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(Compilation of historical articles, notes and papers previously published as Articles, Reports, Working Papers or Journals)

ENGINEERING HISTORY PAPER #95

"Informal History of Shawinigan Engineering Activities in Malaysia"

by Chris Hanson
(former Shawinigan Engineering employee)

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EIC HISTORY AND ARCHIVES

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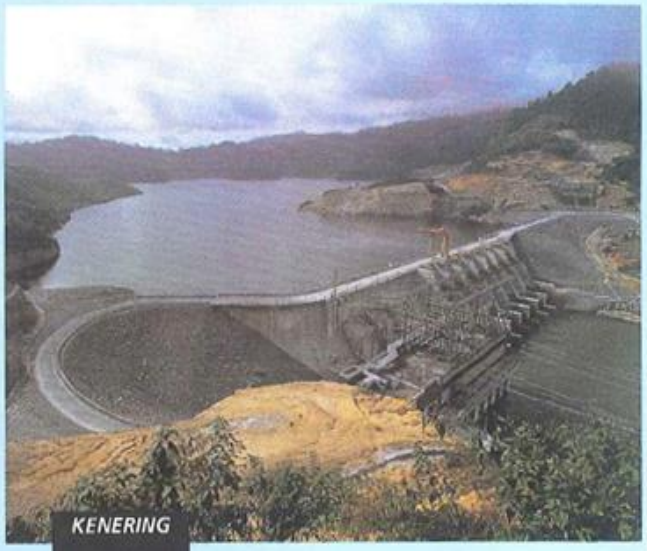
SHAWINIGAN

A Canadian company serving Malaysia for more than 25 years

56

TEMENGOR

Located on the Upper Perak River, the Temengor complex consists of a 126 m high rockfill main dam with a total fill volume of 7.2 million m³. Total installed capacity of the plant is 348 MW.



KENERING

Located on the Perak River, the development consists of a 48 m high concrete gravity dam, a spillway with a discharge capacity of 8960 m³/s and a three-unit powerhouse totalling 120 MW capacity.

SERVICES IN MALAYSIA AND AROUND THE WORLD

STUDIES • PLANNING
ENGINEERING • PROCUREMENT
PROJECT MANAGEMENT • TECHNOLOGY TRANSFER

Shawinigan Engineering Company Limited

A Subsidiary of SNC-SHAWINIGAN Inc., the hydroelectric, water resources and electric transmission division of SNC•LAVALIN Inc.

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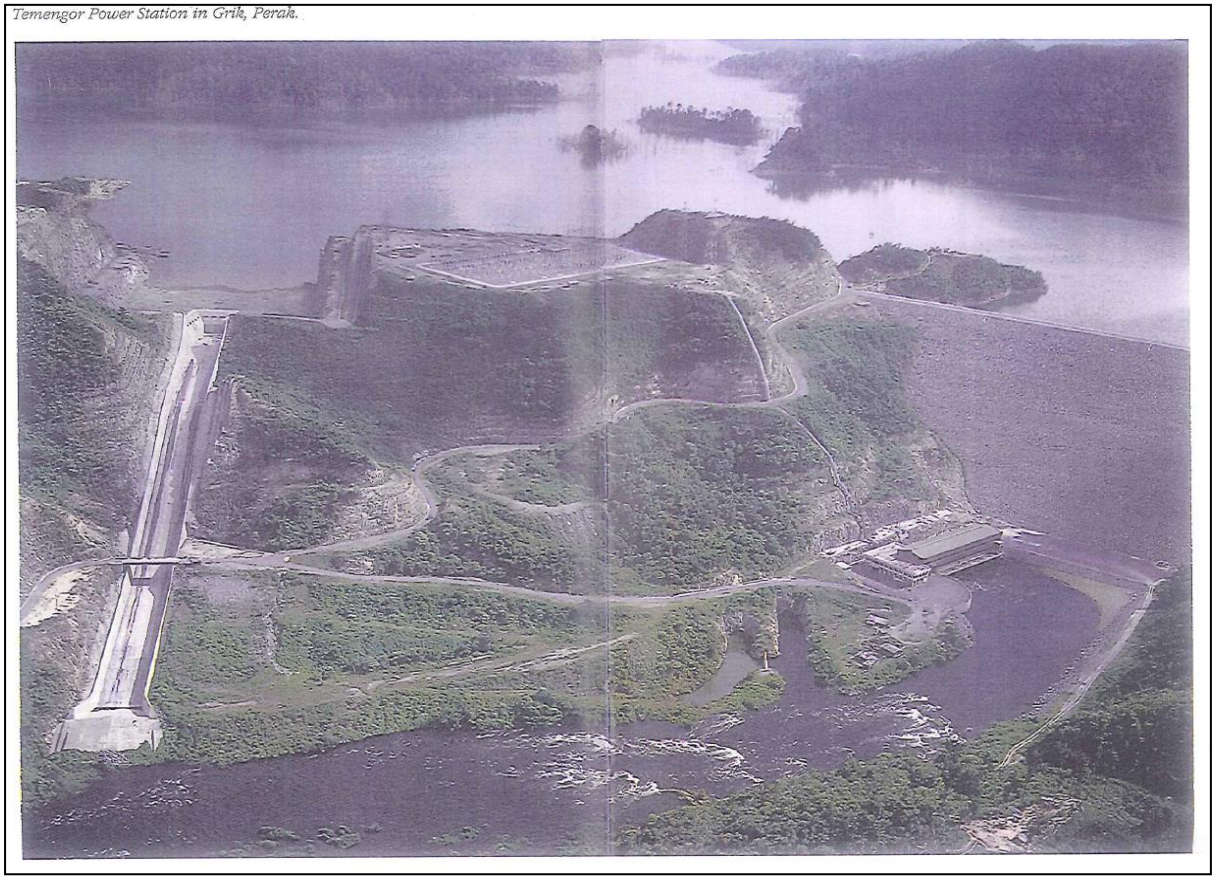
A Brief Overview

of the Involvement of

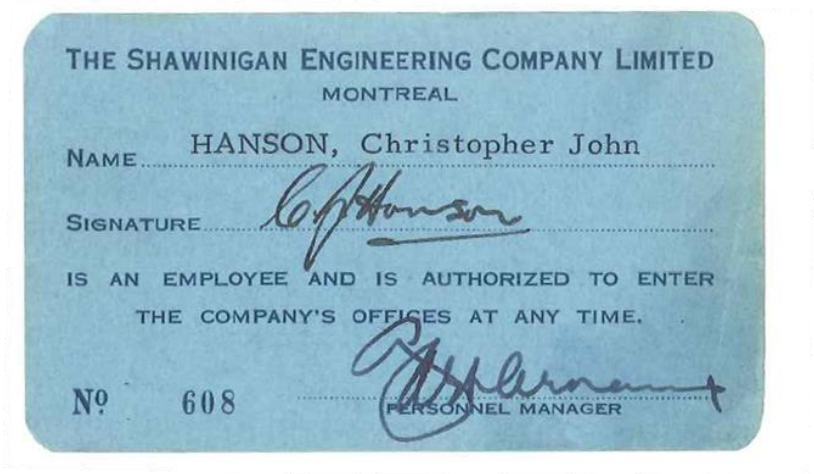
The Shawinigan Engineering Co. Ltd.

in the Development of Hydropower in Malaysia.


Temengor Power Station in Grik, Perak.

Prepared from personal records and recollections by Chris Hanson

with help from Travis, Peter, Gordon Gullan, Hank, Eddie and Ugo.


THE SHAWINIGAN ENGINEERING COMPANY LIMITED
MONTREAL
NAME HANSON, Christopher John
SIGNATURE C J Hanson
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THE COMPANY'S OFFICES AT ANY TIME.
Nº 608
PERSONNEL MANAGER

Capturing the Silver River Cascade in Malaysia

1. Introduction

Shawinigan Engineering Co. Ltd. (SECO), the employee owned hydropower engineering Company that resulted from the Nationalization of Hydropower installations in the Province of Quebec, first became involved with the Sungai Perak (the Silver River) in February 1964. The Government of Canada, under the auspices of the Colombo Plan, authorized SECO to undertake a Feasibility Study of the Hydroelectric potential of the Upper Perak River. That initial involvement led to more than 56 years of the company's involvement of the development of Malaysia's Hydropower.

That long history is coming to an end this year, due largely to the debarment of SNC-Lavalin by the World Bank. This 10-year penalty, for issues unrelated to the Hydropower Group, effectively prevented the Malaysian company SNC-Lavalin Power Malaysia Sdn. Bhd. (SLPM) from winning work in SE Asia even if funding by IFI's was not an issue. Private or National Developers were put off from engaging SLPM's services which ultimately has led to the sad demise of SLPM.

Notwithstanding that, this little memoir will chart the Companies successes in Malaysia. Initially work was for the National Electricity Board (NEB), which later became Lembaga Lektrik Negara (LLN) and eventually today's Tenaga Nasional Berhad (TNB). Staff from these organizations of note would be Tan Sri Raja Zainal, who was their GM and on retirement became the Chairman of our local company; (Freddy) Fong Thin Yew, Chong Cheng Cheng; Tung Yong Huat; Loh Chee Nam; Tuanku Mahmood; Thomas George; Sally Lim, and many more.

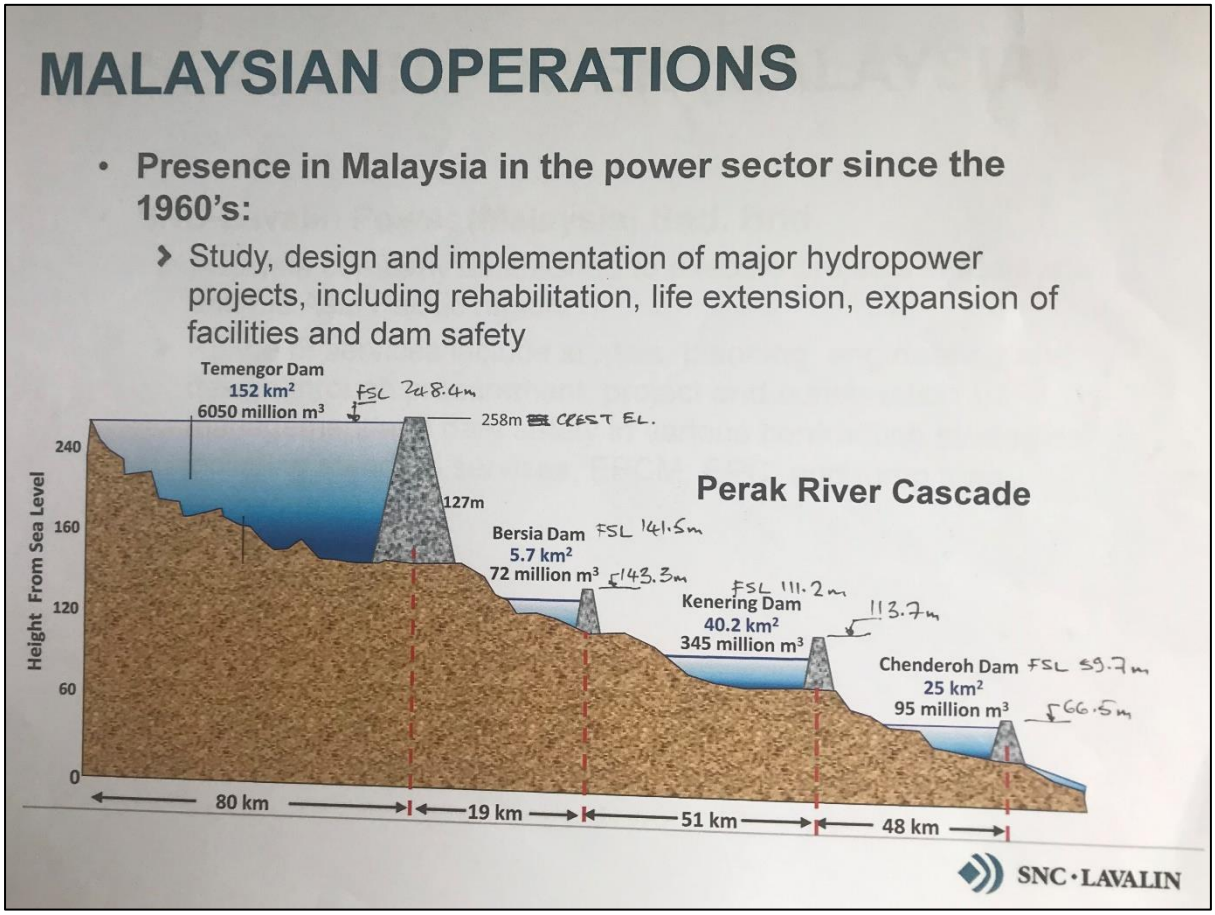
2. Temengor – the Early Days

Located on the western side of the Malaysian Peninsula, the Perak River

(Perak means Silver in Malay) has its source in the jungles bordering Thailand in the far north of the country.

