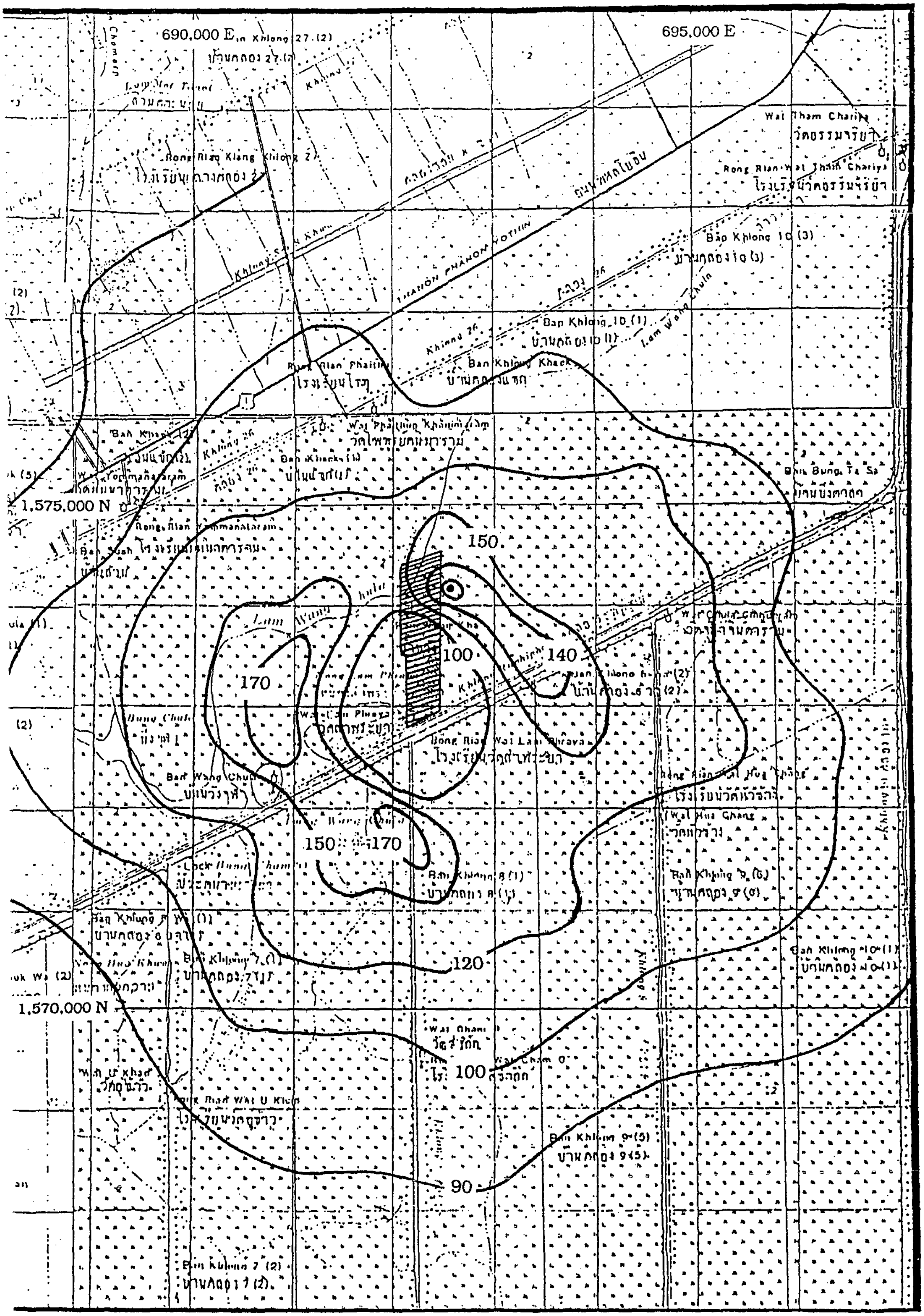

FIGURE 4.2-5 MAX 1 HR CONCENTRATION AT GLC OF NO_2 FROM THE PROJECT : 60 M STACK HEIGHT FOR HRSG(μg/cu.m)

In this case, the noise source is determined at the center of the project site. The maximum predicted noise level is about 100 dBA (as shown in Table 4.3-1). Then such data will be calculated by the Decay Formula Model which is a conservative model in assessment of noise impact at various distances as shown in Figure 4.3-1. It is found that Wat Lam Phraya, about 400-500 m away from the center of the project site, will be affected by the noise level of about 70 dBA. It shows that the effect of noise from the project site will decrease proportionally to the distance. In conclusion, the communities which are close to the boundary of the project site will be disturbed during the construction phase.

4.3.2 Operation Phase

The Decay Formula Model was used to predict noise level from the Power Plant at various distances from the noise source. In this case, the noise source is determined at the center of the project site. Noise levels occur from plant equipment in the operation phase have the maximum values of 85 dBA at 1 m of distance as specified. As a result, at the distance of 60, 120 and 200 m away, noise level will be reduced to 49, 43 and 39 dBA, respectively (Figure 4.3-2). Adding these to the background community noise, therefore the operation of the Power Plant will cause no significant impact of the noise level to surrounding communities.

4.4 SURFACE HYDROLOGY

4.4.1 Construction Phase

(1) During the construction period, certain amount of water from Khlong Raphiphat which is expected to be about 400 cu.m/d or 0.144 MCM/year will be needed for construction activities. The amount of water required for construction of the Power Plant is only 0.02% of annual runoff in Khlong Raphiphat thus it will not affect surface water hydrology in terms of change in flow regime.

(2) The Power Plant is situated on the area where runoff is naturally drained into khlongs around the plant area such as Khlong Raphiphat, Khlong 26 and other sub Khlongs during rainy season. In addition, water from the existing swamp area around the plant site is naturally drained during rainy season. However, the construction activities such as land reclamation and leveling may cause surface erosion during the peak rainy season and result in significant amount of sediments to be carried over into khlongs and swamp area around the Power Plant. This may change flow pattern.

(3) Effects of construction of transmission pipeline from Phra Sri Silp Regulator along the bank of Khlong Raphiphat to the Power Plant, would be minor. The construction of temporary supporting structure of transmission pipe in the canal may obstruct flow of water.

TABLE 4.3–1

EPA IDENTIFICATION OF MAJOR NOISE–SOURCE CATEGORIES OF PRODUCTS

Construction Equipment	Typical Sound Level dBA at 50 ft
Dump truck	86
Portable air compressors	81
Concrete mixer (truck)	85
Jackhammer	88
Scraper	88
Dozer	87
Paver	89
Generator	76
Piledriver	101
Drill	98
Pump	76
Pneumatic tools	85
Backhoe	85

Source : Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances. December 31, 1971. US.EPA., Washington, D.C. 20460. NTID300.1

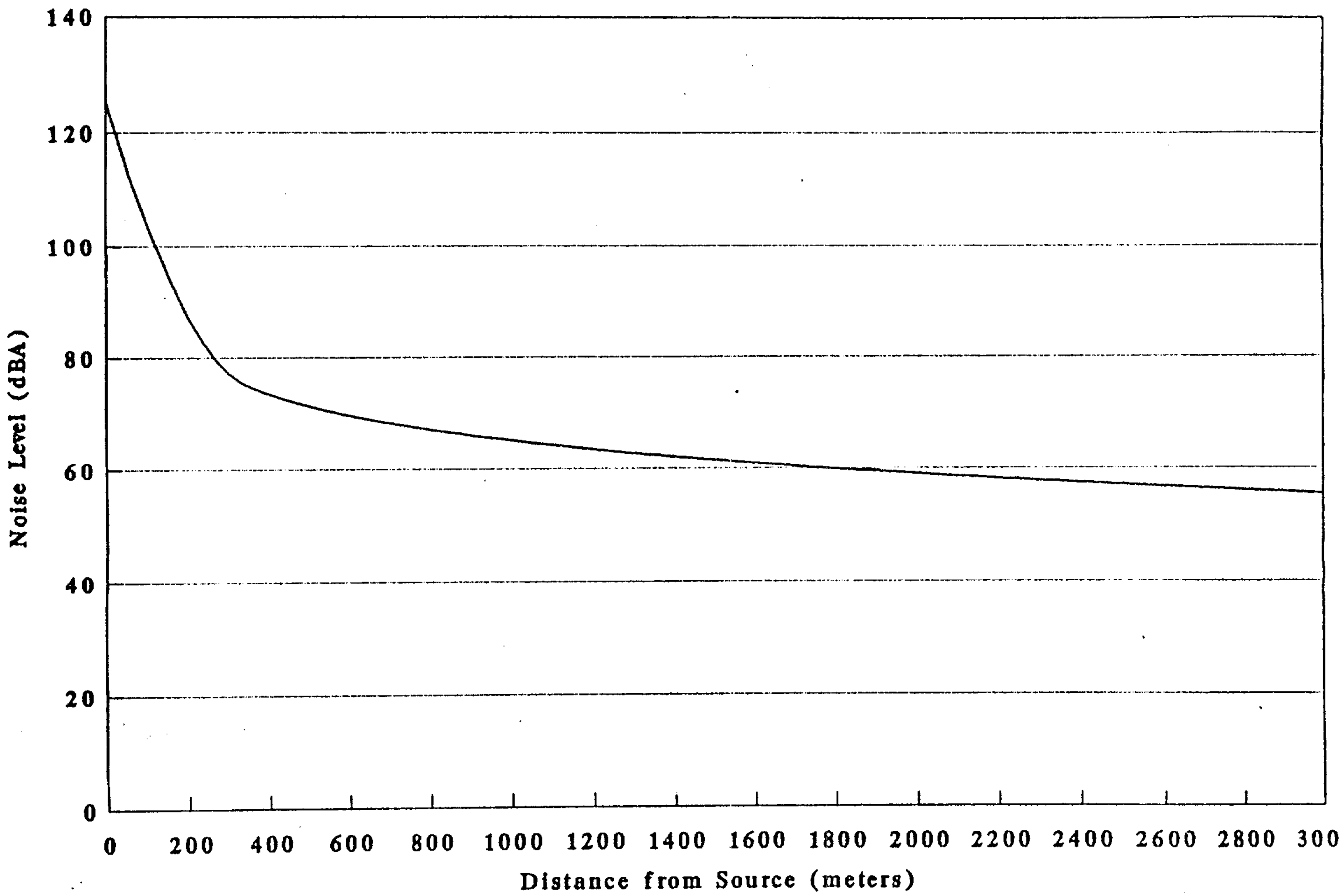

FIGURE 4.3-1 NOISE LEVEL AT VARIOUS DISTANCES ; CONSTRUCTION PHASE

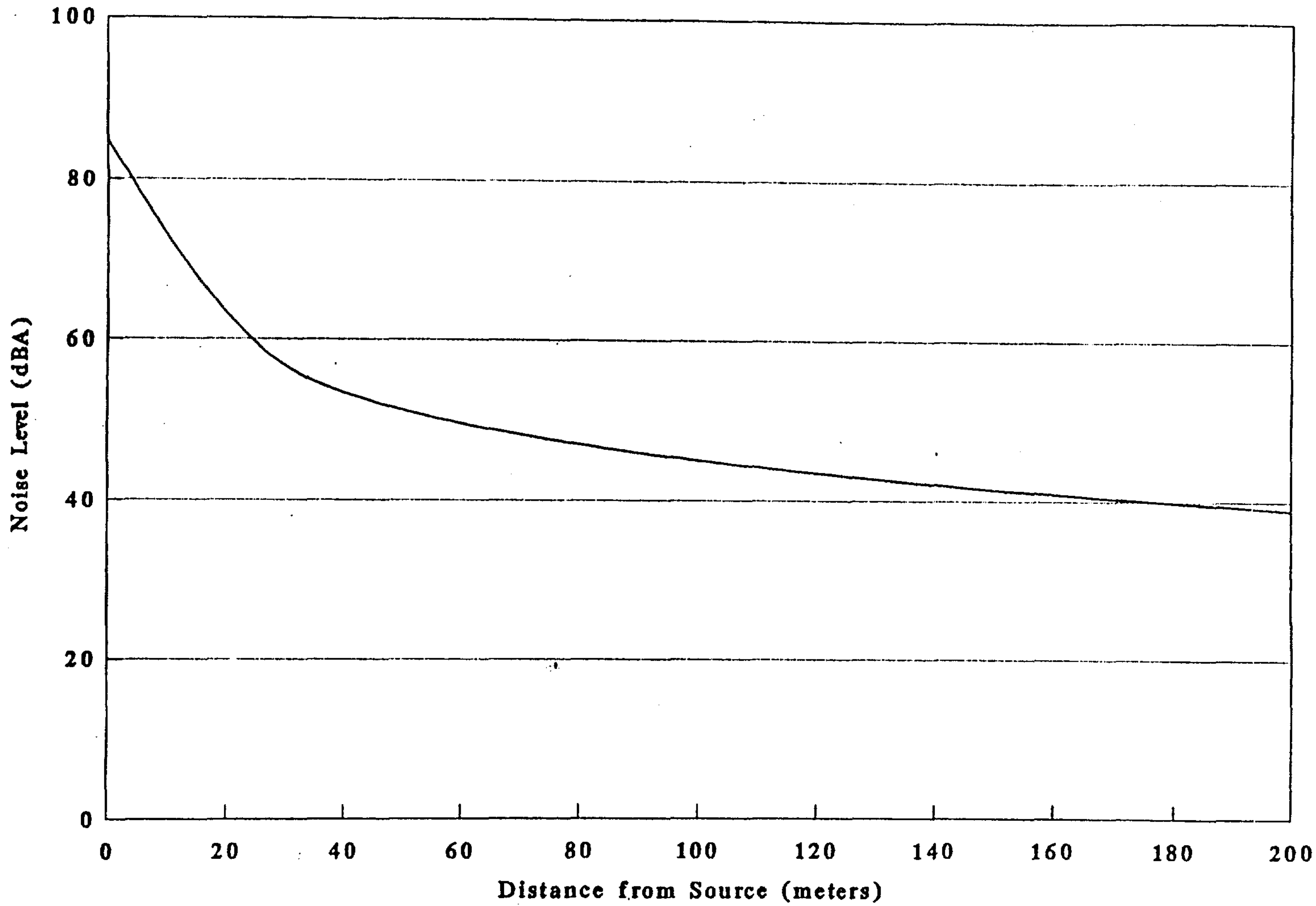

FIGURE 4.3-2 NOISE LEVEL AT VARIOUS DISTANCES ; OPERATION PHASE

4.4.2 Operation Phase

(1) The Power Plant will use water from Khlong Raphiphat by pumping with an average of 1.25 MCM/month or 15 MCM/year. EGAT has planned to build raw water storage pond with capacity of detention time of about 5 days for power plant operation. This storage pond, will supply the raw water to ensure normal operation of the Power Plant in case of the emergency concerning the raw water intake system. The water demand will account for only 6 percent of the minimum monthly runoff in Khlong Raphiphat in July 1992 (21 MCM). In addition, with the completion of the Pasak Project in 1997, the Dam will impound 758 MCM in its reservoir and can secure more stable water to Khlong Raphiphat. This impact, based on the water supply study of Khlong Raphiphat, is not significant.

(2) The surface runoff contributed from the area within the power plant boundary to Khlong Raphiphat and Khlong 26 will be very slightly affected by the internal drainage pattern of the Power Plant for the plant area is only about 1.1 sq.km. The increased runoff due to site development will be insignificant compared with the much larger flow contributing from the catchment area.

4.5 SURFACE WATER QUALITY

Probable effects of the Power Plant on surface water quality exist during both construction phase and operation phase. On the other hand, quality of surface water drawn for different using purposes of the Power Plant can cause adverse impacts on water treatment processes, unit operation processes and raw water transmission pipeline as well.

4.5.1 Construction Phase

Construction of the Power Plant that generates adverse impacts on surface water quality includes construction of raw water supply system comprising of pumping station, transmission pipeline and storage reservoir and construction of the Power Plant and installation of equipments and facilities. Power plant site layout and details of raw water pumping station and transmission pipeline are illustrated in Figures 2-1 and 2-4, respectively.

4.5.1.1 Construction of Pumping Station

Raw water intake structures consist of pumping station located on Khlong Raphiphat bank and suction pipe. Grading, compacting and excavating the area for construction of pumping station will cause short-term increases in turbidity, color and suspended solids in Khlong Raphiphat, especially in rainy season. In addition, deepening the canal bed by dredging may be required for installation of suction pipe and increases in turbidity, color and suspended solids and decrease in DO content due to resuspension of inorganic and organic matters will be resulted. However, the adverse impacts of the pumping station construction on the Khlong Raphiphat bank are relatively minor due to large stream flows of Khlong Raphiphat which will help alleviate the adverse impacts by dilution.

4.5.1.2 Installation of Raw Water Transmission Pipeline

For the intake site at Nong Khae, the raw water transmission pipeline is proposed to run along Khlong Raphiphat to the Power Plant. Soil dredging, compacting, excavating and backfilling works for the pipeline installation are expected to have no impacts on Khlong Raphiphat water quality. Impact on Khlong 26 and Wang Chula canal water quality due to sediment contamination is also expected to be insignificant.

4.5.1.3 Construction of Onsite Structures

Major activities of onsite construction that will generate deleterious effects on surface water quality include not only construction of project structures and buildings but also land grading and compaction. After compaction, excavation will be required for constructing foundation of most structures. Major onsite structures and buildings include raw water reservoir, effluent holding pond, combined cycle buildings, substations, cooling towers, workshop, warehouse and administration buildings. Such activities of the onsite construction conducted on the considerably large area will generate short-term impacts on quality of the existing storm drainage canal, Wang Chula canal, due mainly to the surface soil erosion, particularly during the rainy season. Increases in turbidity, color and solid contents in the canal water will be resulted. Since the project area is very large and the drainage canal is relatively small, significant deterioration of the canal water is therefore expected.

Other deleterious effects of the onsite construction on surface water quality is wastewaters and solid wastes generated by labors and personnels working and living in the project area. It is expected that there are about 1,200 labors and personnels working in the project area during the construction period. Huge amounts of wastewaters and solid wastes will be generated daily. If such amounts of wastewaters contaminate in the drainage canal, significant increases in values of BOD, total and faecal coliform bacteria, suspended solids, turbidity and greases and oils and decrease in DO content will be resulted, i.e. occurrence of water quality deterioration. It is anticipated that if there is no appropriate measure to mitigate the adverse impact, deleterious effects on the canal water will be serious.

4.5.2 Operation Phase

4.5.2.1 Quality and Quantity of Wastewaters

Operation of the proposed Wang Noi Combined Cycle Power Plant will certainly generate a huge quantity of effluent from different processes and activities. Total effluent with the estimated flow rate of 5,197 l/min based on oil fuel and 4,916 l/min based on gas fuel will be collected in the effluent holding pond, prior to discharging to the receiving canal, Khlong Raphiphat. Effluents from cooling tower and from HRSG units contribute the most and the second most quantities with the flow rates of 3,454 l/min and 458 l/min for oil fuel and 3,377 l/min and 672 l/min for gas fuel, respectively. Such effluent will be directly discharged into the holding pond without treatment. Domestic wastewaters, plant equipment drains, chemical area drains and effluent from demineralization system, with the flow rates of 95 l/min, 568 l/min, 38 l/min and 355 l/min for oil fuel and 95 l/min, 568 l/min, 38 l/min and 166 l/min for gas fuel respectively, will be treated to effluent standards in sewage treatment plant, oil separator and neutralization basin, respectively, prior to discharging into the holding pond. Due to mixing of effluent from different sources, quantity and quality, characteristics of holding pond wastewater is therefore not known.

4.5.2.2 Characteristics of Holding Pond Water and Effluent Receiving Water of Rayong Combined Cycle Power Plant

EGAT has monitored quality of effluent holding pond water of the Rayong Combined Cycle Power Plant as well as quality of effluent receiving water in Huai Pong canal prior to and after the plant establishment, as shown in Tables 4.5-1 and 4.5-2, respectively. The results of holding pond water analyses illustrated relatively high value of specific conductivity and high concentrations of total solids, dissolved solids, suspended solids, hardness, and sulphate with the highest values of 800 umho/cm, 1,097 mg/l, 977 mg/l, 188 mg/l, 355 mg/l and 141 mg/l, respectively (Table 3.5-6). However, besides suspended solids, the highest values of those characteristics are less than the industrial effluent standards. It is noted that the concentrations of heavy metals are considerably low, as compared with the effluent standards.

For the Huai Pong canal water, high value of specific conductivity and high concentrations of total solids, dissolved solids, hardness, alkalinity and sulphate were found in April 1991 and June 1992, which were the dry period, with the highest values of 1,220 umho/cm, 1,141 mg/l, 1,102 mg/l, 183 mg/l, 630 mg/l and 189 mg/l, respectively (Table 4.5-2). However, the high values of those parameters were found not only at the power plant effluent receiving area but also at the upstream area. The results indicate that the power plant effluent is not the only source of adverse effects on the Huai Pong canal water quality. Based on surface water quality standards, the existing water quality in the Huai Pong canal is classified to be class 4 which is not suitable for agriculture. As regards to the irrigation water classification criteria (table 3.5-3), the Huai Pong canal water is classified to be class II of Mc Kee and Wolf's classification and class III of RID classification.

4.5.2.3 Effects of Holding Pond Wastewater

In order to estimate effects of the holding pond wastewater on water quality in the receiving canal, Khlong 26 characteristics of holding pond wastewater and wastewater receiving canal water of the Combined Cycle Power Plant, the Rayong Power Plant, monitored by EGAT are reviewed (Tables 3.5-6 and 3.5-7) and employed for the impact estimation. Similar quality and quantitative proportion of different categories of effluents generated by the Rayong Power Plant and the proposed Power Plant are anticipated. Differences between the two power plants are quantities of wastewaters

TABLE 4.5-1

EFFLUENT HOLDING POND WATER CHARACTERISTICS OF RAYONG COMBINED CYCLE POWER PLANT, 1991–1992

Parameters	1991 น/		1992 ฒ/			Industrial Effluent ฌ/ Standard
	Apr	Oct	Jan	Jun	Aug	
Air Temperature, ฐC	29.5	–	28.0	25.5	34.0	–
Water Temperature, ฐC	29	32	28.5	29.0	33.0	<40
pH	7.2	7.0	7.0	8.6	8.6	5.0–9.0
Conductivity, us/cm	160	240	800	550	800	–
Turbidity, NTU	73	5	55	22	25	–
Total Solids, mg/l	90	127	631	412	1,097	–
Dissolved Solids, mg/l	80	90	443	–	977	2,000
Suspended Solids, mg/l	10	37	188	–	120	30–150 4/
Alkalinity, mg/l as $CaCO_3$	42	49	20	110	144	–
Hardness, mg/l as $CaCO_3$	46	46	85	160	355	–
Sulfate, mg/l	9.9	6.5	21.2	58.9	140.8	–
Fe, mg/l	0.9	0.59	0.66	6.7	1.6	–
Netrate, mg/l	0.7	–	0.5	–	–	–
Phosphate, mg/l	–	0.04	–	–	–	–
Dissolved Oxygen, mg/l	7	–	5	13.5	9.5	–
Carbon Dioxide, mg/l	1.6	37	46.6	0	0	–
COD, mg/l	143.6	–	–	–	–	–
BOD, mg/l	1.4	–	–	–	–	20–60
Zn, mg/l	–	nil	0.001	0.001	0.057	5.00
Pb, mg/l	<0.006	nil	nil	nil	nil	0.20
Cu, mg/l	–	0.003	nil	0.001	nil	1.00
Cd, mg/l	<0.006	nil	nil	nil	0.011	0.03
Ni, mg/l	0.006	nil	nil	nil	0.078	0.200
Cr, mg/l	<0.001	nil	nil	nil	0.057	0.500

Remarks:
1/กฟน (2535)
2/กฟน (2535N)
3/NEB (1989)
4/Depend on dilution ratios of wastewater and receiving water

TABLE 4.5-2

WATER CHARACTERISTICS IN HUAI PONG CANAL, PRIOR AND AFTER RECEIVING EFFLUENT FROM RAYONG COMBINED CYCLE POWER PLANT[1]

Parameters	Prior Receiving Effluent	After Receiving Effluent															Surfacewater[2] Quality Standards, Class 4
		Upstream of Power Plant					Near Power Plant					Downstream of Power Plant					
	Nov. 88	Apr. 91	Oct. 91	Jan. 92	Jun. 92	Aug. 92	Apr. 91	Oct. 91	Jan. 92	Jun. 92	Aug. 92	Apr. 91	Oct. 91	Jan. 92	Jun. 92	Aug. 92	
Air Temperature, °C	–	31	–	32	31	32	29.5	–	30	31	34	29	–	29	31	34	–
Water Temperature, °C	–	29	32	26	27	30	28	32.2	27	27	31	28	32	26.5	28	31	n
pH	6.8	7.5	7.0	7.0	7.8	7.4	7.6	7.0	7.0	7.9	7.3	7.6	7.0	7.0	7.3	7.0	5.0–9.0
Conductivity, uS/cm	220	1,200	185	600	1,220	90	1000	135	950	700	300	800	80	800	950	130	–
Turbidity, NTU	4.5	45	9	10	61	23	62	21	45	18	16	72	20	24	32	55	–
Dissolved Oxygen, mg/l	5.2	4.0	2.0	2.0	0.0	0.8	3.0	4.8	2.1	1.4	4.4	3.7	1.6	4.1	0.0	4.5	2.0
BOD, mg/l	–	32.8	–				35.2	–	–	–	–	12	–	–	–	–	
COD, mg/l		126.2	–				143.6	–	–	–	–	121.8	–	–	–	–	
Carbon Diorxde, mg/l	–	49.2	46	61.6	28.2	29.9	35.2	15	60.7	12.3	17.6	45.8	20	52.8	15.8	8.1	–
Total Alkalinity, mg/l as $CaCO_3$	52	530	92	340	630	134	554	45	420	225	26	380	31	450	235	60	–
Total Hardness, mg/l as $CaCO_3$	24	144	36	90	130	66	146	45	140	183	56	108	25	130	80	81	–
NO_3–N, mg/l	7.8	2.7	–	1.3	–	–	3.4	–	3.0	–	–	2.3	–	5	–	–	5.0
PO_4–P, mg/l	–	–	1.44	–	–	–	–	2.24	–	–	–	–	0.04	–	–	–	–
SO_4, mg/l	3.1	15.3	6.2	4.8	19.3	7.5	14.2	3.5	24.8	74.3	27.2	12.1	6.8	25.8	188.8	26.2	–
Fe, mg/l	2.28	0.4	0.59	0.94	7	0.48	0.64	3.80	1.20	0.58	1.3	0.64	3.3	0.39	0.99	1.5	–
Total Solids, mg/l	215	773	75	339	1,141	142	715	69	697	550	238	567	119	623	717	233	–
Dissolved Solids, mg/l	156	726	0	–	1,102	115	688	50	–	–	205	540	84	–	637	193	
Suspended Solids, mg/l	59	47	75	–	39	27	27	19	–	–	33	27	35	–	80	40	
Pb, mg/l	<0.001	<0.001	0.001	nil	nil	nil	<0.006	nil	nil	0.001	nil	<0.006	0.001	0.002	0.001	nil	0.05
Cr, mg/l	0.003	<0.001	nil	nil	nil	0.057	<0.001	nil	0.001	nil	0.076	0.002	nil	nil	nil	0.019	0.05
Cd, mg/l	<0.001	<0.001	nil	nil	nil	0.032	<0.001	nil	nil	nil	nil	<0.001	nil	nil	nil	nil	0.005
Zn, mg/l	<0.001	–	nil	nil	nil	0.057	–	nil	0.004	0.001	0.042	–	nil	0.002	0.001	0.057	1.00
Cu, mg/l	<0.001	–	0.003	nil	nil	nil	–	0.003	nil	0.001	nil	–	0.003	nil	nil	nil	0.10
Ni, mg/l	0.094	0.023	nil	nil	nil	0.078	0.009	nil	nil	0.001	0.078	0.006	nil	nil	nil	0.078	0.10

Remark: [1] กฟผ. (2535) และ กฟผ. (2536)
[2] NEB (1989)

generated by the plants and dilution factors of the wastewater receiving canals. Larger quantity of wastewaters generated by the proposed Wang Noi Power Plant than the Rayong Power Plant is certain.

