Development of an un(low)-powered remote monitoring system of mine wastewater

National Institute of Advanced Industrial Science and Technology (AIST)
Geological survey of Japan

Tetsuo Yasutaka,
Hiromitsu Furukawa, Kenro Kuroki,Tsukasa Fujita

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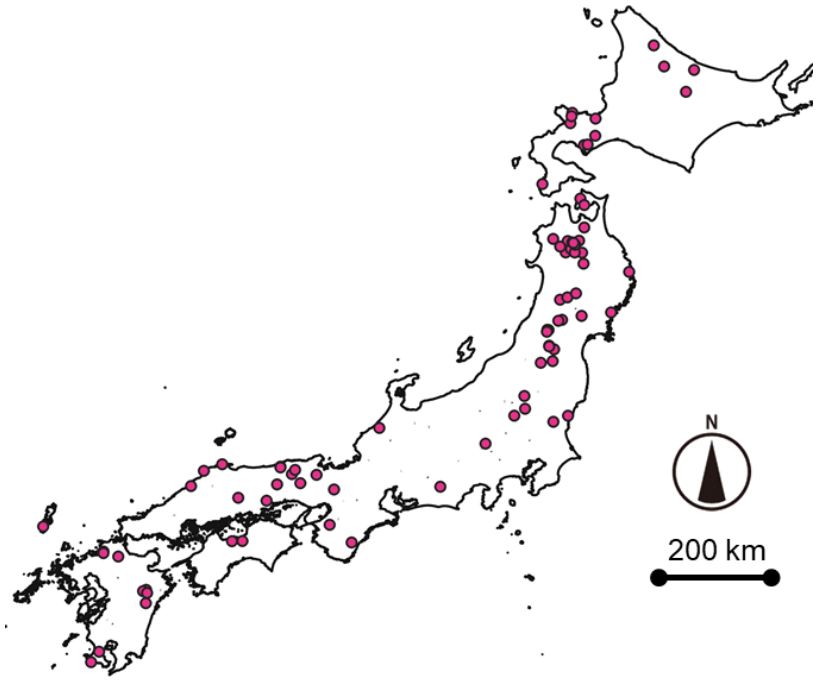
Legacy mines in Japan

- There used to be more than **5,000** mines in Japan.
- But currently there is only **1** commercially active metal mine (Hishikari Gold Mine).
- And now **97** closed metal mines across the country are still being managed by companies and local governments for waste water treatment and pollution management.
- The annual cost of waste water treatment is **2-4 billion yen (15-26 million USD/year)**.
- Cost reduction is very important.



