Nomination Form for Including in the World List of Heritage Irrigation Structures

1. Details of Irrigation Structure Nominated

(a) Name: Fukarayousui Irrigation Canal
(b) The year of commissioning: 1670
(c) Area irrigated or drained: 527.2ha
(d) Geographical coordinates: 35.230083° N, 138.984372° E
(e) River basin or sub-basin where located: Kano River basin
(f) Name of the Nominating National Committee: ICID Japan National Committee

2. Management Detail of Heritage Irrigation Structure

(i) Ownership (If owner and administrator are different, write both)
   a. Name of organization: Shizuoka Prefectural Lake Ashinoko Irrigation Association
   b. Address: 1059 Sano, Susono City, Shizuoka, Japan

(ii) Name and contact details of official(s) of the nominated structure: Hideo Ohba, General Affairs and Administration Dept., General Affairs Division, Susono City (Tel: 055-995-1807, e-mail: soumu@city.susono.shizuoka.jp)

(iii) Present source of funds for operation and maintenance of the nominated structure: Expenses shared among municipalities served by structure (two cities and two towns), supplemented by water utilization fees from hydropower operators, etc.

3. Description giving salient features of the nominated structure

The Fukarayousui Irrigation Canal is an irrigation structure completed in the 17th century, which brings water from Lake Ashinoko (located in Hakone, Ashigarashimo-gun, Kanagawa Prefecture) through a tunnel to the Fukara district (in Susono City, Shizuoka Prefecture), from whence it flows through the Fukara River to the Kise River, thereby delivering water for irrigation of rice paddies in a large area measuring 527.2 hectares and spanning four municipalities (the cities of Susono and Gotemba and the towns of Nagaizumi and Shimizu).

The Fukara district, known as the village of Fukara when the structure was made, is located in the western foothills of Mt. Hakone, to the southeast of the Mt. Fuji foothills. Eruptions of Mt. Fuji had covered the area with volcanic basalt, so water sources such as rainfall and snowmelt from upstream seeped underground and little water flowed into the river, despite high levels of precipitation. Water channels carried insufficient water even for everyday activities such as cooking and laundry, let alone for large-scale agriculture.

Under these circumstances the Fukara villagers were unable to grow rice, the main crop in Japan at the time, and were forced to rely on grains that could withstand drought such as barley and soybeans. They led lives of hardship for many years. To

simultaneously resolve chronic water shortages and facilitate the planting of new rice fields, the village headman, Ohba Gennojo, laid out plans for diverting water from Lake Ashinoko in Hakone to the village of Fukara. The work was to be supervised by Tomono Yoemon, a merchant of Edo (present-day Tokyo) whose outstanding civil engineering skills had been put to use in developing new rice fields throughout Japan.

In August 1666, Tomono Yoemon designated an exit point at 熊洞 on Mt. Hakone, within the confines of the village, and in November decided the position of the sluice gate where water would be diverted from Lake Ashinoko, at Yotsudome below Kojiri Pass. Digging of a tunnel connecting the two points began at both ends. Work was carried out by hand with tools such as chisels, and it was impossible to dig straight through some cliffs, while ground collapses occurred due to the soft and fragile ground of Mt. Hakone. A cumulative total of 840,000 workers were deployed, and completed the work over three and a half years at a total cost of 7,400 ryo (the equivalent of about five to six billion yen today). It was finished in February 1670, and water began flowing through it that April.

The tunnel has a total length of 1,280m, with a height differential of 9.8m between the sluice gate and the tunnel exit, and an average gradient of 1/130 over the length of the tunnel. Near the middle of the tunnel there is a drop of approximately one meter, thought to have occurred because the workers dug the tunnel from both ends and thus were at different heights when they met in the middle. Considering the measurement techniques of the time, however, a height differential of only a single meter is an amazing feat. An alternate explanation is that the drop was created intentionally to alter the force of the water flow.

Over 340 years have passed since the Fukarayousui Irrigation Canal was completed, but it still plays a vital role as an irrigation structure, providing water for the agriculture of the region and in recent years also for household use and hydropower generation. Currently, students at the local junior high school put on a play every year entitled “Canal of Life,” and there is a local historical museum communicating the great achievements of our forebears who built the structure, as well as a Fukarayousui Irrigation Canal Festival held each April. The irrigation canal system is an asset treasured by the entire community.

In 2005, the Ministry of Agriculture, Forestry and Fisheries selected the Fukarayousui Irrigation Canal for a list of Japan’s 100 most important man-made waterways.

