

Impact Assessment for Historical Sites in Rights-of-Way of Natural Gas Transmission Pipeline

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IAIA15: Impact assessment in the digital era

Florence, Italy



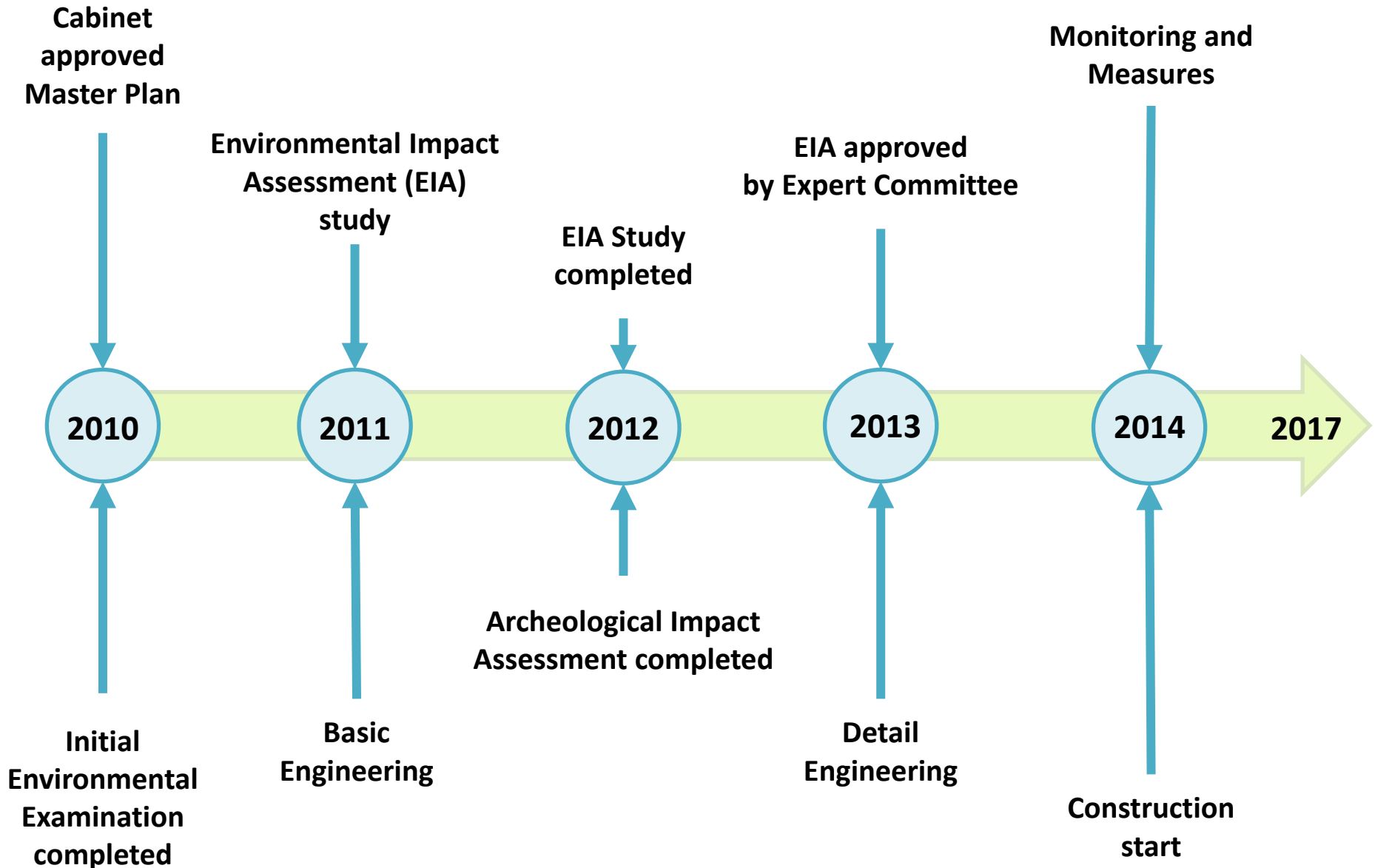
PTT Public Company Limited

- Former Petroleum Authority of Thailand (PTT) was established on December 29, 1978.
- Thai Premier Multinational Energy Company.
- PTT Gas Business Group covers exploration and production, transportation to gas separation and marketing of natural gas.

Project Background

- On 2010 The Thailand Cabinet approve Thailand's long term natural gas development plan and Master plan for natural gas transmission pipeline system No.3 first amendment.
- This plan was used as a guideline for PTT to invest in construction of Nakhon Sawan and Nakhon Ratchasima onshore gas transmission pipeline