Prior to this study there existed the earliest Hydropower development in Malaysia, The Chenderoh Project, located well downstream of the area being studied and built in the 1930's by a pioneering group, documented in the annals of the UK Institution of Civil Engineers. That early project was subject to malaria and other tropical health hazards as well as extreme remoteness at the time.

Thirty odd years later in June 1964, an intrepid group of nine Canadians set foot in the jungle to initiate the studies that would result in the further development of the cascade between Temengor and Chenderoh as shown in the figure below.



The initial field team comprised among others the following:

Jack Scovil (the boss), Alan Graves, Peter Banks, Klaus Santon, Ted Lawrence and Peter Mayers, assisted from time to time by Doug Denovan (project manager), Don Mackenzie, Nick Karnick, and Ken Gray. Mike King was in HO as was the chief hydologist, Shully Solomon.

The initial studies culminated in the recommended development of 3 power stations and associated dams:

- **Temengor:** an earth-core rockfill dam, 128 m high with a crest length of 537 m; an ungated bathtub ogee-crested chute spillway with a capacity of 2,830 m^3/s; and a surface powerhouse with and installed capacity of 348 MW using 4 Francis turbines.

- **Bersia:** a 33 m high concrete gravity dam, with a crest length of 200 m; a 4-gated spillway with a capacity of around 5000 m^3/s; and an integral surface powerhouse with an installed capacity of 75 MW using 3 Francis turbines.
- **Kenering:** a 48 m high concrete gravity dam, with a crest length of 450 m including earth-fill closure sections each side; a 7-gated spillway with a capacity of 9,000 m^3/s; and an integral surface powerhouse with an installed capacity of 120 MW using 3 Francis turbines.

3. Temengor – Implementation

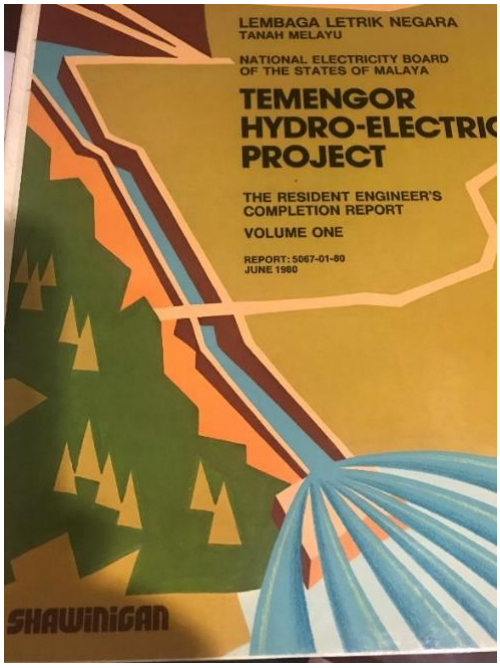
Further field investigations and Tender Design were carried out in 1971-72 and although initial civil works tenders were scheduled for October 1972, a series of design changes delayed the final tender call until April 1973. The main civil contract was awarded in December and the Engineer's Order to Commence given on 22 December 1973. The design team was led by Doug Denovan, with Ken Martin as Contracts Expert, Gary Warner as Chief Designer. Ugo Velicogna, Tony Stockdale, Frank Corbett and Richard Olive were also in the Team. Ron Steedman was the Country Manager.

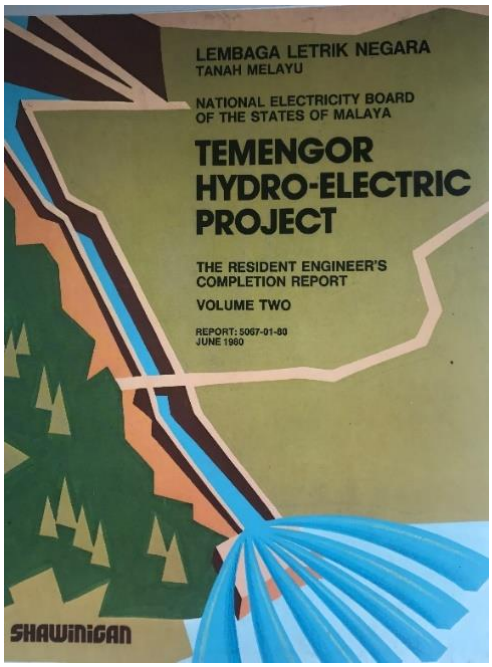
Construction was headed by Ed Irvine with support from Gordon Gullan and other expats together with Tee Boy and Choy among the support seconded from the client. Throughout the construction period the area was subject to insurgency from Chinese terrorist elements which resulted in the death of a Japanese engineer's wife, but although some SECO staff including Don Mackenzie, were involved in an incident where vehicles were shot at, there were thankfully no injuries to SECO personnel. Gordon Gullan's recollection of the incident was as follows:

"He was in the car seat of a Holden Station Wagon with the Chief Surveyor when they were fired upon hitting all tyres etc - only by his quick action to jump forward and grab the wheel while shouting at the driver to put his foot on the accelerator were they saved by getting the car round a bluff - there were 19 holes in the car: through the radiator, block, roof and one through the seat between Don and the Surveyor! (This was detailed to me on arrival by Meng Sang Wong (MS) - our fantastic local-Aussie Contracts Engineer."

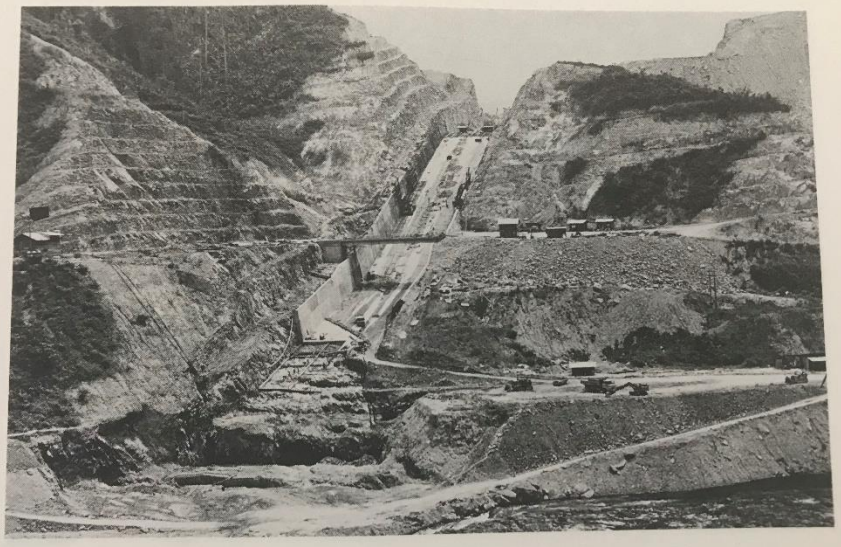
These incidents resulted in shutting down construction which only resumed in 1975

Civil works were started in January 1974 and substantially completed by October 1977 with the Project coming into service in mid-1978. The Project Completion report, a 2-Volume document was compiled by Gordon Gullan and finished from the Montreal Head office, with editorial assistance from his wife Sheila and Bob Ennis and drafting, the non-AutoCad style, by Ian Shurville. As a completion document, probably unmatched by any ever produced, it was proudly presented by Seco President Ken Gray at the opening ceremony in August 1978.





SHAWINIGAN



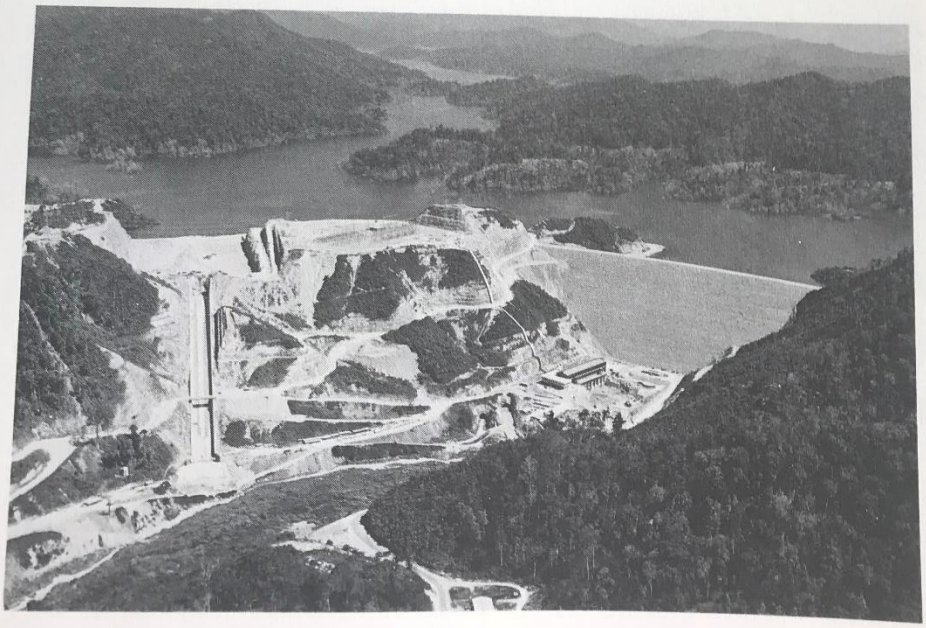
#55 Spillway Chute — Concreting Progressing Upstream from Bridge in 'B' Block and Downstream in 'C' Block towards Flip Bucket (excavation completed) —
30 May 1977

SHAWINIGAN

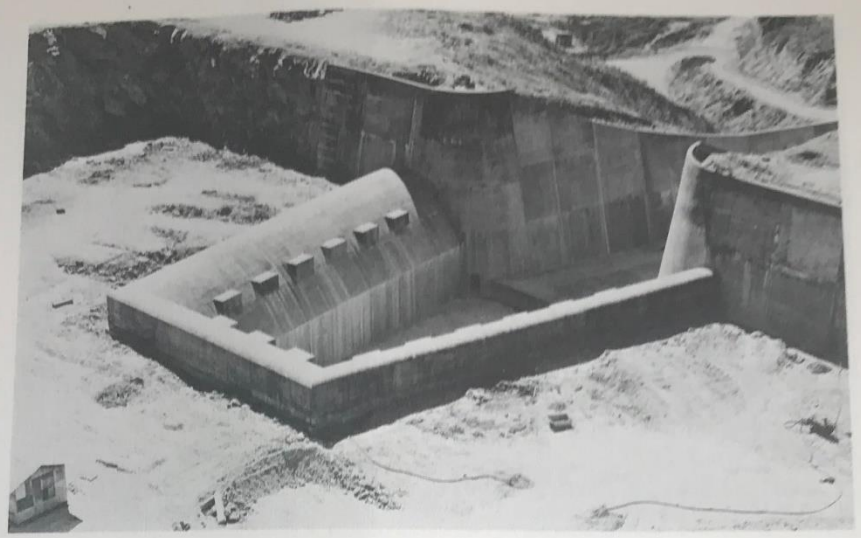
#1 Aerial View of Project Site from Upstream before Start of Construction — December 1973

#2 Aerial View of Project Site from Upstream — 21 February 1976

#3 Aerial View of Project Site from Downstream —
21 February 1976



#4 Aerial View of Project Site From Downstream After Completion of the Civil Works —
1st December 1977



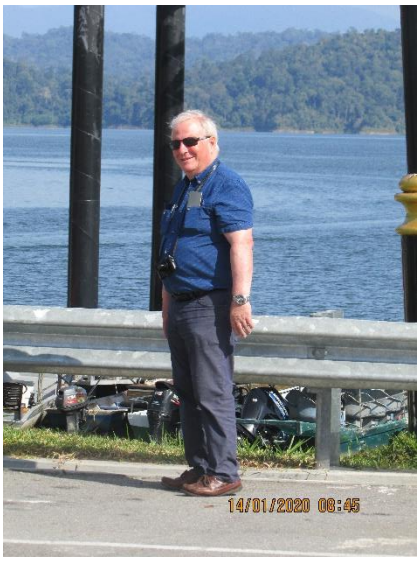
#57 Spillway Intake Chamber — Construction Completed — 29 December 1977

#58 Spillway — View of Completed Chute and Flip Bucket — 28 April 1978

4. Temengor – Operation

The huge reservoir, with an area of 152 km^2 and an FSL gross volume of 6.05 billion m^3, took over 4 years to fill to full supply level, although due to the commencement of impounding prior to fully completing the dam, the units were able to commence operation as soon as minimum operating level 27 m below FSL was achieved. In addition to power generation, the reservoir had a flood surcharge capacity of 850 million m^3, thus providing significant relief from the heavy NE monsoon rains to the river areas below the dam.