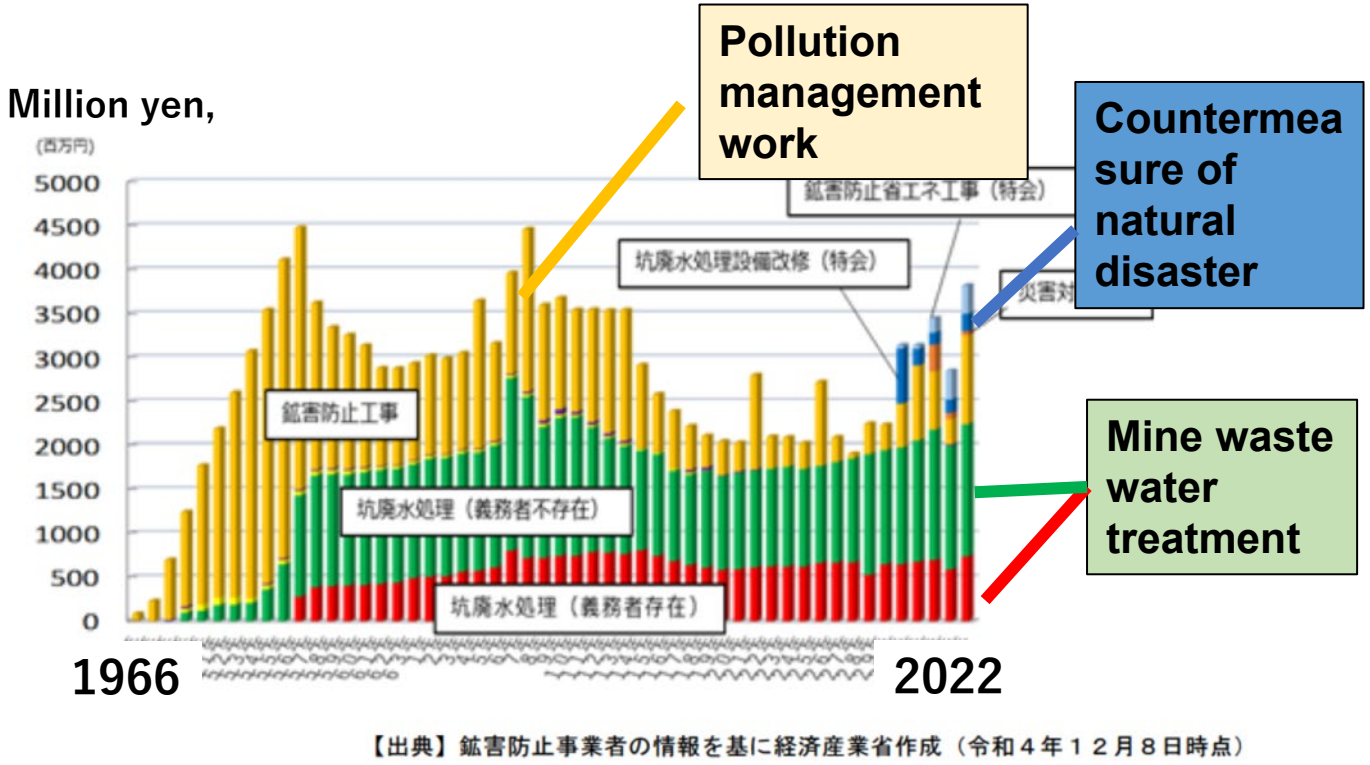
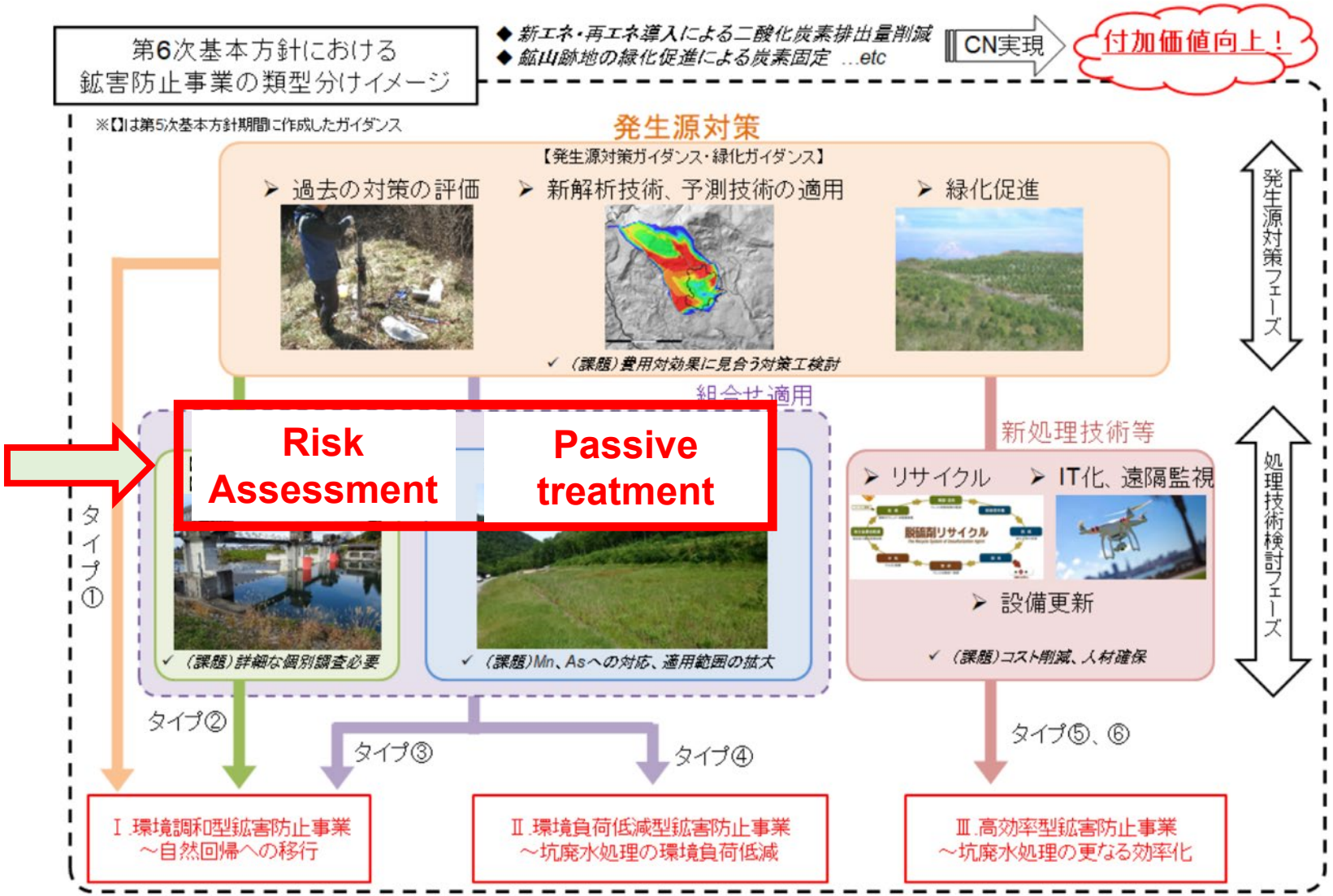


Figure METI-HP:https://www.meti.go.jp/shingikai/hoankyogikai/pdf/g100614e05j.pdf
Figure Reference: METI: http://mric.jogmec.go.jp/kouenkai_index/2011/briefing_110831_1.pdf

The annual budget of legacy mine management from 1966 to 2022

6th Basic Plan for the Prevention of Mining Pollution in Japan. (2023-2032)

- **Accelerated completion of mine wastewater treatment, accelerated cost reduction**



https://www.meti.go.jp/shingikai/hoankyogikai/kinzoku_kogyo/pdf/003_04_00.pdf

Example of the passive treatment project in Japan.

Poster session

Assessing the cost and applicability of passive treatment and risk-based point-of-use management for 26 legacy mine drainages, Kohei Doyama[1], Yuichi Iwasaki[1], Takaya Hamai[2], Tetsuo Yasutaka[1], Shingo Tomiyama[3]

Date: Friday, 26/Apr/2024 morning, Mine Closure & Legacy Issues, Location: Salon D

Understanding a passive treatment mechanism of manganese and zinc at a legacy mine in northern Japan using geochemical modelling, Sereyroith Tum[1], Taiki Katayama[1], Naoyuki Miyata[2], Miho Watanabe[2], Yohey Hashimoto[3], Tetsuo Yasutaka[1]

6th Basic Plan for the Prevention of Mining Pollution in Japan. (2023-2032)