Nakhon Sawan natural gas transmission pipeline project

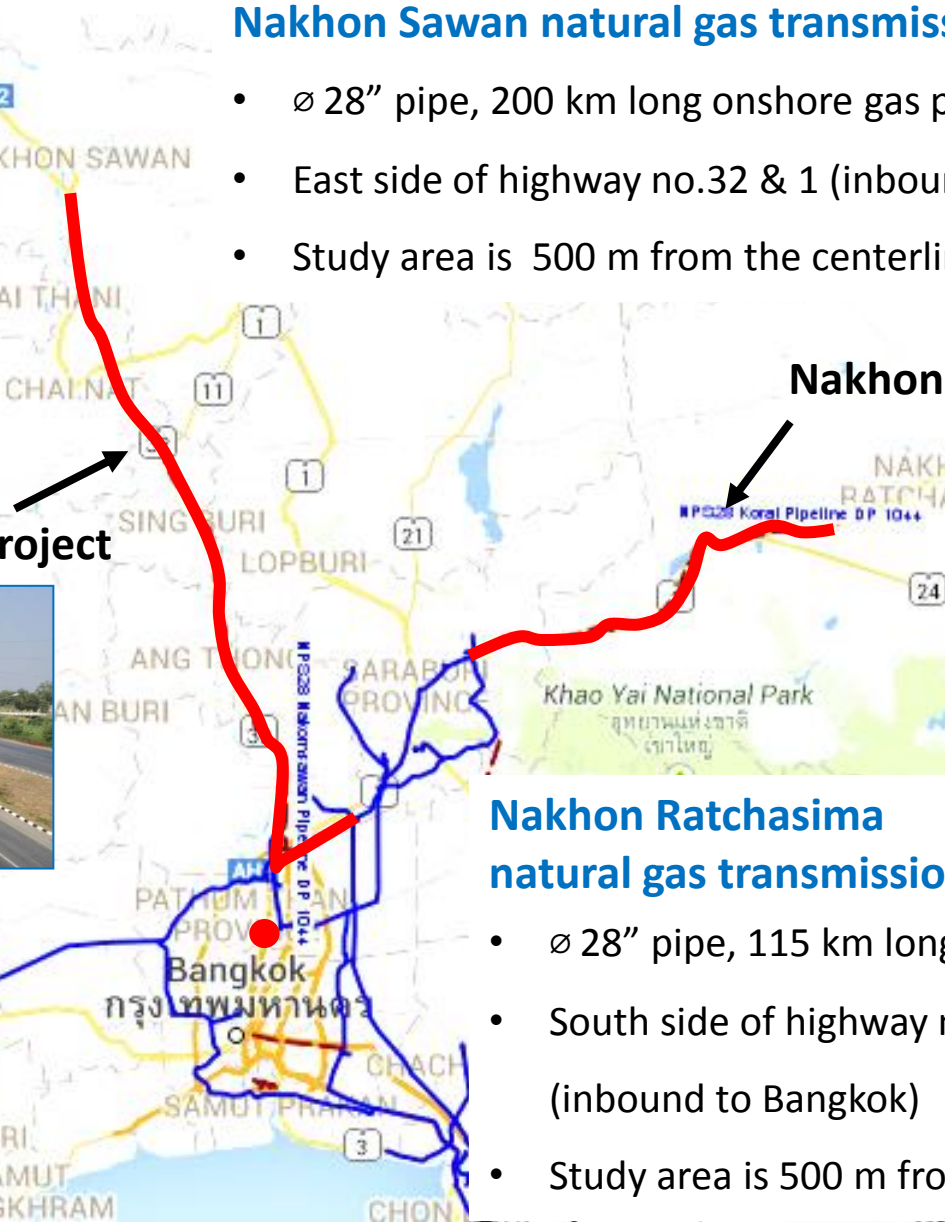
- \varnothing 28" pipe, 200 km long onshore gas pipeline.
- East side of highway no.32 & 1 (inbound to Bangkok)
- Study area is 500 m from the centerline.

Nakhon Ratchasima Project

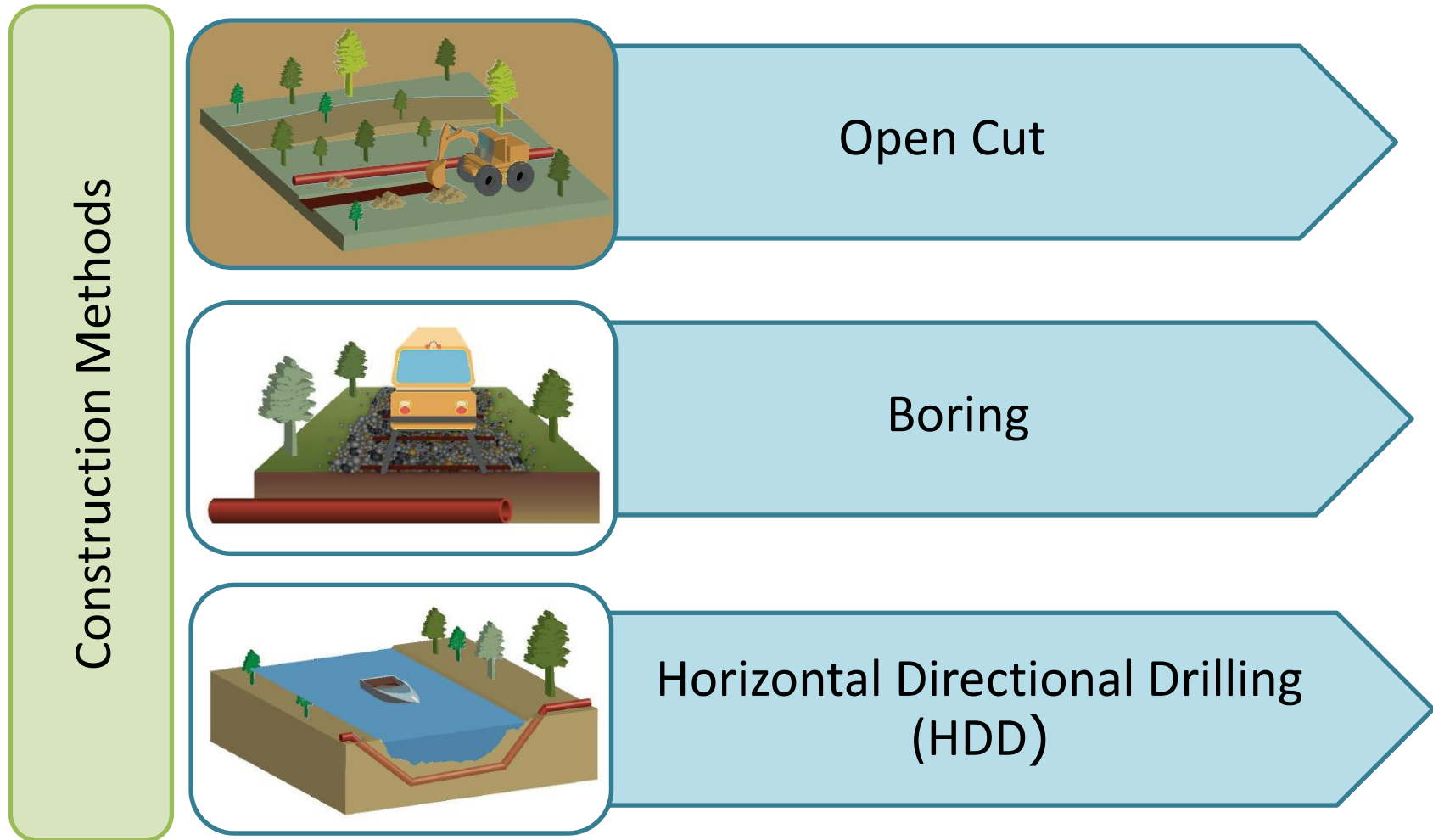
Nakhon Ratchasima natural gas transmission pipeline project

- \varnothing 28" pipe, 115 km long onshore gas pipeline.
- South side of highway no.2 (inbound to Bangkok)
- Study area is 500 m from the centerline.

Nakhon Sawan Project



The construction method considering based on the existing work site, less environmental & health impact, and public acceptance.