Similar to the holding pond wastewater characteristics of the Rayong Power Plant, it is expected that the suspended solids content of the wastewater should be not less than 120-180 mg/l, as compared with 30 mg/l of the industrial effluent standard. In addition, high concentrations of dissolved solids, hardness and sulphate are obvious but such expected concentrations are still within the effluent standards. As regards to phosphate, although TEAM and PAL (1990) anticipated very high concentration to 10 mg/l for holding pond wastewater of the Nam Phong Thermal Power Plant, the phosphate concentration of the holding pond wastewater of the proposed Power Plant is expected to be low, similar to the monitoring result of the Rayong Power Plant.

Since a tremendous volume of wastewater, approx 5,000 l/min or 7,200 m^3/d, with such expected quality as aforementioned will be discharged to Khlong 26 north to the project site, the discharging wastewater will affect significantly downstream water quality of Khlong 26. High concentrations of suspended solids, dissolved solids, hardness and sulphate as well as high value of specific conductivity are anticipated. In addition, chemicals, AA/AMPS copolymer (copolymer of 2-acrylamido-2-methyl propyl sulfonic acid and acrylic acid, 40% active ingredient) and HEDP (1-hydroxyethylidene-1, 1-diphosphonic acid, 60 (as acid) active ingredient), using in the cooling system at the concentrations of 15 ppm and 5 ppm, respectively, will also contaminate in Khlong 26 water. For intermittent chlorination at 1.0 ppm total chlorine residual, it is expected that dechlorination will occur in the cooling process. Changing of such water characteristics will be serious in dry season, due to very low dilution factor caused by low flow in Khlong 26. Since the holding pond wastewater will be continuously discharged to the Khlong 26, it is therefore anticipated that in specific period of time, the Khlong water will become wastewater and its quality will be similar to the holding pond wastewater quality, i.e. specific conductivity, total solids, dissolved solids, suspended solids, hardness, and sulphate may reach to 800 umho/cm, 1,097 mg/l, 977 mg/l, 188 mg/l, 355 mg/l and 141 mg/l, respectively. As regards to criteria of irrigation water supply (Tables 3.5-3 and 3.5-4), the water with such quality is relatively suitable for some plants under certain conditions. For aquatic life and fisheries, the water is also not suitable (Table 3.5-3).

4.5.2.4 Effects of Raw Water Quality on Water Treatment System

Raw water for project uses will be drawn from Khlong Raphiphat at Nong Khae and be treated for different using purposes as shown in Figure 2-9. The raw water quality (Table 3.5-2) is suitable for different treatment systems including make-up water for condenser cooling towers, service water, auxilliary equipment cooling water, fire fighting water and demineralized water make-up for steam cycle. Besides concentrations of iron and pesticides, the raw water is generally suitable for public water supply.

4.6 GROUNDWATER HYDROLOGY AND QUALITY

4.6.1 Construction Phase

During the construction phase, it is estimated that there will be about 1,200 labors and personnels working in the site. Water of 400 cu.m./d. will be withdrawn from Khlong Raphiphat in front of the Power Plant. This amount of water is only 0.6% of monthly runoff (0.012 MCM/month) or 0.06% of annual runoff (0.144 MCM/year). Groundwater is reserved as a back up source of water only. Therefore, the effect on groundwater is insignificant.

4.6.2 Operation Phase

During the operation phase, it is projected that 5.7 cu.m./d of water will be with drawn from the deep wells for domestic use in the Power plant. According to the study, it reveals that most groundwater wells in the study area are drilled at the depth between 100 and 150 m. (from Bangkok and Phra Pradaeng aquifers). The normal yields from these wells range from 9 to 45 cu.m./h with the maximum yield of 200 cu.m./h at some properly managed well. The quality of water is also found suitable for drinking purpose. However, since deep wells in the project site are drilled from the depth of 250 m., it is expected that this aquifer will yield a large amount of water sufficient for plant consumption with good quality of water for various using purposes in the Power Plant. Therefore, the effects on groundwater hydrology and quality will be minimal.

4.7 SOIL

The activities of the Project which will be affected by the nature, characteristic and properties of soil include earthwork, construction of building, excavation of pond, installation of transmission pole, etc. The adverse effects on properties of soil in the area to such activities include low loading capacity, high water table, very high corrosivity of uncoated steel, high total acidity and/or low pH, well to moderately shrink-swell properties, etc. Therefore, before starting any activities such adverse effects of each soil unit have to be considered. Table 4.7-1 summarizes adverse effects of each soil series for certain activities of the Project. In operating any activities of the Project, therefore, it is advised to consider the relevant characteristic and properties from this table as well as from the description and the analytical data of the soil which have already been provided in Section 3.7.

The other aspect that needs to bear in mind when dealing with the earthwork is the nature of the soil profile in the area. Normally, at the depth below 150-200 cm. from the surface of the soil in the area is the unriped marine clay layer and at the depth of 30 and 50 cm. from the surface of Ongkarak and Rangsit soil series, respectively, are the very strongly acid soil material. Depended on the nature of the ancient surface of the area (the surface before the last-transgression of sea level in Thailand which is about 4,000 - 6,000 years B.P.) this unriped marine clay layer will be as deep as 15 m from the surface. Actually, most of these unriped marine clay materials are the

TABLE 4.7-1

SUMMARY OF ADVERSE EFFECTS OF EACH SOIL SERIES

	Ayutthaya Series	Chachoengsao Series	Mahaphot Series	Ongkarak Series	Rangsit Series	Sena Series
- Soild texture	Clay	Clay	Clay	Clay	Clay	Clay
- Degree of shrink-swell	Low	Low	Moderate	Moderate	Moderate	Low
- Total acidity	High	Medium	High	High	High	High
- pH value	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
- Susceptability for flooding	High	High	High	High	High	High
- Supporting capacity	Low	Low	Low	Low	Low	Low
- Permeability	Slow	Slow	Slow	Slow	Slow	Slow
- Water table	High	High	High	High	High	High
- Loading capacity	Low	Low	Low	Low	Low	Low
- Corrosivity of uncoated steel	Very High	Moderate	Very High	Very High	Very High	Very High
- Corrosivity-concrete	High	Moderate	High	High	High	High

"potential acid material". Under natural condition, it is permanently saturated by groundwater and as a consequence, is permanently in reducing condition. Under this condition, its reaction is very alkaline with pH of 8.0 or more. However, when exposed to the air, it will be oxidized and its reaction will drastically change to be very strongly acid with pH of 3.5 or lower. This change also happens to subsurface and subsoil of the Ongkarak and Rangsit series if it is brought up to the surface. Very limited type of crop can be grown on the soil of such reaction. Therefore, when dealing with the earthwork such as excavating a pond, levelling or landscaping of the area, digging the hole for installing the transmission pole, etc., it is advised to avoid to bring up such soil material (the unriped marine clay and the subsurface and subsoil of Ongkarak and Rangsit soil series) to the surface.

4.8 AQUATIC BIOLOGY AND FISHERIES

The construction of the Power Plant would involve earthwork, site clearing, soil excavation, hauling and dumping, and moving of heavy construction equipments, etc. Such tasks would disturb nearby water bodies in various degrees. Changing of water quality on turbidity and suspended solids concentration would certainly affect aquatic organisms in the project area and its vicinity.

4.8.1 Construction Phase

Degradation of the water quality in the downstream area during construction period according to the excavation can cause highly turbid water and will have some adverse effects on plankton, bottom fauna and fishes. Reduction of fish spawning activities in the downstream of the construction area will be the short term effect. However, the effects are believed to be more serious during rainy season.

4.8.2 Operation Phase

The large volume of water discharged from the Power Plant in normal condition will supply water for increase the natural fisheries production of Khlong 26 as well as for aquacultural development on the project areas.

The striking change seems to be the group composition of aquatic organisms which will be different between the pre-construction and operation periods. Changing in flow regimes, type of habitats, as well as nutrient status will be the major effects.

4.9 TERRESTRIAL ECOLOGY

The project area of 718 rai is located in the flat land of Tambon Khao Ngam, Amphoe Wang Noi, Ayudhaya province. This study covers the area within a radius of 5 km around the project area.

Birds will migrate to nearby or surrounding areas which is similar in nature. In the rainy season, birds can easily find food in the rice fields and swamping area of Amphoe Wang Noi as well as Khlong Raphiphat. Fishes and mollusks are favorite food for all kinds of birds in this area. Since the Project proposes to build the Power Plant in an area of 718 rai which is very small area of birds habitat if comparing to Amphoe Wang Noi District and its province. Therefore, it is slightly negative environmental impacts on birds. Likewise, amphibians and reptiles are not much affected by this Power Plant.

In the dry season water level in Khlong 26 and other places is very low and sometimes dry. The positive impact of this Power Plant may help to increase the water level from wastewater. This is going to maintain the living life, i.e. fishes, mollusks, etc. in water as known to be bird food. Amphibians and reptiles can also increase their population in water. Along the canal and Khlong Raphiphat, plants are still green in dry season and some insects and other animals can live. Some insects, i.e. dragon fly have its life cycle in larva stage in water. So, it increases food chain for reptiles, amphibians and other living life, i.e. fishes. Since the water level is stable, fishes, birds and frogs become food for people who are living nearby and surrounding the project area.

However, the wastewater have to be treated not to be toxic to people, reptiles, amphibians and fishes.

4.10 LAND USE

4.10.1 Site Preparation and Construction

Transportation of soil from the pit to the site may damage the existing bridge and road networks that are not in good condition. It is certainly realised that the land use of the earth pit will become a large well. In case of intake water pipeline, it disturbs a small scale on land use.

4.10.2 Crop Production

When the Power Plant starts the operation, a large amount of water will be drained into Khlong 26. If there are some agents contaminating into water during the process, it may destroy some economic crops and fruit trees or land use pattern may change to another form. At the moment there is no evident about the effect of the polluted water on crop production.

4.10.3 Residential Effect

After the Power Plant is settled, the infrastructure will be developed. The agricultural area will be changed to more modernized area which are town-house, apartment, garden village and other residential types.

4.11 TRANSPORTATION

4.11.1 Current Conditions and Impacts

The road network in the project area is good. Route 1 is expanded into 10 lanes up to Saraburi and can serve the Power Plant. In addition, the new outer ring road planned in the west side and east side of Bangkok Metropolis will serve for the growth of transportation around Bang Pa In, Bang Sai, Ayudhaya municipality and also Wang Noi. In 1988-1992 the DOH traffic volume data have shown that on Route 1 at stations near the Power Plant, the traffic volumes were in a range between 20,000-40,000 vehicles per day. The average traffic increasing rate was 6-7% per year on Route 1 at Wang Noi. The data of traffic counts show that traffic volumes on Route 1 in the section where the Power Plant is located have considerable percentage of heavy trucks, indicating the effects of heavy truck transport to Saraburi and the northeastern region.

4.11.2 Construction Phase

During the construction phase, construction activities will create short-term effects on traffic on the related highways mainly on Route 1.

The major causes of such effects will be transport of construction materials, construction workers, machineries and supplies for workers at the site. The major types of work concern with the construction of the Power Plant are as follows:

(1) Earthwork and land reclamation will be done in the first phase. Land reclamation will be done by transporting soil from nearby area about 1.5 km from the plant site. It is expected that the impact during land reclamation will be minor because soil can be transported via an inner lateritic road near the site.

(2) Construction materials will be transported from many sources such as from Bangkok and nearby sites at Saraburi. The cement bulk can be transported on Route 1 from Saraburi to the power plant site because the Siam Cement sub-plant is located nearby.

(3) Machineries and equipment transport of the Power Plant will be from Bangkok along Route 1 to Amphoe Wang Noi.

(4) Daily commuting and minor supplies such as worker's camp facilities will affect traffic in Amphoe Wang Noi.

The major types of vehicles will be heavy trucks, light trucks, passenger cars and motorcycles. According to the EGAT's construction plans, the construction scheme induces manufacturing & testing at factories and shops, delivery to site and site erection. The construction of combustion turbines block 1-4 and block 5-6 will be made during April 1994 to November 1995 and from December 1994 to July 1996, respectively.

The traffic impacts during construction period, are likely to occur in 1994. It is difficult to estimate the exact traffic volumes from construction activities. However, the impacts from traffic are not significant because the existing Route 1 which is a 10 lane divided highway can carry a large volume traffic created by the Project. Another impact which will occur from the transport activities during construction period may be traffic accidents of uncareful or unexpected events.

The raw water pipeline from Nong Khae to the Power Plant will be laid along rights of way of irrigation canal banks therefore impacts on transportation will occur at the period when the irrigation road is dug to lay the pipe across the road to the Plant.

4.11.3 Operation Phase

Considering the existing transport network and travel pattern, road transport is the predominant mode for carrying more than 90 percent of goods and passenger movement for the lower central region. Route 1 is the main route passing in front of the project site. Route 1 is significant for any industrial or agricultural products from the central or northeastern region which would be conveniently transported via truck/or container trucks using the routes.

The activities of the Project will induce certain amount of traffic increase per day due to the growth of communities near the Power Plant and the vicinity areas. However, effects of such a small increase will be minimal.

4.12 WATER USE

The study on water use concerns mainly with runoff in Chao Phraya river from downstream of Chao Phraya Dam to the river mouth and Khlong Raphiphat in the East Bank-Lower Chao Phraya Project. The assessment is performed for 2 stages, namely construction and operation phases.

4.12.1 Construction Phase

During the construction phase, the Power Plant requires about 400 cu.m./d (0.012 MCM/month or 0.144 MCM/y) for construction activities. The water will be pumped via West Raphiphat during January 1994 to November 1995. According to the statistics, water released from Phra Sri Silp Regulator during dry season in March is about 2 MCM. This is very large amount compared to the water required by the Power Plant during the construction phase. The quantity is about 0.6% of monthly runoff or 0.02% of annual runoff. In addition, groundwater will be used as reserved source of domestic water supply. Therefore, water taken by the Power Plant during the construction phase will not affect downstream users in Khlong Raphiphat.

4.12.2 Operation Phase

Surface water source for the Power Plant will be taken from Khlong Raphiphat downstream of Phra Sri Silp Regulator in Amphoe Nong Khae, Saraburi.

a) Impacts on Available Water

Khlong Raphiphat receives water from Phra Narai Regulator near Rama VI Dam and diverts water to the East Bank-Lower Chao Phraya Project. According to records on water diverted into Khlong Raphiphat, there is an average of 2,259 MCM/year with the minimum monthly runoff of about 21 MCM/month (July 1992). However, the Power Plant requires about 1.25 MCM/month which accounts to 6% of the total runoff.

b) Impacts with Pasak Project

The Pasak Project has impacts on the East Bank-Lower Chao Phraya Project by adding water from Pasak river into areas under the East Bank-Lower Chao Phraya Project and reducing water released from Chao Phraya Dam. Figures 4.12-1 and 4.12-2 show that, in dry season, runoff at downstream of Pasak Dam increased from 260 MCM to 1,062 MCM while that in Khlong Chainat - Pasak reduced from 1,680 MCM to 878 MCM. Quantity of water available in dry season is constant at 1,940 MCM. Therefore, it can be concluded that the Pasak Project is designed to efficiently allocate water from Pasak river in dry season. In addition, water flow in Khlong Raphiphat will be more secured and allocation of water can be managed to meet water demand in Khlong Raphiphat.

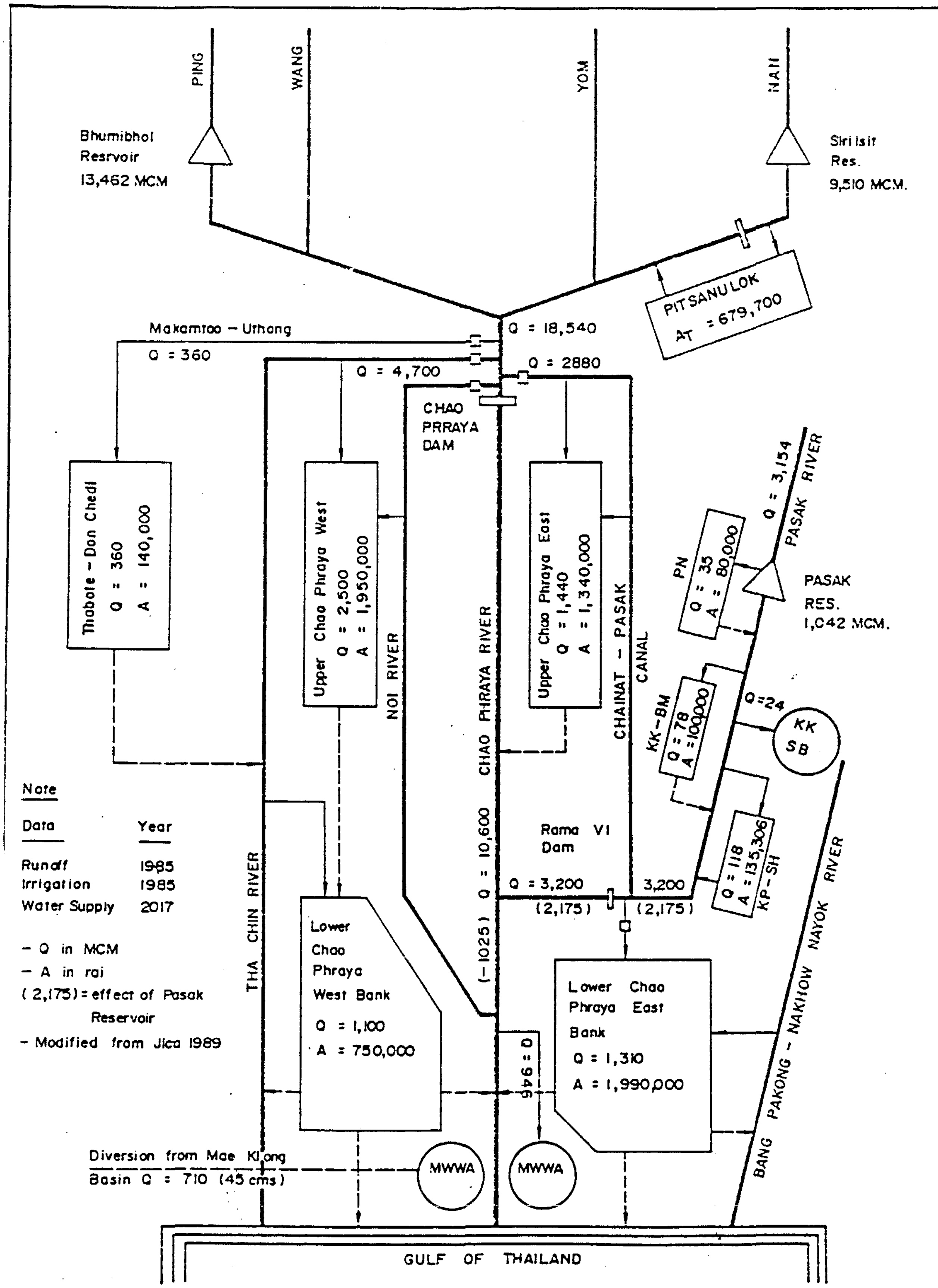

FIGURE 4.12-1 WATER BALANCE IN LOWER CHAO PHRAYA BASIN IN WET SEASON WITH PASAK RESERVOIR

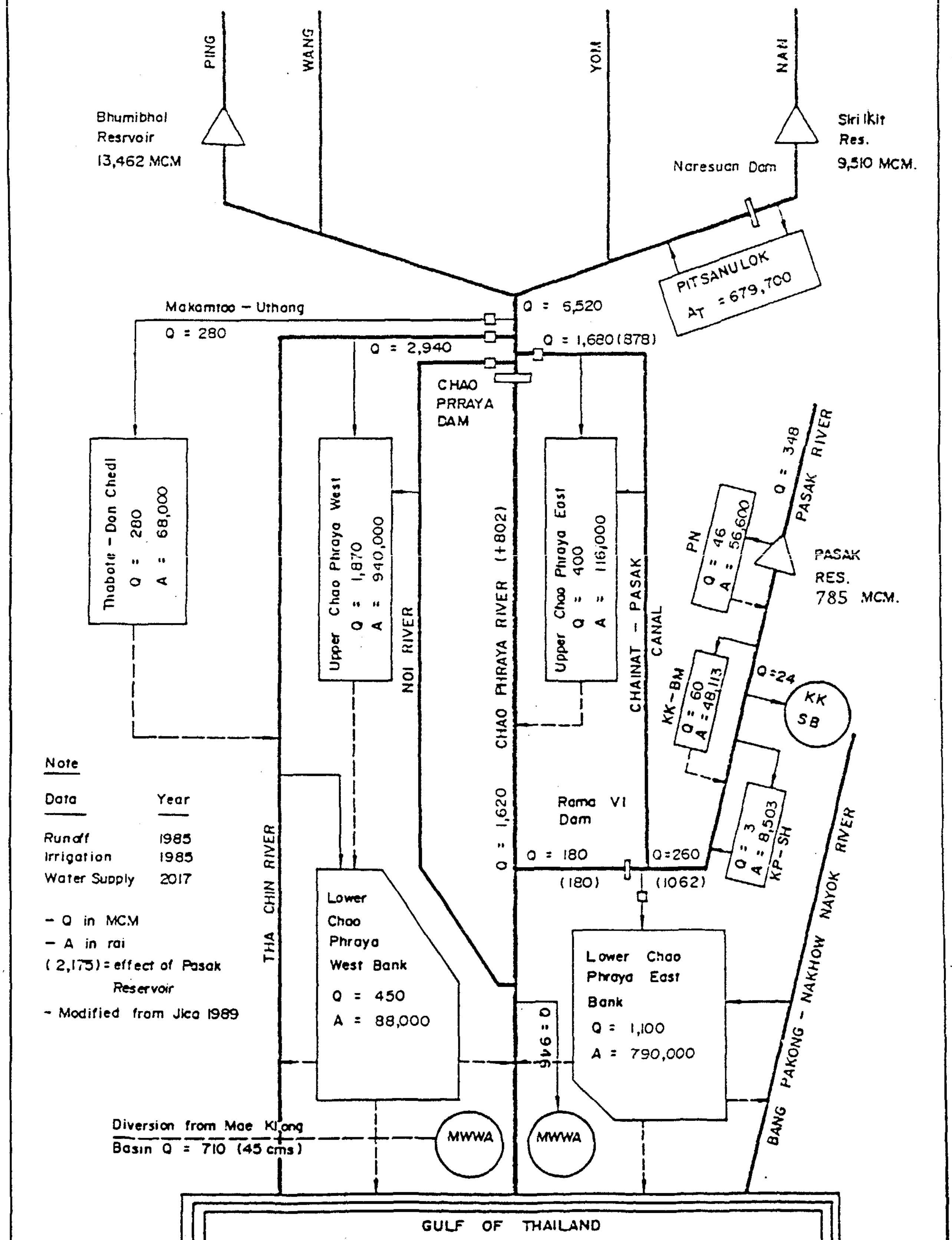

FIGURE 4.12-2 WATER BALANCE IN LOWER CHAO PHRAYA BASIN IN DRY SEASON WITH PASAK RESERVOIR

4.13 SOCIO - ECONOMICS

It was concluded from the attitude survey that villagers had positive feelings towards the Project. Probable impacts can be described as follows:

4.13.1 Construction Phase

1) Noise and dust from transport and construction activities may disturb people living near and around the site.
2) Immigration of construction workers into the area may give rise to disorder, insecurity and unpeacefulness of villages.
3) Villagers will benefit from retailed trading of daily consumer products to construction workers.
4) Villagers will earn more income by being hired as construction workers.
5) There will be resistance movement to the Project if there is no sufficient information or acknowledgement about the Project to villagers.