Because of the massive reservoir area and the inaccessibility of the same, initial logging was only carried out in the few kilometres upstream of the dam, a situation which resulted in the production of Hydrogen Sulphide gases (H_2S) that caused corrosion of non-stainless steel parts and the unpleasant characteristic "bad-eggs" smell, which can still be smelled in the lower parts of the powerstation even today in 2020. Subsequently to impounding though, significant amounts of valuable timber have been harvested by underwater logging techniques and most of the reservoir is now clear of unsightly trees projecting above the water level. Resort facilities have been built on the reservoir which is a wildlife heritage area.



Bridges to and from the island in the reservoir…….Gordon Gullan; ARE 1975-78

Temengor Powerhouse viewed from dam top

And dam viewed from below; powerhouse in lower foreground.

Eddie Fung provided a reminder of the Dam Safety Review:

"In 2003, TNB engaged SLPM to undertake a Dam Safety Review of the Sg. Perak Hydro Scheme. The report recommended:

- *review of the surface cracking to determine if it was due to Alkali Aggregate Reactivity (AAR), the possible occurrence of which was little known at the time Temengor was being designed.*
- *removal of weed growth from spillway chute slab joints; and*
- *grinding of the upstream edges of chute walls where the edge protruded above to downstream edge of the preceding wall section.*
- *It is not known if these recommendations were implemented.*

The Safety Inspection was carried out by Henry Mather and Mr Choy with assistance from TNB staff at site."

Due to the reservoir's major flood protection capability, the spillway has only operated twice. The 1st spill in 1993 was only minor, with a reported outflow of 680 m^3/s, but in the 2014 NE monsoon a major spill occurred which damaged the lower section of the spillway chute.

The pictures below show the Temengor spillway during the Dam Safety inspection in 2003/4 and in May 2006 prior to the flood.

Overflow spillway. Heavily crazed probably due to finishing technique! (2006 Photo) (Note: the 2004 Dam safety Report stated the cracking might be due to AAR.)

Picture T11 – Flip Bucket

Picture T12 – Spillway Chute

Picture T5 – Spillway Joints

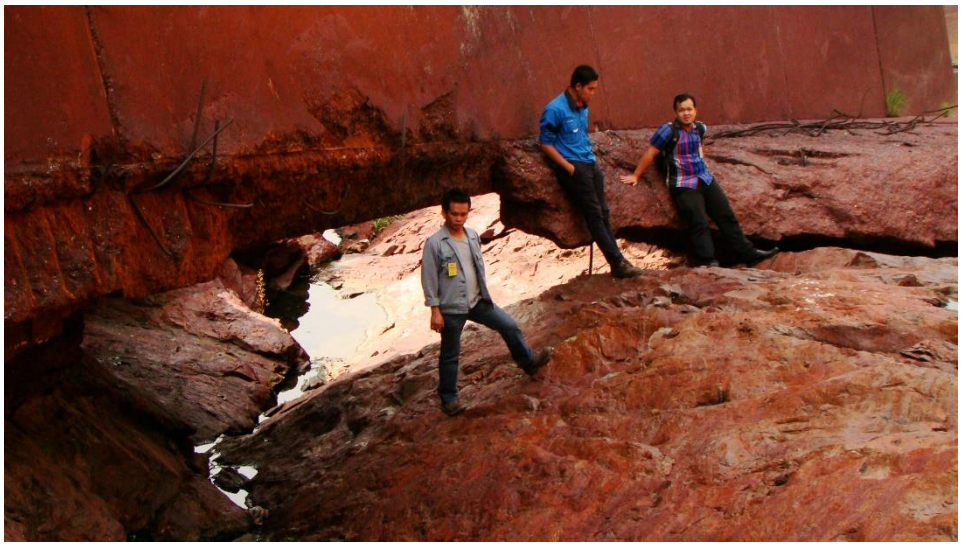
Above Photo and those on previous page from Dam Safety Report 2003/4

Lower section of chute where failure occurred viewed from Bridge. (photo May 2006)

Lower end of chute during December 26, 2014 flood

Failed slab section

Washed out slab.



Wash-out below left side wall inside view.

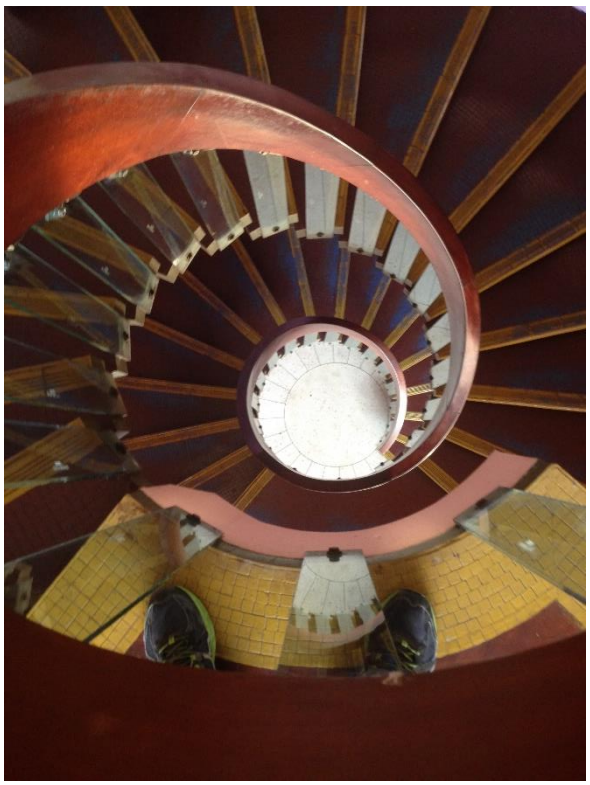
Wash-out below left side wall outside view.

TNB engaged SLPM, led by Dr. Jaysing Choudhary, to review design of repair works.

Chute repair work in progress, January 2016

Repairs to surface crest cracks, January 2020 photo.

Powerhouse viewed in January 2020.



Richard Olive's masterpiece spiral stair design…. seldom used now as overall control is at a new Group Control Centre built later at Bersia (photo in 2020)

5. Thermal Power

On seeing the 1st version of this review, Hank Sherrard commented as follows:

"It is recognized that your primary target was "hydropower", but it is somewhat disappointing that no mention was made of SECo's role in thermal power prior to Temengor Construction. In 1970 Hank Sherrard and Yee Yin Kwan were transferred to Malaysia and undertook the design, procurement, and construction supervision of the Civil Works for the expansion to the Tuanku Ja'afar power station at Port Dickson. Hank pushed some papers around and got the necessary contracts in place but Y.Y., in my opinion, is the only engineer ever to have designed practically every civil element of a thermal plant. The exception was the unique high-tuned foundations of the turbine-generators, which were designed in the Montreal office. A Malaysian Consulting Engineering company, Ganandra, Ahmad & Associates supported SECo with engineering, drafting and administrative staff.
The three units on their high-tuned foundations are still operating to everyone's satisfaction today."

Peter Mayers added the following observation:

"SESEA was the local company set up by Shawinigan, of which Tab Sri Rajah Zainal was Chairman for many years"

6. Bersia and Kenering Design & implementation

While Temengor was being put into service, the tender design of Bersia and Kenering was already underway. Project Manager Hank Sherrard worked with Dr.Bal Bondale Larry Kerkhoven and Richard Olive. When the latter left to join SEBJ in 1978, Chris Hanson joined the team on return from Magat tender design in Manila. On the E&M side were the athletic wind-surfing Italian, Ugo Velicogna, Tony Stockdale, Hugh Farthing, Peter Anderson and Frank Corbett. Alan Graves and Bill Sayers were involved with things geotechnical and Peter Banks worked on Hydrology and had major arguments with Ken Martin over monsoon flood magnitudes. Henri Simon was the ever-secretive cost estimator.

The hydrology issue was over the protection or not afforded by Temengor during the NE and SW monsoon seasons, Malaysia being blessed with abundant rainfall due to having precipitation from both seasons. The initial spillway designs for B&K assumed some protection from both monsoons by Temengor's massive reservoir. However, in the end it was agreed that there was little protection from the SW monsoon and both spillways had extra gates added in the final design.

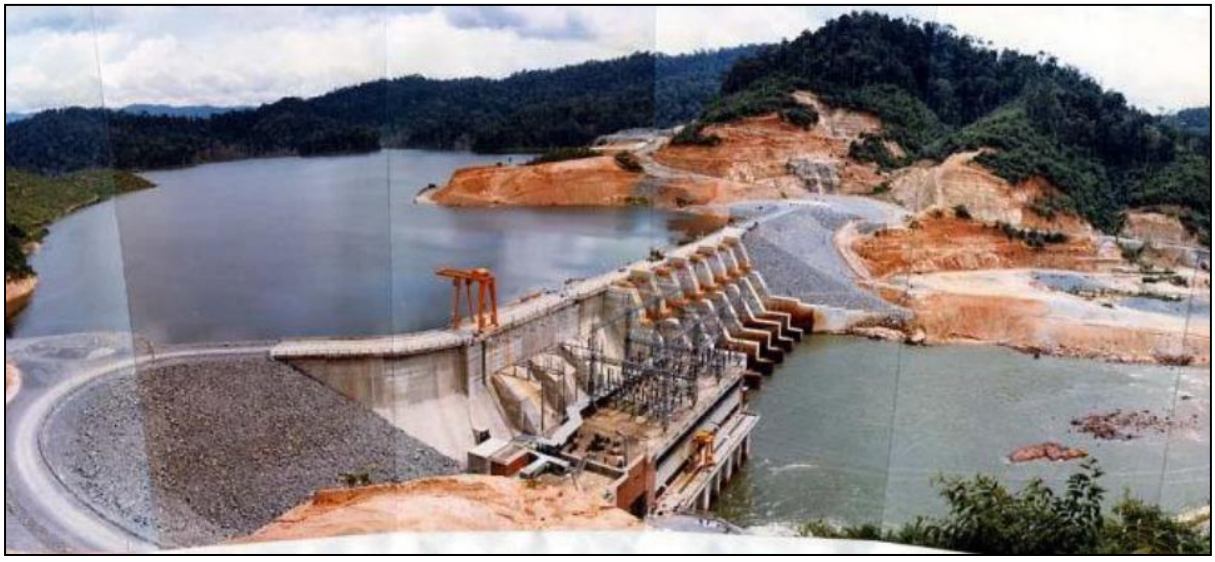
Both projects were put to tender in 1980 and constructed over the next 3 years. Terry Creaney was Malaysian Country Manager from 1981 to 1982 and the site team included, at various times, Keith Lockie, Oliver Baker, Michel Maeyens, Roly Jost, Roger Jeanette and John Russ as well as periodic visits by the head office designers. Terry recalls that on one occasion he went to Kenering site around lunchtime and saw one of the Geotech guys sitting eating his sandwich lunch, unaware of a tiger relaxing behind him, not far away. Fortunately for all, it lost interest and left them without incident! Still a fairly jungle place, unlike today where civilization and development has taken over.

Most of the pictures which follow were taken during visits by me, Chris Hanson, in May 2006 and January 2020.

Bersia powerhouse 2006; tailwater weir, switchyard on the roof

Overview of Bersia Damsite

Bersia Powerstation interior 2006



Overview of Kenering Damsite.

Kenering powerhouse and spillway 2006.

Kenering Powerhouse view 2006

Kenering, January 2020.

Deserted but preserved Army Gun post at Temengor bridge 2020

7. Small Hydro Studies 1980

With the main Silver River pretty much developed, the next SECO involvement was with Derrick Penman and Sam Ramsahoy who spent time looking at some 41 smaller hydro possibilities throughout peninsular Malaysia. I have little knowledge of this as due to delay in it happening, I was not part of the team, having jumped ship to Crippen Consultants for a job in Serendipity Sri Lanka, the fabled pearl-drop south of India.

In 1986 Sam and Derrick completed the Hydro Ranking study, which became the guidebook for all future major hydro developments in Peninsular Malaysia.

Also at about that same time the company undertook a comprehensive assessment of the Chenderoh project, not only dam safety and rehab, but also upgrade which included upgrading the existing plant as well as the possibility of adding an additional unit, which led to the addition of the 5th unit in 2012. Barry Trembath was the PM and there were numerous others involved.

The Bersia Group Control Centre was also established during that time, 1987-88 as I recall. This was the first Malaysian project using fibre optic cable strung on the existing power lines, and required the modernization of control equipment at Temengor to be monitored and run remotely from the new Bersia Group Control, making Richard Olive's client-requested spiral staircase somewhat redundant, but beautifully maintained. Hugh Farthing led the effort in country and was key to its success. A young Malaya EE, an excellent person, worked with Hugh and is now the head of REMACO, the TNB maintenance and repair group that repaired the burnt Tembat spiral cases that are featured later in this document.