Open-Cut Method



Clearing



Trenching



Pipe Hauling



Welding



Coating



Lowering-in

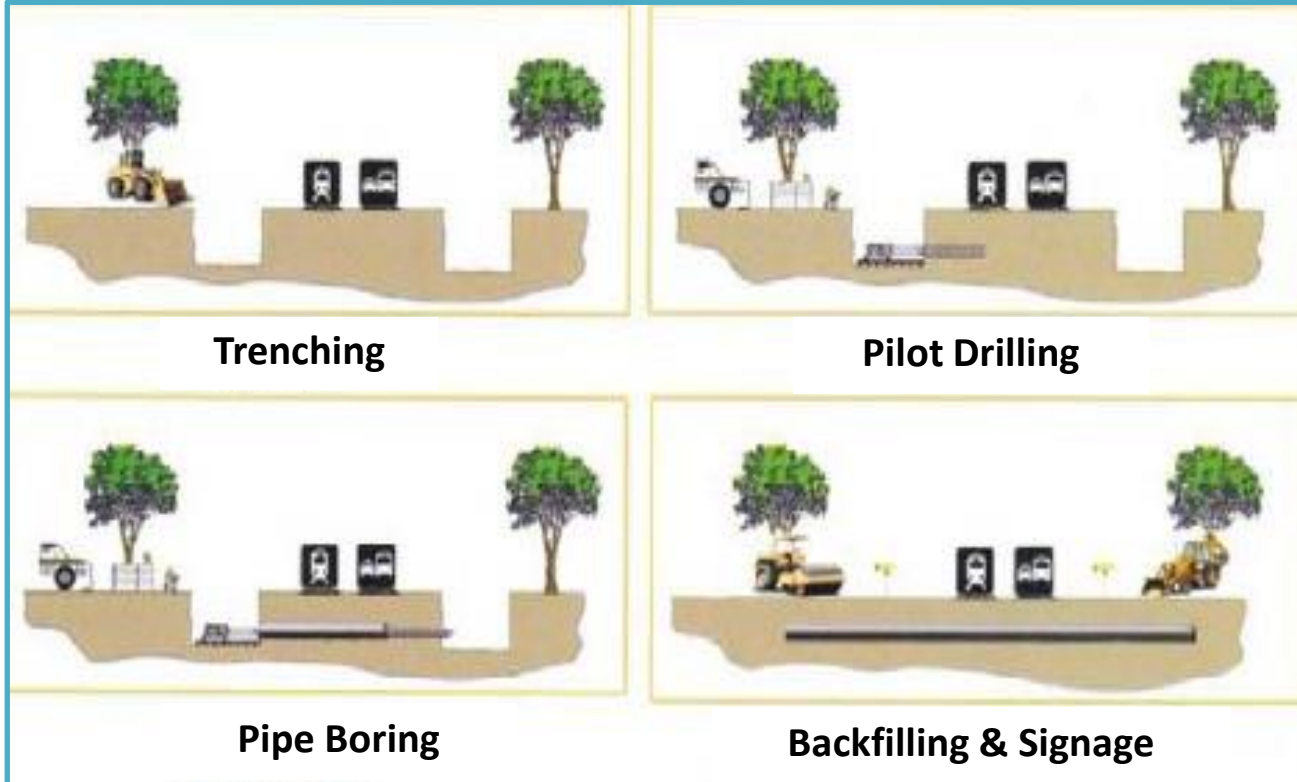


Backfilling

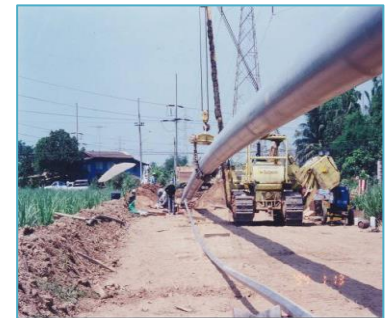
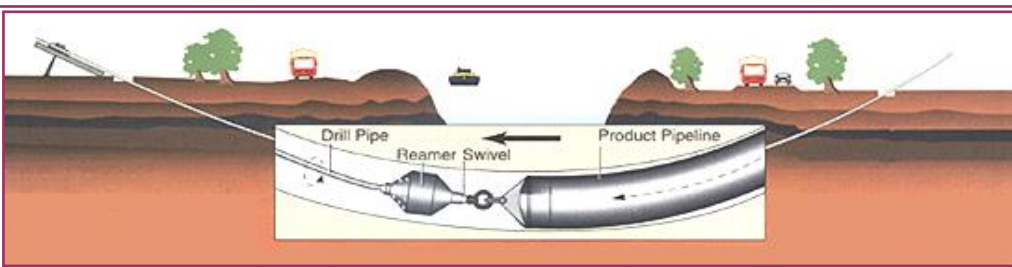
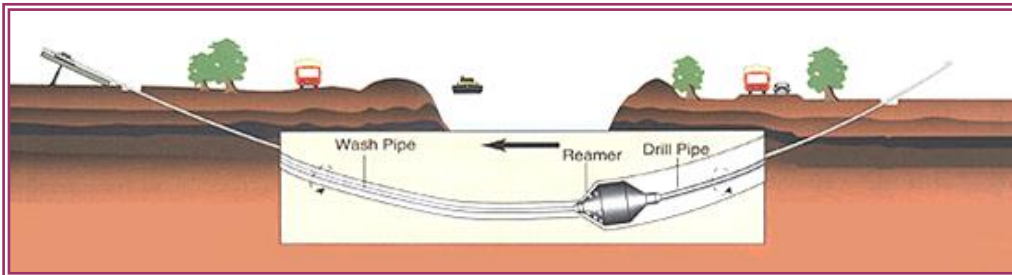
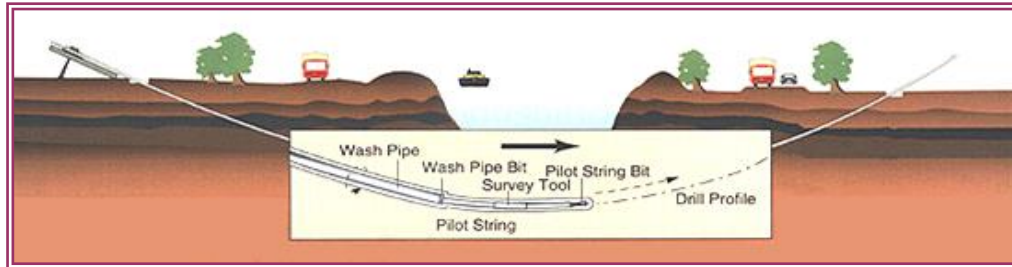