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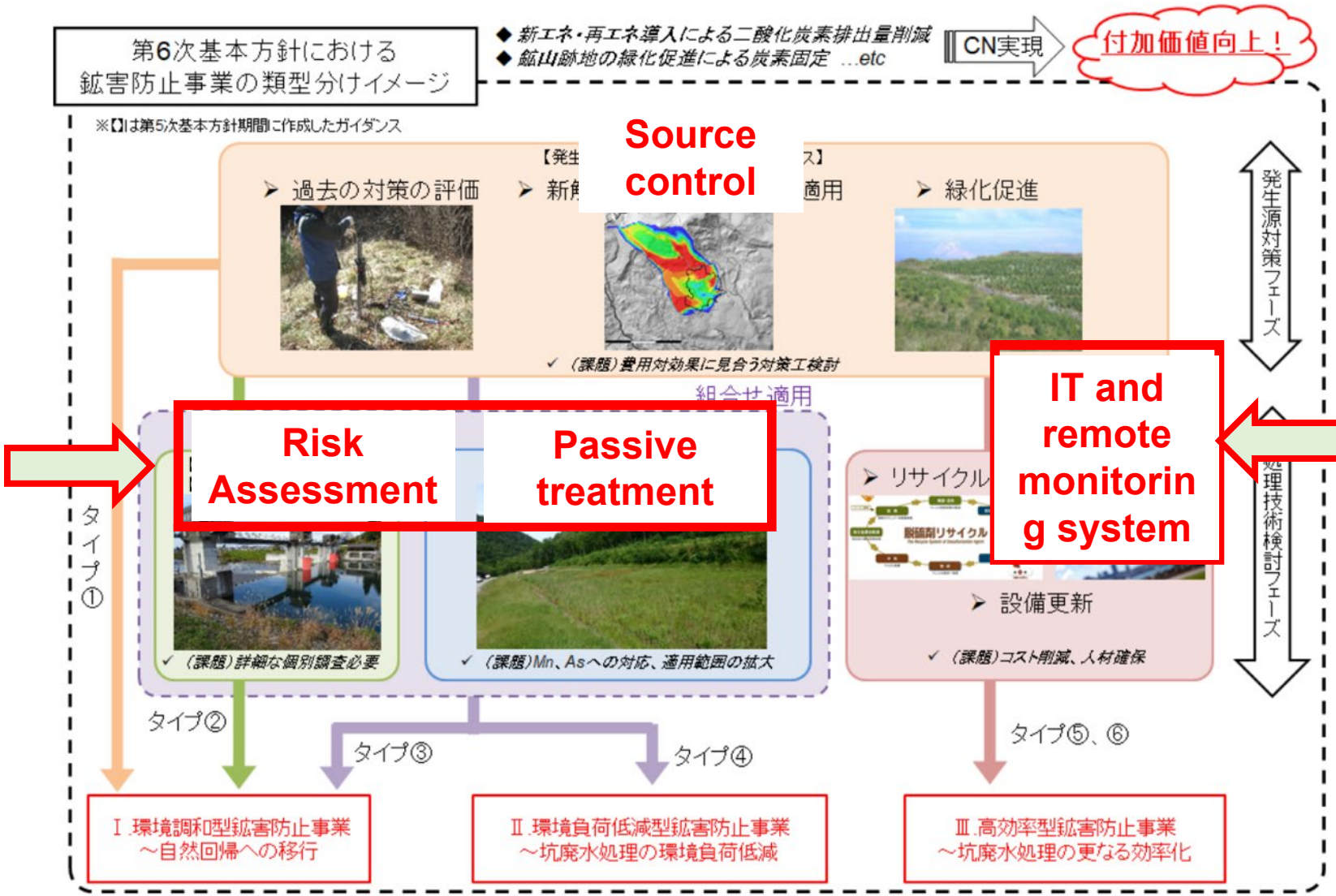


- **Strengthening risk response to natural disasters**
- **Securing human resources and saving labour and manpower for mine wastewater treatment.**

https://www.meti.go.jp/shingikai/hoankyogikai/kinzoku_kogyo/pdf/003_04_00.pdf

Background and purpose

Background

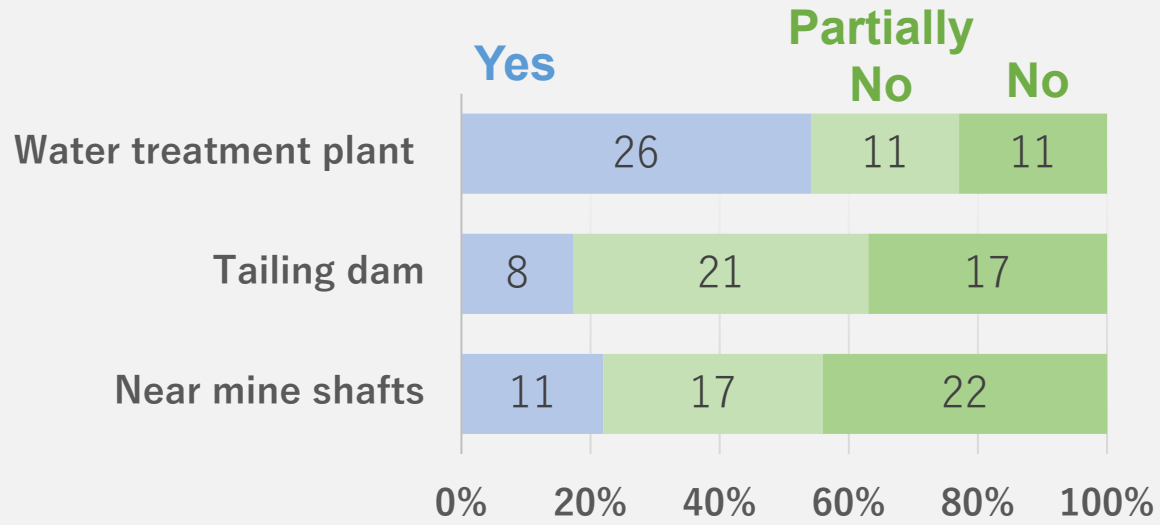
- In Japan, many of the mines are located deep in the mountains and **40-80% of the sites have no electricity or radio waves** (especially tailings dams and mine shafts).
- More than **60%** of the sites had a need for remote monitoring technology.