4. Justification for nomination

(a) Criteria which the nominated structure fulfills and how

〇The structure shall be more than 100 years old
Structure completed in 1670 (over 340 years old)

〇The structures shall fall under one of the following categories
④ Canal system

〇The structure should fulfill one or more of the following criteria.

① The structure should represent a milestone / turning point in development of irrigated agriculture and should bear an exceptional testimony to development of agriculture and increase in food production along with improvement of the economic condition of farmers. ③ Must have made outstanding contribution to enhancing food production, livelihood opportunities, rural prosperity, and poverty alleviation in a region
The 17th century saw the development of new rice paddies throughout Japan, and rice cultivation came to form the backbone of the economy. In this region, however, the lack of a stable water supply meant that only a tiny area could be devoted to rice cultivation, and the local people could barely eke out a living. Under these circumstances, the Fukara villagers had been calling for many years for the unearthing of new water resources and the capability to expand rice paddies. After petitioning the Tokugawa shogunate for three years at the Numazu magistrate's office and the headquarters of the Odawara domain, work on the Fukarayousui Irrigation Canal tunnel finally commenced in 1666, and was completed after three and a half years. As a result Fukara was reborn as one of Shizuoka Prefecture's most abundant rice paddy districts, and the local people grew dramatically more affluent.
② The structure was ahead of its time in terms of project formulation, engineering design, construction techniques, dimensions of the structure itself, etc. ⑦ Was an example of engineering marvel or excellence at the time of its construction.
Because the tunnel was dug by hand using chisels, it does not go straight but follows a meandering course according to the rock formations in the ground. Rapeseed oil was used to light the interior, and there are shelves to place the lights at intervals of five to ten meters. The tunnel has a total length of 1,280m and a diameter of 1.8m, with a height differential of 9.8m between the sluice gate and the tunnel exit, and an average gradient of 1/130 over the length of the tunnel. These properties are ideal for utilizing water that flows through a waterway tunnel. About 520m from the sluice gate there is a drop, where the workers digging the tunnel from both ends met in the middle at slightly different heights. Considering 17th-century measurement techniques and tunneling techniques, however, a height differential of only a single meter is an amazing feat. An alternate explanation exists, namely that the drop was created intentionally to alter the force of the water flow. The tunnel is also characterized by "breathing holes" above it large enough for an adult person to enter. These were dug for ventilation. There are also two vertical shafts connected via side holes, each about 30m in length and connecting the tunnel to the surface of the ground.

(b) Statement on the nominated structure's engineering utility as of today, vis a vis its designed utility.

[Agricultural Irrigation Canal]

The canal is still used for agricultural irrigation (of rice paddies), and during plowing of the paddies it can deliver to the 527.2-hectare area 5.0 cubic meters of water per second, during irrigation between 1.5 and 4.0 cubic meters per second, and during non-irrigation season between 1.2 and 1.5 cubic meters per second.

[Hydropower Generation Canal]

When the structure was first built, it was used solely as an irrigation canal, but since the Taisho Period (1912-1926) it has also been used for hydropower generation, powering three generators at the Fukara River No. 1 Power Station (3,100kw), Fukara River No. 2 Power Station (1,400kw), and Fukara River No. 3 Power Station (1,000kw).

[Differences in utility]

The original wooden sluice gate was replaced with a stone and steel one in 1910, and a supplementary concrete gate was added in 1989 to alleviate age-related degradation.

The water flow capacity of the tunnel is the same as when it was first dug.

5. Present state of conservation

[Conservation of structure]

Currently a water management committee is in charge of managing the Fukarayousui Irrigation Canal. This system was established in 1688, and remains unchanged to this day.

The water management committee plays an important role, determining the volume of water taken from the lake and its distribution. The area to which water is supplied is divided into three blocks (upper, middle, and lower), with two representatives from each block forming a committee of six. Twice a year, before and after irrigation season, water flow is stopped and the committee inspects the inside of the tunnel. An additional two times per year they inspect all the waterways and sluices throughout the entire system, working to maintain and conserve it.

[Regional activities]

The Fukarayousui Irrigation Canal plays an essential role in the region, and local residents recognize its importance. The story of the tremendous achievements of forebears who built it is taught in schools, and each year the students at the local junior high school put on a play every year entitled “Canal of Life” that celebrates it. In the Fukara district there is a local historical museum paying tribute to the great labor involved in making the structure, with illustrations that convey its history to children in easily understandable form. Many people from outside the region visit as well.

This year on April 27, the first Fukarayousui Irrigation Canal Festival was held, featuring a parade of people wearing 17th-century costumes, on-stage events, and rice planting. A large number of residents joined in.