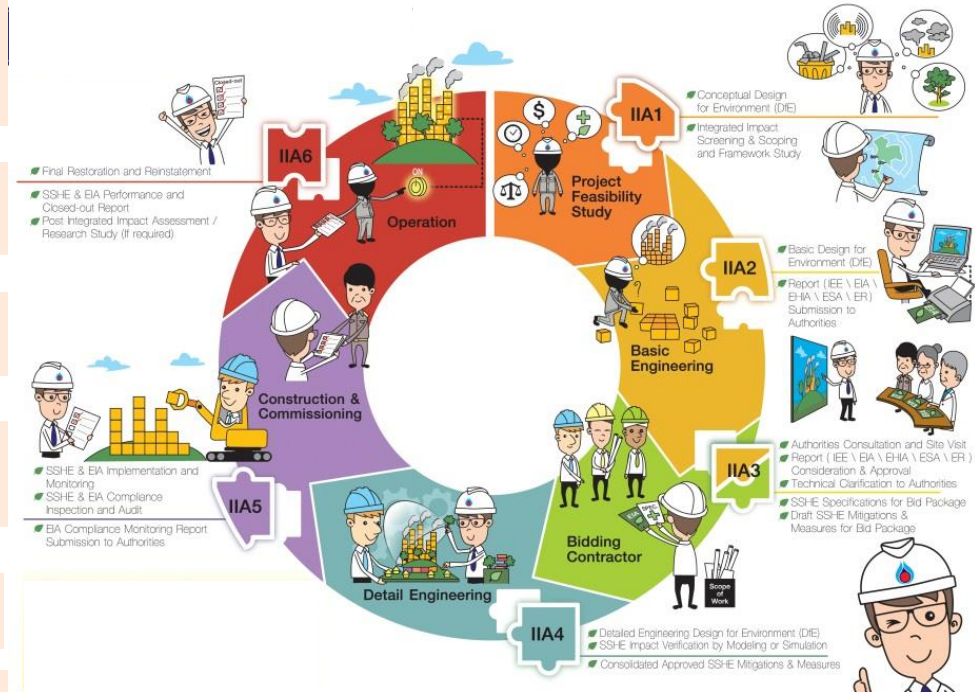
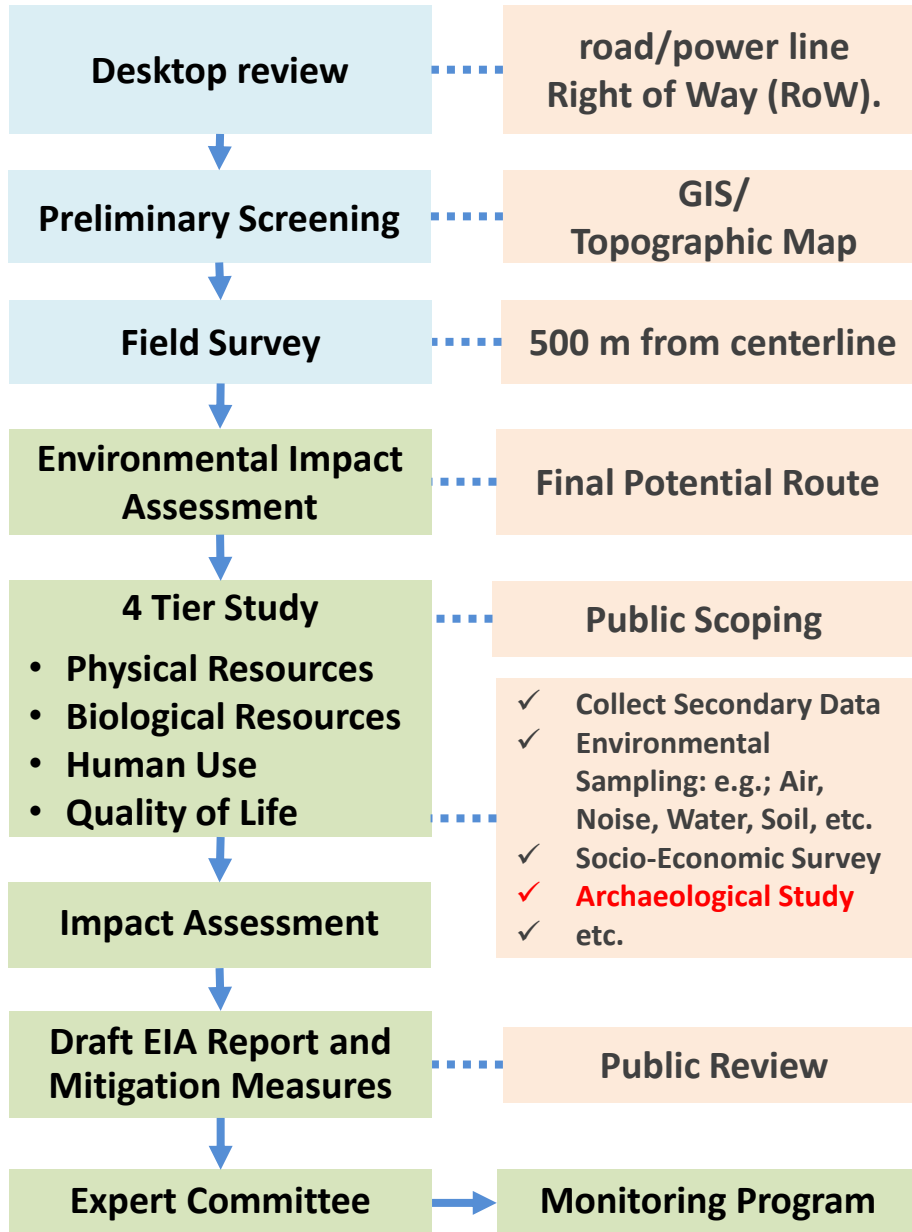
Reinstatement