Purpose

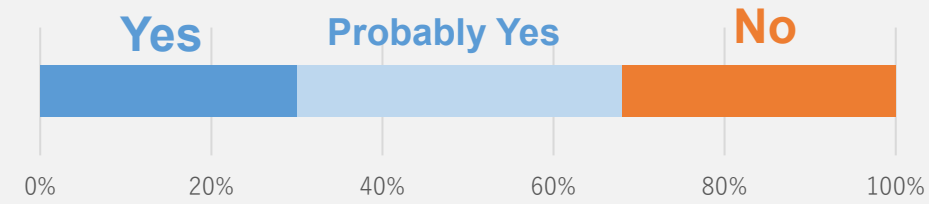
- This study focuses on the development and implementation of an low power remote monitoring system to save labour in the management of legacy mines that have no electricity and/or radio waves.

Result of questionaries for 29 mines managed by private companies, 21 mines managed by municipalities

Q1: Availability of electricity and radio waves at each mine



Q2: Needs for remote monitoring technology



Target:
Water quality, Flow rate, Photo&Movie, Remote control

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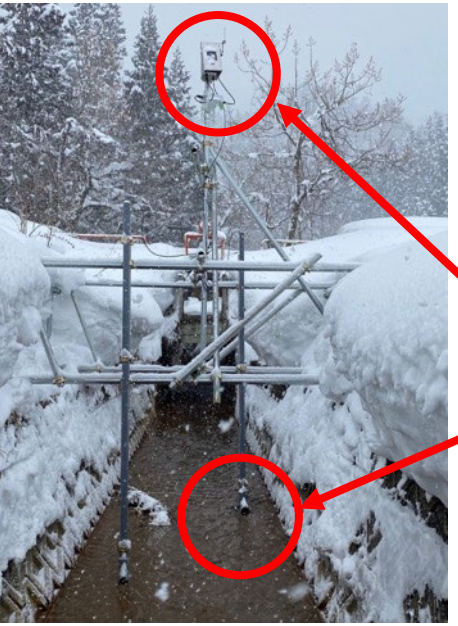
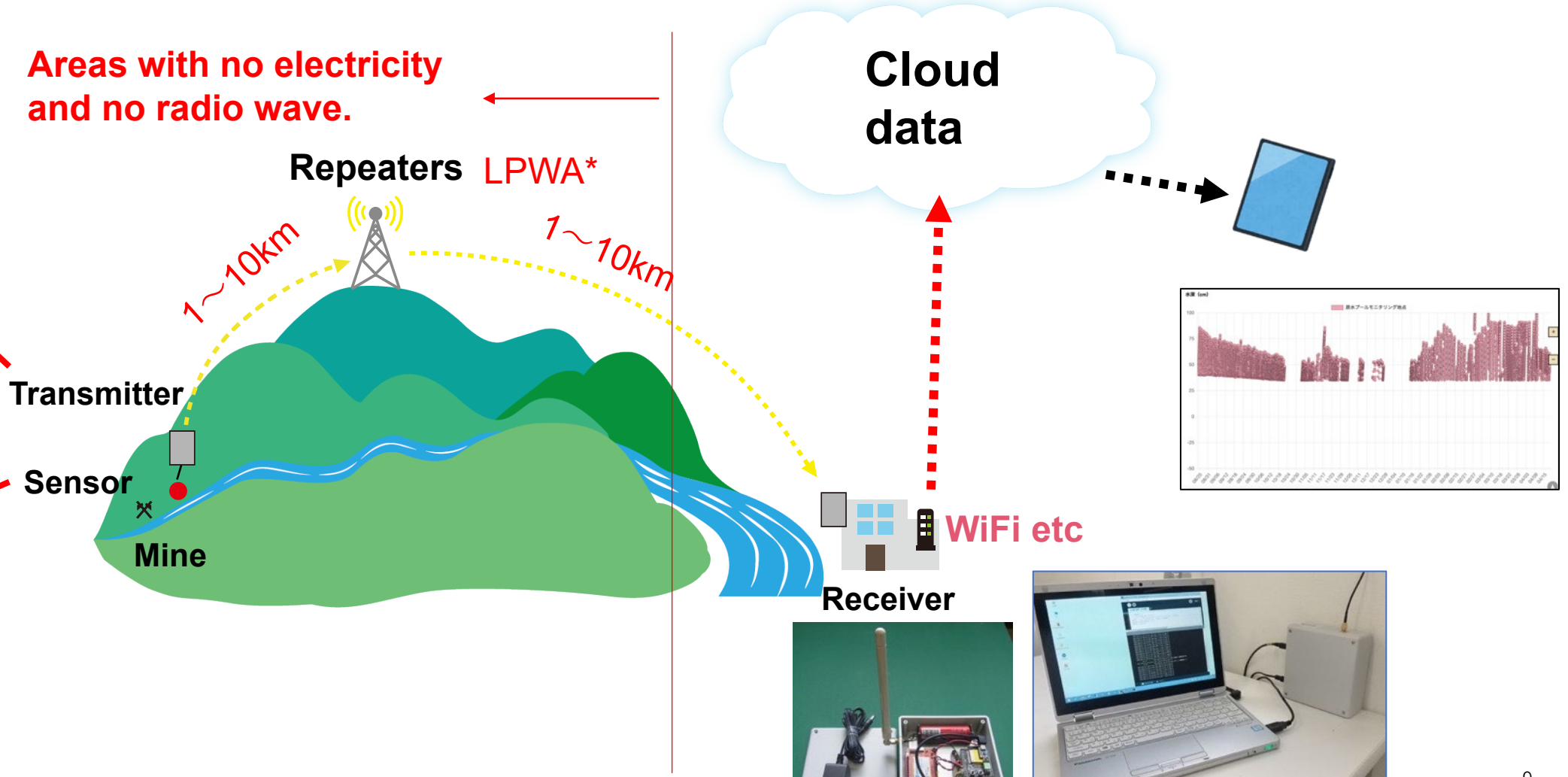
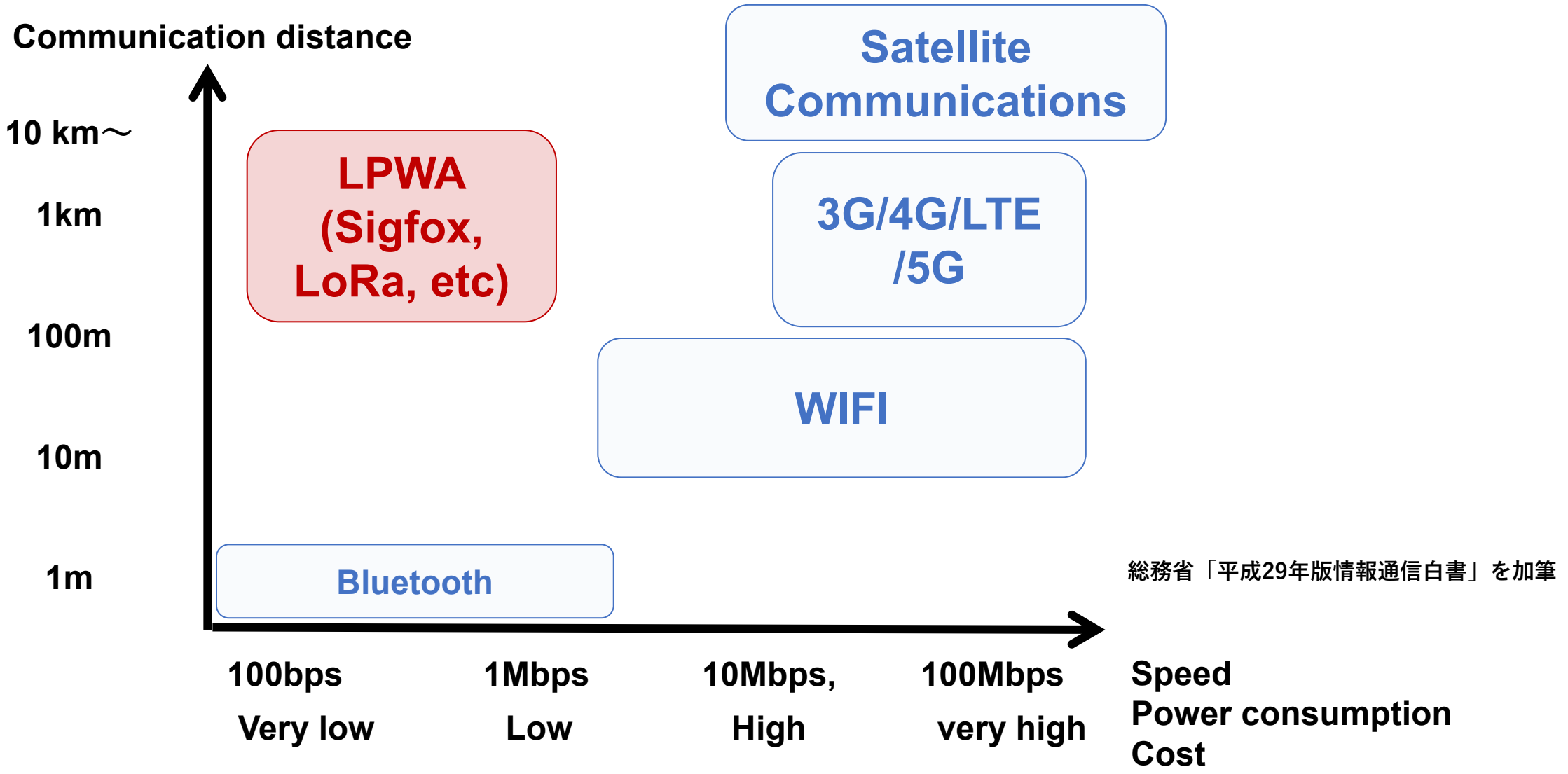
Remote monitoring system

- Development and implementation of an low power remote monitoring system
- LPWA（Low Power Wide Area） is used as a communication method.