4.13.2 Operation Phase

1) Villagers will earn more income by being hired or employed as project personnel.
2) The area will be developed into more urbanized area due to establishment of the Power Plant.
3) Villagers will experience from change in social pattern or their way of living due to more income generation and development of the area.
4) Air and water pollution, if not properly treated, will adversely affect agricultural produce and also health status.

4.14 PUBLIC HEALTH

4.14.1 Current Condition and Effects

Public health statistics presented in existing public health conditions show that health problems in Ayudhaya are similar to conditions of a general semi-urban society in early stage of urban development. These are cases of respiratory disease, e.g. asthma, bronchitis, pneumonia, T.B. and influenza in the province. These illnesses could be caused partly by air pollution emitted from factories or vehicles or agricultural dust. Whereas accidents, sexual transmitted diseases, hypertension, diabetes and arthritis are likely to increase as a result of town development. While problems of gastrointestinal infections due to low standard of food and water sanitation and personal hygiene still exist. Mosquito-borne diseases such as malaria, dengue hemorrhagic fever and encephalitis, which are closely related to poor environmental sanitation are still being the health problem in this area.

Health problems and the deficiency of health personnel can aggravate the public health situation, although, it does not show up now. If the Power Plant is built here there will be thousands of people moving into the province. Thus, the problem may be evident.

4.14.2 Construction Phase

A large number of workers will move into the construction site for construction and installation activities. The construction period will last for about 2 years starting from December 1994 to November 1996. The probable effects will be those arising from under-standard sanitation in the camp site. The effects on public health of construction workers may be caused by the following conditions:

1) non-sanitary bathrooms and toilets
2) lack of clean water supply for domestic and drinking purposes
3) improper practice of wastewater and solid wastes treatment
4) inadequate provision of health services

Such conditions may result in health problems of workers, for example, diarrhea, food poisoning, etc. These diseases can spread out to communities surrounding the project site.

Health effects would also be created by exhaust and dust from construction-related transportation on the access road. Exhaust and dust can cause eye irritation, pulmonary diseases and diseases of respiratory tract. Furthermore, noise and accidents caused by trucks would be a major problem for both workers and people living in the surrounding areas.

4.14.3 Operation Phase

1) Effects of Gaseous Emission :

Although the Power Plant is equipped with air pollution control system for some pollutants, i.e. SO_2 and NO_2, ground level concentrations of those pollutants may increase appreciably. As khown, total suspended particulate and SO_2 have synergistic health effects (Air Pollutant Toxicology, Casarelt and Doull's, 2nd ed., 1980) therefore an incident of diseases of respiratory tract such as chronic bronchitis and asthma could increase. However, concentrations of such pollutants are expected to be far below the ambient air quality standards. The effects on health status of surrounding communities will then be minimal.

2) Effects of Water Supply and Wastewater Discharge :

The problem of public health that may be caused by the operation of the Power Plant is quantity and quality of water. To run the Power Plant, some amount of water will be taken from public used water. Therefore, water in the canal which is one of the source of public used water may be decreased. Another is wastewater from the Power Plant which will be drained into the canal may affect people's lives if it does not meet standard of wastewater.

3) Effects of Noise Generation :

Since it is specified that noise levels at a distance of 122 m from any source in the Power Plant will not exceed 54 dBA, noise should not be a problem for surrounding communities.

4) Effects of Transport Accidents :

Though, during the operation period, number of heavy trucks will reduce considerably from the construction period, number of staff's vehicles will increase instead. Accidents may occur because unawareness of safety of drivers/pedestrians such as ignorance of safety and traffic regulations and improper habits.

4.15 OCCUPATIONAL HEALTH AND SAFETY

4.15.1 Construction Phase

Occupational health problems and accidents could occur during the construction period. Causes of the problems can be divided into three main things. These are workers themselves, working conditions and management.

Most of construction workers are untrained for specific work and generally have limited knowledge. Therefore, causes of accidents due to workers can be lack of safety awareness, improper attitude, lack of knowledge for specific job, etc.

Working conditions that may cause health effect and accidents include equipment, tools or machines defective, improper illumination, ventilation, noise and dust. Also fire hazard can be a problem due to poor housekeeping, poor condition of electric equipment and utensils. Since these may happen in any construction areas and workers' camps, stringent measures are required to reduce the risk of accident and occupational health hazard.

Management that can cause accidents inlcude improper supervisory, safety performance (e.g. inadequacy of safety instruction (safety rules are not enforced, safety is not planned as part of jobs, safety devices are not provided), improper management of construction site, lack of appropriate maintenance of vehicles and equipment.

4.15.2 Operation Phase

Unsuitable working environment can lead to poor occupational health of the workers. Such unfavorable conditions include inadequate ventilation in hot and humid areas, in area where are subjected to leakage of natural gases and other fugitive emission or in confined space, poor lighting within the Power Plant and high noise level. These areas, inside the Power Plant, are located near the boilers, the condensers, the gas turbines and steam turbine sets, and power generators. Proper designs of these units as well as their housing are needed in order to control health hazard in working environment. The main health hazards in the Power Plant during operation phase will be as follows:-

(1) <u>Noise</u>

Since, it is specified that the noise from any source in the Power Plant must not exceed 85 dBA at a distance of 1 m and 54 dBA at the distance of 122 m from the source. Compared with the Notification of Ministry of Interior related to noise in the workplace, such sound pressure level does not exceed the standard (90 dBA).

Therefore, noise emitted from the operation will not cause health effect to the employees of the Power Plant if the design conditions are maintained.

(2) <u>Heat</u>

Certain areas, for instance, combustion turbine, ducts, and auxilliary equipment, will give off heat in the working environment. However, such heat condition will not cause any adverse health effects to the employees because

- The combustion turbine, ducts and auxilliary equipments are inside the enclosure for thermal insulation.

- The employees do not expose to heat continuously. If the design temperatures are maintained regularly, it will not be harmful to the workers.

Based on the design conditions, heat does not exceed the standard notified by Ministry of Interior, that is, the dry bulb temperature should not exceed 45°C. However, to protect the employees' health, WBGT index should be used to assess heat condition because of many factors involved, such as, workload, exposure time, globe temperature, etc.

(3) <u>Accidents</u>

The accidents might occur from unsafe acts of the workers, especially, during maintenance and welding process. Therefore, the recognition of potential hazards should be considered because they might cause a lot of loss such as injury, property, time, etc. Preventive measures should be planned to be implemented during opereation of the Power Plant. The impact depends on the effectiveness of the preventive measures implemented and followed up. If the preventive measures are only partially implemented, the significant impact might be resulted.

If the Power Plant has followed the applicable codes and the design conditions as mentioned above, there will not bring about the impact to health and environment. However, the standard of working conditions according to the Notification of Ministry of Interior should also be taken into account.

4.16 AESTHETIC VALUE AND TOURISM

4.16.1 Construction Phase

The Power Plant is approximately 6 km from Amphoe Wang Noi, 2 km branching off Phahonyothin Road to the power plant site. A rural type of agriculture around the power plant site is still good, calm and serene. However, the existing developments of the areas such as residential buildings by land developers and the existing transmission line in nearby areas will change the rural type to residential and industrial types in the near future.

The construction activities which will start from 1994-1996 may pose some aesthetic impacts on the scenery near the proposed project site. Site clearing, land reclaiming, construction and installation activities of the Power Plant will disturb the environment in terms of dust, noise and vibration. The aesthetic quality during construction phase will reduce the swamp land of 700 rai for the power plant area, ground have been levelled, road have been constructed.

In terms of tourism, there was no impact during construction phase because the project site is not closed to tourist attraction points.

4.16.2 Operation Phase

In operation phase, the Power Plant will be a huge building in the paddy field and can be seen along Phahonyothin Road although it is 2 km far from the road. The plant operation will reduce the aesthetic quality by smog from power plant's stacks. However, existing appearance of some industries and transmission line along Phahonyothin Road near the power plant site has been acceptable. New land developers will also accelerate the change of land use in the study area from rural to residential and industrial. Hence, impacts of the Power Plant on aesthetic quality is insignifieant. However, proper architectural design and landscaping is needed.

4.17 OVERALL ENVIRONMENTAL IMPACT ASSESSMENT

After consideration of overall impacts which will be caused by the Power Plant, it is revealed that the Power Plant will cause impacts to the environment especially in the operation period in terms of water supply of the Power Plant. The environmental resources and values which are expected to be significantly affected by raw water intake of the Power Plant are surface water hydrology, surface water quality, ground water hydrology and quality, aquatic ecology, and land use. Two alternative raw water intake sites, namely the Raphiphat site and the Bang Sai site, have been compared by considering environmental effects on the afore-mentioned aspects. It can then be concluded that both sides are feasible as the raw water intake site since they pose the impacts in acceptable levels.

According to water quality both surface and underground, it is found that quality of water of both khlong Raphiphat and Chao Phraya River is suitable for plant consumption. Quality of ground water which is planned for domestic use is also suitable for drinking purpose.

Owing to aquatic ecology, the study shows that impacts due to mortality of aquatic organisms at the intake structure can be mitigated by design of proper intake structure.

In terms of land use, effects from raw water conveying pipeline from the intake site to the Power Plant are considered. However, the pipeline from Khlong Raphiphat site will be laid along the banks of Khlong Raphiphat thus causing no effects on land use pattern except during construction period at the point where construction is required when the pipe is laid under the road to the Power Plant.

The most significant impacts are put upon surface water hydrology and water use since the Power Plant will consume a considerable amount of water, i.e. 15 MCM/year. If considering withdrawal of water from Chao Phraya river, this amount is less than 1% of total runoff in the river. For Khlong Raphiphat site, the withdrawn water will be only 6% of the total runoff.

In conclusion, environmental impacts of the two sites are comparative therefore. Electricity Generating Authority of Thailand has conducted a site selection for both alternative raw water intake sites by considering other items as follows :

1. investment cost
2. water quality
3. topography of pump house
4. land acquisition
5. environment
6. water stability
7. construction period

The results as summarized in Table 2-2 show that the site at Khlong Raphiphat is more feasible.

CHAPTER 5

MITIGATION MEASURES

CHAPTER 5
MITIGATION MEASURES

5.1 INTRODUCTION

The assessment of probable effects of the construction and operation of the Power Plant on the environmental resources and values in the project area have been qualitatively and/or quantitatively described and discussed in Chapter 4. In this Chapter, alternative measures to mitigate the impacts of the Power Plant, in both construction phase and operation phase, on each environmental component are considered and appropriate mitigation measures are identified and recommended. These recommendations are determined based on environmental conservation and/or preservation, engineering, social and economic basis.

5.2 AIR QUALITY

5.2.1 Construction Phase

During the construction phase, impacts from dust dispersion will be mitigated by the following action.

1) The construction area must be sprayed with water at least twice a day.

2) Non-asphaltic or concrete road in the project site must be sprayed with water at least twice a day.

5.2.2 Operation Phase

At the first stage of operation, distillate oil No.2 will be used for CT. Major pollutants to be emitted which are NO_2 and SO_2 will be well below the ambient air quality standards. At the final stage, natural gas will be used for CT. Predicted ambient concentration of NO_2 will be within the ambient air quality standards. The following mitigation measures should be taken into action.

1) Install stack height of 60 m.

2) Provide appropriate air pollution control equipments.

3) Use distillate oil No.2 with sulphur content of less than 1 percent.

5.3 SURFACE WATER QUALITY

5.3.1 Construction Phase

Major effects on water quality during the construction phase are related to the following activities : i) construction of pumping station, ii) installation of raw water transmission pipeline, and iii) construction and installation of onsite structures.

5.3.1.1 Construction of Pumping Station

Although relatively minor effects of grading, compacting and excavating the area for construction of pumping station and of dredging the Khlong Raphiphat bed for installation of suction pipe on the water quality of Khlong Raphiphat are anticipated, proper disposal of the dredged spoils on appropriate land to avoid or reduce surface soil erosion during rainy season is required to alleviate their subsequent effects on water quality. A holding pond for temporary storage of runoff may be needed. In addition, proper handling or disposal of residual construction materials as well as sewage and other solid and liquid wastes of worker community is also required.

5.3.1.2 Installation of Raw Water Transmission Pipe

Since the effects of installation of raw water transmission pipeline on water quality are expected to be insignificant, appropriate mitigative measures are therefore not required.

5.3.1.3 Construction of Onsite Structures

Land preparation by grading and compacting and land excavation for constructing foundation of most structures, raw water reservoir and effluent holding pond are a major source of adverse impacts on water quality of the storm drainage canal due to the surface soil erosion, particularly during the rainy season. An appropriate measure to alleviate such impacts is to reduce sediment load of runoff prior to discharge to the receiving canal. A simple, inexpensive and effective method is to use a holding pond as a temporary storage of runoff, so that sedimentation and siltation occurs.

Another significant source is domestic wastewater and solid wastes disposed of from 1,200 workers in the worker camp. Appropriate measures to alleviate the problem include providing proper drainage system, proper solid waste disposal method by supplying adequate solid waste receptacles, septic tanks and sanitary latrines. It is also recommended wastewater from bathrooms and kitchens at the construction site should be stored in the holding pond prior to discharge to the receiving canal, so that sullage will be held in the holding pond. In addition, services for solid wastes and sewage collection and treatment of the Lam Ta Sao Sanitary District should be employed.

5.3.2 Operation Phase

5.3.2.1 Effects of Holding Pond Wastewater

During the operation phase, approximately 5,000 l/min of treated wastewater will be discharged from the Power Plant into Khlong 26. The expected high concentrations of suspended solids, dissolved solids, hardness and sulfate, high value of specific conductivity and contamination of treated chemicals, AA/AMPS copolymer and HEDP, will affect significantly Khlong 26 water, particularly in dry season. A simple, inexpensive and effective mitigation measure is dilution method using the Khlong 26 water as dilution water. However, such a mitigation measure is impossible, due to very low flow in Khlong 26 in the dry period. Another appropriate and practical measure is to recycle the effluents from cooling tower and HRSG units by treating such effluents to meet raw water quality to be reused in the Power Plant. This will reduce water consumption. The recommended mitigation method will also alleviate the contamination of the chemicals AA/AMPS and HEDP because no such chemicals is discharged into Khlong 26. Treatment methods include physical treatment processes to reduce suspended solids and chemical treatment processes to reduce conductivity, dissolved solids and hardness. As regards to treated domestic wastewaters, treated plant equipment drains, treated chemical area drains and treated effluent from demineralization system, the wastewaters will be stored in holding pond prior to discharge to Khlong 26.

Presently, EGAT purchased a piece of land of 100 rai, north to the project site, to be used as a landfill site and buffer zone. About 20-30% of treated effluent will be used for gardening purpose. In addition, feasibility study on reuse of treated effluent for agricultural purpose will also be carried out. Some appropriate plant species will be recommended to local agriculturists.

In addition, EGAT should inform local villagers about discharge of wastewater into Khlong 26. EGAT should warn people about toxicity of chemicals used in cooling process. Also, in case of lack of water supply, EGAT should provide water for the communities.

5.4 GROUNDWATER

Mitigation measures to be considered for groundwater aspect are as follows:

1) Rate of groundwater withdrawal should be studied carefully in order to maintain constant supply of the wells.

2) Groundwater wells must be located not less than 30 m far from a septic tank system in order to avoid seepage contamination (US. EPA., 1980).

3) Groundwater should be monitored for its quality at least twice a year at the wells used for plant supply.

4) Land subsidence and drawdown level should be monitored.

5.5 SOILS AND LAND QUALITY

5.5.1 Construction Phase

Impacts of construction activities to soil resources are related to earthwork for site preparation. The earthwork includes excavating wastewater treatment pond, levelling and landscaping of the plant area and installing transmission poles. Actually, impacts of these activities will be confined only in certain areas of the Power Plant and along the transmission line and mostly be involved with the bringing up of the very strongly acid and/or potentially acid subsurface or subsoil materials to the surface. It will be oxidized and its reaction will become very strongly acid with pH of 3.5 or lower. Except very few types, the places with the soil of such reaction cannot be used for growing any kind of crop for at least 2-3 years. However, as afore-described, if the problem of very strongly acid reaction has been eliminated, these soil types will be fertile and can be used for growing any kind of crop.

Since the earthwork in the plant area has already been accomplished, it is believed that such very strongly acid soil problem has already existed in the area. Many of the areas might have already been buried and/or landscaped by very strongly acid and/or potential acid subsurface and subsoil materials.

Practically, this problem can be eliminated by applying lime ($CaCo_3$) to neutralize the acid in the soil and subsequently remove such neutralized materials out of the soil by means of water leaching. Actually this measure is commonly practised by farmers in the area. Acccording to the soil map of the area, the soil of the area where the Plant is located is also the strong acid sulphate soil (The Rangsit series, see also the description of this soil series). Therefore, it means that not only the areas which have been buried and/or landscaped by the very strongly acid and/or potential acid soil material that will have the problem of strongly acid reaction but also the other area of the Plant. To eliminate this problem the following measures are required:-

1. Installation of the drainage system to drain water from the soil of the area.
2. Plowing of surface soil of the area to the depth of about 20-30 cm. from the surface.
3. Simultanously with plowing, application of lime* to the soil with the rate of 3 tons/rai for the areas buried by the strongly acid and/or potential acid soil material and 2 tons/rai for other areas.
4. After lime application, irrigation of the area until the soil is over saturated and let the water drain out of the soil.
5. Irrigation in such a way regularly and continously for a month.
6. Initiation of growing shallow root system crops such as ornament crop, grasses, etc.
7. Irrigation as needed.

8. Other than lime material, application of certain chemical fertilizer especially nitrogen and phosphorus to the soil.

In case of deep root system and/or perennial crops, more intensive soil management is needed. Its growing places are needed to mound by special treat soil materials as high as 20-30 cm from actual surface (surface after plowing and liming).

Such specially treated soil material composes of the normal surface soil of the area, (the soil to the depth of 20 cm from the surface) the manure of compost and lime. The ratio by volume of soil and manure of compost is 1:1. For lime, it is about 10 kg for 1 ton, of such mixing of soil and compost material. After mounding, the hole as deep as 30 cm from surface of the mound, is burrowed. The crop, then, is planted in such a hole.

Owing to the potential acid properties, when oxidized, the subsoil of the area will gradually supply the acidity to the subsurface and surface soil, respectively. To keep the soil in the favourable condition for growing crops, therefore, practically, the same rate (2-3 ton/rai) of lime materials are needed to reapply to the soil every five year.

5.5.2 Operation Phase

For the problem of excavation of storage reservoirs and construction of wastewater treatment units to the soil resources, considering the actual condition of treatment system of the Power Plant and of the soil properties, this problem can be negligible. All of the storage reservoirs and the treatment tanks have been lined therefore no problem of the lateral seepage of such waste material. After treating the somewhat good quality water will be disposed of to the canal. In fact the lateral seepage will occur along the banks of canal. However, considering the quality of the water itself, the rate of the permeability of the soil along the canal which is very slow, the type of clay mineral of the soil which the montmorillonite is dominated and the cation exchangeable capacity (CEC) of the soil in the area which is relatively high, such a problem of lateral seepage is then negligible.

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* The rate and the efficiency of the neutralization of the soil depends on qualities of lime material and soil texture. The good quality lime that will accelerate the neutralization rate should be high in calcium carbonate ($CaCO_3$) percentage and the texture of the lime material should be as fine as possible (at least, it can be passed through the sieve of 50 mesh.)

5.6 AQUATIC BIOLOGY AND FISHERIES

5.6.1 Construction Phase

During construction period, heavy dumping to Chao Phraya River, Khlong 26, and Khlong Raphiphat should be minimized by careful work on heavy dumping and soil work, so that soil erosion is limited. The construction at Khlong Raphiphat should be done during dry season.

5.6.2 Operation Phase

With respect to fisheries resources in Chao Phraya River, Khlong 26, and Khlong Raphiphat, the following recommendations are established:

1) The intake pipe of raw water for power plant use should be installed under water surface at the level at least 2 m deep because the plankton organisms including fish eggs and larvae are usually low density at the deep water level.

2) To prevent aquatic organisms, floating debris and aquatic weeds from obstructing the performance of the intake structure and raw water pump, EGAT should build a different screening structure with different layers and mesh sizes opening around the intake pipe.

3) Establishment of a fisheries management unit, fish stocking program and control of aquatic weeds in Khlong Raphiphat should be introduced.

5.7 LAND USE

Land use will be changed from rice field and fruit orchard to be residential area of workers and officer of the Power Plant. Town-houses and other styles of houses including condominiums will appear at nearby and surrounding the project area. Infrastructure will be improved in the better condition along Khlong Raphiphat and around the Power Plant. The price of land will increase in the faster rate than usual. The water treatment will help to remedy drought during January - May since the people are confronting the critical problem of severe drought.

At present, water pumps are settled along canal 6, 8, 9, 10 and sub canal 2 - left and 3 - left and Khlong Raphiphat. Therefore, the water crisis may start in February. It will cause the shortage of water for fruit orchards, especially, oranges.

Measures to mitigate effects on land use include the followings:

1) A storage reservoir should be constructed to reserve raw water for a 5-d period, in order not to disturb water use pattern of the fruit orchards else the land use pattern may change.

2) Though discharge of treated wastewater will help increase flow in Khlong 26, quality of the treated wastewater must conform to the standards and toxic substances must not be contained in the treated wastewater so that the increased water flow will not be harmful to fruit trees and aquatic lives. Since deterioration of water quality may induce changes in land utilization.

3) Local agencies responsible for awarding construction permits must strictly control development of the area to prevent over growth of the area.

5.8 TRANSPORTATION

5.8.1 Construction Phase

The following mitigation measures are recommended:-

1) On Phahonyothin Road, EGAT should plan to transport the construction materials after rush hour period.

2) Restrict overweighed vehicles (not more than 25 tonnages) to prevent the damage on the road.

3) Careful inspection on trucks not to make dirty on the roads.

4) Installation of traffic warning sign and lighting facilities near the proposed site and, especially, on route laying transmission pipe line.

5) Control speed limit of heavy vehicles not more than 60 km/h.

5.8.2 Operation Phase

1) Installation of traffic warning sign and lighting facilities near the Power Plant and provision of traffic controllers.

2) Close cooperation with concerned government agencies to increase traffic safety.

5.9 SOCIO - ECONOMICS

5.9.1 Construction Phase

1) Dust from transport and construction activities must be prevented by means of water spraying on uncovered areas or gravel/dirt roads and also by planting of grass in some finished areas.

2) Noise level must be kept to the standard by selection of low noise machine and provision of regular maintenance selection as well as avoidance of working and transporting during the night-time.

3) Local people must be given priority in employment opportunity.

4) EGAT should give more understanding of the Project to villagers especially those living in the vicinity of the Power Plant.

5.9.2 Operation Phase

1) Wastewater from the Power Plant must be treated to acceptable levels to prevent deterioration of Khlong 26 quality and thus adversely affecting agricultural farming and health of people.

2) Air and noise pollution must be strictly controlled.

3) EGAT must provide better physical infrastructure to the villages such as roads, electricity, some bus shelters, etc.

4) EGAT must be given priority in employment opportunity to local people this will also help solving housing problems.

5) EGAT should participate as a committee member in Tambon's or village's organization in order to receive information concerning needs of communities and to take chance in spreading project's informations to heads of communities.

6) Project personnel must make familiar with local people.

5.10 PUBLIC HEALTH

5.10.1 Construction Phase

1) Major health problems of the construction workers and their families are likely to be diseases associated with poor environmental sanitation and poor personal hygiene, e.g. diarrhea, food poisoning, malaria, T.B., and dysentery. These diseases are also endemic in this area. During construction period, there will be a problem of water supply and poor environment, thus workers and their families' health problems can be aggravated. Moreover, these diseases can spread out to nearby communities. Therefore, it is very important for EGAT or construction contractors to provide adequate safety water supply, proper drainage and waste disposal system as well as sanitary latrines and seeking assistance from local public health agencies to undertake an environmental health and

sanitation improvement program in the construction site communities and to provide health services, for example, immunization, family planning, and nutrition.

2) Health hazard caused by transportation related construction and construction process such as dust, exhaust emission and noise. These hazards affect not only on workers health but also on health of the neighbors of the construction site. Therefore, EGAT should have strict rules or schedules concerning time to operate some kinds of work that may make noise, concerning traffic, and routine maintenance and check up of vehicles, trucks and machine use in the site. Furthermore, EGAT should manage in any way to reduce or prevent dust caused by transportation in and out of (from the main road to the site) the construction site.

3) Eventhough, in the construction site there will be a very effective safety measure and regulation, injuries and illness can happen any time during or after working hours. Therefore, medical unit with adequate staff and equipments should be made available at the construction site. It should be available not only for the workers but also for their families who live in the project area. This will help in the situation of lacking of health personnel and facilities in Ayudhaya as well. However, serious illness or injuries that the medical unit cannot handle may happen. A transportation to the nearby hospital is necessary. EGAT or construction contractors must provide a stand-by transportation for such cases.