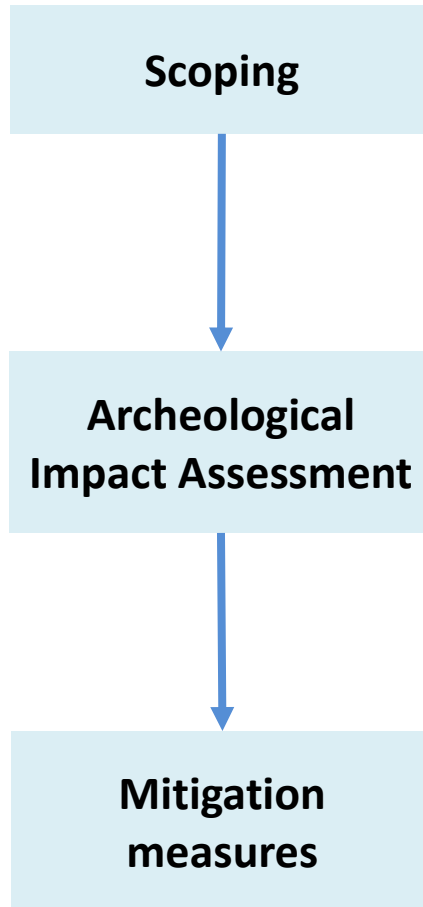
Boring Method



Horizontal Directional Drilling (HDD) Method







Site survey

- *Focus on 20 m (pipeline RoW)*

Criteria used to assess impact

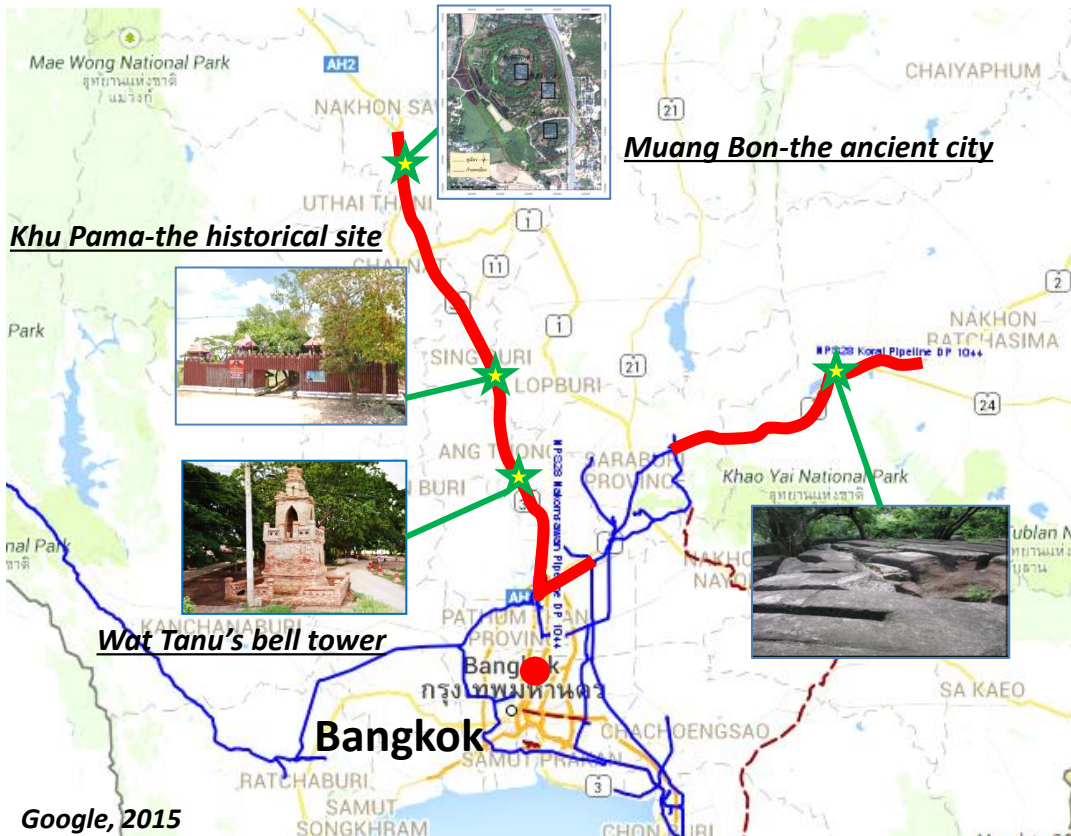
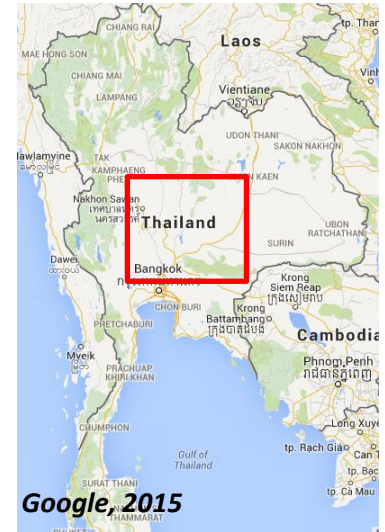
- *Magnitude*
- *Severity*
- *Duration*

Impact management

- *Project relocation*
- *Design change*
- *Protection in situ*
- *Data recovery*

Nakhon Sawan natural gas transmission pipeline project

- *Wat Tanu's bell tower*, Located on the east side of highway no.32, kilometer marker 42 (Nakhon Sawan to Bangkok southward).
- *Khu Pama-the historical site*, Located on both sides of highway No. 32, kilometer marker 77. The ancient fort lies parallel with the highway and perpendicular in some areas.
- *Muang Bon-the ancient city*, located between 307-308 km of Highway No.1 on the East bank of the Chao Phraya river, dates back in the era of Dvaravati, that is 11-12 century.

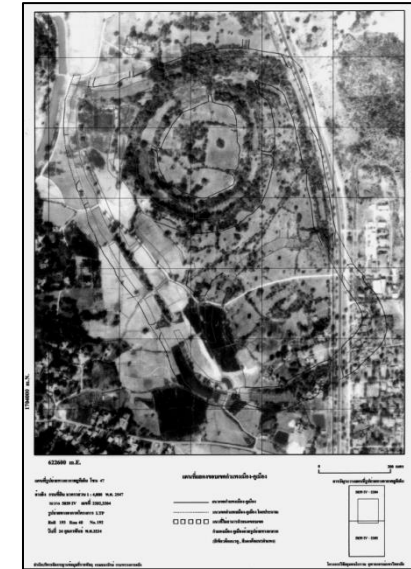


Nakhon Ratchasima natural gas transmission pipeline project

- *Sikhiu-the stone quarry site*, located between 206-207 km of Highway No.2, The site appears as a high mound. Some of the stone was extracted and loosened into rectangular shapes and used as material for constructing ancient temples or shrines in Khmer culture in Thailand.