Means of Communication and Features



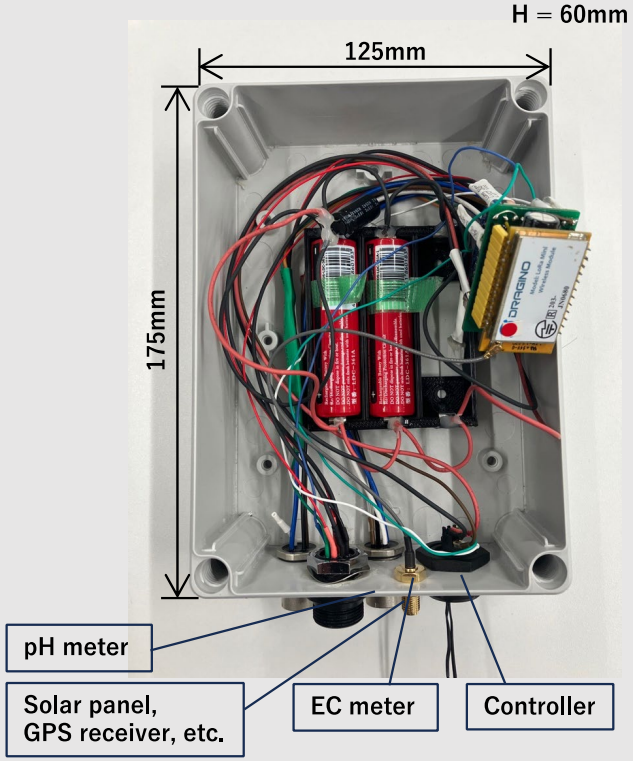
総務省「平成29年版情報通信白書」を加筆

- **The reason for using LPWA is its low cost, low power consumption, and long distance communication.**

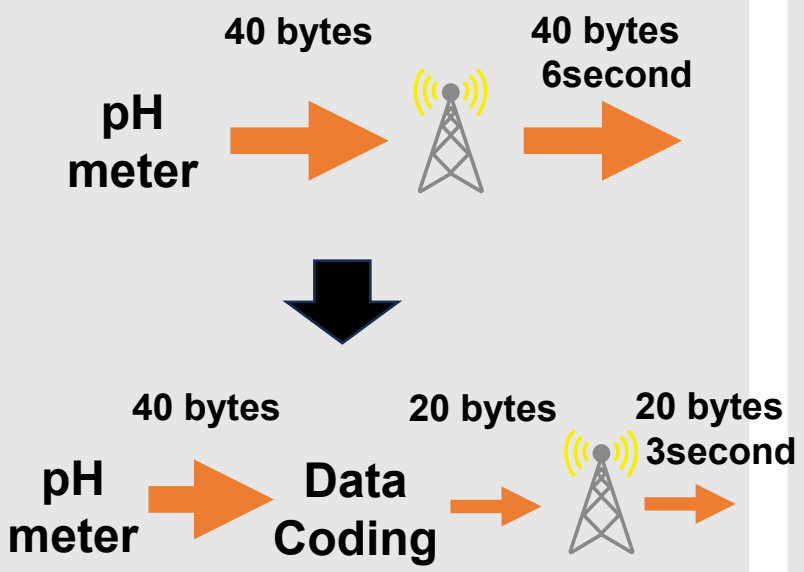
How to reduce the Electric power

- LoRa has low power consumption. But further reducing power consumption is important in order to reduce lithium battery capacity and solar power capacity(and reducing the cost)

Using low EP equipment

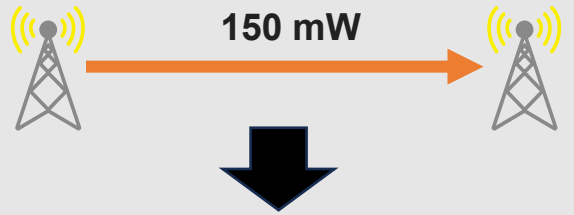


Reduction of communication time through data coding



Reducing the the frequency of communication

Constant communication



Every 5 or 10 or 20 minutes

Synchronization of the communication times using GPS

- We reduce total power consumption from 40-150 mW to an average of 2 mW.

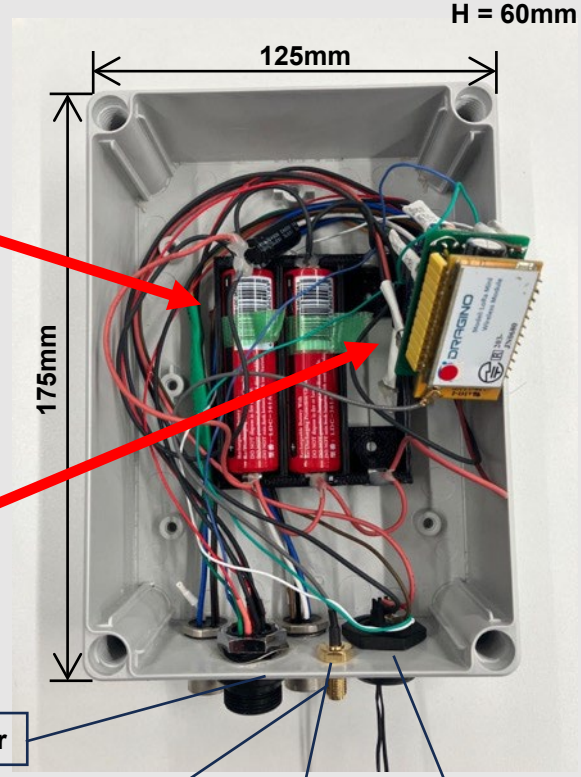
How long will the battery last

- **Total electric power consumption of transmitter average 2 mW.**
- **When we use Lithium Ion Rechargeable Battery(3.7V, 3600 mAh =13.32Wh), the system can be monitored for 250 days without recharging.**
- **Recharge using solar panels.**