8. Sungai Piah

In about 1984, a handsome young greenhorn of a wanna-be engineer by the name of Travis Edward Smith joined SECO. He was projected straight away to the mentoring of Ron Steedman in KL and ended up doing the foot-slogging donkey work on the investigation of the Sg. Piah, a tributary of the Silver River with its confluence above Kenering. He immediately fell in love with the country….. it was not that long before he fell again, this time for a lovely lady from Taiping in the Silver State of Perak. The young guy was energetic and ambitious and was to go far in the company, perhaps further than he ever dreamed in those early jungle-slogging days.

Sg. Piah is a complicated hydro scheme, typical of others in Malaysia, where smaller rivers are captured by drop-shafts and tunnels to make the resulting water flow worthy of hydropower development. It eventually came into reality as two powerplants; the upper one was a surface powerhouse with 15 MW capacity and the lower one an underground limestone cavern with 2 Pelton units totalling 55 MW. Richard Kockel, Domenic Martiniello and Dr. Bal Bondale (who replaced Y.Y.Kwan as PM) were all based in KL in TNB's offices during project execution.

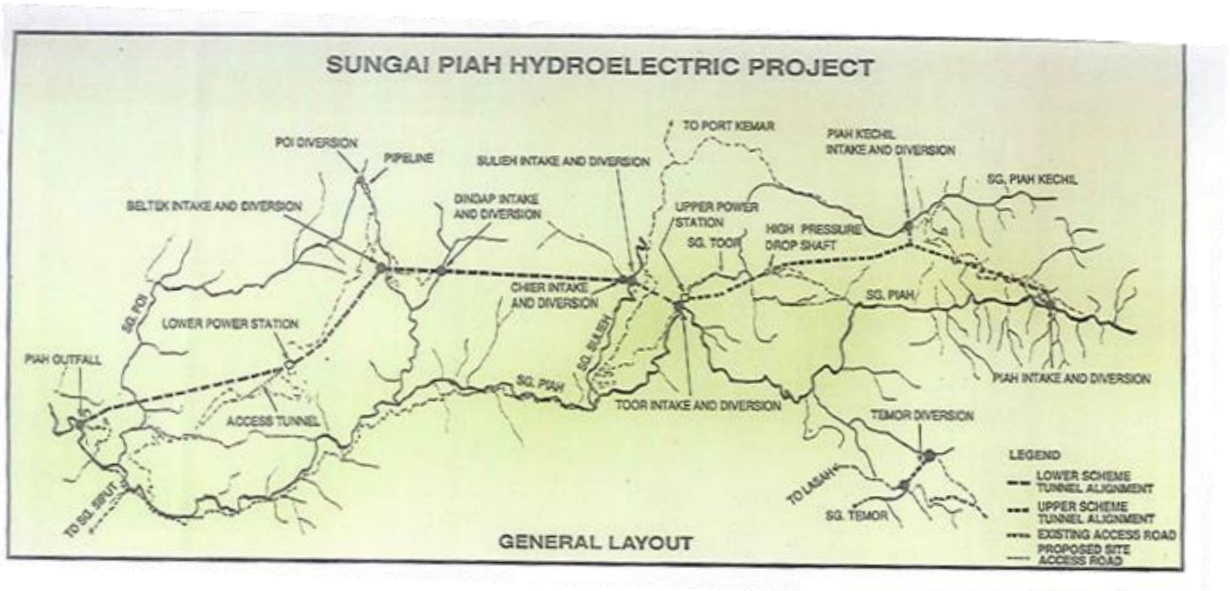
Extensive Hydraulic model testing of the intakes was undertaken in the Montreal LaSalle Hydraulic laboratory, supervised by Jaro Vocadlo, as excluding sand and gravel from the sediment-laden floods of the rivers was paramount to the scheme's long-term success. The Scheme was successfully implemented in the early 1990's, not without some leakage problems in the vertical 400m drop-shaft leading to the lower power cavern. The pictures which follow show the complicated intake desanding and flushing facilities necessary to keep the plants functioning. Fortunately, they did function well, producing valuable prediction exceeding revenue for the power utility.

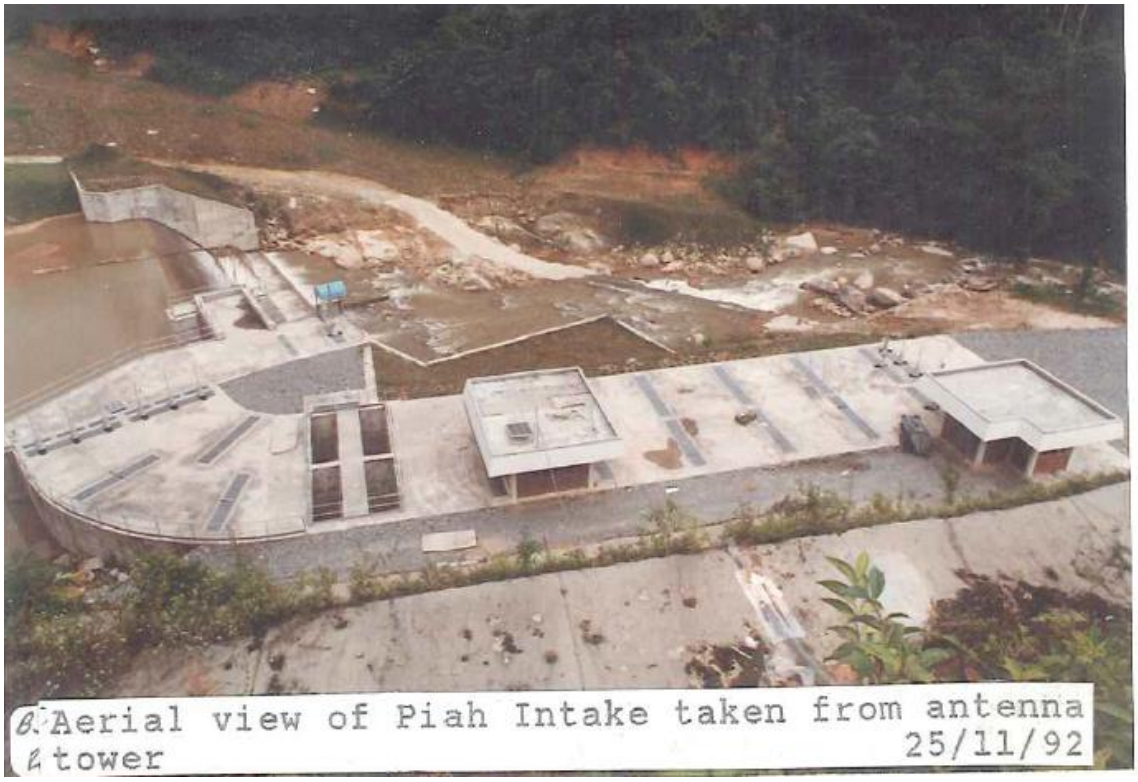
CRE on the job was initially John Russ, who was later followed by John Tasker. The latter was reputed to have made an ultimately futile request to the local Mullah to tone down the volume of the morning call to prayer from the mosque opposite to where he lived in Sungai Siput.

There are many stories that go with this project, including fact that the site was located in a "Black Ops Zone", so movement was only allowed from sun-rise to sun-set and otherwise you stopped wherever you were. All food was weighed going into site and the original trek to Upper Piah was over 10 hours through virgin jungle.

Persons who were of note before SNC got involved included, YY Kwan (PM), Alan Graves and Michel Maeyens (Geotech), Ken Martin, John Russ (1st CRE), Ugo, Tony, Richard Kockel, Dominic Martinello, Dr.Bondale, Tony Rosato, Peter Fudge, and Colin MacPherson, to name but a few!

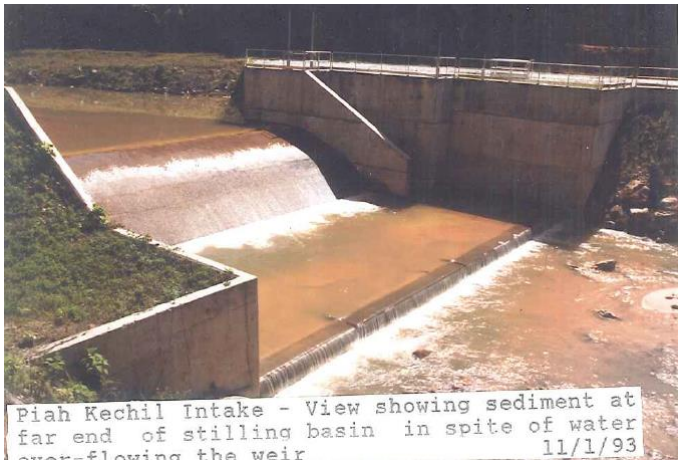
This was the first project where the detailed design was done in Malaysia - Peter Fudge was Lead civil, Colin was Lead draftsman and everything was done on drawing boards, the convention of that time.





8. Aerial view of Piah Intake taken from antenna & tower 25/11/92

General view of Piah Kechil Intake - 30/3/92



Piah Kechil Intake - View showing sediment at far end of stilling basin in spite of water over-flowing the weir 11/1/93

UPPER SCHEME

Catchment Area (km²)	118
Average Flow (m³/s)	5.0
Gross Head (m)	260
Intakes (number)	2
Powerhouse Type	Surface
Total Tunnel Length (km)	7.7
Station Installed Capacity (MW)	14.6
Number of Units	2
TurbineType	2-Jet Horizontal Pelton
Turbine Rated Output (kW)	7,500
Rated Net Head (m)	255
Generator Rated Output (kW)	7,257
Generator Rating	11 kV/8,558 kVA/ 0.85 pf/50 Hz
Annual Average Energy Output (GWh)	80
Switchyard	132 kV SF6 Type
Transmission Line	132 kV Single Circuit

LOWER SCHEME

Catchment Area (km²)	246
Average Flow (m³/s)	11.4
Gross Head (m)	403
Intakes (number)	7
Powerhouse Type	Underground
Total Tunnel Length (km)	13.8
Station Installed Capacity (MW)	55.4
Number of Units	2
Turbine Type	4-Jet Verticle Pelton
Turbine Rated Output (kW)	28,250
Rated Net Head (m)	400
Generator Rated Output (kW)	27,680
Generator Rating	11 kV/27,680 kVA/ 0.85 pf/50Hz
Annual Average Energy Output (GWh)	300
Switchyard	132 kV SF6 Type
Transmission Line	132 kV Double Circuit

During the Sg. Piah claims review led by Dennis Creamer, the team was requested to do an independent review of the contractor's claims for Pergau, a hydroproject in the North of the peninsula that was Britain's and Margaret Thatcher's last gesture to Malaysia, as a Turnkey Project by Balfour Beatty, for which the Owner's Engineer was SMEC.

9. Sungai Pelus

Another tributary of the Silver river, the Sg. Pelus, enters on the left bank downstream of Chenderoh. In 1992, SECO were asked by Impsa, the Argentinian Hydropower equipment Manufacturer, to carry out a pre-feasibility level review of a 210 MW peaking plant on the Sg. Pelus. The objective was to make TNB a turnkey offer to develop the project. I joined Alan Graves in Malaysia in early 1992 and we spent 5 weeks living in the Casuarina Hotel, Ipoh, and travelling daily to the Sg. Pelus area with Impsa's project manager. We had a rented Suzuki 4-WD jeep covered with advertising for Batu Ferringge beach resort in Penang, and a warning ***not*** to carry Durian in the vehicle. The road to Pelus was via dirt logging tracks with occasional speed bumps to slow traffic flow. One morning I forgot a bump and the client's manager suffered a sore head from contact with the jeep's roof!