5.10.2 Operation Phase

1) Respiratory diseases, e.g. asthma, chronic bronchitis, pneumonia, influenza and skin disease whose incident rates are usually high in this area should be given special attention because they are likely to relate to pollutants emitted from the Plant as well. EGAT should have the connection to the surveillance program run by the Ministry of Public Health through Provincial Health Office or District Health Center in Wang Noi. By this way, EGAT can have information of health status of people who live near the Power Plant. Furthermore, EGAT should manage in any way to regularly monitor canal water.

2) To relieve problem of lacking of health personnel and facilities in Ayudhaya, EGAT should provide a medical center with sufficient health personnel and equipments at the power plant to service staff workers and their families who live in the power plant areas. The medical center should be able to provide at least first aid and some clinical services. However, arrangement should be made with nearby hospitals for treatment of personnel whose illness is beyond the service capacity of the medical center.

3) Although the power plant is designed to control gaseous emission to some level and the height of stack is high enough to reduce air pollutant concentrations at the ground level, it should be realized that a higher stack cannot truely solve the problem of pollutant emission. Therefore, in the operation phase, EGAT should set up a monitoring program to monitor at least SO2, NOx and TSP. The monitoring should not be confined only in the plant area; but communities surrounding the

Power Plant should be monitored as well. People especially those who live in the neighborhood of the Power Plant should be informed about the program and the result of the monitoring should be reported to concerned agencies.

4) EGAT should provide proper traffic signs along the access roads to the Power Plant.

5.11 OCCUPATIONAL HEALTH AND SAFETY

5.11.1 Construction Phase

1) Provision of personal protective equipments, e.g., masks, ear plugs/ear muffs, safety hats, gloves and safety shoes.

2) Provision of sufficient public utilities for the workers in accordance to good sanitation concept.

5.11.2 Operation Phase

Eventhough it is believed that occupational health and safety impact will not be significant, additional mitigation measures should be planned and implemented to promote better working condition and workers' health.

1) Fire Prevention and Control

Eventhough the installation of fire detection and protection system is in accordance with the application code, the Notification of Ministry of Interior related to Fire Prevention and Control in Workplace should also be considered, including these important aspects:-

- Fire drill and evacuation of 40 percent of employees in each area of the Power Plant.
- Fire alarm should be installed in every storey for more than two-storeyed building
- Fire exit and fire alarm should be in size and specified in compliance with the law.
- Fire fighting equipment should be provided and installed sufficiently, especially in risky areas such as fuel oil tanks, etc.
- The work procedures should be provided to all employees and also to contractors in order to follow strictly, especially, in the areas of fuel oil storage.
- Permit to work for welding or hot work should be applied under supervision of qualified personnel.

2) Noise

The noise as specified and proposed by the contractors should not exceed 85 dBA at a distance of 1 m. Compared with the standard of Notification of Ministry of Interior related to Noise in Workplace, it is lower than standard (90 dBA). However, in the long run, the machinery such as combustion turbine generator might be worn out and give off higher sound pressure level. Therefore these following measures should be conducted:-

- Maintenance of machinery should be done regularly.
- Insulation of turbine casing should be replaced periodically to reduce sound pressure level and vibration.
- Control room should be provided in case of continuous exposure to noise and ear protective equipment should be provided to the employees.
- Monitoring of sound pressure level should be conducted regularly and in case of installation of new machinery.
- Hearing loss should be tested for the new employees assigned to work in the noisy areas and also for the employees who expose to noise.
- The combustion turbine and all machinery should be installed and fixed properly in order not to give off higher sound pressure level.

5.12 AESTHETIC EFFECTS

Visual impact may be minimized by establishing a buffer zone around the perimeter of the site. Vegetation in the buffer zone will be used to block any visual observation of landfill activities. Visual impact can also be lessened by conducting landfill operations at lower elevations than the surroundings. To reduce the impact of windblown litter, movable screen should be placed as close to the working area of the landfill as possible. The screen must be of mesh fine enough to trap the litter and at the same time allowing air movement through.

During the operation phase, the plant activities may result in air pollution, noise nuisance and dust. This will cause health problems and annoyance effects to the nearby communities, and will also cause the visual impact of passing visitors. Green belts should be designed to prevent fugitive pollutants, improve the scenery, serve as recreation area and provide visual distance.

Strips of green belt should be built surrounding the entire plant area and also laid on both sides of the main artery road to function as a buffer zone to the activities inside the area.

Selected species of plants for green belts should be those which will adopt to climate and existing soil. General guidelines for consideration are as follows:

1) It should have deep, strong root system which will not spread over a wide surface in the area;

2) The trunks of tree should be strong flexible to wind, and not easily broken down;

3) It should grow fast in the beginning by care and maintenance;

4) It should have sufficient height but not too tall;

5) It should live long;

6) It should have dense canopy or crown;

7) It should have branches not subject to breakage and early natural pruning.

The sample of primarily selected species are:

Kratin yak Leucaena leucocephala
Kratin Narong Acacia auriculaformis
Son Thale Casuarina equisetifolia
Eucalyptus spp.
Son Pradiphat Casuarina Junguhaniana

The degree of effectiveness of the green belts is not only the species of plants but also the arrangement of species components. In general, planting trees for green belts involves two or more species of trees which strengthen the effect of wind protection, prevent monoculture and shedding of leaves for certain species in dry season. An expert horticulturist should be engaged to advise in landscaping and planting of trees and shrubs.

5.13 CONCLUSION

Table 5-1 summarizes the mitigation measures for the Wang Noi Combined Cycle Power Plant for both construction and operation periods.

TABLE 5-1

SUMMARY OF MITIGATION MEASURES FOR WANG NOI COMBINED CYCLE POWER PLANT PROJECT BLOCK 1-6

Activity	No of Years to be Performed (Years)	Year 1994				1995				1996				1997				Responsible Agency
		3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	
Construction Period																		
1. Water spraying and plant covering to reduce dust in the construction area	3-1/2																	EGAT
2. Construction of temporary holding ponds to prevent eroded soil into water courses	1/6																	EGAT
3. Provision of worker camp with good sanitation	1/6																	EGAT
4. Construction of storage reservoir for plant use	1/2																	EGAT
5. Construction of air pollution control system	3-1/4																	EGAT
6. Construction of wastewater treatment plant	2																	EGAT
7. Construction of a first aid unit and provision of related equipment	1/2																	EGAT
8. Monitoring of environmental quality	3-1/4																	EGAT
Operation Period																		
1. Monitoring of influent and effluent	every 3 month																	EGAT
2. Monitoring of stack emission	twice a yr																	EGAT
3. Monitoring of raw water and surface water quality	in Oct. and Apr.																	EGAT
4. Monitoring of ambient air quality	twice a yr																	EGAT
5. Monitoring of socio-economic status	every 2 yr.																	EGAT
6. Monitoring of public health status	annually																	EGAT
7. Monitoring of working conditions	annually																	EGAT
8. Monitoring of groundwater quality	twice a yr.																	EGAT
9. Monitoring of aquatic ecology	once in dry season																	EGAT

CHAPTER 6

MONITORING PROGRAM

CHAPTER 6
ENVIRONMENTAL MONITORING PROGRAMS

6.1 AIR QUALITY

During Construction

Parameter	:	TSP
Locations	:	Wat Lam Phraya (Figure 6-1).
Frequency	:	Every 4 month, each measurement must be made 3 days continuously.
Methodology	:	Follow methods recommended by MOSTE or equivalent.

During Operation

This monitoring program is proposed in order to ensure effectiveness of the mitigation measures. Monitoring data may imply malfunctioning or poor operation of equipment or the control systems. Therefore, monitoring can provoke alertness of the operators to correct the malfunctioning or strengthen the control measures in time before the situation becomes serious.

(1) Ambient Air Quality

Parameters	:	- Nitrogen dioxide - Sulphur dioxide - Wind speed and wind direction
Locations	:	- 5 stations as shown in Figure 6-2 1. Wat Rat Bamroong School 2. Suwaphan Sanitwong Phittaya School 3. Wat Chula Chindaram School 4. Hiranpong Anusorn School 5. Wat Sawang Arom School
Frequency	:	Twice annually, i.e., in the northeast and southwest monsoon seasons. Each measurement must be conducted for 7 days continuously.
Methodology	:	Follow method recommended by MOSTE or equivalent.

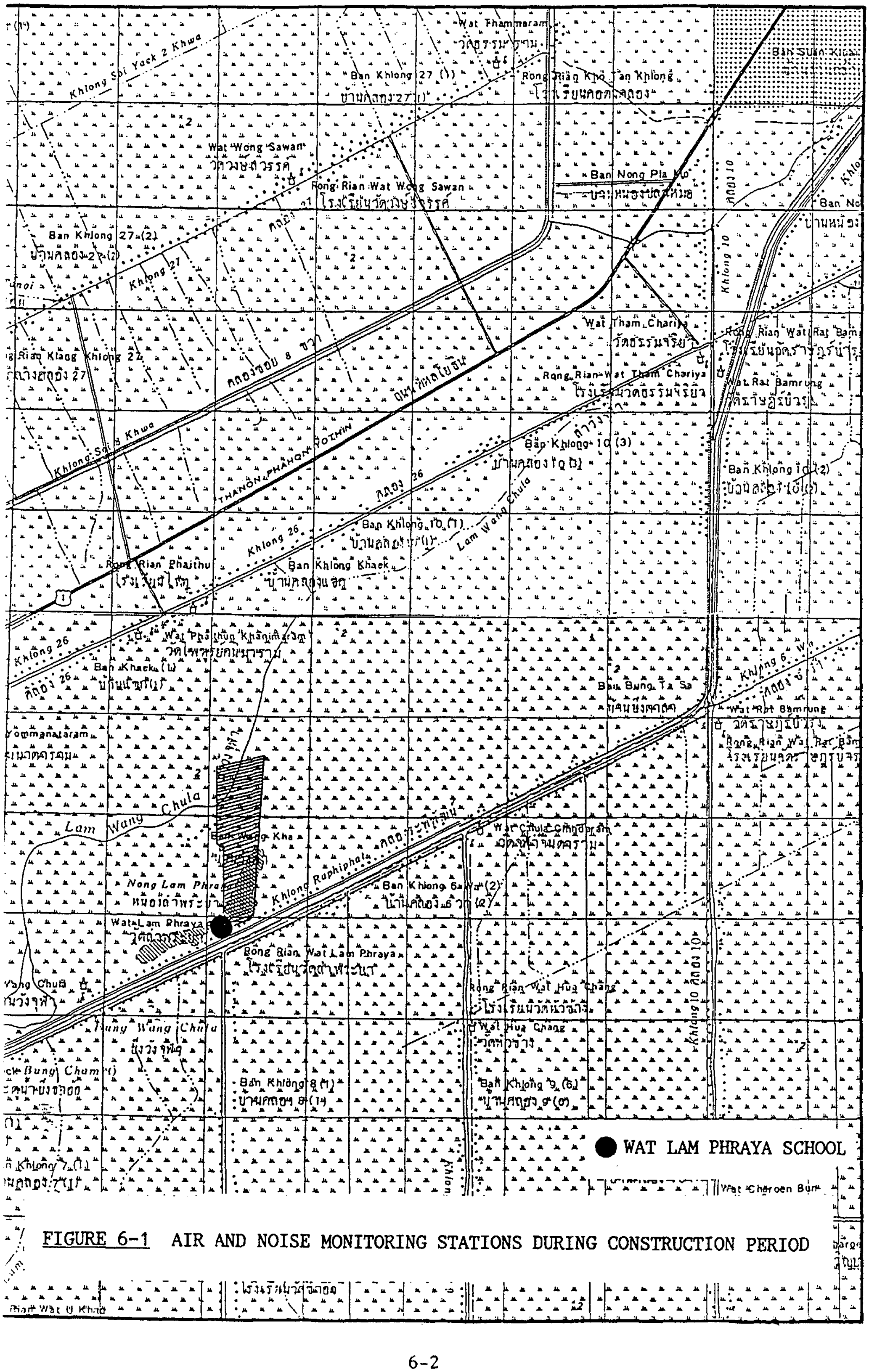
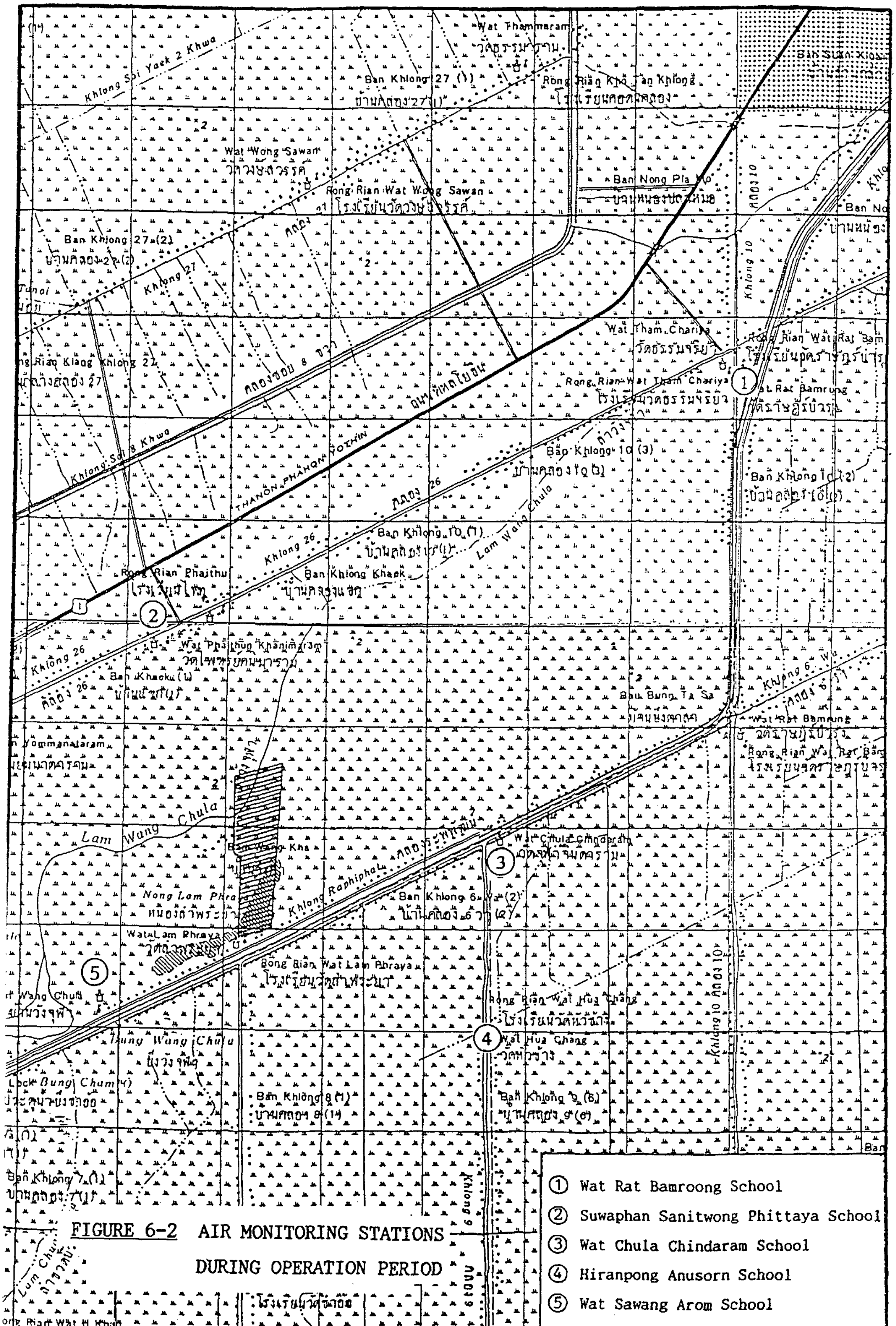


FIGURE 6-1 AIR AND NOISE MONITORING STATIONS DURING CONSTRUCTION PERIOD



① Wat Rat Bamroong School
② Suwaphan Sanitwong Phittaya School
③ Wat Chula Chindaram School
④ Hiranpong Anusorn School
⑤ Wat Sawang Arom School

FIGURE 6-2 AIR MONITORING STATIONS DURING OPERATION PERIOD

(2) Stack Gas

Parameters	:	- Sulphur dioxide (for distillate oil No. 2) - Nitrogen oxides (for NG or distillate oil No. 2)
Locations	:	- CT stacks or/and - HRSG stacks
Frequency	:	Twice annually concurrently with ambient air monitoring.
Methodology	:	Stack gas sampling method
Details	:	The results must also include details on quantity of fuel used and percentage of sulphur in the fuel, as well as capacity of production during monitoring.

6.2 NOISE

Parameter	:	leq (24)
Location	:	One location at Wat Lam Phraya (Figure 6-1).
Frequency/Period	:	Twice a year, each measurement for 24 h.

6.3 OCCUPATIONAL HEALTH AND SAFETY

- Noise

Parameter	:	Noise Level
Location	:	Generator and instrument air unit
Frequency	:	once a year

- Heat

Parameter	:	WBGT
Location	:	Combustion turbine generator area
Frequency	:	once a year

- Physical Examination

Parameter	:	Hearing loss test
Location	:	For employees who are exposed to loud noise, i.e, those working in the generator and instrument air unit area.
Frequency	:	once a year

- Record of Sickness/Accident

Every case of sickness/accident of all levels of severity must be recorded throughout the course of operation. If possible, accident investigation should be applied for all cases, including "near-miss" events.

6.4 SURFACE WATER QUALITY AND WASTEWATER

During Construction

Parameters : Water Quality : Temperature, pH, Conductivity, Turbidity, Suspended Solids, Dissolved Solids, Alkalinity, Hardness, Dissolved Oxygen, BOD, Grease and Oil, and Color

Location : 7 Stations as shown in Figure 6-3

1. raw water intake site at Phra Sri Silp Regulator, A. Nong Khae, Saraburi
2. overflow from temporary holding pond
3. Khlong Wang Chula
4. West Raphiphat in front of the Plant
5. 500 m downstream of station 4
6. 500 m upstream of station 4
7. effluent discharge point in Khlong 26

During Operation

Parameters : Water Quality : Temperature, pH, Conductivity, Turbidity, Suspended Solids, Dissolved Solids, Alkalinity, Hardness, Dissolved Oxygen, BOD, Hydrogen Sulphide, Grease and Oil, and heavy metals.

Location : 6 stations as shown in Figure 6-4

1. raw water intake site at Phra Sri Silp Regulator, A. Nong Khae, Saraburi
2. effluent discharge point in Khlong 26
3. 500 m downstream of station 2
4. 500 m upstream of station 2
5. influent to holding pond
6. effluent of holding pond

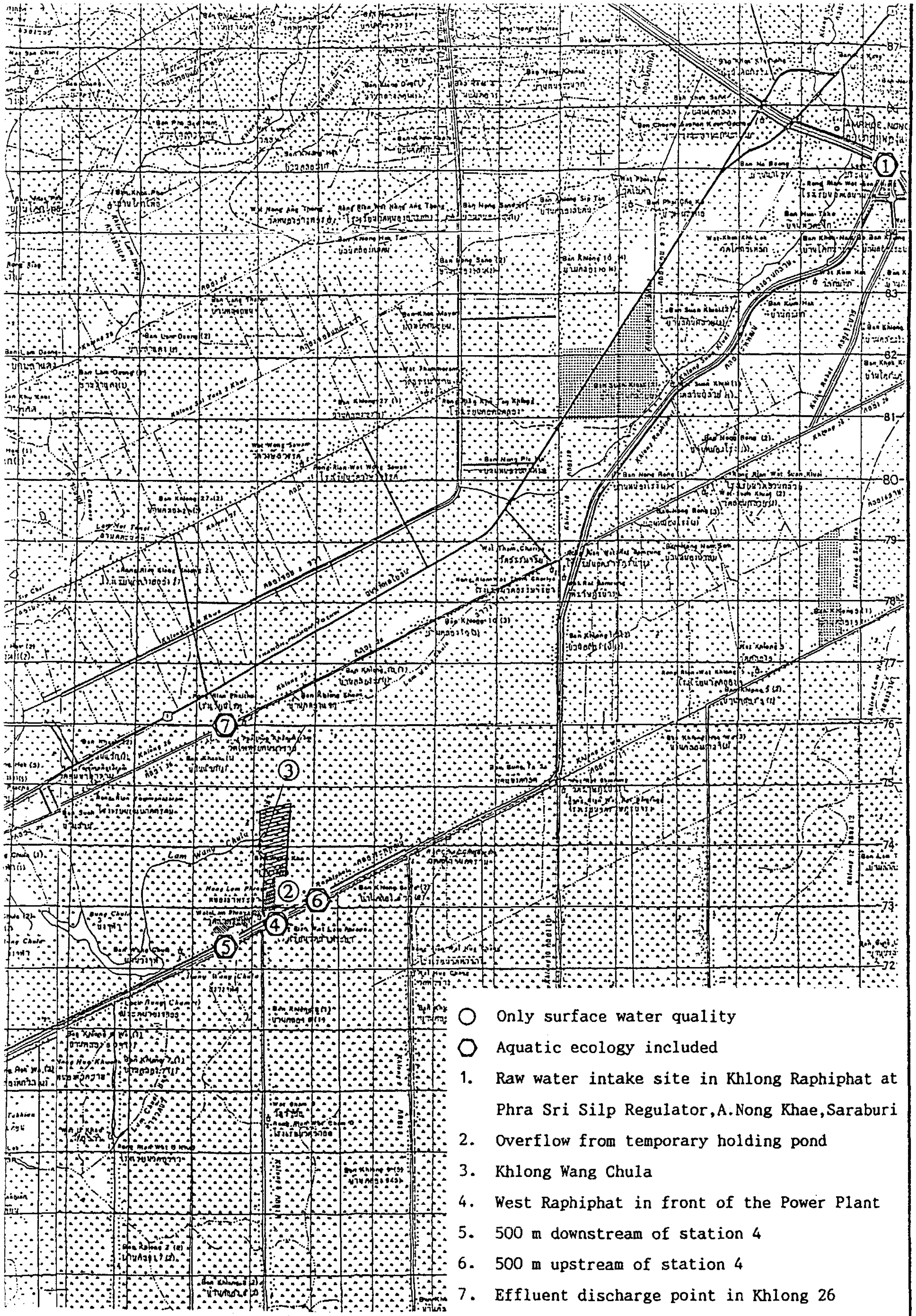


FIGURE 6-3 SURFACE WATER QUALITY,AQUATIC ECOLOGY AND WASTEWATER CHARACTERISTICS MONITORING STATIONS DURING CONSTRUCTION PERIOD

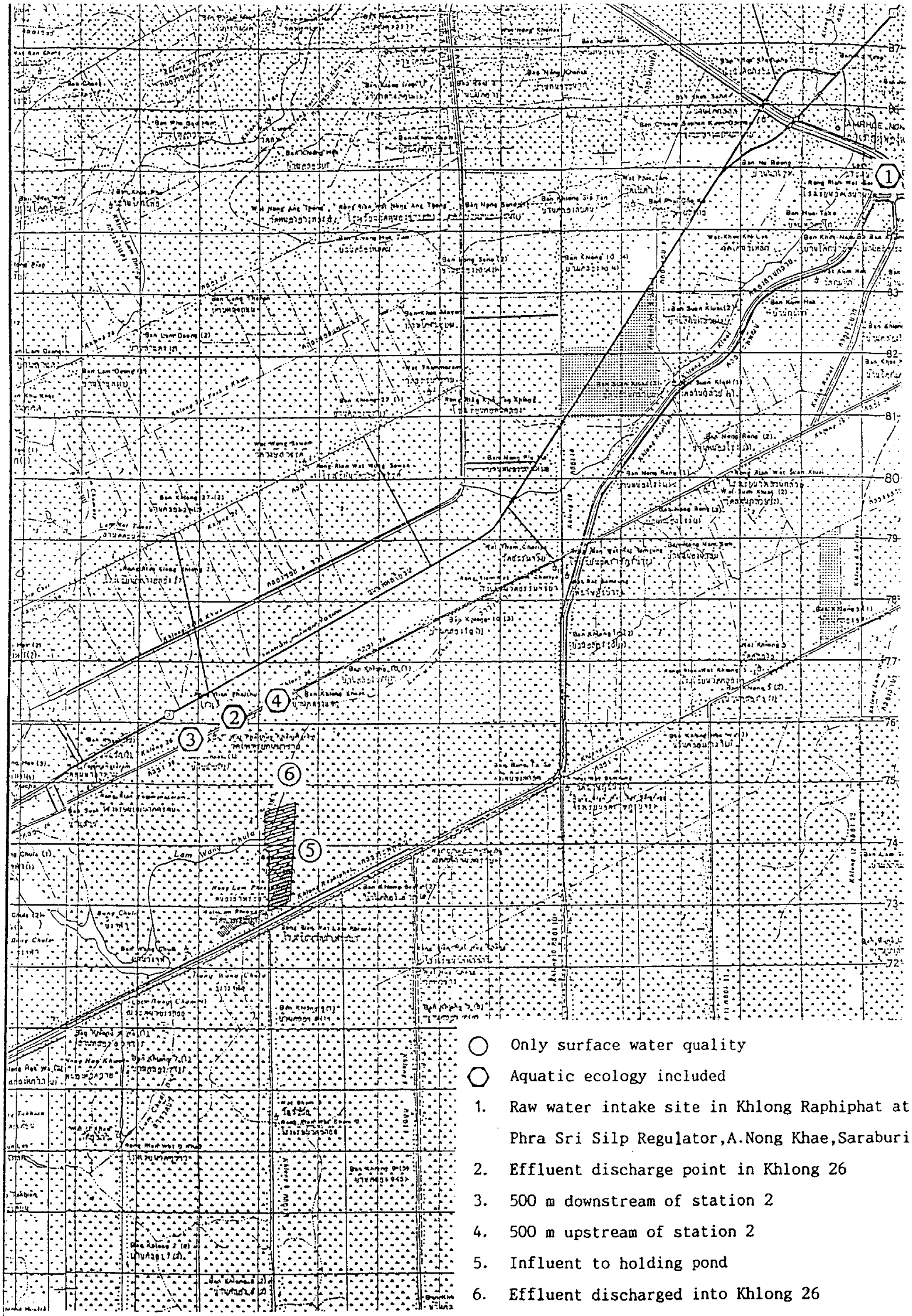


FIGURE 6-4 SURFACE WATER QUALITY,AQUATIC ECOLOGY AND WASTEWATER CHARACTERISTICS MONITORING STATIONS DURING OPERATION PERIOD

Frequency	:	Twice a year in October (rainy season) and in April (dry season).
Methodology	:	Follow NEB guideline for surface water quality survey and Standard Methods for the Examination of Water and Wastewater
Heavy metals	:	In dry season : Pb, Cr, Cu, Zn, Hg, Mn, Ni and Cd.
Pesticides	:	In rainy season

6.5 GROUNDWATER QUALITY

During Construction and Operation

Parameters	:	pH, Conductivity, Turbidity, Dissolved Solids, Suspended Solids, Alkalinity, Hardness, Calcium, Magnesium, Iron, Manganese, Chloride, Sulphate, and Nitrate.
Location	:	2 wells in the Power Plant site.
Frequency	:	Twice a year in October (rainy season) and in April (dry season)
Methodology	:	Follow Standard Methods for the Examination of Water and Wastewater.