Transmitter

18650 Lithium Ion Rechargeable Battery
- **3.7V**
- **3600mAh**

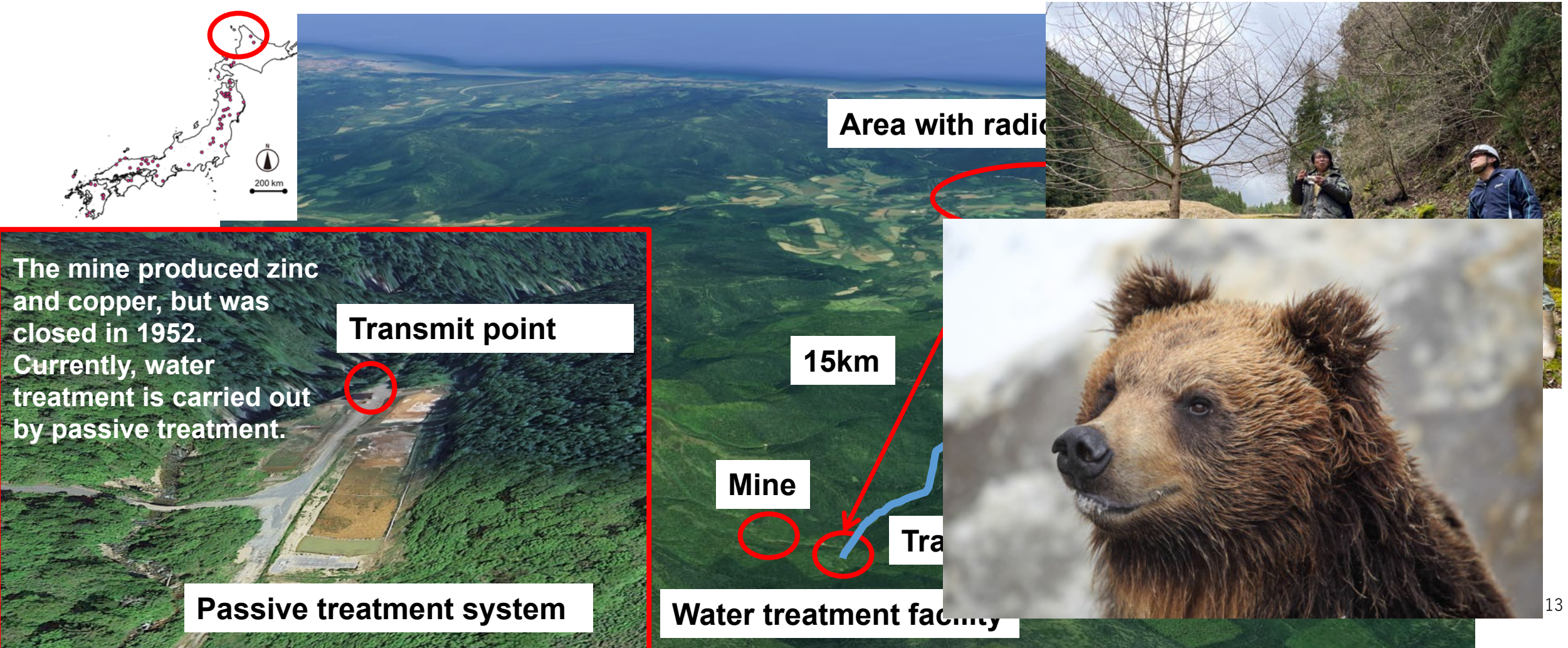
LoRa module
DRAGINO LoRa Mini
- VCC：0.5 - 3.9V
- Sleep Mode：22μA
- TX Mode：88mA@20dBm



Recharge using solar panels.
9 cm x 12 cm, 1.2W

How to search the good location of Repeater and Receiver :Mine C

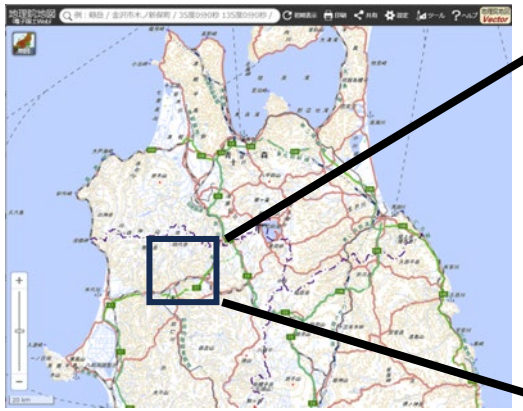
- LoRa is capable of communicating for 10 km in the absence of obstructions.
- On the other hand, mountains interfere with the radio waves, so suitable receiver and repeater points need to be found.
- Walking to find the point is time-consuming. And there is also a risk of encountering dangerous wild animals.



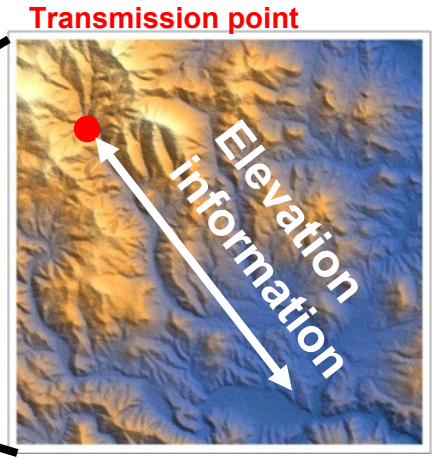
Development the calculating radio losses from topographical and elevation information.

- To reduce the effort required to find the best repeater and receiver points, we developed the program calculating radio losses from topographical and elevation information.
- The best point can be selected by overlaying the results obtained with the range of commercial radio signals and roads.
- With this program, the optimum point within a 10 km x 10 km range can be calculated in 10 minutes.