CJH (aka a Pirate from the Caribbean) with trusty local guide

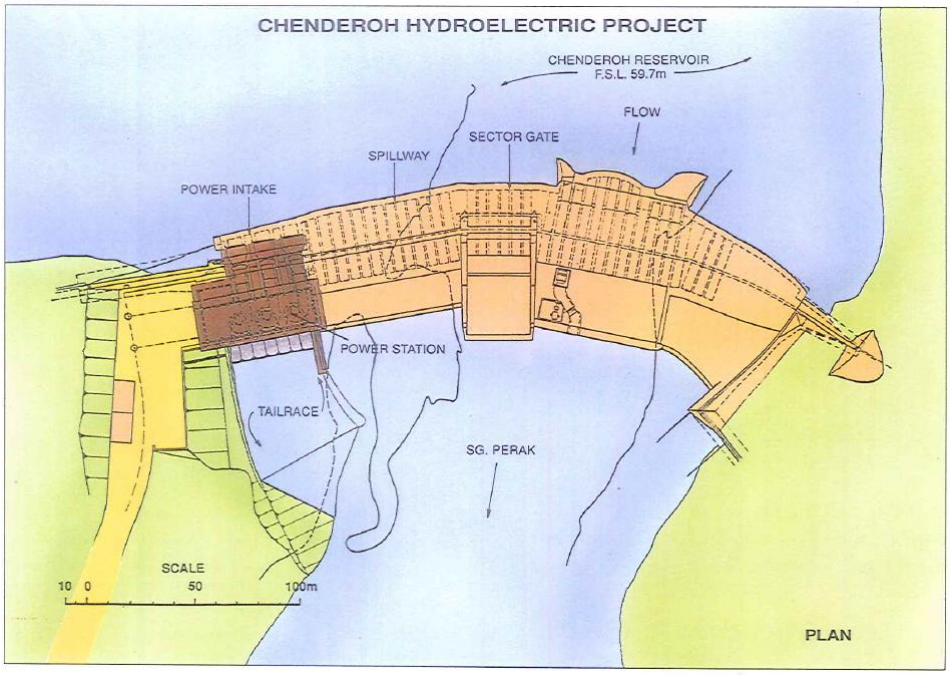
There were not many trails and the rivers were often the only way to travel, with suitable canvas jungle boots!

At that time, the scheme was envisaged as a 210 MW Peaking plant with a small reservoir created by an RCC dam. The flows of 3 small rivers were to be diverted using 3 tunnels totalling some 30 km in length. A power tunnel then led from the small reservoir to an underground powerhouse, whose tailrace tunnel was to discharge into a reregulation pond retained by a rubber dam mounted on an ogee weir.

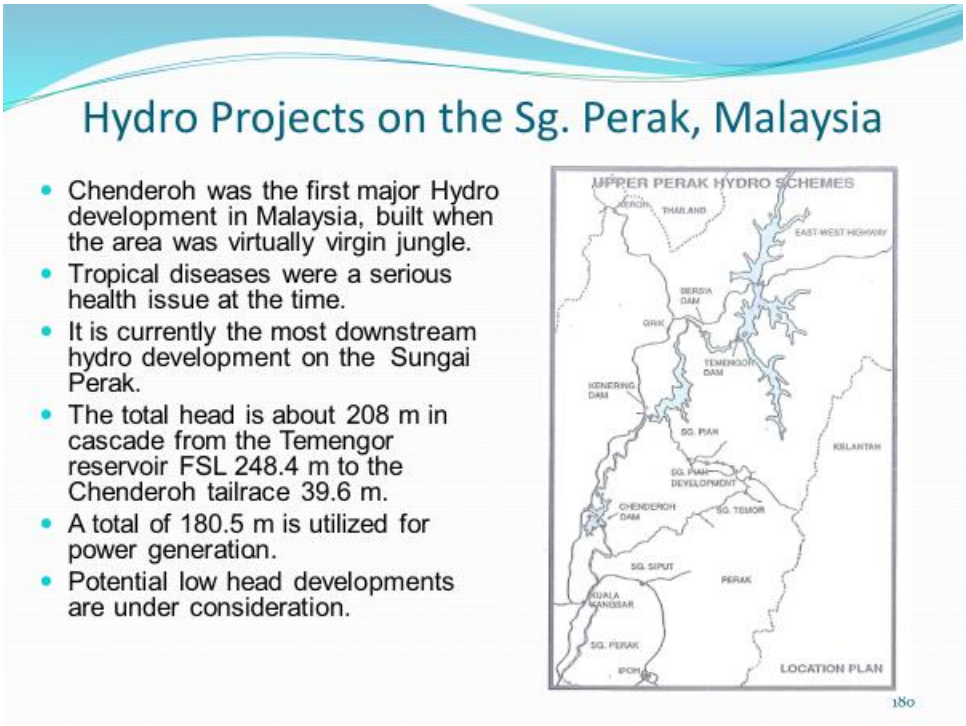
The TNB did not at the time accept the turnkey offer from Impsa and the scheme is currently changed to a 25 MW run-of-river option, as the reservoir area was not available.

10. **Chenderoh Additional Capacity**.

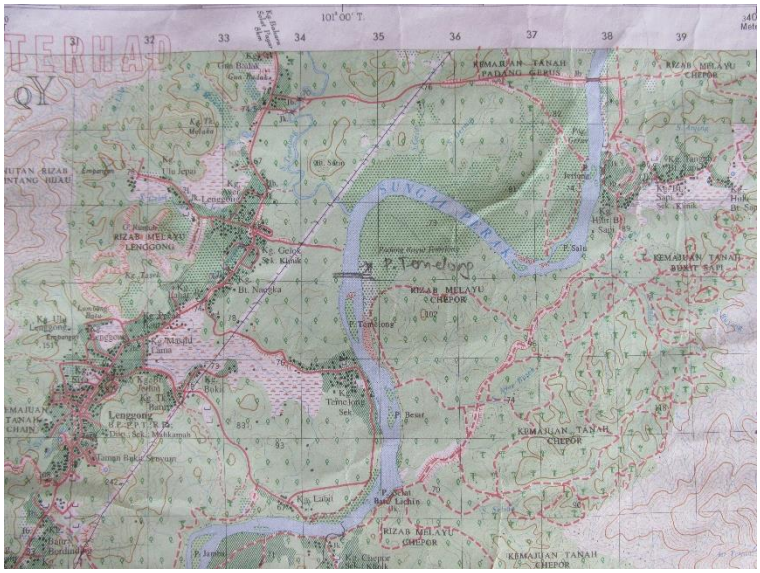
An initial assessment of adding extra capacity to the 1931 built Chenderoh dam was undertaken in 1986 but was not implemented until a re-assessment study was carried out by SLPM in 2011. The company also prepared the tender documents for the upgrade of the existing 3 units and provided technical support to TNB during the upgrade work which TNB had decided to undertake managing the project in-house. The 12 MW 5th unit was tendered in 2013 requiring replacing a section of the original dam with a new intake structure and buried penstock. Completion was in 2016.



11. Small Hydro prospects for Sg. Perak undeveloped head



Although 180.5 m of the head of the Silver River Cascade was developed by Temengor, Bersia, Kenering and Chenderoh, there remained the possibility of implementing additional low-head plants. Since the implementation of small hydro schemes had been opened up for private developers, SPLM undertook studies in 2015 for utilizing 5m head at Temelong between Kenering and Chenderoh and 4.5 m at Tengah downstream of Chenderoh. After further field survey the latter scheme was dropped, but the Temelong scheme was taken to tender design stage based on a rubber-dam configuration with S-turbines. Work was undertaken by Georges Casagran, Charlie Cadou, Jaysing Choudhary, Eddie Fung, and Ugo Velicogna with some guidance and oversight by me, Chris Hanson.



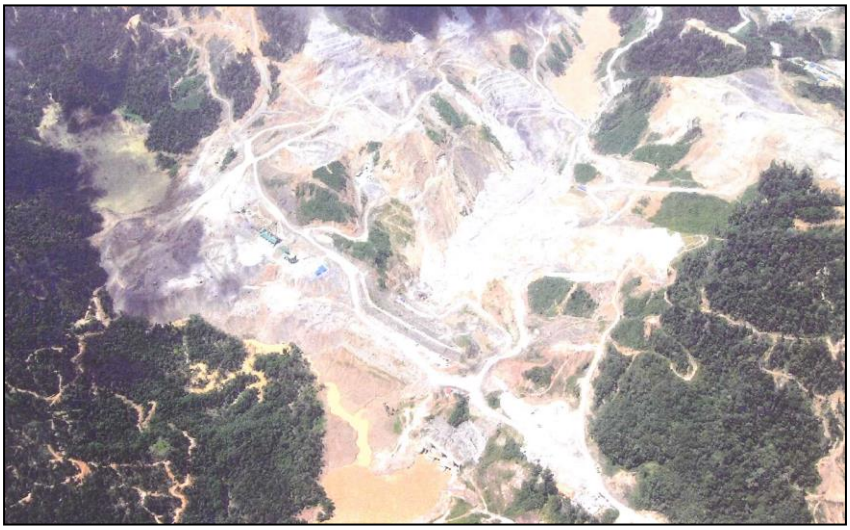
Temelong original Low-head hydro Site

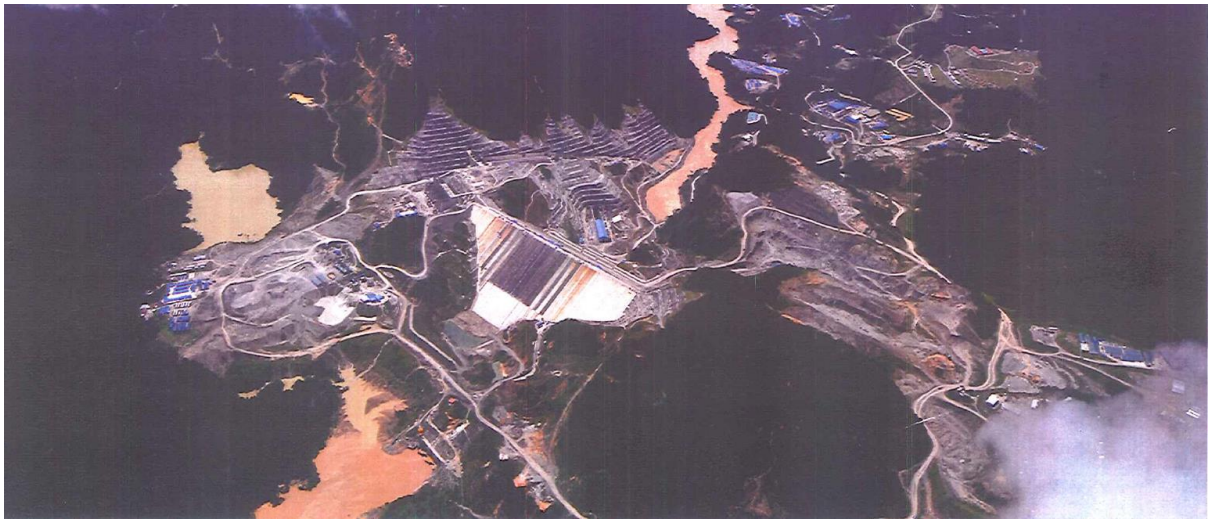
12. Projects far from the Silver River.

Under the able leadership and guidance of dynamic Canadian of Italian heritage, Dominic Martiniello, SLPM's presence in Malaysia continued to flourish and the company successfully participated in projects elsewhere than in the Sg. Perak catchment. In 2003 SNC-Lavalin was engaged by the Malaysia China Hydro Joint Venture (MCHJV) to review design and implementation of the Bakun Project in Sarawak. Three years later in 2006, SLPM was hired by TNB to undertake supervision of the Rehabilitation of the Cameron Highlands Hydro Cascade during which Dominic sadly passed away. His role as Regional Manager was taken over by Travis Smith, a position he held until he was promoted to be the Manager of Hydro West Group in Vancouver and his place taken by Rob Grant. During Travis's tenure, SLPM undertook a design review of the Ulu Jelai project, performed almost single-handedly by Jack Linard in his inimitable self-sufficient style, with cost estimating and planning help from Ted Dobinson. And last but not least, the construction design and supervision of the Hulu Terengganu Project on the east coast. Brief descriptions of these undertakings follow.

13. Bakun Dam, Sarawak, East Malaysia.

This massive project had been designed in the 1990's and construction had commenced when the financial crash of 1997 hit, halting work after only the three diversion tunnels had been built. Work was resumed in 2002 with the completion of the tunnels and the building of the diversion cofferdams, an event which was only achieved after 29 failures due the unpredictable flash floods from the huge catchment. SNC-Lavalin's involvement began in 2003 when Sime Darby, the Malaysian lead partner for the MCHJV turnkey Civil Works Contract, enlisted their services to review designs undertaken by the Chinese Design Group NIDRI as well as construction planning and implementation. The team included Gilles Porlier, Lee Stanton, Alexei Maiorov, Travis Smith and me. The dam was a Concrete Faced Rockfill with a height of 205 m, at the time the 2nd highest CFRD in the world. The surface powerhouse contained 8 x 300 MW Francis units fed by separate intakes, penstock tunnels and shafts. A 15,000m^3/s radial gated chute spillway terminated in twin flip buckets. The massive reservoir stretches some 60 km and had a gross storage of 44 billion m^3, bigger than even the huge reservoir of the Three Gorges Dam. Bakun Dam Excavation pictured below in 2003.





Upstream Slab Construction

Intake to 3 No. x 13m dia. Diversion Tunnels. Post impounding it was reported that 250,000 tonnes of driftwood were trapped by the Worthington log boom.