6.6 AQUATIC ECOLOGY

During Construction

Parameters	:	Plankton and benthic organisms.
Location	:	5 stations as shown in Figure 6-3 for surface water quality study.
Frequency	:	Same period as surface water quality study.
Methodology	:	Standard methods

During Operation

Parameters	:	Plankton and benthic organisms.
Location	:	4 stations as shown in Figure 6-4 for surface water quality study.
Frequency	:	Same period as surface water quality study.
Methodology	:	Standard methods

6.7 SOCIO-ECONOMICS

In order to monitor social and economic conditions of villagers, the following monitoring programs must be taken into action.

Since socio-economic conditions of nearby villages seems to be significantly affected by project establishment, the following monitoring programs must be taken into action to investigate changes in social and economic conditions.

1. EGAT should assign personnel to participate as a committee member in local organization. This is to learn about problems, needs, and attitudes of villagers and, at the same time, to acknowledge villagers with informations about project activities to prevent possible conflicts.

2. The Public Relations Division of the Wang Noi Power Plant should provide a suggestion box or personnel for villagers to give their opinions about the Plant. This is to directly contact with the public.

3. EGAT should make a survey on changes in occupation, income and other socio-economic parameters of villagers by interviews every 2 year.

6.8 SOIL SUBSIDENCE

Parameter	:	ground level
Location	:	2 sites in the power plant site
Frequency	:	Once a year

6.9 FUEL

Continuous gas detectors with on-line alarming system should be installed to monitor leakage of natural gas pipeline.

APPENDIX A
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APPENDIX B

SOILS AND LAND QUALITY

1. Analytical Data of Ayuthaya Series

Soil samples were collected from paddy field in Amphoe, Bang Sai, Ayuttaya Province

SOIL TEXTURE OF AYUTTHAYA SERIES

Soil depth (m)	USDA GRADING (%)			USDA Textural Classification
	Sand	Silt	Clay	
0–20	3.0	30.0	67.0	Clay
20–50	4.5	26.0	69.5	Clay
50–90	4.0	33.5	68.5	Clay
90–145	17.5	17.0	65.5	Clay
145–200	4.0	31.0	65.0	Clay
200–250	1.5	31.0	67.5	Clay
250–300	1.5	35.0	63.5	Clay
300–350	1.5	33.5	65.0	Clay

MINERALS COMPOSITION OF AYUTTHAYA SERIES (ANALYSED BY X-RAY FLUORESENCE)

Soil Depth,m	0-20	20-40	40-60	60-80	80-100
H_2O %	16.8	26.5	35.1	44.2	54.5
pH	4.1	3.9	3.7	3.7	3.7
Ign.Loss @ 450°C %	7.6	6.4	5.6	6.1	5.8
avail.P,ppm	2.0				
act.Fe%	1.4	1.9	2.4	3.3	2.1
ext.Al,me/100g	2.8	6.8	7.6	8.1	9.7
ext.H,me/100g	15.8	13.5	12.7	15.0	15.8
ext.Ca,me/100g	13.8	8.7	8.6	7.1	7.8
ext.Mg,me/100g	4.5	3.0	3.0	2.6	3.3
ext.Na,me/100g	0.9	0.6	0.6	0.6	0.7
ext.K,me/100g	0.54	0.33	0.36	0.36	0.42
CEC by summation	38.2	32.9	33.0	33.2	36.1
% Base Satn.	51.5	38.3	38.4	31.8	33.8
% Al Satn.	12.4	35.0	37.7	43.3	44.2
tot.S-ext.(Ca+Mg),me/100g	-10.5	-3.9	-4.8	-0.3	-3.8
tot.Si%	28.7	29.2	28.5	27.9	29.4
tot.Al%	11.5	11.3	11.1	10.4	10.9
tot.Fe%	4.10	5.31	5.55	6.99	5.10
tot.Ti%	0.64	0.70	0.72	0.70	0.72
tot.S%	0.13	0.13	0.11	0.15	0.12
ext.S%	0.11	0.11	0.10	0.13	0.08
ext.S-ext.Ca,me/100g	-7.0	1.6	-2.2	1.0	-2.7
tot.Ca%	0.39	0.27	0.24	0.21	0.20
tot.Mg%	0.42	0.42	0.43	0.41	0.42
tot.Na%	0.15	0.15	0.18	0.16	0.17
tot.K%	1.38	1.54	1.62	1.53	1.51
tot.Mn,ppm	280	130	95	90	85
tot.P,ppm	220	175	160	170	170
tot.Cl,ppm	10	<10	<10	<10	<10
res.Fe%	2.05	1.95	1.91	2.13	2.21
res.S%	0.02	0.02	0.01	0.02	0.04

Remark

Ign. = Ignition
avail. = available
act. = active
ext. = extractable
tot. = total
res. = residual

2. Analytical Data of Chachoengsao Series

Soil Samples were collected from paddy field in Amphoe Bang Sai, Ayuthaya province

SOIL TEXTURE OF CHACHOENGSAO SERIES

Soil depth (m)	USDA GRADING (%)			USDA Textural Classification
	Sand	Silt	Clay	
0−20	0.1	35.5	63.9	Clay
20−40	1.3	28.2	70.5	Clay
40−70	2.7	39.9	57.4	Clay
70−120	6.5	45.4	48.1	Silty Clay
120−160	6.6	46.5	46.9	Silty Clay
160−260	6.2	57.6	36.2	Silty Clay

MINERALS COMPOSITION OF CHACHOENGSAO SERIES (ANALYSED BY X-RAY FLUORESENCE)

Soil Depth,m	0-20	20-40	40-60	60-80	80-100
H_2O %	55.6	40.2	40.8	48.1	61.0
pH	4.6	4.6	4.2	4.2	4.8
Ign.Loss @ 450°C %	5.3	3.6	3.3	4.1	4.4
avail.P,ppm	9.0				
act.Fe%	0.8	0.9	1.1	2.2	1.2
ext.Al,me/100g	<0.5	1.2	2.1	1.5	1.0
ext.H,me/100g	>10.0	8.3	8.5	8.8	8.7
ext.Ca,me/100g	10.7	7.2	4.8	4.8	5.3
ext.Mg,me/100g	7.7	9.6	11.6	14.3	17.7
ext.Na,me/100g	1.1	1.4	1.5	1.9	2.2
ext.K,me/100g	0.90	0.88	0.87	0.94	1.06
CEC by summation	30.8	28.6	29.5	32.1	36.0
% Base Satn.	66.0	66.7	64.1	68.0	73.2
% Al Satn.	<2.4	5.8	9.9	6.3	3.6
tot.S-ext.(Ca+Mg),me/100g	-15.2	-14.2	-13.6	-16.0	-20.8
tot.Si%	31.8	31.5	30.6	29.3	29.6
tot.Al%	9.8	10.4	10.6	10.3	10.3
tot.Fe%	3.05	3.15	3.96	5.69	4.79
tot.Ti%	0.64	0.65	0.64	0.61	0.62
tot.S%	0.05	0.04	0.05	0.05	0.04
ext.S%	0.04	0.04	0.05	0.05	0.04
ext.S-ext.Ca,me/100g	-8.2	-4.7	-1.9	-1.7	-3.1
tot.Ca%	0.31	0.21	0.16	0.16	0.16
tot.Mg%	0.50	0.56	0.62	0.69	0.74
tot.Na%	0.22	0.24	0.26	0.26	0.28
tot.K%	1.33	1.40	1.47	1.49	1.50
tot.Mn,ppm	205	165	140	145	170
tot.P,ppm	235	160	135	140	135
tot.Cl,ppm	85	120	140	180	190
res.Fe%	1.81	1.86	2.13	2.56	2.62
res.S%	0.01	-	-	-	-

Remark

Ign. = Ignition
avail. = available
act. = active
ext. = extractable
tot. = total
res. = residual

3. Analytical Data of Mahaphot Series

Soil Sample were collected from paddy field in Amphoe Bang Sai, Ayutthaya Province and analyzed as shown in Tables 3.7–5 and 3.7–6.

SOIL TEXTURE OF MAHAPHOT SERIES

Soil depth (m)	USDA GRADING (%)			USDA Textural Classification
	Sand	Silt	Clay	
0–20	3.0	39.0	58.0	Clay
20–40	4.0	35.0	61.0	Clay
40–80	8.0	39.0	53.0	Clay
80–140	5.0	33.0	62.0	Clay
140–190	2.0	29.0	69.0	Clay
190–220	1.0	32.0	67.0	Clay

MINERALS COMPOSITION OF MAHAPHOT SERIES (ANALYSED BY X-RAY FLUORESENCE)

Soil Depth,m	0-20	20-40	40-60	60-80	80-100
H_2O %	36.2	31.9	30.8	35.2	43.3
pH	4.4	4.0	3.8	3.6	3.5
Ign.Loss @ 450°C %	7.7	6.1	5.3	5.0	5.1
avail.P,ppm	10.0				
act.Fe%	0.7	0.7	1.3	2.4	1.7
ext.Al,me/100g	2.9	8.9	10.0	12.2	13.6
ext.H,me/100g	13.2	11.7	11.6	10.8	9.4
ext.Ca,me/100g	5.0	2.2	1.5	1.8	1.9
ext.Mg,me/100g	2.5	2.4	3.1	3.9	4.4
ext.Na,me/100g	0.9	1.0	1.1	1.3	1.3
ext.K,me/100g	0.31	0.25	0.27	0.33	0.37
CEC by summation	24.8	26.4	27.6	30.3	31.0
% Base Satn.	35.0	22.2	21.7	24.1	25.8
% Al Satn.	25.1	60.3	62.5	62.7	63.0
tot.S-ext.(Ca+Mg),me/100g	-3.0	-0.9	-1.2	-0.5	6.2
tot.Si%	31.9	31.2	30.7	29.6	29.4
tot.Al%	10.3	11.0	10.8	10.9	11.4
tot.Fe%	2.50	2.79	3.85	5.38	4.34
tot.Ti%	0.63	0.63	0.65	0.69	0.71
tot.S%	0.07	0.06	0.06	0.08	0.20
ext.S%	0.04	0.05	0.05	0.08	0.20
ext.S-ext.Ca,me/100g	-2.7	0.8	1.9	3.4	10.5
tot.Ca%	0.18	0.09	0.07	0.08	0.08
tot.Mg%	0.41	0.45	0.45	0.45	0.47
tot.Na%	0.18	0.17	0.16	0.17	0.18
tot.K%	1.18	1.33	1.34	1.38	1.48
tot.Mn,ppm	150	110	85	80	85
tot.P,ppm	310	235	225	210	155
tot.Cl,ppm	65	10	<10	<10	10
res.Fe%	1.41	1.57	1.64	1.90	2.09
res.S%	0.03	0.01	0.01	-	-

Remark

Ign. = Ignition
avail. = available
act. = active
ext. = extractable
tot. = total
res. = residual
Satn. = saturation

Analytical Data of Ongkarak Series

Soil Sample were collected from paddy field in Amphoe Bang Sai, Ayuttaya Province

SOIL TEXTURE OF ONGKARAK SERIES

Soil depth (m)	USDA GRADING (%)			USDA Textural Classification
	Sand	Silt	Clay	
0–20	1.2	43.3	55.5	Silty Clay
20–40	4.3	33.0	62.7	Clay
40–80	3.1	29.4	67.5	Clay
80–120	2.5	27.3	70.2	Clay
120–160	1.5	23.8	74.6	Clay
160–200	1.4	28.4	70.2	Clay
200–300	1.1	26.5	72.4	Clay

MINERALS COMPOSITION OF ONGKARAK SERIES
(ANALYSED BY X-RAY FLUORESENCE)

Soil Depth,m	0-20	20-40	40-60	60-80	80-100
H_2O %	33.7	45.1	55.7	64.0	71.6
pH	4.2	3.8	3.6	3.3	3.4
Ign.Loss @ 450°C %	9.3	8.8	6.9	6.2	5.6
avail.P,ppm	7.0	–	–	–	–
act.Fe%	0.8	0.5	1.8	3.4	1.9
ext.Al,me/100g	3.1	11.5	13.5	11.7	10.7
ext.H,me/100g	15.0	9.5	8.2	11.9	11.3
ext.Ca,me/100g	10.2	5.5	4.7	4.7	4.9
ext.Mg,me/100g	5.9	4.1	4.3	4.7	5.3
ext.Na,me/100g	3.3	2.4	2.0	2.3	2.4
ext.K,me/100g	1.33	0.88	0.66	0.60	0.66
CEC by summation	38.8	33.9	33.4	35.9	35.3
% Base Satn.	53.5	38.1	35.0	34.2	37.6
% Al Satn.	13.1	47.1	55.2	48.9	44.6
tot.S–ext.(Ca+Mg),me/100g	–4.5	0	–2.3	4.1	–0.9
tot.Si%	28.8	28.9	29.1	26.8	27.7
tot.Al%	10.9	11.4	10.7	8.9	10.0
tot.Fe%	3.33	2.90	4.83	10.21	7.05
tot.Ti%	0.61	0.63	0.67	0.63	0.66
tot.S%	0.19	0.15	0.11	0.22	0.15
ext.S%	0.13	0.10	0.09	0.20	0.13
ext.S–ext.Ca,me/100g	–2.4	1.0	0.7	7.7	1.8
tot.Ca%	0.32	0.17	0.13	0.12	0.14
tot.Mg%	0.51	0.48	0.52	0.46	0.53
tot.Na%	0.16	0.17	0.19	0.18	0.18
tot.K%	1.24	1.26	1.44	1.47	1.52
tot.Mn,ppm	230	140	105	105	105
tot.P,ppm	350	270	165	160	125
tot.Cl,ppm	90	75	75	100	70
res.Fe%	1.92	2.03	2.11	2.13	2.20
res.S%	0.06	0.05	0.02	0.02	0.02

Remark
Ign. = Ignition
avail. = available
act. = active
ext. = extractable
tot. = total
res. = residual
Satn. = saturation

Analytical Data of Rangsit Series

Soil Sample were collected from paddy field in Amphoe Bang Sai, Ayuttaya Province

SOIL TEXTURE OF RANGSIT SERIES

Soil depth (m)	USDA GRADING (%)			USDA Textural Classification
	Sand	Silt	Clay	
0–20	1.5	26.2	72.3	Clay
20–50	0.6	27.4	72.0	Clay
50–80	1.2	28.5	70.3	Clay
80–110	3.2	27.6	69.2	Clay
110–160	3.1	24.8	72.1	Clay
160–200	1.3	28.0	76.7	Clay
200–350	2.2	30.4	67.4	Clay

MINERALS COMPOSITION OF RANGSIT SERIES (ANALYSED BY X-RAY FLUORESENCE)

Soil Depth,m	0-20	20-40	40-60	60-80	80-100
H_2O %	39.9	36.6	38.9	47.8	57.1
pH	4.2	4.0	3.5	3.4	3.3
Ign.Loss @ 450°C %	10.2	7.0	6.9	6.0	5.5
avail.P,ppm	19.0				
act.Fe%	0.4	0.8	4.1	3.7	3.3
ext.Al,me/100g	4.5	9.4	10.9	9.8	10.6
ext.H,me/100g	11.5	5.4	5.7	7.3	5.5
ext.Ca,me/100g	6.1	4.2	4.0	3.8	3.7
ext.Mg,me/100g	3.3	2.5	2.5	2.7	2.8
ext.Na,me/100g	1.1	0.6	0.6	0.7	0.7
ext.K,me/100g	0.90	0.50	0.47	0.54	0.53
CEC by summation	27.4	22.7	24.1	24.8	23.7
% Base Satn.	41.4	34.6	31.2	31.0	32.5
% Al Satn.	28.4	54.5	59.1	56.0	57.8
tot.S-ext.(Ca+Mg),me/100g	49.0	17.2	51.2	29.4	29.2
tot.Si%	28.3	29.5	25.1	27.0	27.4
tot.Al%	11.0	10.6	7.8	8.8	9.2
tot.Fe%	2.17	2.92	12.55	8.93	7.93
tot.Ti%	0.50	0.62	0.61	0.66	0.65
tot.S%	0.94	0.38	0.92	0.57	0.57
ext.S%	0.45	0.27	0.89	0.55	0.55
ext.S-ext.Ca,me/100g	21.7	12.3	51.5	30.7	30.7
tot.Ca%	0.23	0.15	0.13	0.13	0.12
tot.Mg%	0.33	0.40	0.33	0.38	0.38
tot.Na%	0.26	0.20	0.16	0.15	0.17
tot.K%	1.08	1.19	1.59	1.57	1.61
tot.Mn,ppm	195	115	70	75	75
tot.P,ppm	480	230	140	135	110
tot.Cl,ppm	162	85	35	40	70
res.Fe%	1.53	1.68	1.71	1.96	1.95
res.S%	0.49	0.11	0.03	0.02	0.02

Remark

Ign. = Ignition
avail. = available
act. = active
ext. = extractable
tot. = total
res. = residual
Satn. = saturation

Analythical Data of Sena Series

Soil samples were collected from paddy field in Amphoe Bang Sai, Autthaya Province and analyzed as shown in tables 3.7–11 and 3.7–12

SOIL TEXTURE OF SENA SERIES

Soil depth (m)	USDA GRADING (%)			USDA Textural Classification
	Sand	Silt	Clay	
0–20	11.9	39.7	48.4	Clay
20–40	11.3	38.7	50.0	Clay
40–80	5.9	33.0	61.1	Clay
80–110	1.8	29.0	69.2	Clay
110–150	4.4	32.4	63.2	Clay
150–200	0.2	34.1	65.7	Clay
200–240	1.6	38.5	59.9	Clay
240–330	1.8	40.0	58.2	Clay

APPENDIX C

TRANSPORTATION

TABLE C-1

Annual Average Daily Traffic Volumes of the Important Routes of Wang Noi Power Plant Project In 1988

Route No.	Control Section	Terminal	Station Km.	Average Daily Traffic by Type							% Heavy-Vehicle	Bi & Tri Cycles	Motor Cycles	Area Code
				Car & Taxi	Light Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Total				
1	0100	Km. 16 + 441 – Rang Sit	19+100	25476	583	2894	5740	1572	1517	37782	15.8	330	8368	411
1	0100	Km. 16 + 441 – Rang Sit	24+685	13468	2355	3111	3124	2179	2480	26717	29.08	628	6589	411
1	0201	Rangsit – Bang Pa–In	35+000	16523	5573	6971	7139	6738	10875	53819	45.67	178	3886	416
1	0202	Bang Pa–In – Jct Wang Noi	48+100	1322	3004	4199	4564	3076	12077	40141	48.2	263	2453	413
1	0301	Bang Pa–In – Jct Wang Noi	60+800	6100	1030	1482	1294	1174	9718	20798	59.5	117	652	413
1	0302	Jct Wang Noi – Km. 80 + 000	67+900	6250	2967	3015	3037	3787	11616	30672	60.04	793	1787	432
1	0400	Km. 80 + 000 (Ayutthaya) – Saraburi	102+000	13119	853	1683	2619	3627	8648	30549	45.69	189	3129	432
32	0401	Jct R. No. 1 – Jct. Ayutthaya	55+850	5657	709	1466	2051	938	2693	13514	37.7	7	782	413
32	0500	Jct R. No. 309 – Jct. Ang Thong	96+800	3266	226	997	1740	1008	2286	9523	45.05	81	615	413
308	0100	Jct R. No. 32 – Bang Pa–In	1+609	1040	691	302	649	342	1049	4073	41.56	157	891	413
309	0100	Jct. Wang Noi – Ayutthaya	10+337	397	241	194	343	134	88	1397	29.77	3	445	413
309	0100	Jct. Wang Noi – Ayutthaya	18+000	2309	723	721	1177	448	597	5975	29.55	170	2383	413
3309	0200	Bang Sai – Sinlapachip Phiset	7+000	227	155	113	162	104	493	1254	56.61	125	196	413
3309	0300	Jct No. 308 – Tha Nam Bang Sai	3+000	305	110	152	281	116	524	1488	53.22	61	210	413

Source Department of Highway

TABLE C-2

Annual Average Daily Traffic Volumes of the Important Routes of Wang Noi Power Plant Project In 1989

Route No.	Control Section	Terminal	Station Km.	Average Daily Traffic by Type							% Heavy-Vehicle	Bi & Tri Cycles	Motor Cycles	Area Code
				Car & Taxi	Light Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Total				
1	0100	Km. 16 + 441 – Rang Sit	19+100	24521	790	2992	8117	2356	2438	41214	18.89	384	8226	411
1	0100	Km. 16 + 441 – Rang Sit	24+685	12987	1521	3063	3472	2277	3604	26924	33.22	760	5275	411
1	0201	Rangsit – Bang Pa–In	35+000	17382	5936	5924	6203	7751	3104	46300	36.24	442	5158	416
1	0202	Bang Pa–In – Jct Wang Noi	48+100	16110	4427	5128	6345	4228	16743	52981	49.26	172	3303	413
1	0202	Bang Pa–In – Jct Wang Noi	60+800	6448	1771	2029	2723	2258	12950	28179	61.17	434	1203	413
1	0301	Jct Wang Noi – Km. 80 + 000 (Saraburi)	67+900	7006	2742	2659	2877	3050	12387	30721	58.9	1070	2336	413
1	0302	Km. 80 + 000 (Ayutthaya) – Saraburi	102+000	13049	2343	2931	4119	8373	8588	39403	50.5	158	4096	432
32	0401	Jct R. No. 1 – Jct. Ayutthaya	55+850	6654	638	1789	1757	1148	2822	14806	38.8	24	1226	413
32	0500	Jct R. No. 309 – Jct. Ang Thong	96+800	3107	440	1332	3079	1118	2810	11886	44.25	92	1058	413
308	0100	Jct R. No. 32 – Bang Pa–In	1+609	1961	212	480	1065	569	1462	5749	43.7	180	132	413
309	0100	Jct. Wang Noi – Ayutthaya	10+337	429	209	200	447	205	133	1623	33.15	0	469	413
309	0100	Jct. Wang Noi – Ayutthaya	18+000	3639	956	1052	1726	533	747	8653	26.9	287	3565	413
3309	0200	Bang Sai – Sinlapachip Phiset	7+000	525	77	106	186	704	111	1598	57.6	745	906	413
3309	0300	Jct No. 308 – Tha Nam Bang Sai	3+000	429	461	164	377	860	212	2503	49.4	432	1645	413

Source : Department of Highway

TABLE C-3

Annual Average Daily Traffic Volumes of the Important Routes of Wang Noi Power Plant Project In 1990

Route No.	Control Section	Terminal	Station Km.	Average Daily Traffic by Type: Car & Taxi	Light Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Total	% Heavy-Vehicle	Bi & Tri Cycles	Motor Cycles	Area Code
1	0100	Km. 16 + 441 – Rang Sit	19+100	26048	1013	3382	6278	2815	3080	42616	21.7	161	4093	411
1	0100	Km. 16 + 441 – Rang Sit	24+685	17400	1825	2602	3585	2774	3080	31224	26.9	267	2696	411
1	0201	Rangsit – Bang Pa-In	35+000	17824	3962	5439	5639	8034	3178	44076	37.8	217	2376	416
1	0202	Bang Pa-In – Jct Wang Noi	48+100	14886	4572	4780	7200	5009	16112	52559	49.3	62	1242	413
1	0301	Bang Pa-In – Jct Wang Noi	60+800	7899	2030	2043	2540	2126	14301	30939	59.7	38	394	413
1	0302	Jct Wang Noi – Km. 80 + 000	67+900	7648	2669	2741	2995	3732	12083	31868	58.2	219	1059	432
1	0400	Km. 80 + 000 (Ayutthaya) – Saraburi	102+000	9383	504	1801	3141	2700	7980	25509	48.9	49	1271	432
32	0401	Jct R. No. 1 – Km. 80 + 000	55+850	8265	193	1826	1085	2162	903	14434	33.8	2	519	413
32	0500	Jct R. No. 309 – Ang Thong	96+800	3296	451	1588	2893	1395	2155	11778	43.6	44	672	413
308	0100	Jct R. No. 32 – Bang Pa-In	1+609	943	331	188	725	243	1445	3875	48.4	40	344	413
309	0100	Jct. Wang Noi – Ayutthaya	10+337	509	111	191	737	192	361	2101	35.4	200	1130	413
309	0100	Jct. Wang Noi – Ayutthaya	18+000	3791	441	689	2039	390	583	7933	20.95	51	1978	413
3309	0200	Bang Sai – Sinlapachip Phiset	7+000	366	255	149	267	184	477	1698	47.7	96	199	413
3309	0300	Jct No. 308 – Tha Nam Bang Sai	3+000	410	231	279	314	204	591	2029	52.9	24	249	413