Nakhon Sawan Project

- *Wat Tanu's bell tower*
หอรฆฆังวัดตะหนุ
- *Khu Pama-the historical site*
คูปมา
- *Muang Bon-the ancient city*
เมืองโบราณเมืองบน

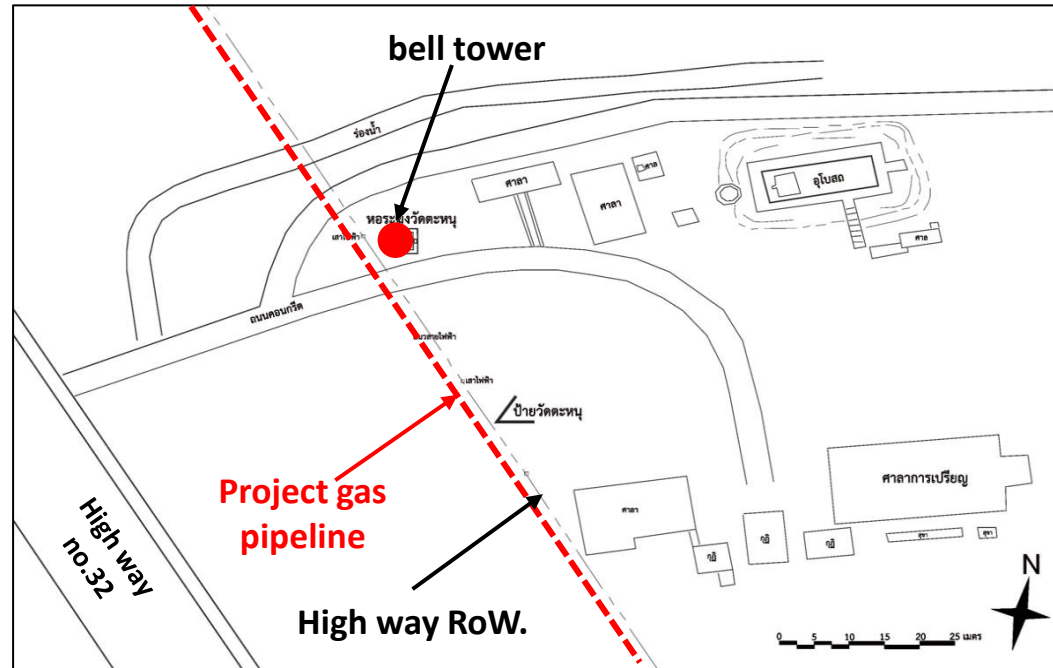


Nakhon Ratchasima Project

- *Sikhiu-the stone quarry site*
แหล่งหินตัดสี่คิ้ว



- The bell tower was built in the reign of King Narai the Great (300 year ago).
- Located on the east side of highway no.32, kilometer marker 42.
- A significant object is the belfry. The belfry is built from brick, 4.5 m high, perforated body, peaked accolade shape, encircled by a low fence.



Archaeological assessment and discussion

- Department of Highways allow PTT to construct gas pipeline 5 m away from highway RoW.
- Normal construction activities (open cut) may cause vibration impacts.
- Horizontal Directional Drilling (HDD) technique will be used to reduce vibration impacts on belfry
- Vibration impact to belfry measured in term of Peak particle velocity (PPV) that can be calculated from the following equation;

$$PPV_{\text{equip}} = PPV_{\text{ref}} \times \left(\frac{25}{D} \right)^{1.5}$$

Where

PPV _{equip}	=	PPV arisen from machines at different distances (in/s)
PPV _{ref}	=	PPV at the reference distance of 25 ft (in/s)
D	=	Distance from a machine to a receptor (ft)

Archaeological assessment and discussion

- The maximum estimated PPV at 7.62 m (25 feet) from drilling head during construction is 2.26 mm/s
- Drilling head should be 12 m deep from the ground
- PPV will reduce with further distance, hence PPV at the base of Bell tower is 1.14 mm/s
- When the DIN4150 Structural vibration standard is considered, there are no dangers to even ancient buildings.

Distance from machine to bell tower underground structures (m)	Maximum PPV (mm/s)		Impact
	25 feet from machine	At underground structures	
12	2.26	1.14	<ul style="list-style-type: none">- Feeling of vibration- No impacts and damages on any structures

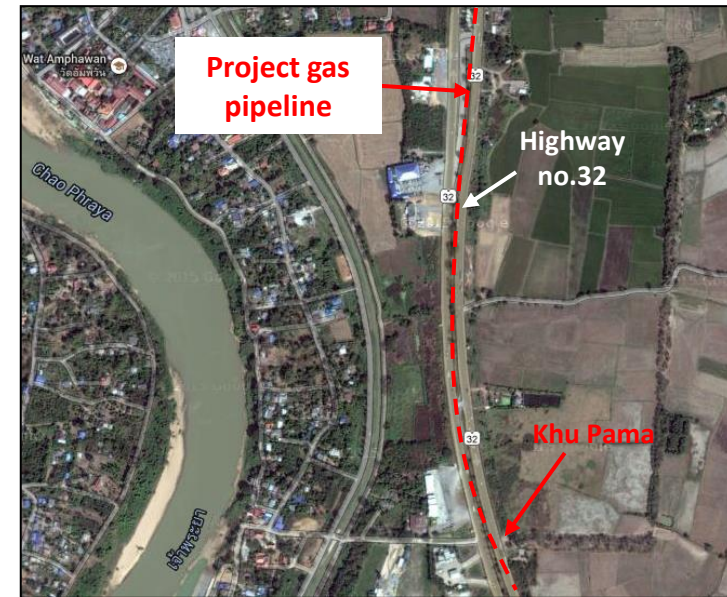
Mitigation measures

- Employ HDD technic, drilling head should be 12 m deep from surface
- PTT must request for a permit from the 3rd regional office of Fine Arts Department before construction.
- The construction must be under serious supervision of archaeologists.