Spillway under construction……

……and with one chute in operation.

View of plinth construction

Overview of completed Bakun project during impounding that took around 1.5 years. Substantial riparian flow had to be released for river transport downstream

Ugo Velicogna added the following:

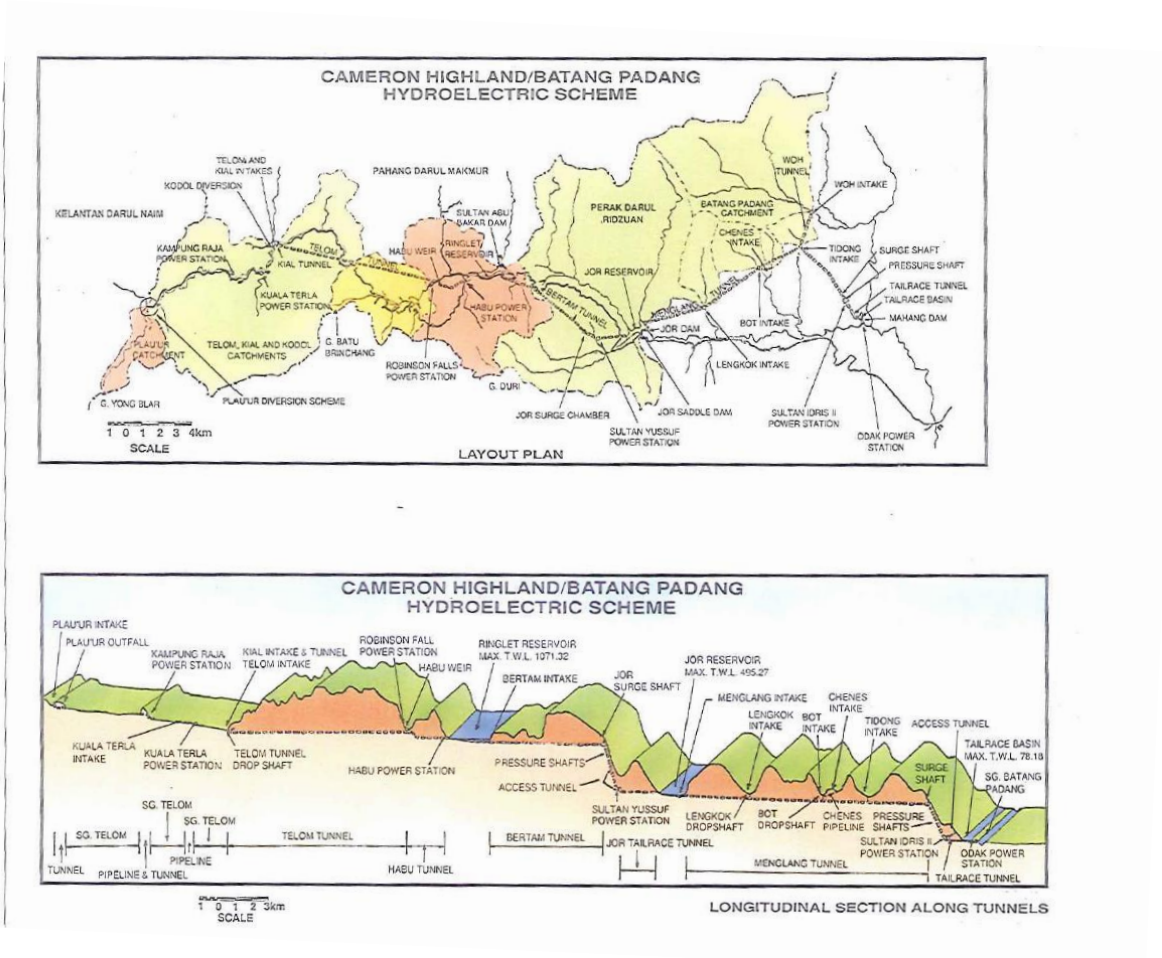
"During the first years of operation the hydro-electric components of 4 units at Bakun were extensively damaged by the corrosions caused by the hydrogen sulphide. In 2013, Members of the old Shawinigan Eng. Co were called on to carry out inspection and rectification works to the turbines, generators and electro-mechanical auxiliary components of unit 6 and 8. Travis Smith was the project director, site works were carried out by Ugo Velicogna and several electrical engineers."

15. **Cameron Highlands Rehabilitation Project.**

The Cameron Highlands Scheme was designed and supervised by Binnie & Partners in the 1960's and comprised the following powerstations with a total installed capacity of 265 MW:

- Robinson Falls – 3 x 300 kW
- Habu – 2 x 2.75 MW
- Jor – 4 x 26 MW
- Woh – 3 x 50 MW
- Odak – 3 x 1.6 MW

A concrete buttress dam created Ringlet Lake downstream of the Habu Powerhouse and afforded live storage to permit reregulation of flows to meet peaking power demands and gave reason for the famous Lakehouse Hotel, a mock-Tudor half-timbered building. Heavy sedimentation of the Ringlet Lake was reducing the live capacity and the units were reaching an age of over 40 years, so in 2005 SLPM won a contract to supervise dredging of the Ringlet Lake and replacement of the Turbine/generators at Jor and Woh.

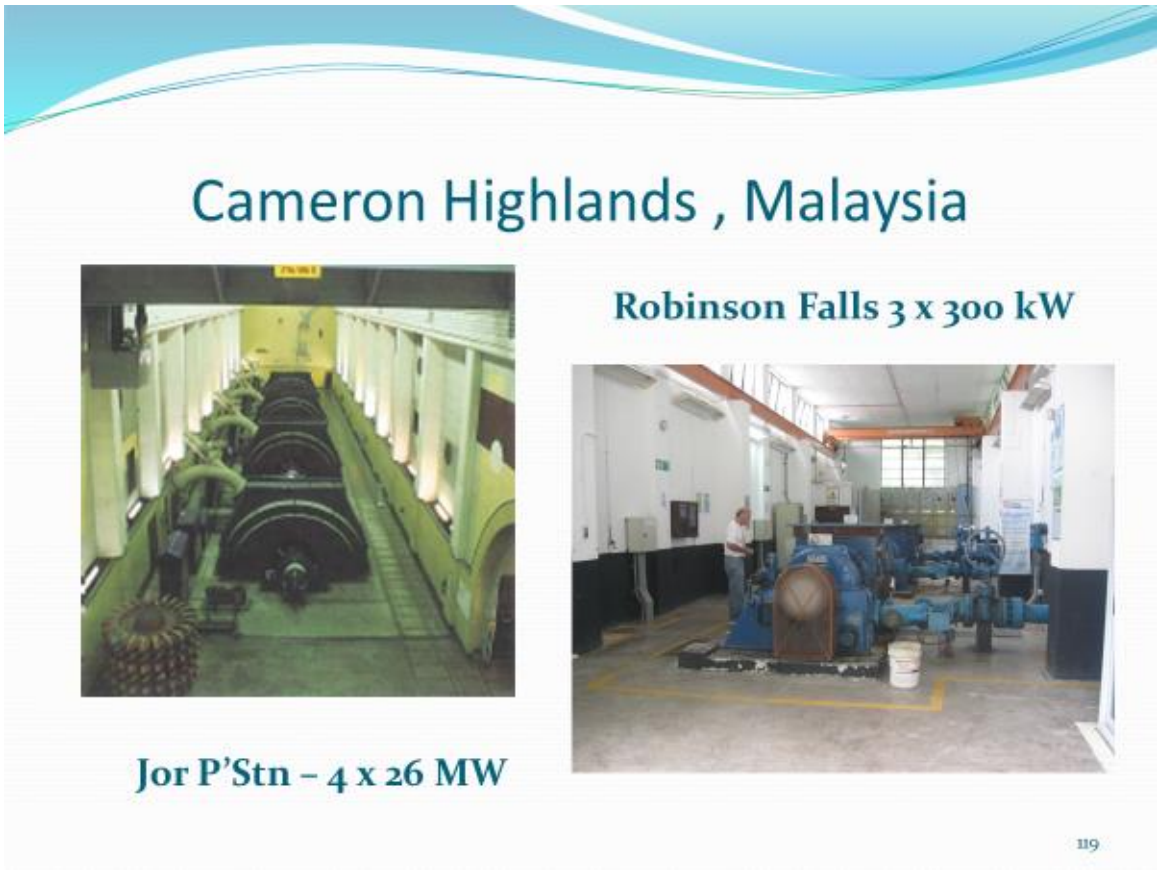


The dredging of the Ringlet Lake was by suction dredgers, which pumped the sediment into 3 settling lagoons to allow drainage of the water. The drained sediment was then trucked and deposited and compacted behind rockfill retaining dams in an adjacent valley. The team

involved with the project included Gilles Porlier, Michael Rooker, Robert Toombs, Derek Pereira, Jacques Vezina, Eddie Fung, Madan Rana and me.

The Lake dredging was headed from KL by Bertrand Masse, who eventually found out that road signs indicating “Pusat Bandara” was Malay for downtown KL and not some distant other place. During the dredging of the lake its surface became covered entirely by water hyacinth, which had to be removed and disposed of by trucking to a disposal area.

The dredging operation continues to the present day with a change from suction dredging to pontoon mounted long-arm backhoes, thus reducing the fluid volume to be pumped to the drying lagoon.



Ringlet Lake dredging when covered by water hyacinth in 2006. Nicer looking than muddy water some might say?

Ringlet Lake dredging using Backhoes on pontoons in 2019.

Impromptu inspection of the 1957 Robinson Falls Turbine by a curious Electrical Engineer

16. Sabah Hydropower Inventory

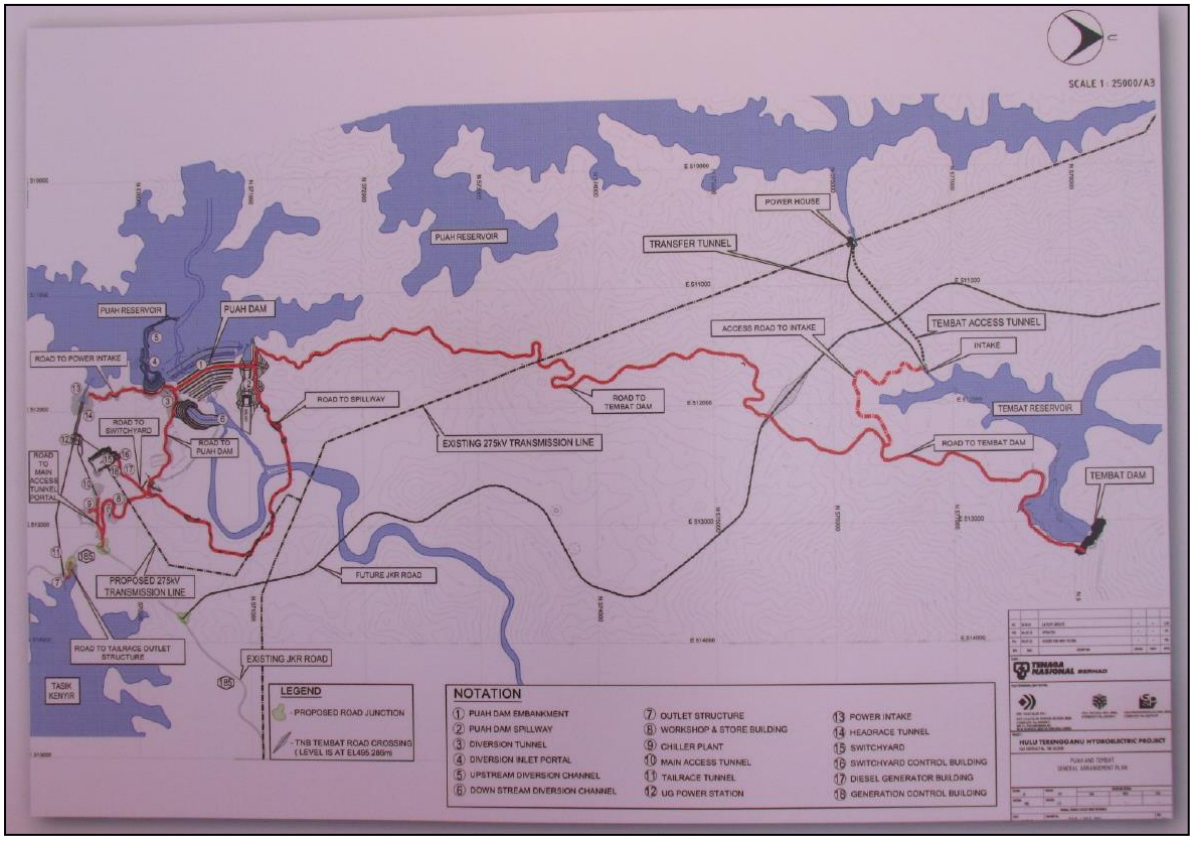
An inventory of Sabah Hydropower in East Malaysia was undertaken with Charly Cadou as the PM for majority of the project, and Juan Yupanqui finishing it up. It relied heavily on aerial photos and mapping of terrain using IFSAR the predecessor to LIDAR. SRTM (Shuttle Radar Topographic Mission), which was unable to detect the difference between treetops and the ground, resulting in a need to estimate tree heights in determining ground contours and reservoir volumes. It was used to produce a Digital Elevation Model (DEM), available globally with a cell size of 3 seconds of arc, representing approximately 90 metres at the equator and with a vertical precision in cell elevation of the order of 10 metres.