Source Department of Highway

TABLE C–4

Annual Average Daily Traffic Volumes of the Important Routes of Wang Noi Power Plant Project

In 1991

Route No.	Control Section	Terminal	Station Km.	Average Daily Traffic by Type: Car & Taxi	Light Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Total	% Heavy–Vehicle	Bi & Tri Cycles	Motor Cycles	Area Code
1	0100	Km. 16 + 441 – Rang Sit	19+100	47462	1115	4173	7632	3975	2720	67077	16.20	174	4677	411
1	0100	Km. 16 + 441 – Rang Sit	24+685	17089	1229	2638	2557	3008	1540	28061	25.6	93	3251	411
1	0201	Rangsit – Bang Pa–In	35+000	14219	4270	4527	3717	8310	1471	36514	39.18	232	2155	416
1	0202	Bang Pa–In – Jct Wang Noi	48+100	22374	4860	7563	9750	6971	21283	72801	49.2	87	1607	413
1	0202	Bang Pa–In – Jct Wang Noi	60+800	10837	2655	2442	3935	3026	18794	41689	58.20	49	735	413
1	0301	Jct Wang Noi – Km. 80 + 000	67+900	9733	3176	3294	3304	3626	18376	41509	60.94	234	1442	413
1	0302	Km. 80 + 000 (Ayutthaya) – Saraburi	102+000	10289	269	2374	4717	5676	12898	36223	57.83	53	2102	432
32	0401	Jct R. No. 1 – Km. 80 + 100	55+850	10231	277	2080	2371	2222	1864	19045	32.38	3	710	413
32	0500	Jct R. No. 309 – Ang Thong	96+800	4024	946	1718	3948	1760	3354	15750	43.38	72	774	413
308	0100	Jct R. No. 32 – Bang Pa–In	1+609	3742	193	427	310	1184	1338	7194	40.99	40	737	413
309	0101	Jct. Wang Noi – Ayutthaya	10+337	769	339	187	651	302	668	2916	39.68	0	443	413
309	0101	Jct. Wang Noi – Ayutthaya	18+000	8691	588	1099	1944	760	1379	14461	22.39	57	3644	413
3309	0200	Bang Sai – Sinlapachip Phiset	7+000	854	42	171	513	368	1109	3057	53.91	71	359	413
3309	0300	Jct No. 308 – Tha Nam Bang Sai	3+000	1260	646	204	478	1214	1138	4940	51.74	51	425	413

Source : Department of Highway

TABLE C-5

Annual Average Daily Traffic Volumes of the Important Routes of Wang Noi Power Plant Project

In 1992

Route No.	Control Section	Terminal	Station Km.	Average Daily Traffic by Type							%	Bi & Tri	Motor	Area
				Car & Taxi	Light Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Total	Heavy-Vehicle	Cycles	Cycles	Code
1	0100	Km. 16 + 441 – Rang Sit	24+685	24438	800	3271	9347	1189	1368	40413	14.42	130	4360	411
1	0201	Rangsit – Bang Pa–In	35+550	15652	4282	5375	4977	6309	5367	41962	40.63	612	3372	416
1	0202	Bang Pa–In – Jct Wang Noi	48+100	12296	3658	3592	9454	4120	9353	42473	40.17	15	2577	413
1	0202	Bang Pa–In – Jct Wang Noi	51+100	14119	8923	3506	7743	4426	9020	47737	35.51	67	2477	413
1	0301	Jct Wang Noi – Km. 80 + 000 (Saraburi)	67+300	4415	173	1759	12277	2550	10049	31223	45.98	27	1205	413
1	0301	Jct Wang Noi – Km. 80 + 000 (Saraburi)	71+500	11326	1171	2445	8581	3155	14753	41431	49.12	39	964	413
1	0302	Rangsit – Saraburi	84+000	7980	179	1763	7911	2283	9670	29786	46.04	55	1201	432
1	0302	Km. 80 + 000 (Ayutthaya) – Saraburi	88+000	12143	428	1640	1958	2179	8057	26405	44.97	144	1931	432
32	0401	Jct. R. No. 1 (Bang Pa–In) – Jct. Ayutthaya Km. 68 + 000	53+293	5769	1268	1983	5012	1242	2594	17868	32.56	15	1685	413
32	0500	Jct R. No. 309 (Jct. Ayutthaya) – Jct. To Ang Thong	96+800	4046	419	1297	4980	1305	2913	14960	36.86	18	696	413
308	0100	Jct R. No. 32 – Bang Pa–In	1+609	3737	978	974	1720	1398	2148	10955	41.25	119	1602	413
309	0101	Jct. Wang Noi – Ayutthaya	10+337	2224	123	277	1748	327	1937	6096	32.82	0	919	413
309	0103	Jct. Wang Noi – Ayutthaya	21+450	5626	3891	3730	4361	3119	1783	22510	38.34	183	2587	413
3309	0200	Bang Sai – Sinlapachip Phiset	7+000	2051	156	180	407	427	1728	4949	47.18	194	571	413
3309	0300	Jct No. 308 – Tha Nam Bang Sai	3+000	2495	1648	627	633	2081	1263	8747	45.39	13	1286	413

Source Department of Highway

APPENDIX D

SOCIO-ECONOMICS

แบบสอบถามชุดที่ __________ ชื่อผู้สัมภาษณ์ ____________________

แบบสัมภาษณ์หัวหน้าครัวเรือน

ชื่อผู้ให้สัมภาษณ์ ____

บ้านเลขที่ __________ หมู่ที่ __________ ตำบล ________________ อำเภอ วังน้อย

จังหวัด พระนครศรีอยุธยา

วันสัมภาษณ์ ____________________________

,___ สัมภาษณ์เสร็จ

,___ สัมภาษณ์ไม่เสร็จ

,___ สัมภาษณ์ใหม่ วันที่ ______________________ เวลา ______________

1. **สภาพเศรษฐกิจของครัวเรือน**

รายได้รวมของครัวเรือนในรอบปี 2536

1.1 รายได้ของครัวเรือนในคาบปี 2536 รวม ______________ บาท

โดยแบ่งตามแหล่งรายได้

(1) การเพาะปลูก ____________________________ บาท

(2) การเลี้ยงสัตว์ ____________________________ บาท

(3) การประกอบอุตสาหกรรม ______________________ บาท

(4) การรับจ้างภาคเอกชน ________________________ บาท

(5) การรับราชการ/ลูกจ้าง ______________________ บาท

(6) อื่น ๆ __________________________________ บาท

รายได้ที่มีอยู่พอเพียงมากน้อยเพียงไร?

,___ เหลือ

,___ พอดี

,___ ไม่พอ

ในปีใหม่นี้ครัวเรือนของท่านจะมีรายจ่ายเพิ่มขึ้นหรือไม่

,___ เพิ่มขึ้น เพราะ ______________________________

,___ ไม่เพิ่ม

,___ ลดลง เพราะ ______________________________

ท่านมีลู่ทางที่จะทำให้รายจ่ายครัวเรือนลดลงหรือไม่

,___ มี อย่างไร (ระบุ) ______________________________

, ______________________________

,___ ไม่มี

การมีโรงไฟฟ้าจะทำให้รายจ่ายของครัวเรือนของท่านเพิ่มขึ้นหรือไม่

,___ เพิ่มขึ้น เพราะ ______________________________

,___ ไม่เพิ่ม

,___ ลดลง เพราะ ______________________________

1.3 <u>หนี้สิน</u>

ขณะนี้ครัวเรือนมีหนี้สินทั้งหมด ______________ บาท

จากแหล่งใดบ้าง

,___ ธนาคารเพื่อการเกษตร ______________ บาท

,___ ธนาคารอื่น ๆ ______________ บาท

,___ สถาบันการเงินซึ่งไม่ใช่ธนาคาร ______________ บาท

,___ กองทุนเงินกู้ ______________ บาท

,___ เพื่อนฝูง ญาติพี่น้อง ______________ บาท

,___ อื่น ๆ ______________ บาท

ปีต่อไปครัวเรือนของท่านจะมีสภาพหนี้สินอย่างไร

,___ เพิ่มขึ้น

,___ ไม่เพิ่มขึ้น

,___ ลดลง

ท่านมีลู่ทางจะลดหนี้สินหรือไม่

,___ มี อย่างไร (ระบุ) ______________________________

,___ ไม่มี

การมีโรงไฟฟ้าจะช่วยให้หนี้สินของท่านลดลงหรือไม่

,___ ช่วยให้หนี้สินลดลง อย่างไร (ระบุ) ______________________

,___ ไม่ตอบ

1.4 <u>การออม</u>

ขณะนี้ครัวเรือนของท่านมีเงินออมทั้งหมด ____________ บาท

โดยแบ่งเป็น

(1) เงินฝากธนาคารหรือสถาบันทางการเงิน __________ บาท

(2) เก็บไว้กับบ้าน __________ บาท

(3) อื่น ๆ ______________________ __________ บาท

ท่านคิดที่จะใช้เงินออมทำอะไรบ้าง ?

,___ เป็นค่าใช้จ่ายครอบครัวต่อไป

,___ ส่งเสียลูกเรียนในระดับสูงต่อไป

,___ ลงทุนทำการค้า

,___ ลงทุนผลิตสินค้าอุตสาหกรรม

,___ เก็บไว้เฉพาะ

,___ อื่น ๆ (ระบุ) ______________________________

ท่านมีความคิดที่จะเก็บออมเพิ่มขึ้นหรือไม่ ?

,___ มี

,___ ไม่มี เพราะอะไร (ระบุ) ______________________________

1.5 **<u>ทรัพย์สินของครัวเรือน</u>**

ครัวเรือนนี้มีทรัพย์สิน (ตีค่าเป็นเงิน) รวมทั้งสิ้น ________________ บาท โดยแบ่งเป็น

,___ เงินสด ______________ บาท

,___ บ้านและที่ดิน ______________ บาท

,___ เครื่องจักรกลและเครื่องมือประกอบอาชีพ (รวมยานพาหนะ) ______________ บาท

,___ สินค้าและผลผลิตการเกษตร ________________ บาท

,___ เงินให้ผู้อื่นกู้ยืม ___________________ บาท

,___ อื่น ๆ _______________ บาท

1.6 **<u>ปัญหาทางเศรษฐกิจและข้อเสนอแนะ</u>**

ท่านมีปัญหาเกี่ยวกับการทำมาหากินอะไรบ้าง ?

(1) ____

(2) ____

(3) ____

(4) ____

(5) ____

ท่านคิดจะแก้ไขหรือเสนอให้มีการแก้ไขอย่างไร ?

(1) ____

(2) ____

(3) ____

(4) ____

(5) ____

2. **<u>สภาพสังคมของครัวเรือน</u>**

2.1 ครัวเรือนของท่านอยู่ในชุมชนนี้มาแต่เดิมหรือไม่ ?

,___ อยู่มาแต่เดิม

,___ ย้ายมาใหม่ ย้ายมาจากไหน (ระบุ) ______________________________

2.2 ก่อนแต่งงาน พ่อบ้าน (สามี) มาจากไหน ?

,___ คนในชุมชนนี้

,___ มาจากที่อื่น จากที่ไหน (ระบุ) ______________________________

2.3 ก่อนแต่งงาน แม่บ้าน (ภรรยา) มาจากไหน ?

,___ คนในชุมชนนี้

,___ มาจากที่อื่น จากที่ไหน (ระบุ) ______________________________

2.4 ท่านคิดจะย้ายครอบครัวไปที่อื่นหรือไม่ ?

,___ คิดจะย้าย ไปที่ใด ? (ระบุ) ______________________________

เพราะเหตุใด (ระบุ) ______________________________

,___ ไม่ย้าย

2.5 ท่านหรือบุคคลในครัวเรือนเป็นสมาชิกของกลุ่มที่จัดตั้งขึ้น ณ ชุมชนบ้างหรือไม่ ?

,___ เป็น กลุ่มใด ? และตำแหน่งอะไร ?

กลุ่ม (1) ____________________ ตำแหน่ง (1) ______________

(2) ____________________ ตำแหน่ง (2) ______________

(3) ____________________ ตำแหน่ง (3) ______________

(4) ____________________ ตำแหน่ง (4) ______________

(5) ____________________ ตำแหน่ง (5) ______________

,___ ไม่เป็น เพราะเหตุใด (ระบุ) ______________________________

2.6 ท่านหรือบุคคลในครอบครัวของท่านเข้าร่วมงานที่จัดขึ้นในหมู่บ้านหรือละแวกใกล้เคียงมากน้อยเพียงไร ?

,___ แทบทุกงาน

,___ บางงาน

,___ ไม่ค่อยได้เข้าร่วม

,___ ไม่เข้าร่วมเลย เพราะ (ระบุ) ______________________________

2.7 ท่านอ่านหนังสือพิมพ์เป็นประจำหรือไม่ ?

,___ ทุกวัน

,___ แทบทุกวัน

,___ บางครั้ง

,___ ไม่ค่อยได้อ่าน

,___ ไม่อ่านเลย เพราะ (ระบุ) ______________________________

ในกรณีที่ไม่มีเครื่องรับโทรทัศท์, ท่านดูโทรทัศน์บ่อยหรือไม่ ?

,___ ดู ที่ไหน ? (ระบุ) ______________________________

,___ ไม่ดู

2.9 ท่านรับฟังข่าววิทยุเป็นประจำหรือไม่ ?

,___ เป็นประจำ

,___ บางครั้ง

,___ นาน ๆ ครั้ง

,___ ไม่ได้ฟังข่าวเลย

2.10 ท่านคิดว่าโรงไฟฟ้าที่จะตั้งขึ้นจะมีประโยชน์ต่อสังคม ศาสนา และวัฒนธรรมของชุมชนบ้างหรือไม่

,___ มี อย่างไร (ระบุ) ______________________________

,___ ไม่มี

2.11 ท่านคิดว่าโรงไฟฟ้าที่จะตั้งขึ้นจะให้โทษทางสังคม ศาสนา และวัฒนธรรมบ้างหรือไม่ ?

,___ มี อย่างไร (ระบุ) ______________________________

,___ ไม่มี

3. <u>สภาพสิ่งแวดล้อม</u>

3.1 ท่านคิดว่า ท่านทราบเรื่องการตั้งโรงไฟฟ้ามากน้อยเพียงไร ?

,___ ดี

,___ ปานกลาง

,___ น้อย

,___ น้อยมาก

3.2 ท่านทราบเรื่องการตั้งโรงไฟฟ้าจากไหน (ระบุ) ______________________

,____

3.3 ท่านคิดว่าโรงไฟฟ้าจะทำให้เกิดฝุ่นละอองรบกวนชาวบ้านหรือไม่ ?

,___ เกิด ท่านเสนอให้มีการแก้ไขอย่างไร (ระบุ) ______________________

,____

,___ ไม่เกิด

3.4 ท่านคิดว่าโรงไฟฟ้าจะทำให้เกิดเสียงรบกวนชาวบ้านหรือไม่ ?

,___ เกิด ท่านเสนอให้มีการแก้ไขอย่างไร (ระบุ) ______________________

,____

,___ ไม่เกิด

3.5 ท่านคิดว่าโรงไฟฟ้าจะทำให้เกิดน้ำเสียกระทบต่อสภาพแวดล้อมและการเกษตรหรือไม่ ?

,___ เกิด ท่านเสนอให้มีการแก้ไขอย่างไร (ระบุ) ______________________

,____

,___ ไม่เกิด

3.6 ท่านคิดว่าโรงไฟฟ้าจะช่วยให้ชาวบ้านมีงานทำเพิ่มขึ้นหรือไม่ ?

,___ เพิ่มขึ้น ครอบครัวของท่านมีคนที่จะทำงานกับโรงไฟฟ้าหรือไม่

 ,___ มี งานประเภทไหน ? (ระบุ) ______________________

 ,___ ไม่มี

,___ ไม่เพิ่ม

3.7 การมีโรงไฟฟ้าทำให้ชุมชนเจริญขึ้นหรือไม่ ?

,___ เจริญขึ้น เพราะเหตุใด (ระบุ) ______________________

,___ ไม่เจริญขึ้น

,___ กลับเสื่อมลง เพราะเหตุใด (ระบุ) ______________________

3.8 โรงไฟฟ้าจะทำลายสิ่งแวดล้อมหรือไม่ ?

,___ ทำลาย อย่างไร (ระบุ) ______________________

 ,____

,___ ไม่ทำลาย

3.9 การตั้งโรงไฟฟ้าช่วยให้เศรษฐกิจของชุมชนดีขึ้นหรือไม่ ?

,___ ช่วยให้ดีขึ้น เพราะเหตุใด (ระบุ) ______________________________

,___ ไม่ช่วย

,___ กลับทำให้เศรษฐกิจแย่ลง เพราะเหตุใด (ระบุ) ______________________

,____

3.10 พิจารณาโดยรวมแล้ว การตั้งโรงไฟฟ้าจะเป็นผลดีมากกว่าผลเสียหรือผลเสียมากกว่าผลดี ?

,___ ผลดีมากกว่าผลเสีย

,___ ผลดีพอ ๆ กับผลเสีย

,___ ผลเสียมากกว่าผลดี

กรณีที่ผลเสียเท่าหรือมากกว่าผลดี ควรจะทำอย่างไรจึงจะทำให้ผลดีมากขึ้น (ระบุ) _____

,____

,____

APPENDIX E

PUBLIC HEALTH

TABLE E-1
LIVEBIRTH, DEATH, AND NATURAL INCREASE RATES AYUTTHAYA IN 1990, 1992 AND 1993

Year	Livebirth		Death		Natural increase
	Number	Rate per 1,000	Number	Rate per 1,000	%
1990	6,535	9.79	3,120	4.67	0.51
1992	7,569	11.02	3,638	5.30	0.57
1993	7,853	10.30	4,081	5.35	0.49

Source of Data: Provincial Health Office, Ayutthaya

TABLE E-2

LIST 10 LEADING CAUSE GROUPS OF DEATH BY RATE PER 100,000 POPULATION ACCORDING TO ICD BASIC TABULATION LIST, 9th Revision 1987-1991

Cause Group	(1987)		(1988)		(1989)		(1990)		(1991)	
	Order	Rate	Order	Rate	Order	Rate	Order	Rate	Order	Rate
Diseases of pumonay circulation and other forms of heart disease	1	40.3	1	42.1	1	47.3	1	49.6	1	52.5
Other accidents, including late effect	4	16.4	3	18.7	2	21.4	2	25.3	2	25.8
Malignant neoplasm of other and unspecificed sites	3	17.8	3	18.7	3	20.1	3	22.0	3	21.9
Diseases of the digestive system other than oral cavity, salivary grands and jaws.	2	19.8	2	18.8	4	19.0	4	18.4	4	18.5
Transport accident	10	8.6	6	10.4	6	12.4	5	15.2	5	18.3
Diseases of the respiratory system other than the upper respiratory tract	5	12.6	5	12.6	5	13.7	6	13.0	6	13.9
Cerebrovascular disease	9	9.5	9	9.6	7	10.4	7	10.5	7	11.1
Malignant neoplams of digestive organas and peritoneum	-	7.1	-	8.0	10	9.2	9	9.7	8	10.7
Diseases of nervous system	6	10.4	8	9.9	8	10.0	8	10.0	9	10.3
Disease of urinary system	-	7.3	-	7.1	-	7.8	-	8.2	10	8.7
Tuberculosis	7	10.2	10	8.2	-	7.6	-	7	-	6.5
Homicide and injury purposely inflicted by other persons	8	9.8	7	10.0	9	9.4	10	8.5	-	8.2

Reference: Public Health Statistics, 1991, Health Statistics Division, Office of the Permanent Secretary Ministry of Public Health

TABLE E–3
FIRST 10 LEADING CAUSES OF DEATH IN AYUTTHAYA
(RATE PER 100,000 POPULATION) 1990–1992

Cause of Death	1990		1991		1992	
	Rank	Rate	Rank	Rate	Rank	Rate
Heart Disease	1	37.45	1	46.29	1	63.1
Transport Accident	2	18.57	2	25.47	2	34.3
Cancer	4	15.13	3	21.72	3	25.3
Hypertensive Disease	3	16.03	5	11.54	4	12.3
Other Accident	5	11.83			5	10.6
Diseases of Respiratory System Except upper Respiratory Tract	6	10.93	4	16.63	6	8.7
Drowning	8	4.94	6	7.49	7	6.9
Paralysis, all types	–	–	–	–	8	6.2
Homicide and Injury	10	4.54	7	5.54	9	5.3
Diabetes	–	–	–	–	10	4.8

Source of Data: Provincial Health Office, Ayutthaya 1990–1992

TABLE E-4
TOP TEN MORBIDITY RATE OF DISEASES UNDER SURVEILLANCE, THAILAND, 1990–1991

Diseases	1990				1991			
	Rank	Cases	Deaths	Morbidity Rate (per 100,000 pop.)	Rank	Cases	Deaths	Morbidity Rate (per 100,000 pop.)
Acute Diarrhoea	1	723221	490	1284.66	1	792513	473	1398.67
Pyrexia of Unknown Origin	2	347083	175	616.52	2	268576	103	474.00
Pneumonia	5	122214	463	217.09	3	98338	1090	173.55
Sexually Transmitted Diseases	4	109193	7	193.96	4	90555	8	159.82
Malaria	3	93417	1060	165.94	5	88267	325	155.78
Dysentery–total	7	92005	414	163.43	6	86868	18	153.31
Conjunctivities (haemorrhagic)	9	87839	41	156.03	7	69196	–	122.12
Influenza	8	72832	3	129.37	8	62459	2	110.23
Food Poisoning	10	61404	–	109.07	9	59708	16	105.38
Den Haemorrhagic Fever–Total	6	55662	25	98.87	10	43511	137	76.79

Reference : Annual Epidermiological Sureillance Report 1990–1991
Division of Epidemiology, Office of Permanent Secretary for Public Health,
Minitry of Public Health

TABLE E-5
TOP TEN MORBIDITY RATE OF DISEASES UNDER SURVEILLANCE, THAILAND, 1990-1991

Diseases	1990				1991			
	Rank	Cases	Deaths	Morbidity Rate (per 100,000 pop.)	Rank	Cases	Deaths	Morbidity Rate (per 100,000 pop.)
Pneumonia	1	93417	1060	1.88	1	98338	1090	1.92
Acute Diarrhoea	2	723221	490	0.87	2	792513	473	0.83
Malaria	3	122214	463	0.82	3	88267	325	0.57
Tuberculosis-Total	5	92005	414	0.74	4	21107	262	0.46
Suicide by liquid Substance	–	20237	285	0.51	5	2946	170	0.30
Rabies	6	185	185	0.33	6	171	171	0.30
Den Haemorrhagic fever-total	4	347083	175	0.34	7	43511	137	0.24
Encephalities-Total	8	1192	151	0.27	8	959	108	0.19
Pyrexia of unknown origin	7	813	113	0.2	9	268576	103	0.18
Tetanus-Total	9	16832	73	0.13	10	706	90	0.16

Reference: Annual Epidemiological Surveillance Report 1990-1991 Division of Epidemiology, Office of Permanent Secretary for Public Health, Ministry of Public Health

TABLE E–6

REPORTED CASES AND DEATHS BY PROVINCES, THAILAND, 2535 (1992)

Reporting Areas	1. Cholera		2. Acute diarrhoea		3. Food poisoning		4. Dysentery total		bacillary		amoebic		unspecified	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	–	–	834953	388	64800	23	81919	28	5347	4	1760	2	74812	22
CENTRAL REGION	–	–	241937	71	17567	3	13782	9	874	3	235	–	12673	6
1 Bangkok Metropolis	–	–	41364	6	2044	1	1186	1	148	–	22	–	1016	1
2 Samut Sakhon	–	–	5344	1	168	–	94	–	–	–	1	–	93	–
3 Samut Prakan	–	–	13741	1	562	–	579	–	21	–	1	–	557	–
4 Samut Songkhram	–	–	4218	–	93	–	283	–	3	–	2	–	278	–
5 Nonthaburi	–	–	9955	4	359	–	353	1	21	–	4	–	328	1
6 Pathum Thani	–	–	8005	4	573	–	528	–	10	–	10	–	508	–
7 Nakhon Pathom	–	–	10418	5	1037	–	690	2	62	1	21	–	607	1
8 Ratchaburi	–	–	9285	–	1095	–	715	–	63	–	12	–	640	–
9 Kanchanaburi	–	–	13294	6	764	–	1000	–	36	–	16	–	948	–
10 Phetchaburi	–	–	3989	2	522	–	163	2	17	1	5	–	141	1
11 Prachuap Khiri Khan	–	–	5000	2	423	–	181	1	30	1	7	–	144	–
12 Suphan Buri	–	–	10531	3	743	–	915	–	56	–	13	–	846	–
13 Sing Buri	–	–	2313	–	93	–	124	–	6	–	2	–	116	–
14 Ayutthaya	–	–	10547	6	1344	–	776	–	56	–	16	–	704	–
15 Saraburi	–	–	9706	4	1142	–	787	–	13	–	14	–	760	–
16 Lop Buri	–	–	10377	–	478	1	390	–	65	–	13	–	312	–
17 Chai Nat	–	–	3423	4	231	–	224	–	11	–	–	–	213	–
18 Ang Thong	–	–	3628	–	98	1	80	–	11	–	2	–	67	–
19 Nakhon Nayok	–	–	3977	1	236	–	193	–	39	–	2	–	152	–
20 Chon Buri	–	–	17485	3	1760	–	1352	1	71	–	49	–	1232	1
21 Chachoengsao	–	–	9981	2	543	–	360	–	10	–	2	–	348	–
22 Rayong	–	–	11157	6	1049	–	649	–	35	–	8	–	606	–
23 Chanthaburi	–	–	7797	8	768	–	1120	1	35	–	3	–	1082	1
24 Trat	–	–	4433	1	487	–	394	–	9	–	5	–	380	–
25 Prachin Buri	–	–	11969	2	956	–	646	–	46	–	5	–	595	–