Around this date over 340 years ago, on April 25, 1670, water first began flowing through the canal. To commemorate the day, this festival will be held around the end of April from next year onward as well. In the future, the community will continue conveying the rich history and spectacular engineering of this irrigation structure to posterity.

6. Documents attached

a. Map
b. Current photograph(s)

c. Fukarayousui Irrigation Canal pamphlet, documents related to Fukara Junior High School “Canal of Life” play, materials related to Fukarayousui Irrigation Canal Festival

7. Certification by the National Committee/Committee

(i) Authentication:

a. It is certified that the above information is correct to the best of our knowledge and the relevant institutions/departments have been contacted or informed about this nomination.

b. ational Committee will undertake the actions required to disseminate the information befitting the listed Heritage Irrigation Structure.

(ii) No Objection:

We have no objection to ICID using the information provided with this nomination form for marketing and to give publicity to the historical irrigation structure nominated.

a. Signatures 佐藤洋平

Chairman/ Secretary of Nominating National Committee/Committee

b. Name Yohei SATO

c. Address 1-2-1, Kasumigaseki, Chiyodaku, Tokyo 100-8950, Japan

d. Seal

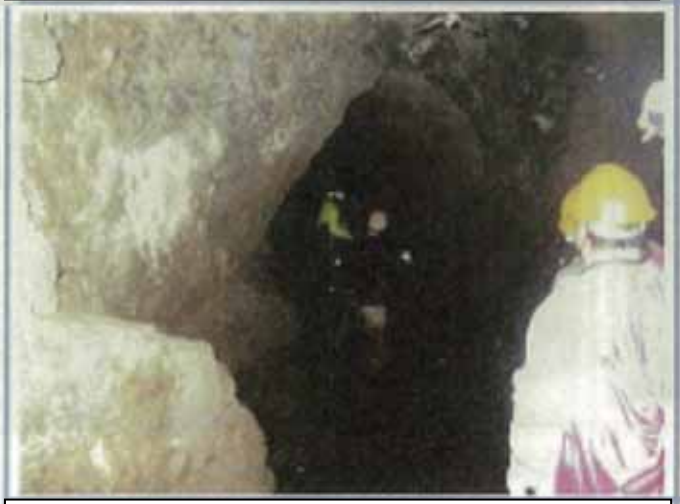
Map of Heritage Irrigation Structure: Fukarasosui Irrigation Canal

Photos of Heritage Irrigation Structure: Fukarasosui Irrigation Canal

Name	Fukarasosui Irrigation Canal
Location	Fukara, Susono City, Shizuoka Prefecture, Japan
Structure category	Canal system
Year of commissioning	1670

Drop near middle of tunnel, where work crews digging from either end are thought to have met

Fukara Suimon (Lake Ashinoko Sluice Gate)



