

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

S.Kittiphong, H.Worawut, P.Penrug, C.Narasak, S.Poramate and C. Yaowalak

*Engineering Environmental and Health Management Division*

*Sustainable Management and Project Engineering Business Unit, PTT Public Company Limited, THAILAND*

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PTT Public Company Limited. (PTT) is a national oil and gas company that plays a major role in supplying natural gas to customers in industrial, commercial and transportation sectors through pipeline systems more than 4,000 kilometer (km) in length. Although route selection process has been performed to avoid archaeological and historical sites, in some areas this has not been possible. For example, 4 historical sites Wat Tanu's bell tower, the historical site of Khu Pama, the ancient city of Muang Bon-, and the stone quarry site of Sikhiu- are found within the rights-of-way (ROW), less than 10 m from the centerline of Nakhon Sawan and Nakhon Ratchasima transmission pipeline. In order to minimize the negative impacts on these vulnerable areas, stringent regulations and measures are required. After the environmental impact assessment has been conducted, Horizontal Directional Drilling (HDD) technique is selected with determination of safe distance for locating machines at the entry and exit pit by using in house calculation. Specific mitigation and measure plans are well established for implementation such as underground surveys for historical remains and buried artifacts by archaeologist prior to commencing activities, provision for on site archaeologists to supervise and closely monitor construction activities in these vulnerable areas. The ROW restoration near by the archaeological sites would be instructed by archaeologist in order to avoid contradiction to the archaeological architecture.

*Keywords:* archaeological and historical sites, rights-of-way (ROW), vulnerable, natural gas transmission pipeline, environmental impact assessment

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## Introduction

PTT is Thailand's largest public company. The PTT is the country's only fully integrated oil, gas and petrochemical business, combining upstream, transmission, and downstream operations. Since 1981, PTT has played an important role in strengthening national energy security by constructing and operating a natural gas pipeline system of over 4,000 km in length, both onshore and offshore and laid through different area classifications i.e., marine, forest, agriculture, rural, urban, city areas and near to archaeological and historical sites.. According to the Enhancement and Conservation of National Environmental Quality Act, 1992, natural gas pipeline systems of all sizes are listed as projects that requires a preparation of Environmental Impact Assessment (EIA) report prior to commencement of construction. In Thailand, an EIA report consists of five parts that are Project Description, Existing Environmental Condition, Environmental Impact Assessment, Mitigation Measures, and Monitoring Program. The assessment of environmental impacts covers 4 tiers that are Physical, Biological, Quality of life and Human use, which also includes archaeological impact assessment.

The archaeological heritage is a cultural resource for human society and is irreplaceable when physically destroyed, either by nature or human. Archaeology is the study of heritage created by mankind, and it also serves to further the acknowledgement of history, culture and the sociological change which cannot be studied through other sciences. Both major and minor developments which are constructed through our economy nowadays might destroy the archaeological heritage. Thus, to generate sustainable archaeology, it is important to avoid damaging such heritage. By gaining as much information as possible, we can initiate all possible measures and approaches in order to decrease the impact in the future.

The archaeological impact assessment procedure is composed of two principal components: assessment and impact management. Assessment is primarily concerned with the inventory and evaluation of archaeological resources, and the assessment of potential impacts of project. Impact management follows directly from assessment and is primarily concerned with managing unavoidable adverse impacts as well as unanticipated impacts. It is important to recognize that the assessment and impact management stages are approached sequentially in association with specific levels of project planning. The success of this process is dependent upon effective communication and cooperation between project proponents and the Authority, and their mutual respect for development and archaeological resource management objectives.

The underground transmission pipeline project which has been conducted by PTT is a project from the Long-term Natural Gas Procurement plan and the Pipeline System Master Plan by the National Energy Council. The plan is to create energy stability and to meet the demand for Natural Gas in every region of Thailand, and in all levels of the economy; household, the industrial sector, transportation, electricity and the Gas Separation Plant. As a result, some parts of the pipeline system have come across archaeological sites and heritage. PTT has acknowledged this issue, and the company has always supported the study of archaeological impacts from the pipeline. The network of the natural gas transmission pipeline in Thailand is shown below.



Figure 1: The network of the natural gas transmission pipeline in Thailand

### Scopes of Study

The purpose of the study is to collect data for impact assessment, and then use the data to suggest ways in which to amend or mitigate the impact on works of art and archaeological sites, which are overlapped by the project.

The limitation of this study is that the archaeological survey can be conducted only over the accessible soil surface and open air area without any cover on the surface. Thus, there are possibilities of missing archaeological evidence underground. Another limitation is the information and geographic coordinates with the scale of 1: 50,000; therefore, some particular archaeological sites that were directly impacted by the pipeline project were inspected in more detail using aerial photographs and smaller scale maps.