TABLE E–6 CONT'D

	5. Enteric fever								6. Hepatitis									
	Total		Typhoid		Paratyphoid		Unspecified		total		A		B					
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	14312	7	7513	4	28	–	6771	3	19186	62	751	1	3172	3	92	–	15171	58
CENTRAL REGION	2040	–	1224	–	9	–	807	–	5870	24	103	1	1980	2	26	–	3761	21
1 Bangkok Metropolis	178	–	81	–	2	–	95	–	2122	5	42	–	1216	2	8	–	856	3
2 Samut Sakhon	113	–	110	–	–	–	3	–	60	–	1	–	42	–	–	–	17	–
3 Samut Prakan	135	–	42	–	–	–	93	–	446	–	3	–	189	–	–	–	254	–
4 Samut Songkhram	29	–	15	–	–	–	14	–	42	–	–	–	5	–	–	–	37	–
5 Nonthaburi	74	–	27	–	–	–	47	–	205	–	5	–	67	–	1	–	132	–
6 Pathum Thani	46	–	13	–	–	–	33	–	125	–	8	–	61	–	–	–	56	–
7 Nakhon Pathom	84	–	26	–	–	–	58	–	177	1	3	–	65	–	1	–	108	1
8 Ratchaburi	162	–	70	–	2	–	90	–	188	–	2	–	27	–	2	–	157	–
9 Kanchanaburi	32	–	18	–	–	–	14	–	283	3	2	–	35	–	–	–	246	3
10 Phetchaburi	59	–	41	–	–	–	18	–	98	2	3	–	11	–	–	–	84	2
11 Prachuap Khiri Khan	175	–	88	–	–	–	87	–	91	–	5	–	9	–	–	–	77	–
12 Suphan Buri	68	–	44	–	–	–	24	–	171	2	7	–	20	–	5	–	139	2
13 Sing Buri	31	–	15	–	–	–	16	–	131	–	1	–	6	–	–	–	124	–
14 Ayutthaya	57	–	32	–	–	–	25	–	85	1	2	–	20	–	1	–	62	1
15 Saraburi	18	–	6	–	–	–	12	–	135	2	–	–	18	–	–	–	117	2
16 Lop Buri	48	–	30	–	–	–	18	–	113	2	3	1	19	–	5	–	86	1
17 Chai Nat	8	–	2	–	–	–	6	–	53	–	1	–	6	–	–	–	46	–
18 Ang Thong	39	–	24	–	–	–	15	–	33	–	–	–	8	–	–	–	25	–
19 Nakhon Nayok	6	–	4	–	–	–	2	–	42	–	–	–	17	–	–	–	25	–
20 Chon Buri	40	–	17	–	3	–	20	–	300	2	4	–	12	–	1	–	283	2
21 Chachoengsao	25	–	17	–	–	–	8	–	125	–	–	–	21	–	2	–	102	–
22 Rayong	74	–	54	–	1	–	19	–	226	3	6	–	15	–	–	–	205	3
23 Chanthaburi	23	–	9	–	–	–	14	–	188	–	2	–	18	–	–	–	168	–
24 Trat	34	–	11	–	–	–	23	–	83	–	1	–	13	–	–	–	69	–
25 Prachin Buri	482	–	428	–	1	–	53	–	348	1	2	–	60	–	–	–	286	1

TABLE E–6 CONT'D

	13. Influenza		14. P.U.O.		15. D.H.F. total		shock		16. Encephalitis total		Janpanese B		unspecified	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	52105	4	237974	121	42809	138	669	51	945	119	10	–	935	119
CENTRAL REGION	14388	–	38981	29	9568	21	129	7	187	16	6	–	181	16
1 Bangkok Metropolis	656	–	1392	3	1558	–	13	–	22	2	–	–	22	2
2 Samut Sakhon	158	–	233	–	29	–	–	–	4	–	–	–	4	–
3 Samut Prakan	397	–	1324	1	409	–	1	–	7	3	2	–	5	3
4 Samut Songkhram	706	–	908	–	51	–	1	–	–	–	–	–	–	–
5 Nonthaburi	635	–	1191	2	234	–	2	–	7	–	1	–	6	–
6 Pathum Thani	503	–	1556	1	74	–	1	–	1	–	–	–	1	–
7 Nakhon Pathom	867	–	1668	3	469	2	3	–	17	2	–	–	17	2
8 Ratchaburi	898	–	3238	1	522	–	8	–	21	1	–	–	21	1
9 Kanchanaburi	779	–	3742	1	430	2	10	2	16	3	–	–	16	3
10 Phetchaburi	1221	–	1312	–	251	1	–	–	5	–	–	–	5	–
11 Prachuap Khiri Khan	792	–	1586	1	295	–	10	–	5	–	–	–	5	–
12 Suphan Buri	451	–	2213	–	345	3	4	2	10	1	1	–	9	1
13 Sing Buri	142	–	242	–	123	–	–	–	–	–	–	–	–	–
14 Ayutthaya	522	–	2014	3	464	2	5	–	14	–	–	–	14	–
15 Saraburi	84	–	2130	2	192	–	3	–	1	–	–	–	1	–
16 Lop Buri	207	–	1244	1	513	4	17	–	12	2	–	–	12	2
17 Chai Nat	157	–	162	–	467	1	10	–	7	–	–	–	7	–
18 Ang Thong	66	–	433	–	104	1	1	1	4	–	–	–	4	–
19 Nakhon Nayok	123	–	593	–	405	–	13	–	2	–	–	–	2	–
20 Chon Buri	2253	–	2462	1	852	1	9	–	–	–	–	–	–	–
21 Chachoengsao	745	–	1107	1	622	1	15	–	5	1	1	–	4	1
22 Rayong	600	–	2001	2	326	–	–	–	4	–	–	–	4	–
23 Chanthaburi	670	–	1851	6	243	1	–	–	7	–	–	–	7	–
24 Trat	261	–	2537	–	78	–	–	–	4	–	–	–	4	–
25 Prachin Buri	495	–	1842	–	512	2	3	2	12	1	1	–	11	1

TABLE E – 6 CONT'D

Reporting Areas	17. Malaria		18. Diphtheria		19. Pertussis		20. Tetanus Total		20. Tetanus Neonatorum		21. Meningo-coccal Meningitis		22. Pneumonia	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	79443	276	39	6	416	2	588	77	120	34	36	11	92689	963
CENTRAL REGION	47158	148	12	2	146	–	122	17	17	5	12	5	21227	284
1 Bangkok Metropolis	497	1	2	–	67	–	10	–	–	–	2	2	3913	29
2 Samut Sakhon	44	–	–	–	–	–	2	1	–	–	–	–	185	–
3 Samut Prakan	86	–	2	1	4	–	1	–	–	–	1	1	836	5
4 Samut Songkhram	94	1	–	–	–	–	4	–	–	–	–	–	158	1
5 Nonthaburi	98	–	–	–	5	–	3	–	–	–	1	–	734	1
6 Pathum Thani	53	–	–	–	2	–	–	–	–	–	–	–	419	2
7 Nakhon Pathom	138	3	–	–	–	–	4	–	–	–	–	–	951	25
8 Ratchaburi	3494	6	–	–	7	–	5	1	1	–	1	1	1656	14
9 Kanchanaburi	12155	65	–	–	9	–	10	3	4	1	1	–	1222	49
10 Phetchaburi	921	3	–	–	1	–	11	2	1	1	–	–	513	3
11 Prachuap Khiri Khan	1350	3	–	–	–	–	2	2	–	–	1	–	1046	4
12 Suphan Buri	518	3	–	–	4	–	7	–	2	–	1	–	591	11
13 Sing Buri	19	–	–	–	2	–	1	–	–	–	–	–	168	2
14 Ayutthaya	37	3	–	–	1	–	7	1	1	–	2	–	1170	15
15 Saraburi	53	–	–	–	2	–	3	1	–	–	–	–	429	16
16 Lop Buri	61	3	–	–	4	–	10	4	–	–	–	–	847	30
17 Chai Nat	35	–	–	–	5	–	4	–	–	–	–	–	385	4
18 Ang Thong	17	–	–	–	–	–	3	–	–	–	–	–	128	1
19 Nakhon Nayok	339	2	–	–	4	–	2	–	–	–	–	–	430	4
20 Chon Buri	447	–	–	–	1	–	7	–	2	–	1	–	1752	3
21 Chachoengsao	191	1	–	–	19	–	5	–	1	–	–	–	399	5
22 Rayong	1246	8	–	–	5	–	7	–	–	–	–	–	595	15
23 Chanthaburi	8327	14	–	–	–	–	4	–	–	–	1	1	1235	7
24 Trat	13886	25	–	–	–	–	2	–	–	–	–	–	250	9
25 Prachin Buri	3052	7	–	–	4	–	8	–	–	–	–	–	1180	29

TABLE E-6 CONT'D

Reporting Areas	23. Leprosy		24. Tuberculosis total		pulmonary		others		25. Yaws. Infectious		26. Lepto-spirosis		27. Scrub typhus	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	627	–	21531	239	20263	201	1268	38	–	–	93	–	1149	6
CENTRAL REGION	134	–	6080	85	5822	74	258	11	–	–	11	–	79	2
1 Bangkok Metropolis	25	–	1320	6	1256	5	64	1	–	–	1	–	9	1
2 Samut Sakhon	1	–	54	–	52	–	2	–	–	–	–	–	–	–
3 Samut Prakan	2	–	300	3	291	3	9	–	–	–	–	–	–	–
4 Samut Songkhram	–	–	37	–	31	–	6	–	–	–	–	–	–	–
5 Nonthaburi	2	–	219	1	211	1	8	–	–	–	–	–	–	–
6 Pathum Thani	1	–	116	2	112	2	4	–	–	–	–	–	–	–
7 Nakhon Pathom	3	–	195	1	190	1	5	–	–	–	1	–	1	–
8 Ratchaburi	5	–	252	2	233	2	19	–	–	–	1	–	2	–
9 Kanchanaburi	15	–	305	17	300	15	5	–	–	–	4	–	9	–
10 Phetchaburi	4	–	117	1	109	1	8	–	–	–	–	–	4	–
11 Prachuap Khiri Khan	4	–	223	3	218	3	5	2	–	–	–	–	10	–
12 Suphan Buri	10	–	300	2	289	2	11	–	–	–	–	–	–	–
13 Sing Buri	2	–	82	–	78	–	4	–	–	–	–	–	–	–
14 Ayutthaya	7	–	281	5	275	4	6	–	–	–	–	–	11	–
15 Saraburi	1	–	261	10	259	10	2	–	–	–	1	–	–	–
16 Lop Buri	2	–	313	9	303	8	10	–	–	–	–	–	–	–
17 Chai Nat	–	–	76	–	72	–	4	–	–	–	–	–	2	–
18 Ang Thong	4	–	76	2	75	2	1	–	–	–	–	–	4	–
19 Nakhon Nayok	1	–	55	1	50	–	5	1	–	–	–	–	7	–
20 Chon Buri	6	–	321	2	305	2	16	–	–	–	1	–	–	–
21 Chachoengsao	9	–	164	–	142	–	22	–	–	–	2	–	–	–
22 Rayong	14	–	207	11	197	8	10	3	–	–	–	–	1	–
23 Chanthaburi	2	–	382	1	375	1	7	–	–	–	–	–	15	–
24 Trat	2	–	148	4	138	2	10	2	–	–	–	–	3	–
25 Prachin Buri	12	–	276	2	261	2	15	–	–	–	–	–	1	–

TABLE E-6 CONT'D

Reporting Areas	28. Sexually Transmitted Diseases													
	total		Syphilis		gonorrhoea		Chascrold		L.G.V.		NSU/V		others V.D	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	70664	6	9368	6	32573	–	2203	–	2016	–	14104	–	10400	–
CENTRAL REGION	32563	5	4489	5	16001	–	945	–	840	–	5799	–	4489	–
1 Bangkok Metropolis	5306	–	891	–	1168	–	177	–	72	–	1519	–	1479	–
2 Samut Sakhon	245	–	57	–	64	–	5	–	1	–	31	–	87	–
3 Samut Prakan	1563	–	243	–	557	–	50	–	62	–	531	–	120	–
4 Samut Songkhram	904	–	40	–	826	–	2	–	1	–	24	–	11	–
5 Nonthaburi	1115	–	98	–	377	–	30	–	17	–	482	–	111	–
6 Pathum Thani	469	–	73	–	270	–	11	–	5	–	95	–	15	–
7 Nakhon Pathom	2206	–	278	–	1509	–	28	–	62	–	142	–	187	–
8 Ratchaburi	1745	1	150	1	1280	–	49	–	12	–	194	–	60	–
9 Kanchanaburi	493	1	102	1	200	–	33	–	28	–	95	–	35	–
10 Phetchaburi	562	–	44	–	210	–	10	–	8	–	241	–	49	–
11 Prachuap Khiri Khan	810	–	110	–	430	–	21	–	43	–	184	–	22	–
12 Suphan Buri	2181	–	403	–	1031	–	39	–	114	–	298	–	296	–
13 Sing Buri	163	1	40	1	117	–	–	–	–	–	3	–	3	–
14 Ayutthaya	1730	–	427	–	1082	–	36	–	8	–	163	–	14	–
15 Saraburi	528	–	38	–	335	–	11	–	11	–	89	–	44	–
16 Lop Buri	1525	1	139	1	1039	–	18	–	34	–	50	–	245	–
17 Chai Nat	276	–	24	–	153	–	14	–	5	–	67	–	13	–
18 Ang Thong	388	–	48	–	85	–	12	–	59	–	27	–	157	–
19 Nakhon Nayok	149	–	22	–	99	–	4	–	2	–	10	–	12	–
20 Chon Buri	2242	–	269	–	1121	–	64	–	7	–	613	–	168	–
21 Chachoengsao	1959	–	89	–	972	–	107	–	18	–	151	–	622	–
22 Rayong	2753	1	487	1	1391	–	78	–	169	–	438	–	190	–
23 Chanthaburi	773	–	141	–	329	–	35	–	32	–	90	–	146	–
24 Trat	814	–	103	–	475	–	50	–	26	–	150	–	10	–
25 Prachin Buri	1664	–	173	–	881	–	61	–	44	–	112	–	393	–

Reference: Annual Epidemiological Surveillance Report 1992 Division of Epidemiology. Office of Permanent Secretary for Public Healths, Ministry of Public Health.

REPORTED CASES AND DEATHS BY PROVINCES, THAILAND, 2535 (1992)

Reporting Areas	1. Cholera		2. Acute diarrhoea		3. Food poisoning		4. Dysentery total		bacillary		amoebic		unspecified	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	–	–	792513	473	59708	16	86868	18	7371	7	2363	–	77134	11
CENTRAL REGION	–	–	238838	105	17604	4	16407	5	1470	1	330	–	14607	4
1 Bangkok Metropolis	–	–	45914	11	2367	–	1858	–	304	–	59	–	1495	–
2 Samut Sakhon	–	–	7835	1	609	–	261	–	83	–	5	–	173	–
3 Samut Prakan	–	–	15042	4	392	–	668	–	26	–	5	–	637	–
4 Samut Songkhram	–	–	3985	–	106	–	405	–	10	–	7	–	388	–
5 Nonthaburi	–	–	8561	2	388	–	532	–	32	–	19	–	481	–
6 Pathum Thani	–	–	6538	2	435	–	518	–	62	–	14	–	442	·
7 Nakhon Pathom	–	–	9799	8	905	–	949	–	31	–	7	–	911	–
8 Ratchaburi	–	–	10221	6	1053	–	798	–	54	–	6	–	738	–
9 Kanchanaburi	–	–	12956	8	489	–	779	1	23	–	4	–	752	1
10 Phetchaburi	–	–	5961	1	617	–	389	–	51	–	8	–	330	–
11 Prachuap Khiri Khan	–	–	5274	4	483	2	294	–	68	–	14	–	212	–
12 Suphan Buri	–	–	10483	7	648	–	858	–	49	–	21	–	788	–
13 Sing Buri	–	–	1974	4	69	–	175	–	44	–	–	–	131	–
14 Ayutthaya	–	–	9880	4	1530	–	1154	1	135	–	32	–	987	1
15 Saraburi	–	–	6968	6	792	–	448	1	29	1	5	–	414	–
16 Lop Buri	–	–	8384	5	452	–	357	–	42	–	9	–	306	–
17 Chai Nat	–	–	3194	6	305	–	274	–	31	–	4	–	239	–
18 Ang Thong	–	–	4078	2	138	–	155	–	38	–	2	–	115	–
19 Nakhon Nayok	–	–	3840	3	213	–	249	–	41	–	1	–	207	–
20 Chon Buri	–	–	16217	1	1869	–	1460	–	63	–	50	–	1347	–
21 Chachoengsao	–	–	9249	2	586	–	508	–	25	–	1	–	482	–
22 Rayong	–	–	10022	5	1056	–	735	–	32	–	18	–	685	–
23 Chanthaburi	–	–	7820	7	775	–	1235	1	93	–	23	–	1119	1
24 Trat	–	–	3899	2	300	–	457	–	17	–	4	–	436	–
25 Prachin Buri	–	–	10744	4	1027	2	891	1	87	–	12	–	792	1

TABLE E–7 CONT'D

Reporting Areas	5. Enteric fever								6. Hepatitis									
	total		typhoid		paratyphoid		unspecified		total		A.		B.		Non–A Non–B		unspecified	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	17096	5	9430	5	54	–	7612	–	17782	49	308	–	3391	3	70	–	14013	46
CENTAL REGION	2738	1	1709	1	20	–	1009	–	6134	24	139	–	2223	2	20	–	3752	22
1 Bangkok Metropolis	271	–	101	–	9	–	161	–	2414	3	48	–	1427	1	9	–	930	2
2 Samut Sakhon	92	–	78	–	–	–	14	–	84	–	2	–	47	–	–	–	35	–
3 Samut Prakan	74	–	57	–	–	–	17	–	415	–	7	–	206	–	1	–	201	–
4 Samut Songkhram	32	–	16	–	–	–	16	–	52	1	2	–	10	–	–	–	40	1
5 Nonthaburi	65	–	24	–	–	–	41	–	214	–	7	–	87	–	2	–	118	–
6 Pathum Thani	49	–	10	–	–	–	39	–	132	–	14	–	66	–	–	–	52	–
7 Nakhon Pathom	124	–	49	–	1	–	74	–	179	2	2	–	69	–	1	–	107	2
8 Ratchaburi	185	–	69	–	–	–	116	–	204	–	1	–	24	–	2	–	177	1
9 Kanchanaburi	55	–	31	–	1	–	23	–	200	–	2	–	17	–	1	–	180	–
10 Phetchaburi	80	1	47	1	–	–	33	–	64	1	–	–	11	1	–	–	53	–
11 Prachuap Khiri Khan	235	–	113	–	–	–	122	–	72	–	–	–	10	–	–	–	62	–
12 Suphan Buri	110	–	79	–	–	–	31	–	175	–	15	–	25	–	–	–	135	–
13 Sing Buri	25	–	13	–	–	–	12	–	109	1	2	–	1	–	–	–	106	1
14 Ayutthaya	73	–	49	–	–	–	24	–	124	–	6	–	17	–	–	–	101	–
15 Saraburi	29	–	14	–	–	–	15	–	150	2	3	–	9	–	–	–	138	2
16 Lop Buri	68	–	37	–	6	–	25	–	103	–	9	–	18	–	–	–	76	–
17 Chai Nat	3	–	1	–	–	–	2	–	45	2	1	–	5	–	–	–	39	2
18 Ang Thong	77	–	56	–	–	–	21	–	63	1	1	–	12	–	–	–	50	1
19 Nakhon Nayok	11	–	8	–	–	–	3	–	73	1	5	–	18	–	–	–	50	1
20 Chon Buri	59	–	35	–	–	–	24	–	278	2	6	–	23	–	2	–	247	2
21 Chachoengsao	51	–	15	–	–	–	36	–	217	–	1	–	30	–	–	–	186	–
22 Rayong	90	–	54	–	3	–	33	–	187	4	2	–	17	–	1	–	167	4
23 Chanthaburi	31	–	21	–		–	10	–	154	1	–	–	14	–	–	–	140	1
24 Trat	24	–	10	–		–	14	–	130	1	–	–	23	–	–	–	107	1
25 Prachin Buri	825	–	722	–		–	103	–	296	1	3	–	37	–	1	–	255	1

Reporting Areas	13. Influenza		14. P.U.O.		15. D.H.F. total		15. D.H.F. shock syndrome		16. Encephalitis total		16. Encephalitis Japanese B.		16. Encephalitis unspecified	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	62459	2	268576	103	43511	137	611	51	959	108	25	2	933	106
CENTAL REGION	18750		45100	29	10538	21	125	11	195	18	16		179	18
1 Bangkok Metropolis	1176		2027		2051	1	14		37	1	3		34	1
2 Samut Sakhon	287		502		128	1	6		4				4	
3 Samut Prakan	237		1389		342		4		7				7	
4 Samut Songkhram	860		929		71		2		5				5	
5 Nonthaburi	434		1342		187	1	2	1	2		1		1	
6 Pathum Thani	666		1796		113		1		2				2	
7 Nakhon Pathom	920		1700	4	428		4		11				11	
8 Ratchaburi	1395		3817	1	804	1	13	1	26	3			26	3
9 Kanchanaburi	966		4377	1	676	4	21	4	11	3	1		10	3
10 Phetchaburi	1243		2111	4	382	2	7	2	5		1		4	
11 Prachuap Khiri Khan	1027		1884		432	2	6	1	5		1		4	
12 Suphan Buri	571		3385	1	962	1	5		8	1	1		7	1
13 Sing Buri	154		324	1	341		3		2	1	1		1	1
14 Ayutthaya	697		2625		510	1	1	1	4				4	
15 Saraburi	137		1272	1	360	1	1		8	2			8	2
16 Lop Buri	541		1102		692		11		12	3			12	3
17 Chai Nat	114		227		432	2	5		4				4	
18 Ang Thong	136		660		440		6		3				3	
19 Nakhon Nayok	207		597		131		8		4				4	
20 Chon Buri	2545		2537		274	2	3	1	7	1	5		2	1
21 Chachoengsao	1141		1418	1	109				3		1		2	
22 Rayong	702		2755		252	1	1		4	1	1		3	1
23 Chanthaburi	757		2238	5	233	1	1		10	1			10	1
24 Trat	298		2088	8	62	1			2	1			2	1
25 Prachin Buri	1539		1998	1	126				9				9	

TABLE E–7 CONT'D

Reporting Areas	13. Influenza		14. P.U.O.		15. D.H.F. total		shock		16. Encephalltis total		amoeble		unspecified	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	52105	4	237974	121	42809	138	669	51	945	119	10	–	935	119
CENTRAL REGION	14388	–	38981	29	9568	21	129	7	187	16	6	–	181	16
1 Bangkok Metropolis	656	–	1392	3	1558	–	13	–	22	2	–	–	22	2
2 Samut Sakhon	158	–	233	–	29	–	–	–	4	–	–	–	4	–
3 Samut Prakan	397	–	1324	1	409	–	1	–	7	3	2	–	5	3
4 Samut Songkhram	706	–	908	–	51	–	1	–	–	–	–	–	–	–
5 Nonthaburi	635	–	1191	2	234	–	2	–	7	–	1	–	6	–
6 Pathum Thani	503	–	1556	1	74	–	1	–	1	–	–	–	1	–
7 Nakhon Pathom	867	–	1668	3	469	2	3	–	17	2	–	–	17	2
8 Ratchaburi	898	–	3238	1	522	–	8	–	21	1	–	–	21	1
9 Kanchanaburi	779	–	3742	1	430	2	10	2	16	3	–	–	16	3
10 Phetchaburi	1221	–	1312	–	251	1	–	–	5	–	–	–	5	–
11 Prachuap Khiri Khan	792	–	1586	1	295	–	10	–	5	–	–	–	5	–
12 Suphan Buri	451	–	2213	–	345	3	4	2	10	1	1	–	9	1
13 Sing Buri	142	–	242	–	123	–	–	–	–	–	–	–	–	–
14 Ayutthaya	522	–	2014	3	464	2	5	–	14	–	–	–	14	–
15 Saraburi	84	–	2130	2	192	–	3	–	1	–	–	–	1	–
16 Lop Buri	207	–	1244	1	513	4	17	–	12	2	–	–	12	2
17 Chai Nat	157	–	162	–	467	1	10	–	7	–	–	–	7	–
18 Ang Thong	66	–	433	–	104	1	1	1	4	–	–	–	4	–
19 Nakhon Nayok	123	–	593	–	405	–	13	–	2	–	–	–	2	–
20 Chon Buri	2253	–	2462	1	852	1	9	–	–	–	–	–	–	–
21 Chachoengsao	745	–	1107	1	622	1	15	–	5	1	1	–	4	1
22 Rayong	600	–	2001	2	326	–	–	–	4	–	–	–	4	–
23 Chanthaburi	670	–	1851	6	243	1	–	–	7	–	–	–	7	–
24 Trat	261	–	2537	–	78	–	–	–	4	–	–	–	4	–
25 Prachin Buri	495	–	1842	–	512	2	3	2	12	1	1	–	11	1