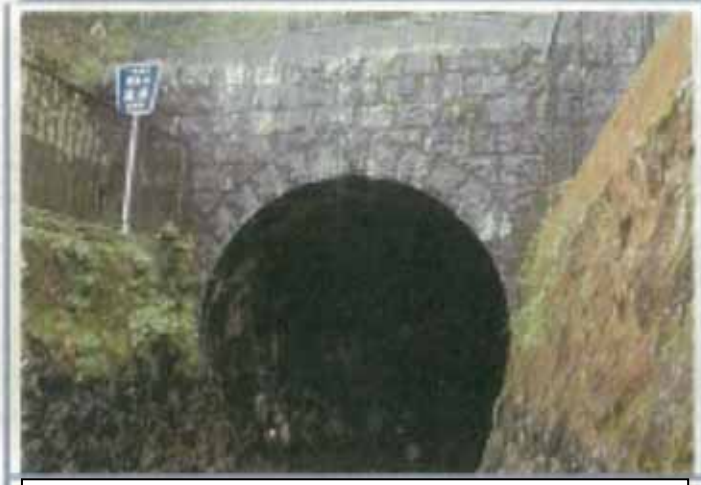
Inside the tunnel

“Breathing hole” inside the tunnel

Photos of Heritage Irrigation Structure: Fukarasosui Irrigation Canal

A horseshoe-shaped section of the tunnel where water flows gently

Sluice gate and Intake canal



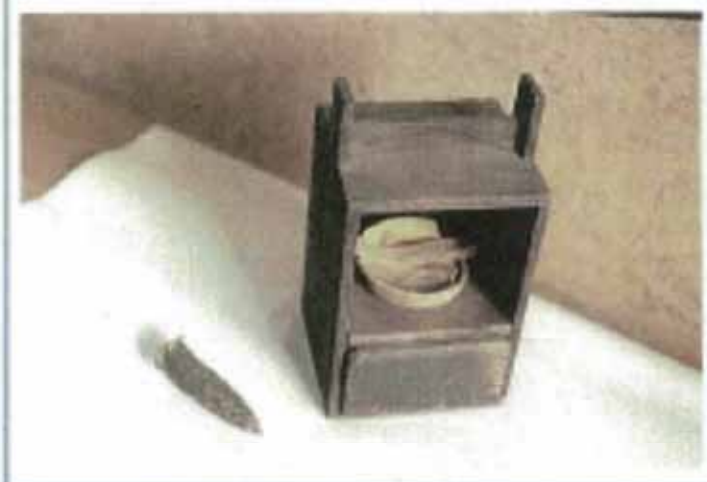
Tunnel exit

Looking downstream from the tunnel exit

Inspecting the interior of the tunnel

Memorial stone with inscription

Photos of Heritage Irrigation Structure: Fukarasosui Irrigation Canal



Tools used to dig the tunnel (chisel, lantern stand)

View of paddy field in Fukara district

Scene from “Canal of Life,” the play about the Fukarasosui Irrigation Canal performed by junior high school students

Scene from “Canal of Life,” the play about the Fukarasosui Irrigation Canal performed by junior high school students

Fukara Canal Festival (costumed procession)

Fukara Canal Festival (rice transplanting)

Ministry of Agriculture, Forestry and Fisheries

list of “Japan’s 100 most important man-made waterways”

Fukarasosui Irrigation Canal

made by hand with bravery and wisdom

The Fukara River in spring

Mt. Fuji as seen from Fukara

Inside the water tunnel

Lake Ashinoko

The Fukara district, which we call home, is located in the western foothills of Mt. Hakone. It retains traces of history and culture stretching back to the Nara (710-794) and Heian (794-1185) periods, as well as of the feudal Kamakura (1185-1333) and Muromachi (1337-1573) eras when samurai warlords such as the Omori clan thrived, and of the Edo (1603-1868) period when the entire area flourished thanks to the Fukarasosui Irrigation Canal. Throughout this long history human hands have shaped the land and enabled people to dwell happily in the district as they do today. Most notably, in the 17th century the courage and wisdom of village headman Ohba Gennojo, civil engineer Tomono Yoemon, and their associates, and the toil of countless workers, led to the completion of the Fukarasosui Irrigation Canal, which brought water to a region that had long suffered from inability to grow the staple rice crop due to water shortages.

The Fukarasosui Irrigation Canal was made a reality by digging a tunnel and a canal to divert water

from Lake Ashinoko, building dams, and channeling water to rice paddies efficiently and equally, then planting and waiting for the first autumn harvest. It was a historic example of the most outstanding technological feats of our forebears accompanied by judicious use of the blessings of nature.

In 2005, the Ministry of Agriculture, Forestry and Fisheries selected the Fukarasosui Irrigation Canal for a list of Japan’s 100 most important man-made waterways. This was a testament to the efforts of many people over the centuries that have preserved this legacy over 330 years, and ensured that it serves us as an indispensable part of our daily lives to this day. We hope to pass the Fukarasosui Irrigation Canal on to future generations as a living piece of history.

Fukara District Regional History Museum
Shizuoka Prefectural Lake Ashinoko Irrigation Association

HAKONE (FUKARA) Irrigation Canal: A Water Conveyance Tunnel

Withdrawing Water from the Lake ASHI

The FUKARA Irrigation Canal was completed in 1670. It conveys the water of Lake ASHI to SUSONO City, SHIZUOKA Prefecture, through a tunnel of 1,280 m long. People had difficulty in securing even the water for existing paddies in those days, not to mention of additional water for executing new paddy field development. The irrigation canal brought large benefit and joy to the people. In addition, the system is of full technical interests.

The water of the lake was deemed as the belonging of the God and it was necessary to obtain the permission from the HAKONE GONGEN Shrine for its use. The construction of the system was only commenced after an agreement was reached to contribute the token of gratitude in rice of 200 KOKU (30 ton) a year to the Shrine after its completion.