12 m

- Located on both sides of highway No. 32, the ancient fort lies parallel with the highway and perpendicular in some areas.
- Aerial photographs of this ancient fort show the evidence of square-shaped moat. Currently, there are only 2 sides of the fort left.
- Field surveys report that these leftover walls appear to be a connected ridge, 8-10 meters high and 25 meters width.
- Some parts of the wall are missing due to the construction of highway no. 32
- Historical records say that this ancient fort was built by King Chiang Mai in 2127 B.E. (1584)



Archaeological assessment and discussion

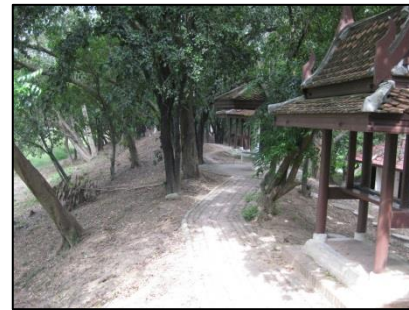
- Khu Pama-the historical site has significant historical value.
- Department of Fine Arts has registered it as a national historic site since 1975.
- Visual pollution should be concern during construction



Historical site entrance



Somdet Phra Naresuan
Maharat Monument
(สมเด็จพระนเรศวรมหาราช)

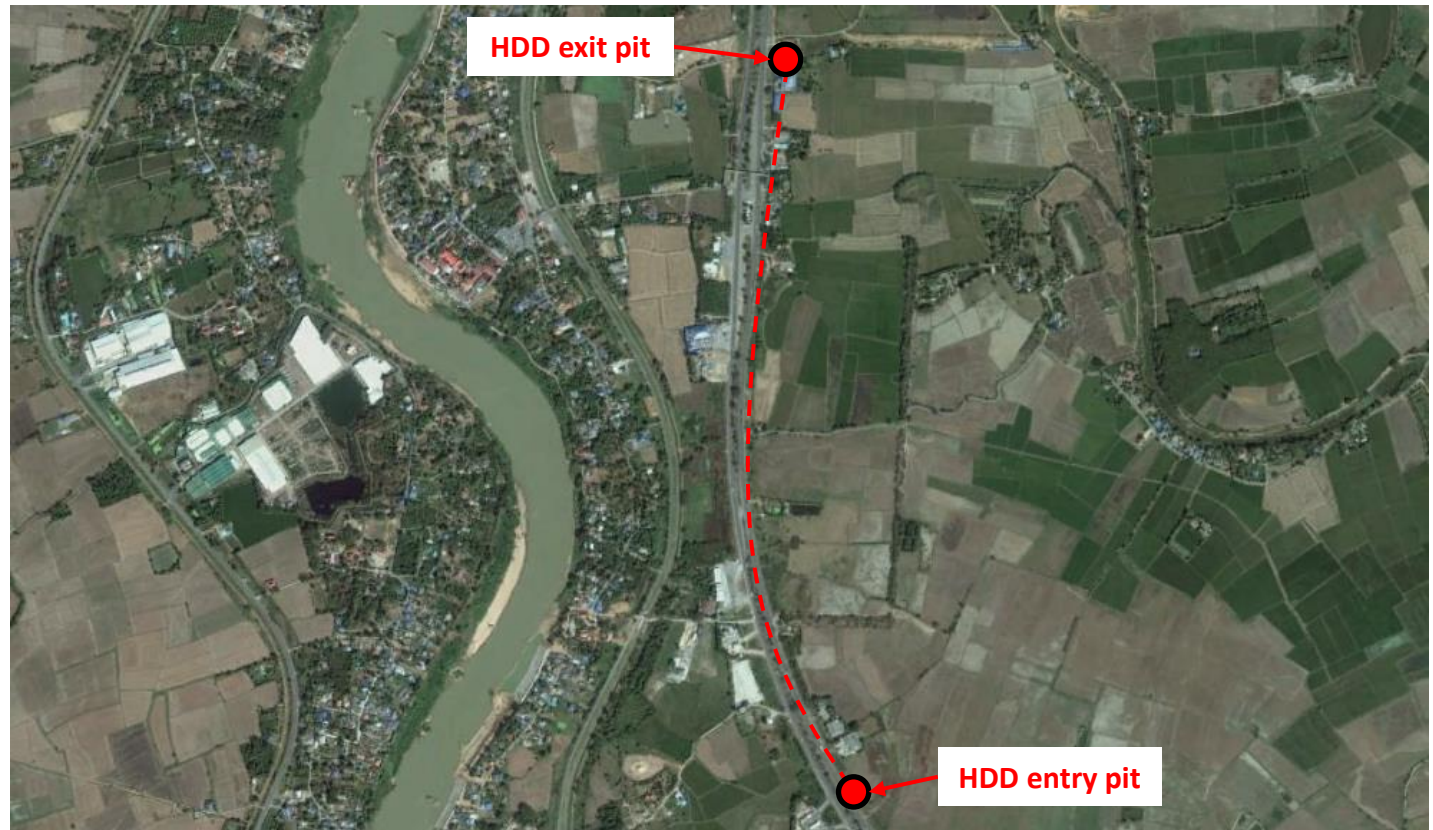


Rampart

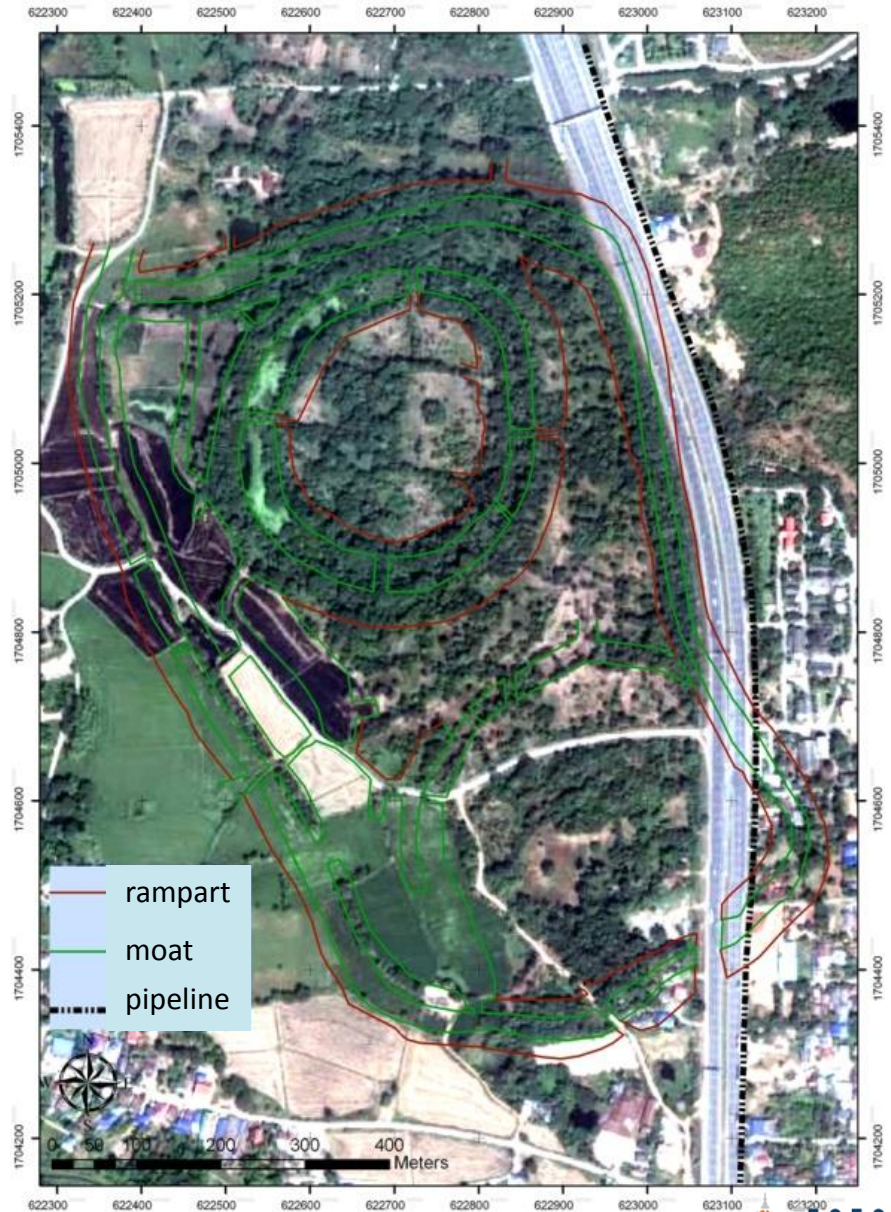


Mitigation measures

- Employ HDD technique, there will be no ground opening for 2 km.
- PTT must request for a permit from the 3rd regional office of Fine Arts Department before construction.
- The construction must be under serious supervision of archaeologists.



- Located between 307-308 km of Highway No.1 on the East bank of the Chao Phraya river, dates back in the era of Dvaravati, that is 11-12 century.
- Some of the town's moat and rampart were overlapped by Highway No.1 in 1936, causing them to disappear without any trace. Whereas other areas of the moat and rampart still exist in their best condition.
- Archaeological excavation in this ancient town by Fine Arts Department in 1964 and at least 12 ancient monuments were found.
- Treasury Department had already bordered off the town in 1991

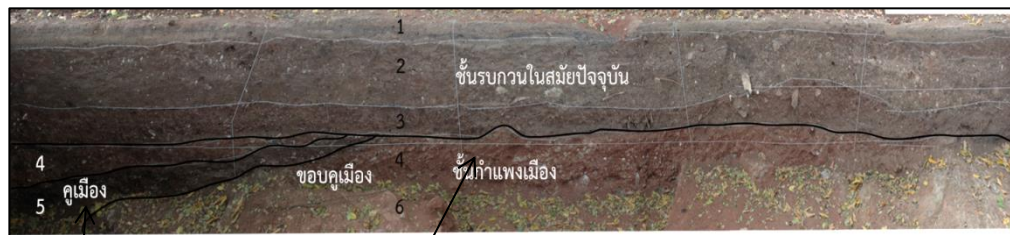


Archaeological assessment and discussion

- The gas pipeline construction project passing 2 sections of city moat with length of 1 km will affect archaeological site.

Mitigation measures and result

- PTT and Department of Archaeology, Faculty of Archaeology, Silpakorn University study and survey of the archaeological impact on 2011.
- Culture layer under pipeline route was destroyed due to the highway no.1.
- No important underground artifacts found in pipeline RoW area.
- Open cut technique will be conducted in this area, under supervision of authorized archeologists.



Moat

Rampart layer