17. Hulu Terengganu Hydro Development

In 2011, SLPM was engaged by TNB to undertake Construction Design and Supervision of the 265 MW Hulu Terengganu Development in Terengganu State NE peninsular Malaysia. Tenders had already been received and contracts for Civil and E&M works awarded. The design team, initially led by Robert Gibson, included Milos Bozin, Fred Allard, Carlos Fontes, Zark Bedalov, Jaysing Choudhari and Juan Yupanqui, our Peruvian hydraulics expert, with support from Charly Cadou. Subsequently in 2012, I took over as PM until work was substantially completed in 2016. The site team involved at various times CREs Gareth James, Jean-Francois Normande, and Gordon Euinton, supported by Terry Page, Howard Fries, Sonia Larrivee, Simon Clark, Paul Caplan, Ulrich Glawe, Madan Rana, Benito Nepomuceno, our Filipino scheduler, Jackson Semple and last but not least the legendary Commissioning Engineer, Zark Bedalov, author of a recently published best-selling book explaining the mysteries of electricity to aspiring Graduate Electrical Engineers. Others included Choy Fook Kun, Afif Muhammad, Tony Dell,

Gray Finalyson, Rudy Tutipkalawan (from our days at Bakun), Robert Toombs, Eddie Fung, et al.

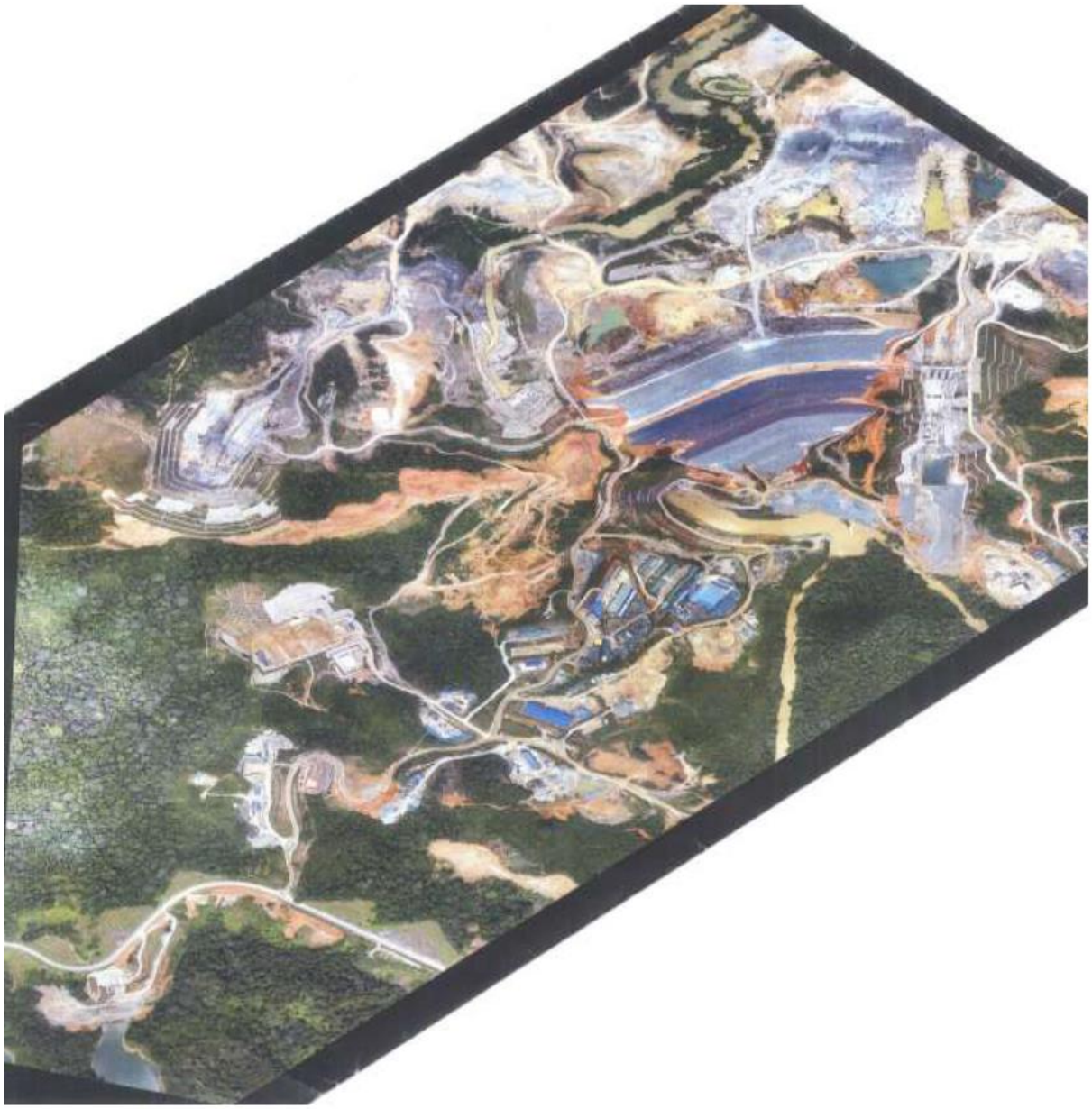
The project comprised a 79 m high, 600 m long earth-fill dam to create Lake Puah, a 15,000 m^3/s gated chute spillway, and a 250 MW underground powerhouse with a 1800 m long tailrace tunnel discharging into Kenyir Lake, a reservoir scheme that was implemented in the 1980's by SLPM's major competitor SMEC. A 2nd reservoir was created by a 38 m high, 200 m long concrete gravity dam at Tembat and the flow diverted through a 1300 m long tunnel to a surface 15 MW powerstation, discharging into the Puah Lake. The overall scheme is depicted in the map below:



During construction, TNB authorized a LIDAR survey to be made to verify reservoir volumes and areas. The resulting increase in capacity was remarkable, as LIDAR gets down to the ground level, especially in the valleys where the trees are tallest!

PUAH RESERVOIR AREA/VOLUME

LEVEL	LIDAR		IFSAR		Area	Volume
	Area	Volume	Area	Volume	increase	Increase
m	km2	mcm	km2	mcm	%	%
270	36.40	437.430	22.75	310.5	160%	141%
280	45.31	820.100	34.56	595.3	131%	138%
285	52.41	1064.422	41.49	785.1	126%	136%
290	60.05	1345.599	48.53	1009.9	124%	133%
295	68.12	1665.899	55.86	1270.3	122%	131%
299	74.92	1952.051	62.14	1506.1	121%	130%



Google Earth and down-to-earth views of Puah spillway and dam under construction.

Puah Spillway and Dam during construction.

Puah Power intake after impounding.

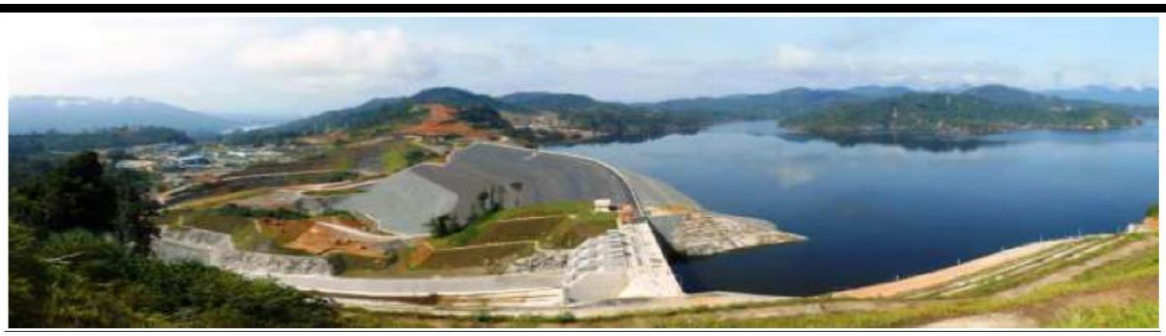
Puah Underground powerhouse during spiral case Installation.

Puah 2-unit Power cavern completed with Giertsen PVC drip ceiling.

Google Earth view of Puah Lake with Underground works superimposed.

Sunrise over Puah Dam

Puah Dam viewed from Right abutment.



Overview of Puah Dam, Spillway and Lake from Left Abutment

Overview of Puah Dam and Lake from Right Abutment

Puah Spillway looking Upstream

And downstream view. 275 kV Transmission line LILO connection in background

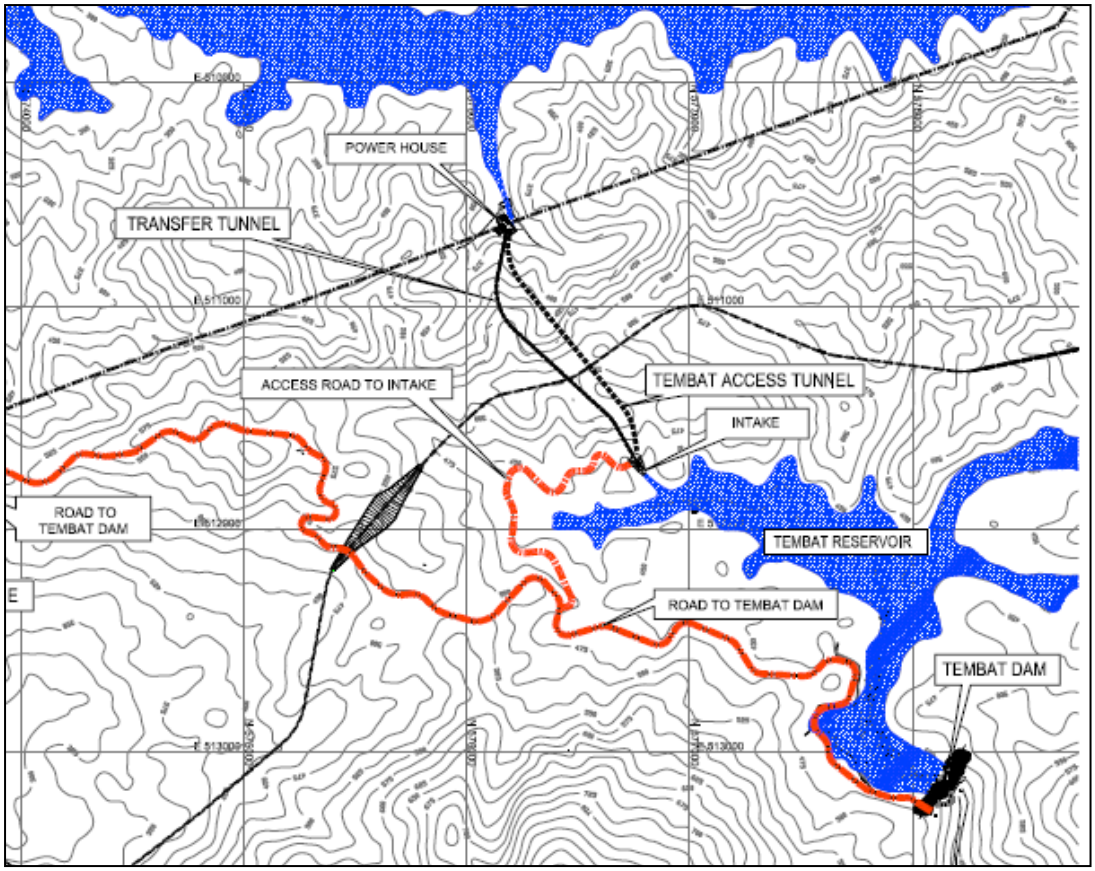
Puah Spillway with Riparian release flow of 1.0 m^3/s

Puah Power intake

Puah Tailrace outlet gate structure during construction

Tailrace outlet as completed with Gabion Weir.