The Survey Techniques Employed

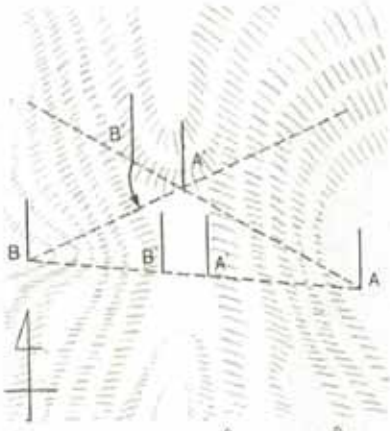
The construction of the tunnel started from both portals of the Lake ASHI side and FUKARA side in 1666.

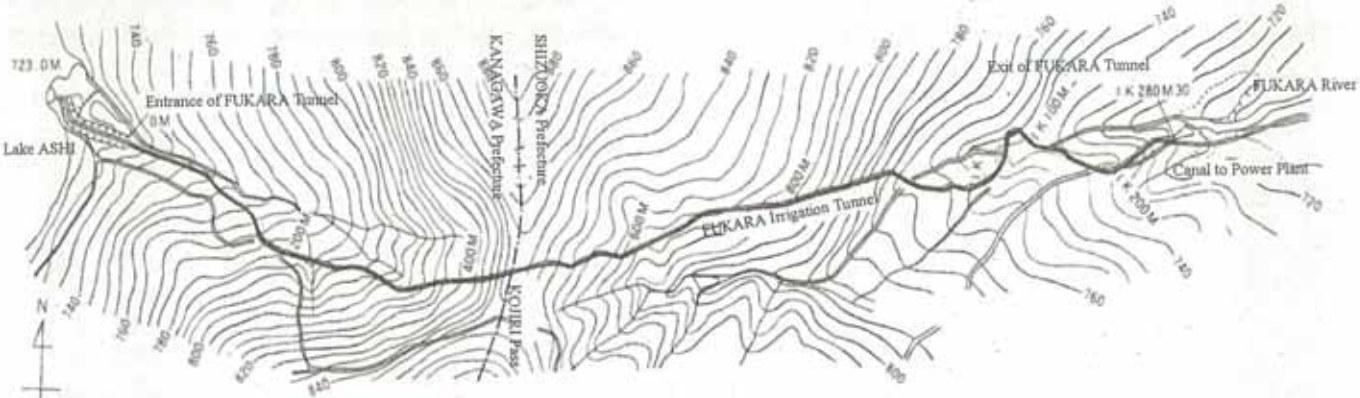
In the topographical survey for the construction, the NOJIRI pass, from where direct sighting of both portals was possible, was set as the datum point. Then the tunnel slope was determined, figuring out the elevation difference between the Lake ASHI and FUKARA portal. The tunnel slope thus determined was 1/130, as the total fall was 10 m and the distance was 1,280 m.

Survey Method:

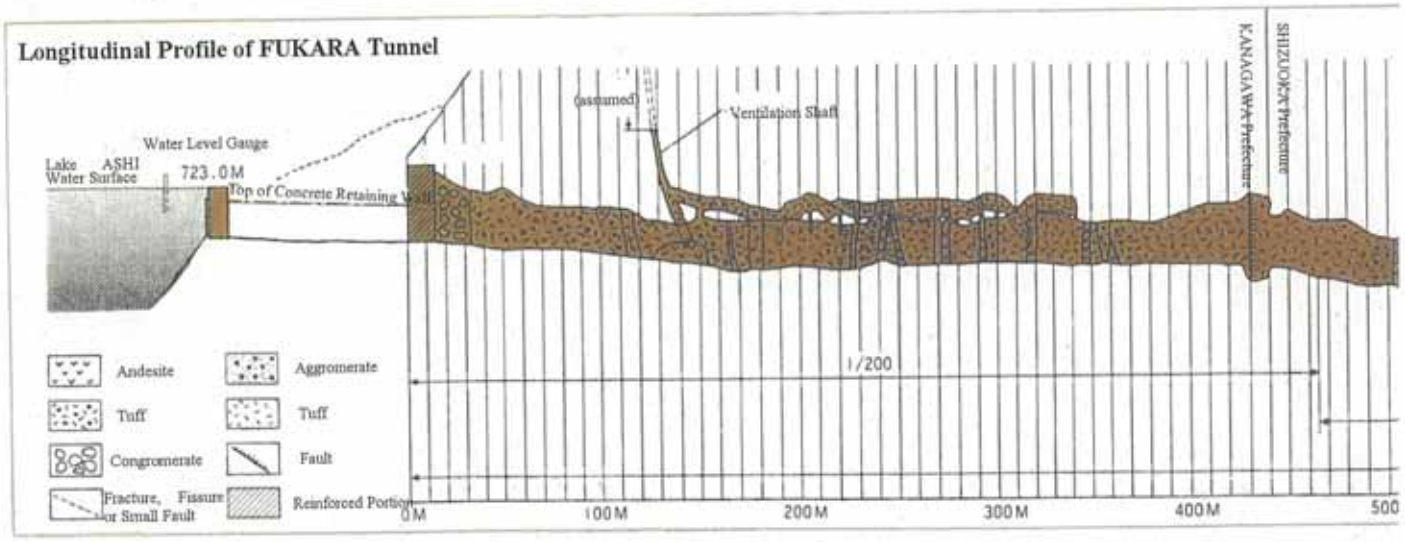
So-called NAMBAN survey method was employed for the tunnel construction, with instruments for leveling, magnet, rulers, protractors, measuring ropes and survey poles. To find the straight line between the two portals, they set up two poles and moved them so that they should be on a single line, observing the poles from the both portals. Then, the direction was measured with magnet and the tunnel was dug along that line thus determined.