The archaeological survey is a significant composition of the study. Prior to the survey, there was a compilation and revision of data, both historical and archaeological. Once the number of archaeological sites in the area has been received, the information is used as a database for the survey. During the survey, there is a process of filling in forms and recording all the important data; names, details, geographic coordinates, etc. and monitoring the location of art works and archaeological sites within 500 meters (m) of the centerline of pipeline.

Consequently, after the archaeological survey, the next process is to collect all data and assess the impact from the pipeline project, both during the under construction process and the operation process. Both positive and negative aspects are taken into the assessment, as well as the impact from all kinds of activities from the pipeline project; severe danger that might impact surroundings, impact from the construction. Impacts are categorized by cause and result, both direct and indirect, and the level of the impact and the connection of each impact.

Once the assessment is done, the next step is to suggest the preventive and amending method. Practical and suitable ways to lessen the impact are provided, each one listed with its pros and cons for both the construction and operation periods. The methods are then summarizes and the most suitable measure chosen.

### Results and Discussions

The archaeological surveys in the area within 500 m of the centerline of pipeline, the historical and archaeological sites found, and the study of impacts from the gas transmission pipeline, are as follows.

- **Wat Tanu's bell tower**

Wat Tanu's bell tower is located next to the Asian highway, on the west side (Nakhon Sawan to Bangkok southward), at km marker 42. According to historical records, the belfry in the area was built in King Narai Maharaj's reign (approximately 300 year ago). Wat Tanu hosts an ordination hall, square in shape, with one boundary stone left on the east side. Presumably, it is an original ordination hall. Within the area, the brick line of a building foundation was found. A significant object in the temple is the belfry, located on the west side of the ordination hall, 20 m away from the Asian highway. The belfry is built from brick, 4.5 m high, perforated body, peaked accolade shape and is encircled by a low fence. The fence is perforated with a cross shape, the wall covered plaster is peeling and a brick bond can be seen in some parts of the wall.

#### Archaeological assessment and discussion

Wat Tanu's bell tower's belfry is a significant ancient remain. The condition of the belfry is almost perfect. When the construction is crossing this area, HDD will be used to reduce vibration impacts on the belfry. Vibration impacts to the belfry were measured in term of Peak particle velocity (PPV) calculated from the following equation;

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

Where

- PPV<sub>equip</sub> = PPV arisen from machines at different distances (in/s)
- PPV<sub>ref</sub> = PPV at the reference distance of 25 ft (in/s)
- D = Distance from a machine to a receptor (ft)

Drilling and receiving pits should be at least 250 m from the tower and 12 m deep from ground level to reduce impacts on the bell tower and underground structures. The maximum estimated PPV at 7.62 m from drilling head during construction is 2.26 mm/s (0.089 in/s). This will reduce with further distance, hence PPV at the base of Bell tower is 1.14 mm/s (0.045 in/s). Comparing the PPV to the standard criteria of Whiffin and Leonard, the level will cause no impacts or damage to any structures. When the DIN4150 structural vibration standard is considered, there are no dangers to even ancient buildings. Details are given in below;

Distance from machine to bell tower underground structures (m)	Maximum PPV (mm/s)		Impact
	7.62 m from machine	At underground structures	
12	2.26	1.14	- Feeling of vibration - <b>No impacts</b> and damages on any structures

The project has consulted with the 3<sup>rd</sup> regional office of Fine Arts Department of Phra Nakhon Si Ayutthaya. PTT must ask for a permit from the 3<sup>rd</sup> regional office of Fine Arts Department to survey archaeological evidences related to Wat Tanu bell tower under serious supervision of archaeologists.

- **Khu Pama-the historical site (Myanmar's ancient fort)**

The historical site of Khu Pama is 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 evidence of a square-shaped moat. Currently, there are only two sides of the fort left. Field surveys report that these leftover walls appear to be a connected ridge, 8-10 m high and 25 m width. Some parts of the wall are missing due to the construction of highway 32. Numerous historical records say that this ancient fort was built by King Chiang Mai in 2127 B.E.

#### Archaeological assessment and discussion

Khu Pama has significant historical value. Not only can much archaeological evidence be found around the fort area, but also some of this is situated directly within the pipeline construction line.

In order to reduce impacts on Khu Pama, PTT has designed the construction crossing the area by using HDD at depth of 8 m. There will be no ground opening for 2 km. Locations of receiving/drilling pits are designed to be at least 500 m away from the moat.

However, PTT has recognized the importance of the site and given a clear plan of works to be done in this area. Although most of the site was destroyed by modern constructions, in order to preserve archaeological evidence and keep impacts from the project construction as minimal as possible, PTT has selected HDD for construction across the ancient moat. However, PTT must also conduct an archaeological survey of the construction site, with permission from the 3<sup>rd</sup> regional office of Fine Arts Department, Phra Nakhon Si Ayutthaya, to examine archaeological evidences relating to the moat under supervision of archeologists or the 3<sup>rd</sup> regional office of Fine Arts Department.