Earthenware sherds

- Located between 206-207 km of Highway No.2. The site appears as a high mound, consists of 20x20 meters high-quality white solid sandstone terrace.
- Currently mortised rectangle shallow holes can be found around the terrace. Presumably these holes were caused by the mortise of the surface sandstone. Some of the stone was extracted and loosened into rectangular shapes as they were prepared to be removed.
- From the analysis of stone type and size, together with stone elements from nearby ancient ruins, it shows that ancient ruins in Khmer culture in Thailand mostly used sandstone as the main material in constructing temples or shrines.



Archaeological assessment and discussion

Values of vibration from HDD Drilling Rod to ground surface level.

Vibration Results Comparing with Depth in Transverse Dimension

V_0 (mm s ⁻¹)	α (m ⁻¹)	Distance (m)	V (mm s ⁻¹)
31	0.242	5	31
31	0.242	4.5	24.34
31	0.242	4	14.37
31	0.242	3.5	9.55
31	0.242	3	6.77
31	0.242	2.5	4.99
31	0.242	2	3.79
31	0.242	1.5	2.94
31	0.242	1	2.31
31	0.242	0	1.84

Vibration Results Comparing with Depth in Vertical & Longitudinal Dimension

V_0 (mm s ⁻¹)	α (m ⁻¹)	Distance (m)	V (mm s ⁻¹)
36	0.231	5.5	36
36	0.231	4.5	28.57
36	0.231	4	16.97
36	0.231	3.5	11.34
36	0.231	3	8.08
36	0.231	2.5	6
36	0.231	1.5	3.57
36	0.231	1	2.83
36	0.231	0.5	2.27
36	0.231	0	1.84

Mitigation measures

- During construction at Si Khio Quarry site, the depth of the drilling rod and pipeline shall be more than 5.5 m from the ground surface for the vibration to not exceed 2 mm/s (DIN4150).
- Monitor vibration on the quarry site during construction.
- Have archaeologists or officers from the 12th Regional Office of Fine Arts (Nakhon Ratchasima) to observe during construction crossing Si Khio Quarry site.
- During construction period, if there is any environmental effect to Si Khio Stone Quarry project, construction must stop and find the a solution to prevent and mitigate the environmental impacts immediately.

Site	Impact	Impact management	Mitigation
Wat Tanu's bell tower	Physical impact (vibration)	Design change	HDD technic to reduce vibration impact
Khu Pama	Visual impact	Design change	HDD technic to reduce visual impact during construction
Muang Bon	Direct impact to site	Data recovery	Archeological survey prior construction
Sikhiu-the stone quarry site	Physical impact (vibration)	Design change	HDD technic to reduce vibration impact

Thank you

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