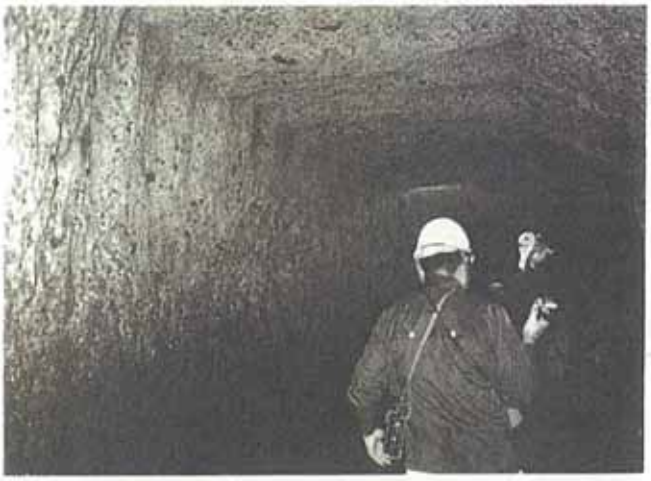
(1)Determine the locations (A & B) of tunnel portals.
(2)Stand two poles on the ridge and name them A' and B'.
(3)Move A' and B' to a straight line when sighted from both A and B.
(4)Measure the angle of the A-B line from the datum line at A.



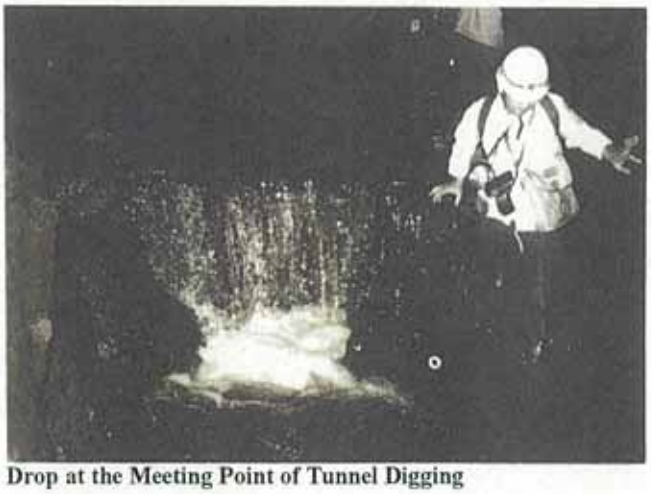


The topographical Map of FUKARA Tunnel:
The meandering seen appears to escape the portion of hard rock or to adjust the alignment of daily excavation errors. The technique to have the tunnel pass just beneath the lowest point of the ridge is masterly.





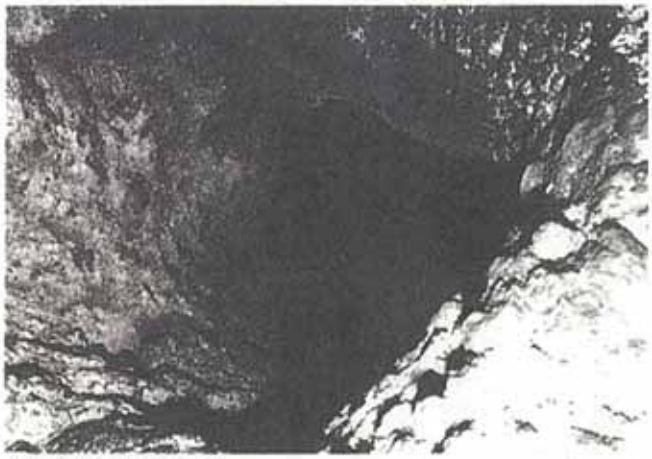
Interior of the Tunnel
There is a drop of one meter in the tunnel at present. It is not clear whether this is the error in excavation or is designed in advance.