- ***Muang Bon-the ancient city (Khok Mai Den)***

Located on the East side of the Chao Phraya River, the ancient city of Muang Bon dates back to the era of Dvaravati, to 1100-1200 B.E. The city is encircled by 3 rings of moat and rampart. There were also ancient monuments found in Khok Mai Dan Buddhist Temple which are believed to be related to the religious legend of Queen Camadevi. The historical record says that she built these monuments in Khok Mai Dan Buddhist Temple in the years 1300 B.E. and called it “Mueang Phra Bang”. This name was also mentioned in Stone Inscription No. 3 (Nakhon Chum Stone Inscription). There was an archaeological excavation in this ancient town by the Fine Arts Department in 1964 and at least 12 ancient monuments were found both on plain and mountain areas. In addition, from the excavation near the city’s moat and rampart, glass beads and earthenware sherds were found.

#### Archaeological assessment and discussion

The ancient city of Muang Bon (Khok Mai Den) is a large city which dates back to the Dvaravati period. The Treasury Department had already bordered off the town and found that some of the town’s moat and rampart were overlapped by Highway No. 32, causing them to disappear without any trace. Whereas other areas of the moat and rampart still exist in their best condition.

The gas pipeline passes the area of the city moat with a length of 1 km and will affect the archaeological site. Thus, before trenching, digging for archeological survey will be done. Planning of surveyed pits in the area in front of Muang Bon will be undertaken with a permit from the 4<sup>th</sup> regional office of Fine Arts Department, Lop Buri. This will examine related archaeological evidences under careful supervision of the 4<sup>th</sup> regional office of Fine Arts Department, Lop Buri and archaeologists.

- ***Sikhiu-the stone quarry site: Lang Hin Tad archaeological site***

The site is located on Mittraphap Road between 206<sup>th</sup> – 207<sup>th</sup> km stack, on the opposite side of Si Khio Waterworks. The site appears as a high mound, consisting of 20x20 m high-quality white solid sandstone terrace. Currently, mortised rectangular 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. For instance, Phimai Historical Park, Phanomwan Historical Park, etc.

#### Archaeological assessment and discussion

The stone quarry site of Sikhiu is an important ancient raw-material-type site. The ancient people utilized stone from this site to construct temples and other types of building. Additionally, this site became a significant part of the ancient society. This ancient site reveals to us the origin of how the ancient people chose their building material and what technique they used to extract stone.

In order to reduce impacts on Sikhiu-the stone quarry site, PTT has designed the construction crossing the area by using HDD at depth of 5.5 m. During construction period, if there is any environmental effect to Sikhiu Stone Quarry site, construction must stop and find the a solution to prevent and mitigate the environmental impacts immediately.

## **Conclusions**

Every project that is involved with the pipeline system needs to conduct research prior to the construction in order to protect or generate minimal impact upon communities and the environment. Assessment is required under the Enhancement and Conservation of National Environmental Quality Act. Thus, PTT is aware of the potential for the construction of the pipeline, which is the reason for conducting the research and the assessment as to protect the communities, to impact on important religious sites and archaeological areas. These places are considered to be the cultural heritage of Thailand. In case the company needs to reduce the impact from the pipeline system that overlaps or comes close to the archaeological area, the main measure is to conduct an archaeological survey thoroughly. Also, to conduct an archaeological excavation in order to inspect the cultural layer as well as to evaluate the complete impact area. The excavation is the initial stage to indicate the age and the significant value of the site. After the excavation, PTT can determine which measures need to be used in order to construct the pipeline system. The HDD method will be conducted in an area that has no impact in the archaeological areas. Lastly, PTT will provide authorized archaeologists to closely observe all aspects of the construction.

## **Proposed Mitigation Measures**

After conducting an archeological survey and impact assessment on archaeological sites, in order to avoid and/or minimize the damage that will occur because of the construction of the pipeline, the following method is highly recommended.

1. In cases where the archeological site or ancient ruin or religious temple will be directly impacted by the construction of the pipeline system, the constructor should avoid constructing in that area. If the construction has to be in that area, the constructor should minimize the damage that might occur by using the study and archeological research in the area prior to the construction. The HDD measure must be enforced in order to install the pipeline system under the cultural layer of the archaeological sites. Also, the constructor must identify the extent of the area of the archaeological site in order to determine the position of the pipeline is far enough away for the safety of the archaeological site. The archaeological excavation is the most useful way to study the below surface, cultural layers and to inspect the quantity of artifacts and to determine the specific area of the site. Then, after the excavation, a construction plan and the pipeline position can be determined.

2. In cases, the archeological sites, ancient ruins or religious temples may be indirectly impacted from the pipeline construction, such as, from the vibration caused by machines. The buildings in the archaeological area may be dilapidated. Thus, damage control measures must be prepared and enforced prior to the construction. Archeology sites, ancient ruins and religion temples should be observed periodically before and after, as well as during the construction in order to detect any damages that may occur.

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