Reporting Areas	17. Malaria		18. Diphitheria		19. Pertussis		20. Tetanus total		20. Tetanus neonatorum		21. Meningococcal meningitis		22. Pneumonia	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	88267	325	53	11	295	1	706	90	166	27	16	3	98338	109
CENTAL REGION	52357	141	19	5	108	1	141	16	19	3	2		23136	281
1 Bangkok Metropolis	646	3	1		52		19	2	1		1		4559	21
2 Samut Sakhon	101		1		2		1						461	2
3 Samut Prakan	125	1	2		14		1						879	2
4 Samut Songkhram	63	1					2						177	3
5 Nonthaburi	114		1	1	4		1						714	7
6 Pathum Thani	66				1								629	3
7 Nakhon Pathom	166						1		1				890	17
8 Ratchaburi	1368	4	2		10		3	1					2102	13
9 Kanchanaburi	13008	37			2		17	6	5	2			1115	24
10 Phetchaburi	710	6	1				6	1					494	12
11 Prachuap Khiri Khan	1429	2	1	1			5						1265	7
12 Suphan Buri	574	3	1		3		13						648	5
13 Sing Buri	36	1			1		2						212	4
14 Ayutthaya	66				3		6		1		1		1105	21
15 Saraburi	88				1		12	2					516	30
16 Lop Buri	151	2			3		10	4	2	1			909	41
17 Chai Nat	53	1	1				2		1				275	
18 Ang Thong	28						3						163	1
19 Nakhon Nayok	322				2		2		1				597	11
20 Chon Buri	681		1	1	2		10		1				1922	3
21 Chachoengsao	441	1	1		4		1						387	1
22 Rayong	2065	9	1		2		7		1				509	20
23 Chanthaburi	11116	29					1		1				1153	13
24 Trat	14841	36	2	1			1						286	9
25 Prachin Buri	4099	5	3	1	2		15		4				1169	16

TABLE E-7 CONT'D

Reporting Areas	23. Lepross		24. Tu total		pulmonary		15. D.H.F. total		25. Yaws infectious		26. Lepto spirosis		27. Scrub Typhus	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	548		21107	262	20036	222	1071	40	19		158	2	1196	6
CENTAL REGION	159		6212	99	6025	88	187	11			19		125	
1 Bangkok Metropolis	37		1289	10	1241	9	48	1			1		2	
2 Samut Sakhon			103		102		1							
3 Samut Prakan	2		258	2	250	2	8							
4 Samut Songkhram			53	1	52	1	1				2			
5 Nonthaburi	3		220	4	215	4	5						4	
6 Pathum Thani	2		148	3	145	3	3							
7 Nakhon Pathom	5		221	5	217	5	4				1			
8 Ratchaburi	7		298	2	284	2	14				2		1	
9 Kanchanaburi	17		259	12	254	11	5	1			1		12	
10 Phetchaburi	3		161		157		4						1	
11 Prachuap Khiri Khan	3		180		178		2							
12 Suphan Buri	15		288	3	275	1	13	2					3	
13 Sing Buri	1		114	4	106	4	8							
14 Ayutthaya	8		272	2	270	2	2						20	
15 Saraburi	4		342	25	333	24	9	1			1		1	
16 Lop Buri	8		312	6	305	6	7				2			
17 Chai Nat	1		79	1	76	1	3				2			
18 Ang Thong	1		93	1	93	1							6	
19 Nakhon Nayok	1		149		143		6				1		8	
20 Chon Buri	4		265	1	263		2	1			1		1	
21 Chachoengsao	9		107		102		5				1			
22 Rayong	14		185	7	174	5	11	2					1	
23 Chanthaburi	6		358	7	354	7	4				2		63	
24 Trat	1		124	3	113		11	3			1			
25 Prachin Buri	7		334		323		11				1		2	

Reporting Areas	total		syphilis		28. Sexually Transmitted Diseases gonorrhoen		chancroid		L.G.V.		NSU/C		others V.D.	
	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.	C.	D.
TOTAL	90555	8	10477	8	42797		4390		4685		1860		9446	
CENTAL REGION	43295	5	5418	5	21431		1824		1914		9211		3497	
1 Bangkok Metropolis	7491		1320		2454		285		54		2592		786	
2 Samut Sakhon	895		127		336		71		44		197		120	
3 Samut Prakan	2502		338		1007		111		119		800		127	
4 Samut Songkhram	941		76		764		24		7		66		4	
5 Nonthaburi	2517		153		718		94		48		1368		136	
6 Pathum Thani	678		122		319		34		10		168		25	
7 Nakhon Pathom	3667	1	275	1	2598		71		118		355		250	
8 Ratchaburi	2020	1	191	1	1401		96		29		275		28	
9 Kanchanaburi	1214	1	106	1	731		115		80		125		57	
10 Phetchaburi	383		34		195		15		15		103		21	
11 Prachuap Khiri Khan	1670		228		1054		62		27		271		28	
12 Suphan Buri	2272		384		1154		57		86		323		268	
13 Sing Buri	364	1	80	1	256		2		4		10		12	
14 Ayutthaya	2248		451		1467		69		11		219		31	
15 Saraburi	157		27		66		8		15		20		21	
16 Lop Buri	2067		211		1451		30		63		118		194	
17 Chai Nat	395		25		242		24		13		77		14	
18 Ang Thong	509		72		163		33		42		60		139	
19 Nakhon Nayok	348		69		233		14		2		14		16	
20 Chon Buri	2522		238		922		157		112		1010		83	
21 Chachoengsao	2105		76		1105		93		273		134		424	
22 Rayong	2533	1	450	1	964		162		476		369		112	
23 Chanthaburi	1073		143		491		41		124		31		243	
24 Trat	725		79		373		39		44		181		9	
25 Prachin Buri	1999		143		967		117		98		325		349	

Reference: Amunal Epidmiblogical Surrcillance Report 1991
Division of Epidemiology, Office of Perrnanent Secretary for Public Health,
Minitry of Public Health

TABLE E – 8

NUMBER AND RATE PER 100,000 POPULATION OF DISEASES TRANSMITTED BY FOOD AND WATER, AYUTTHAYA 1990–1992

Disease	1990		1991		1992	
	Number	Rate	Number	Rate	Number	Rate
Acute diarrhea	92	13.78	55	8.14	45	6.55
Diarrhea	9386	1406.17	9259	1370.90	1062.4	1546.8
Food poisoning	1307	195.81	1440	213.21	1534	223.34
Dysentory–total	1182	177.08	1136	168.20	881	128.27
Hepatitis–total	146	21.87	103	15.25	68	9.90
Typhoid	85	12.73	53	7.85	40	5.82

Source of Data: Provincial Health Office, Ayutthaya

TABLE E-9

FIRST 10 CAUSES OF ILLNESS OF OUT PATIENTS IN AYUTTHAYA NUMBER AND RATE PER 1,000 POPULATION 1990-1992

Illness	1990		1991	1992
	Number	Rate	Rate	Rate
1. Respiratory System	163899	208.54	239.19	238.62
2. Digestive System	74416	97.91	99.81	108.34
3. Accident and Poisoning	58546	72.52	83.09	85.24
4. Muscle and tendon	33380	38.40	42.95	48.59
5. Skin and Subcutancous Disease Mental Disorder	11693	–	36.08	17.02
6. Infections and parasit	32778	43.57	44.95	47.72
7. Blood Circulation System	32159	43.61	54.72	46.82
8. Nervous System and Sense Organs	29614	38.60	41.70	43.11
9. Endocrine and Metabolic Disease	24446	32.66	21.69	35.59
10. Genito-Urinary System	15269	23.81	–	22.23

Source of Data: Provincial Health Office, Ayutthaya

TABLE E-10
FIRST 10 CAUSES OF ILLNESS OF OUT PATIENTS IN AYUTTHAYA
NUMBER AND RATE PER 1,000 POPULATION 1990-1992

Cause of illness	1990	1991	1992
Complication of Pregnancy & Childbirth	1,206.76	1326.81	1,378.20
Enteritis and Other Diarrhea Disease	466.82	358.76	450.03
Transport Acident	325.39	340.55	400.90
Bronchitis, Asthma, Emphysima	279.70	311.97	316.37
Other Accidents	-	177.23	304.73
Difficulty of Labor, Birth injury	122.85	N.R	195.09
Hypertensive Disease	176.18	N.R	187.52
Pneumonia	N.R	N.R	147.05
Peptic Ulcer	167.04	156.50	129.87
Other kind of Heart Disease	N.R	N.R	111.08
Inflectious and Parasitic Disease	122.25	N.R	N.R
Pyrexia of Unknow Origin	139.48	N.R	N.R

N.R. : not report

Source of Data: Provincial Health Office, Ayutthaya

TABLE E-11
NUMBER AND RATE PER 100,000 POPULATION OF DISEASE OF RESPIRATORY SYSTEM IN AYUTTHAYA 1990-1992

Disease	1990		1991		1992	
	Number	Rate	Number	Rate	Number	Rate
Influenza	842	126.14	614	90.91	516	75.13
Pnumonia	818	122.55	943	139.63	1096	146.61
T.B.	240	35.96	227	33.61	332	48.34
Total	1900	284.65	1784	264.15	1944	270.88

Source of Data: Provincial Health Office, Ayutthaya, 1992

APPENDIX F

PHOTOGRAPHS

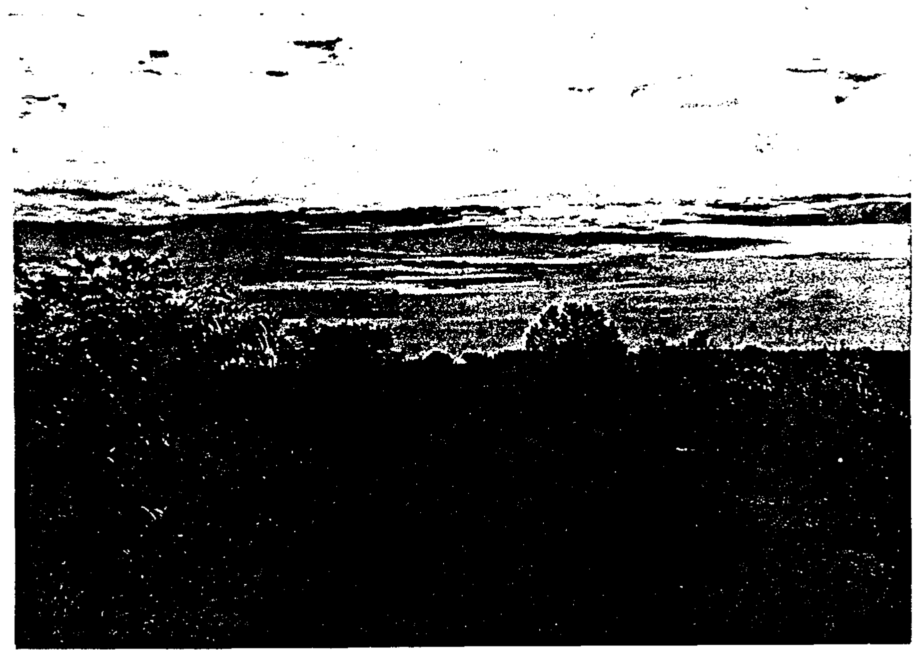

PHOTO F-1 THE ENTRANCE OF THE PROPOSED POWER PLANT

PHOTO F-2 PROPOSED POWER PLANT AREA

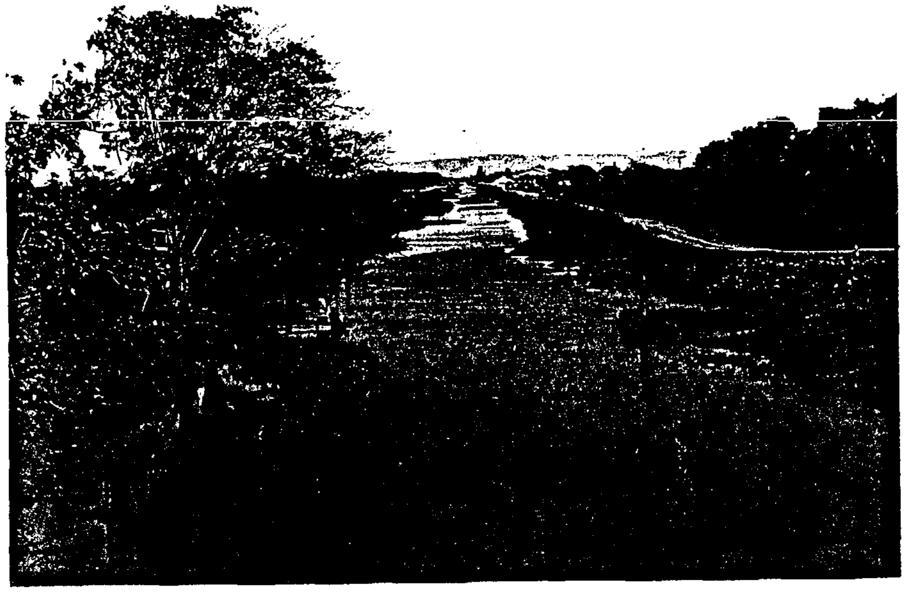

PHOTO F-3 EXISTING KHLONG RAPHIPHAT NEAR POWER PLANT AREA

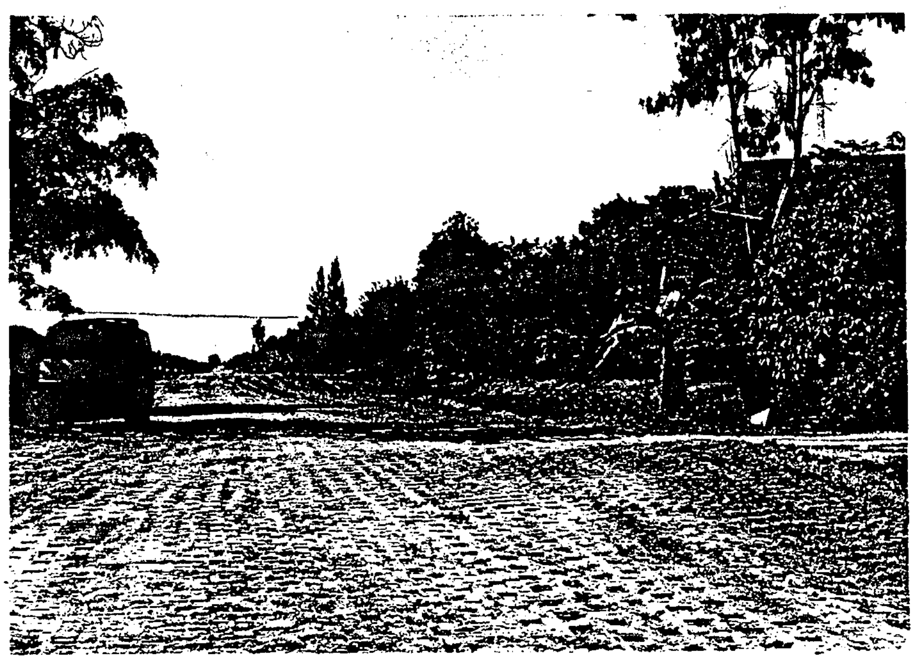

PHOTO F-4 ROAD ALONG KHLONG RAPHIPHAT DURING CONSTRUCTION BY RID

PHOTO F-5 AESTHETICS QUALITY AROUND PROPOSED POWER PLANT

PHOTO F-6 SWAMP AREA AROUND PROPOSED POWER PLANT

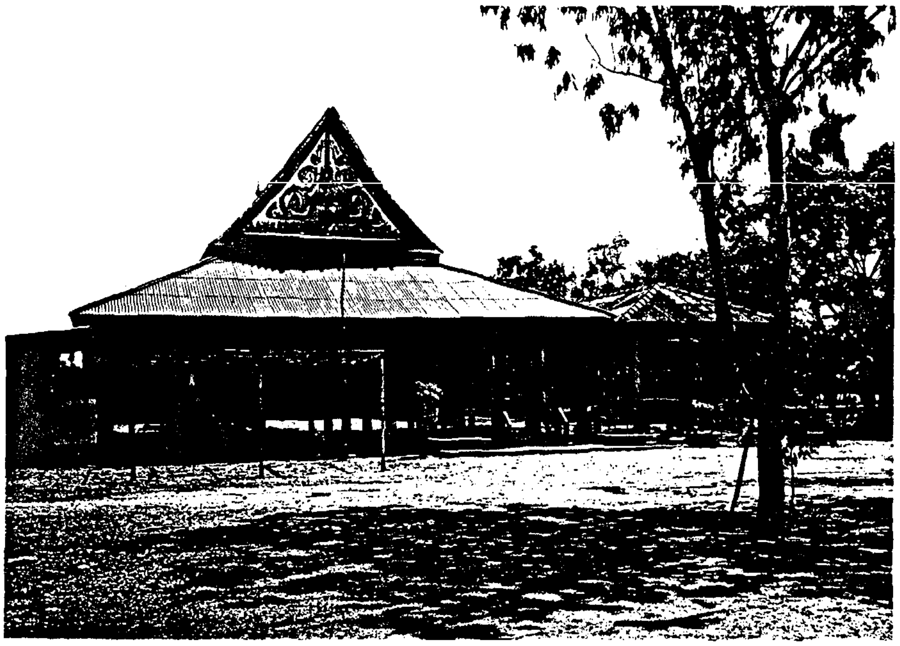

PHOTO F-7 WAT LAM PHRAYA NEAR PROPOSED POWER PLANT

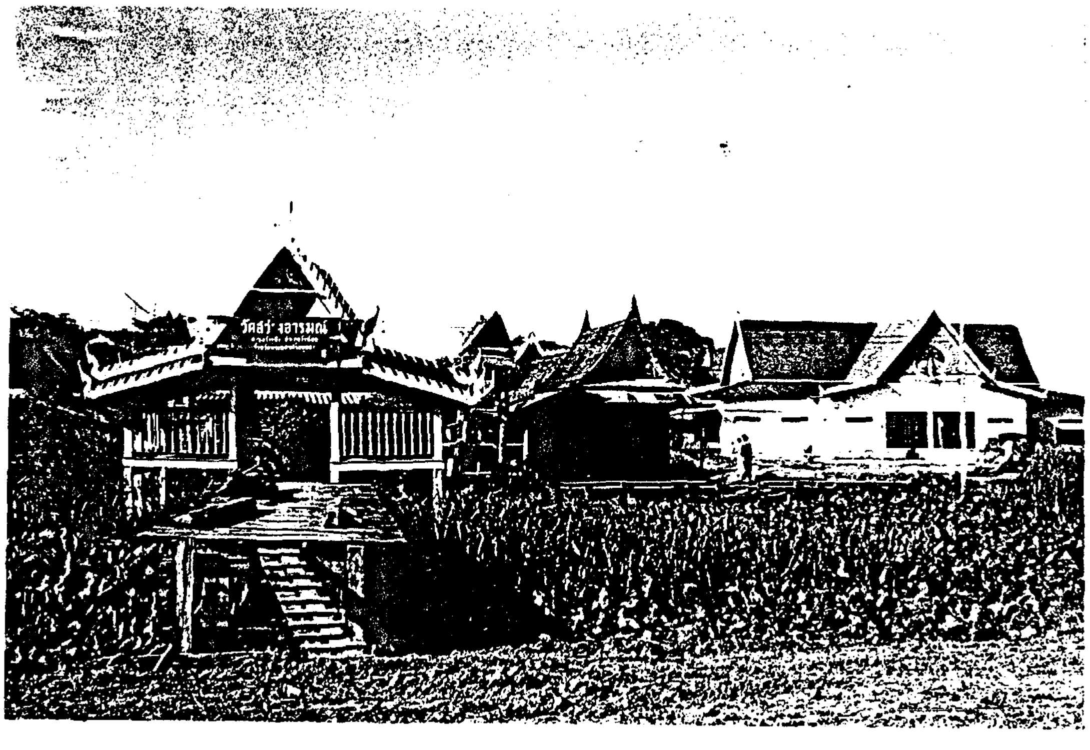

PHOTO F-8 WAT SAWANG AROM 2 KM FROM POWER PLANT

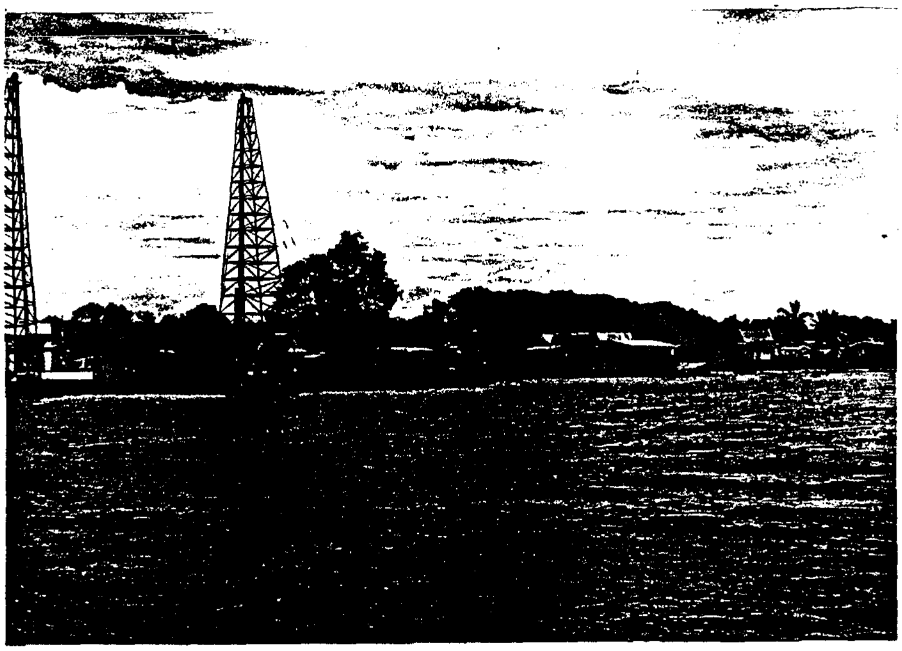

PHOTO F-9 WATER SAMPLING STATION NO.1 AT BANG SAI

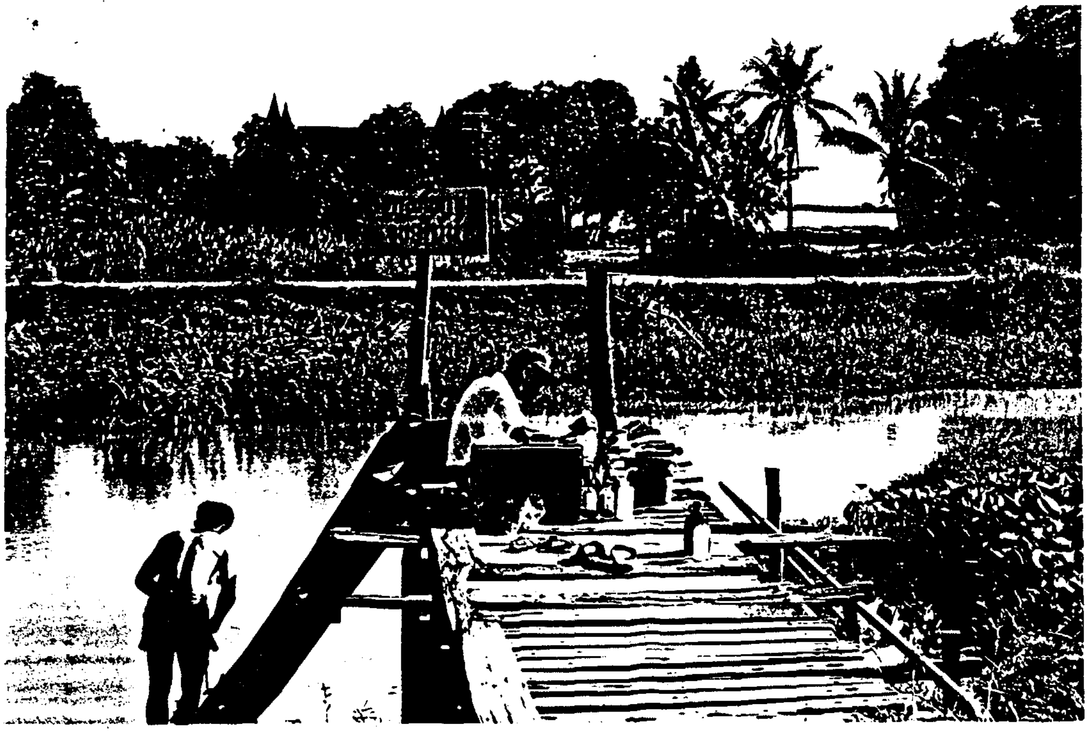

PHOTO F-10 WATER SAMPLING STATION NO.2 AT KHLONG RAPHIPHAT

UPSTREAM NEAR WAT SAWANG AROM

PHOTO F-11 WATER SAMPLING STATION NO.3 (KHONG RAPHIPHAT)

AT POWER PLANT

PHOTO F-12 WATER SAMPLING STATION NO.4 (KHLONG RAPHIPHAT) 500 METERS

DOWNSTREAM FROM THE POWER PLANT

PHOTO F-13 WATER SAMPLING STATION NO. 5 (KHLONG RAPHIPHAT) 1 KM DOWNSTEAM FROM THE POWER PLANT