Drop at the Meeting Point of Tunnel Digging

Method of Excavation

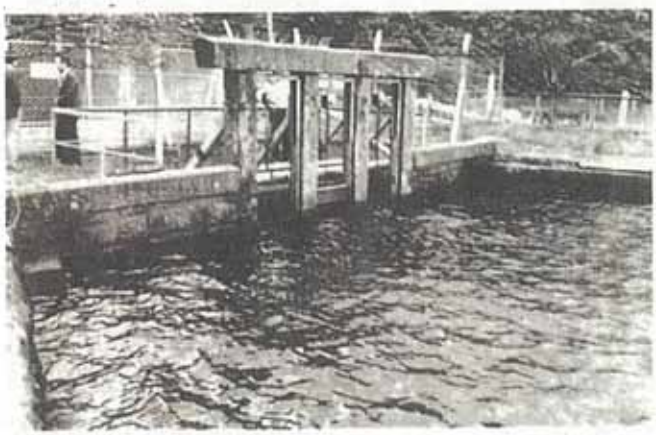
The direction of tunnel excavation was examined and confirmed daily at the digging front by use of a portable lantern. Pickaxes and chisels used in mines in those days were main tools of excavation. However, the excavation was continuation of very hard work and people suffered from faults, fissured belts, collapses and gushing water in the tunnel route which mainly consists of tuff. The route meandered in plan. The reason for this meandering came from avoiding the portions of hard rock en route and constant checking and adjustment of direction in the tunnel excavation. There are two vertical shafts apparently used for ventilation at about 150 m from the portals on both sides, in addition to a drop at the middle of the tunnel.



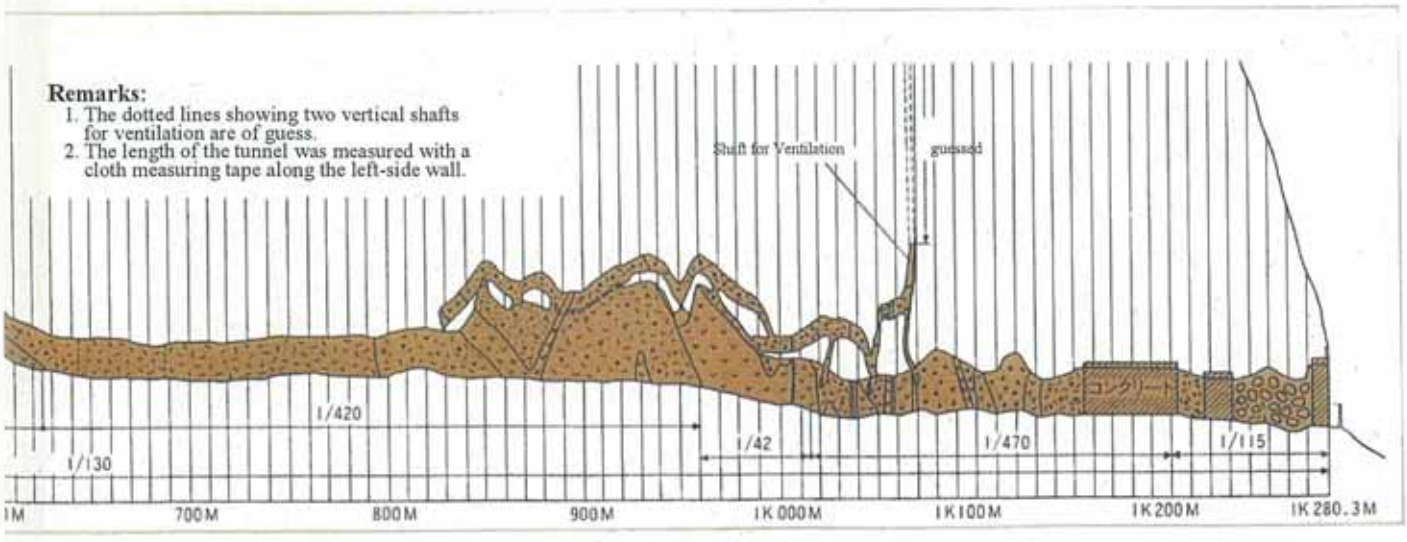
Shaft for Ventilation

In 1670, the tunnel was made through beneath the NOJIRI pass. It took four years, 834 thousand man-days of labor and 7,300 RYO of construction cost, far surpassing the magnitude of ordinary undertaking of the time.