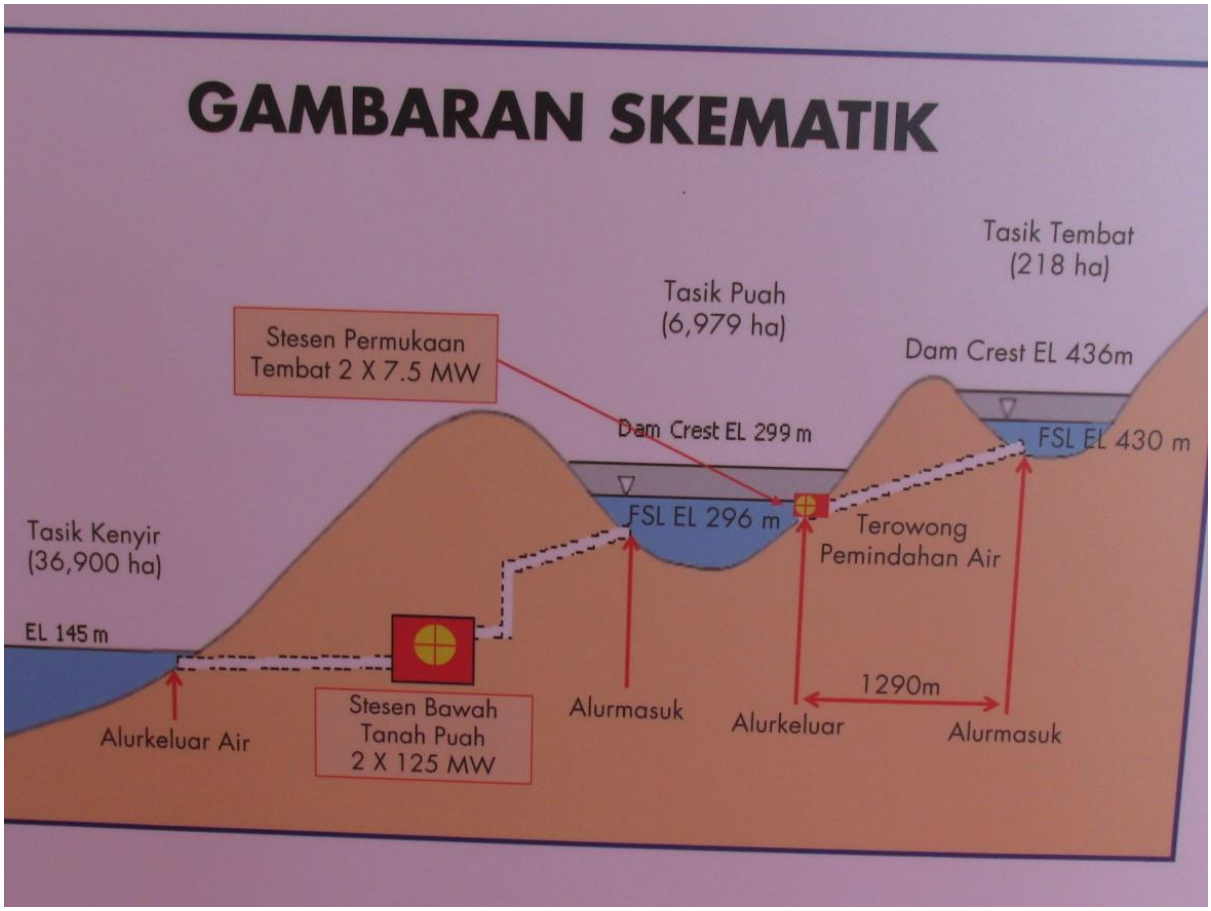
The winding 10 km road to Tembat with Puah Lake in background January 2020



Layout of Tembat Scheme. Unusual access to surface powerhouse by tunnel.

Lidar view of Tembat dam during construction. Yellow line indicates reservoir FSL.

Tembat dam overtopped by monsoon flood during construction



Schematic section of Puah-Tembat- Kenyir flow sequence.

Tembat Dam viewed from Left Bank

Tembat Dam viewed from Right Bank

Tembat Spilling – Tapered chute from 60m to 40m. Riparian release a bottom right

Rocky riverbed after spilling during 2019 NE monsoon. 0.5 m^3/s riparian release January 2020

Tembat Intake Forebay and Logboom

Tembat Powerhouse Manifold during Concrete surround placement

Tembat Spiral cases after unexplained fire on board during shipment from India to Malaysia.

Tembat Powerhouse: 2 x 7.5 MW horizontal axis Francis units, installed after refurbished by REMACO

Tembat Powerhouse – 65 tonne EOT Crane

Tembat Tailrace and Boat boom – Turbine output at 105% rated flow (~ 14 m^3/s)

(Note: Boat boom to prevent boaters on Puah Reservoir accessing the tailrace)

Tembat Tailrace outlet to Puah Lake.

Tembat Hollow cone valve operating at about 15 m^3/s

SECO Club (Malaysian Branch) in Mont Kiara, June 2014

Celebratory lunch at Puah Lake Impounding 01 October 2014. Gordon Euinton in centre.

Some of the Site Hulu Terengganu Team at Watering-up party 0ctober 2014. Richard Olive ERB chairman at right end.

The celebration Calendar of the Hulu Terengganu Civil Works Contractor.

This brings me to the end of my presentation today.

As you can see Hydropower is a fascinating and varied topic and has given me an unbelievable engineering career.....

....which I am happy to say is still continuing.

When I was an undergraduate in UK in 1962-65, I read about Cameron Highlands and Batang Padang in papers written by Binnie & Partners and published by UK Institution of Civil Engineers....but never at that time did I expect to spend the last years of my life working and enjoying living here in Malaysia.

I first walked through the doors of the office of the Shawinigan Engineering Co. Ltd. at 620, Dorchester Blvd., Montreal, Canada in June 1965, and so in June 2015 I will have reached my working half-century. It has been and continues to be an extraordinary experience.

I hope you will enjoy the career satisfaction that I have had and wish you luck in your future Hydropower endeavors.

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The Montreal Office Shawinigan-Lavalin Team - not all but many!

18. Epilogue

This rather personal review of the Shawinigan Engineering Company's major contribution to the hydroelectric power system of Malaysia, is a tribute to those who have made it such a success. It is sad that such sterling efforts should have come to the current situation, with the company closing down its operations in the country. Of course, none of the above would have been possible without a diligent, rather noisy at times, accountant, namely the other Italian in the Malaysian mafia, Franco Rende!

My own departure from SNC-Lavalin, the ultimate owner of Shawinigan's expertise, came after 37 years in 2016 and was marked by the photo below with members of the dedicated local Staff who helped along the way to bring the many achievements to operating reality.

Temengor	348 MW	1978
Bersia	75 MW	1983
Kenering	120 MW	1983
Sungai Piah	70 MW	1993
Cameron refit	250 MW	2008
Bakun	2400 MW	2008
Chenderoh	12 MW	2016
Hulu T	265 MW	2016
TOTAL	**3540 MW**	**2020**

Chris Hanson Hydro Experience 1965 to 2020

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8
	Project name	Country	Scope	MW	Head (m)	Turbine type	Remarks
1	Kettle Rapids	Manitoba, Canada	EPCM	1236	30	12 x 103 Kaplan	450kV HVDC transmission line 895 km long
2	Camlough	Newry, N. Ireland	Tender design	230		2 x Pump Turbine	Project stopped due to IRA
3	Mada River	Benue, Nigeria	FS	20		Not Built	Irrigation dam with Hydro -not built
4	Gull Island/Muskrat falls	Labrador, Canada	FS	3074		5 x 450 Francis; 4 x 206 Kaplan	400 kV HVDC T/line with undersea tunnel link to Newfoundland
5	Magat River	Luzon, Philippines	Tender design	540	100	4 x 90 Francis	Provision for 2 x 90 MW expansion . Major 31,000 m^3/s spillway. High seismicity
6	Bersia &….	Perak, Malaysia	Tender design	72	35	3 x 24 Kaplan	Concrete gravity dams, run-of river powerplants
7	….Kenering			120	42	3 x 40 Francis	
8	Mersey River	Nova Scotia, Canada	Rehab/replacement	20		multiple cascade	AAR problem with concrete.
9	Maduru Oya	Sri Lanka	EPCM	7.2	35	Planned - not built	3 -Small units on irrigation outlets
10	Cumberland River	St. Vincent, West Indies	EPCM	3.4	160, 80, 50	Horiz Axis Francis 1 x 1.4, 2 x 0.6, 2 x 0.4	6.5 km of woodstave and steel surface pipelines. 5 substations and 21 km of 33 kV transmission
11	Roseau River	Commonweath of Dominica	FS; EPCM	6.2	210, 280, 140	Horiz Axis Pelton 1 x 1.1, 2 x 1.7, 2 x 0.75	4.2 km of woodstave and steel surface pipelines, 900m transbasin diversion.
12	Nepal Micro Hydro	Nepal	Project assessment model			Cross-flow, small Pelton	Developed ranking program for Bank financing of small community rural electricity generation
13	Serpent River	Ontario, Canada	EPCM	6.5	50	Horiz axis double draft tube Francis, 2 x 3.25	Award winning Private Power Development, 1.5 km 2.74 m dia. woodstave pipeline
14	Tatinga	Anjuan, Comoros Islands	Project Review	4.5	210	Small Horiz. Axis Pelton	Head developed by surface pipelines
15	Grande Baleine	Quebec, Canada	FS	583	99	Francis	Not Built
16	National Energy Plan	Cote d'Ivoire, West Africa	Review of Hydro Plan				Assessment of potential capacity
17	Sungai Pelus	Perak, Malaysia	FS	210		Francis	Study for IMPSA, Peaking plant
18	Asahan	Sumatra, Indonesia	FS	210		Francis	Brief review of study
19	Nottaway,Broadback Rupert Complex	Quebec, Canada	Review of 25-yr studies	8200	Various , Cascade	Francis	Transfer scheme to develop 3 adjacent rivers by plants on one river only
20	Hydro Project Ranking	Nepal	Ranking of projects up to 50 MW				Development of spreadsheet analysis of Run of river developments
21	Otomona River	Irian Jaya, Indonesia	Pre- FS	233	826, 736	Pelton	Fast Track initial study
22	Wabageshik	Ontario, Canada	Rehab/replacement	8	22		Run-of-river, surface steel pipeline
23	Upper Snare	NWT, Canada	FS	24		S-turbine	Run-of- river, tunnel scheme.
24	Balambano	Sulawesi Selatan, Indonesia	EPCM	139	84.5	2 x Francis	RCC dam, run-of river powerplant
25	Shuibuya	Hubei, China	FS	1600	230	4 x Francis	Highest CFRD in world 230 m
26	Uma Oya	Sri Lanka	FS	130	700	3 x Pelton	Transbasin tunnel diversion
27	Wanmipo	Hunan, China	Value Engineering	240	60	3 x Francis	Review of Chinese Design
28	Three Hydro retrofit	Thailand	FS	28	10, 20, 64	x S-turbine, I x Horiz Axis Francis	Study to retro-fit small hydro to existing Irrigation dams
29	Isle Maligne &	Quebec, Canada	FS	75	35	Kaplan	Study to add hydro to existing power stations
30	Shipshaw			225	63	Francis	
31	Bakun	Sarawak, Malaysia	Construction Design Review	2400	200	8 x Francis	2nd Highest CFRD in world 205 m, largest reservoir in SE Asia
32	Karebbe	Sulawesi Selatan, Indonesia	Construction Supervision	130	70	2 x Francis	Hydro Combine (power house under spillway) Concrete gravity dam
33	Lasolo	Sulawesi Selatan, Indonesia	Pre-feasibility	100	100	2 x Francis	RCC dam, run-of river powerplant
34	Cameron Highlands	Pahang, Malaysia	Rehab/replacement	263	various	6 power plants	Dredging of reservoir, rehab of 40 year old turbines and generators
35	Herrick	B.C Canada	Pre-feasibility	40	93	2 x Francis	Run-of- river, tunnel scheme.
36	Mc Gregor	B.C Canada	Pre-feasibility	113	74	3 x Francis	RCC dam, run-of river powerplant
37	Nam Ngiep	People's Republic of Lao	Value Engineering	290	150	2 x 135 Francis; 1 x 20 Bulb	Review of design and cost of BOT scheme; 150 m RCC dam
38	Hulu Terengganu , Puah & Tembat	Terengganu, Malaysia	EPCM	265	151, 134	2 x 125 Francis; 2 x Horiz axis Francis	79 m high Earthfill dam and 36 m high concrete gravity dam. Undergound power house and 5.3 km of tunnels
39	Temelong Hydro IPP	Perak, Malaysia	Feasibility	10	5	3 x S-unit Propeller	6m Rubber Dam weir, surface Poweerhouse
40	Nalgad Hydro	Kathmandu, Nepal	FS Update & Tender Docs.	417	708	4 x 103.25 Pelton	248 m high RCC dam, 8.5 km Headrace tunnel. Undrground powerhouse
			Total	**21273**	**MW**		
24	in service		**Total in service**	**7558**	**MW**		