However, no technical record of this tunnel called FUKARA tunnel has been left. This is thought that the Shogunate Government feared the spreading of the magnificent excavation techniques to private sector.



FUKARA Intake Sluice



Nokei No. 118
June 24, 2014

Mr. Yohei Sato, Chairman
Japanese National Committee of the ICID

Agreement for application for heritage irrigation structure status

In response to an application concerning Fukarayousui Irrigation Canal that was submitted by Shizuoka Prefecture's Ashinoko Irrigation Association (manager: Kenji Takamura, mayor of Susono City) on June 23, 2014, I hereby declare my support for said application based on my belief that the facility to be registered as a heritage irrigation structure has sufficient value based on the following reasons.

Yasuhiro Nochi
Director
Transport Infrastructure Department
Shizuoka Prefecture

Contribution to agricultural and rural development

- Fukarayousui Irrigation Canal is an irrigation canal that was built in 1670 to convey water from Lake Ashi in Kanagawa Prefecture to the Sunto region of Shizuoka Prefecture (Susono City, Gotemba City, Nagaizumi Town, and Shimizu Town) via an aqueduct tunnel (total length: 1,280 meters; elevation difference: 9.8 meters). It was built because water shortages made it difficult for this region to secure irrigation water for existing fields, let alone for fields to be newly developed. Today, the canal continues to support local agriculture as an important form of agricultural infrastructure that services some 650 ha of farmland. It also makes a major contribution to the development of rural towns in such fields as power generation, the environment, and fire prevention.

Advanced and unsurpassed technologies

- The aqueduct tunnel was built in three and a half years by a total of 840,000 people. Digging began simultaneously at both entrances. However, despite the fact that workers dug by hand using only chisels, the height difference when they met in the

middle was only about 1 meter (the downstream side was lower than the upstream side, although some claim that this difference was planned from the outset). Such precision demonstrates the high sophistication of the surveying skills that were employed.

- A variety of advanced technologies were fully employed, including the opening of air holes for ventilation in the top of the tunnel.
- The average grade of the tunnel is 1/130, which is considered the ideal grade. Thus, it sets a high standard even in terms of irrigation technology.

Status of preservation

- Water intake as well as allocation and regulation to each field are skillfully managed by a water allocator system that has continued since the time of the canal's construction. The water allocator also regularly inspects the facility for maintenance purposes.
- The Fukara district hosts various activities that include the "Fukara Yosui Festival," which is held to tell coming generations of the remarkable accomplishments of our ancestors and give thanks to the canal.

農計第　118　号
平成26年6月24日

国際かんがい排水委員会日本国内委員会
委員長　佐藤 洋平 様

静岡県交通基
野知

かんがい施設遺産申請についての意見書

平成26年6月23日付けで、静岡県芦湖水利組合（管理者　裾野市長　高村謙二）から申請のあった「深良用水」については、下記理由により、かんがい施設遺産に登録する施設として十分な価値があると考えますので、申請内容に賛同します。

記

（農業農村の発展への貢献）
・　深良用水は、水不足により新田開発はおろか、既に開かれていた水田への用水確保も困難であった静岡県駿東地域（裾野市、御殿場市、長泉町、清水町）に、神奈川県芦ノ湖の湖水を水路トンネル（全長１，２８０m、高低差９．８m）で導水するため、寛文１０（１６７０）年に造成された農業用水路であり、現在もこの地域の約６５０ｈａの農地を潤す重要な農業生産基盤として地域農業を支えるとともに、発電、環境、防災等の様々な役割を担い、農村の発展に大きく貢献している。
（先進的・卓越した技術）
・　水路トンネル工事は、延べ８４万人の作業員により、３年半の歳月を要した。出入口両側から同時に掘削を開始したが、ノミを使った手掘りであるにもかかわらず、合流地点での高低差はわずか１m程度（下流側が上流側より低くなっており、当初から計画されたとの説もある）であり、高度な測量技術が用いられた。
・　坑道の上には、換気をするための息抜き穴が掘られていたことなど、先進的な技術を駆使していた。
・　水路トンネルの平均勾配は、理想的な勾配とされる１／130 となっており、水利技術においても高い水準であった。
（保全状況）
・　建設当時から続いている水配人制度により、取水、各ほ場への分配調整等を巧みに行っているほか、水配人は施設を維持管理するための点検を定期的に実施している。
・　深良地区では、先人の偉業を後世に伝え、深良用水に感謝することを目的とした「深良用水まつり」を開催するなど様々な取組を行っている。