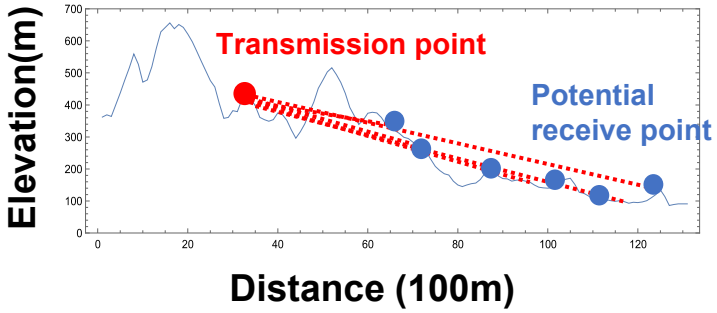
GSI Maps



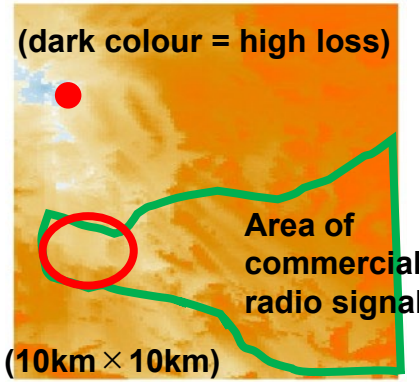
Topographical data



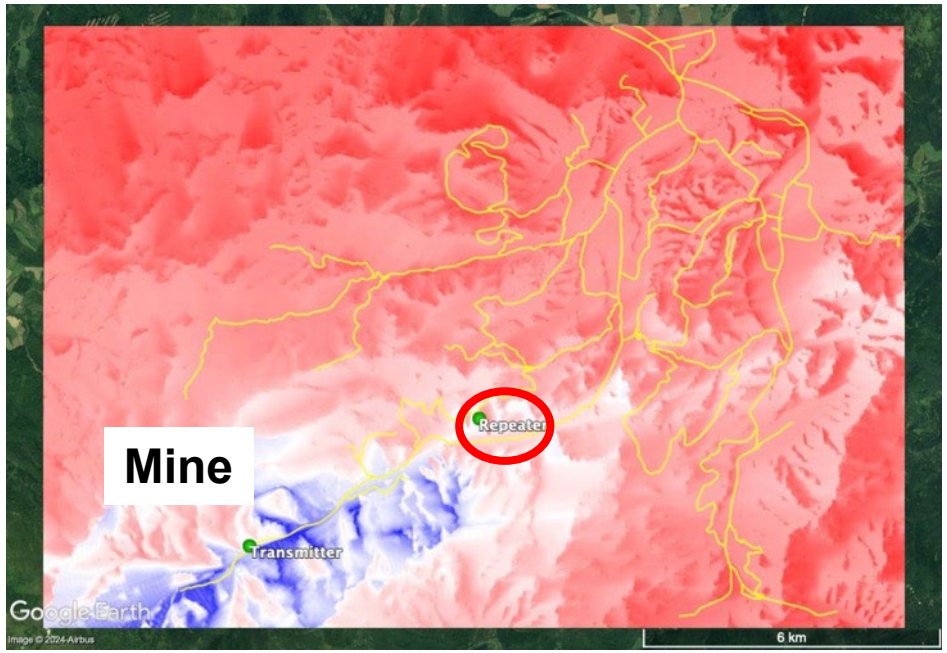
Calculating radio losses



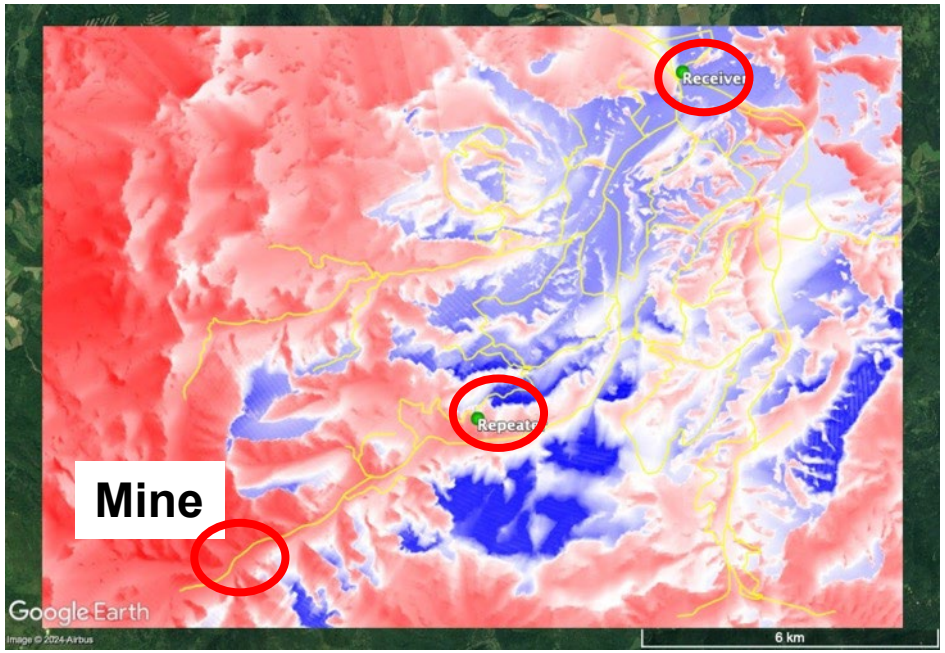
Draw the radio losses map over the entire area



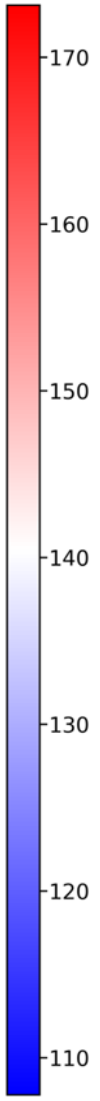
Analysis results of Mine C



Transmitter to Repeater

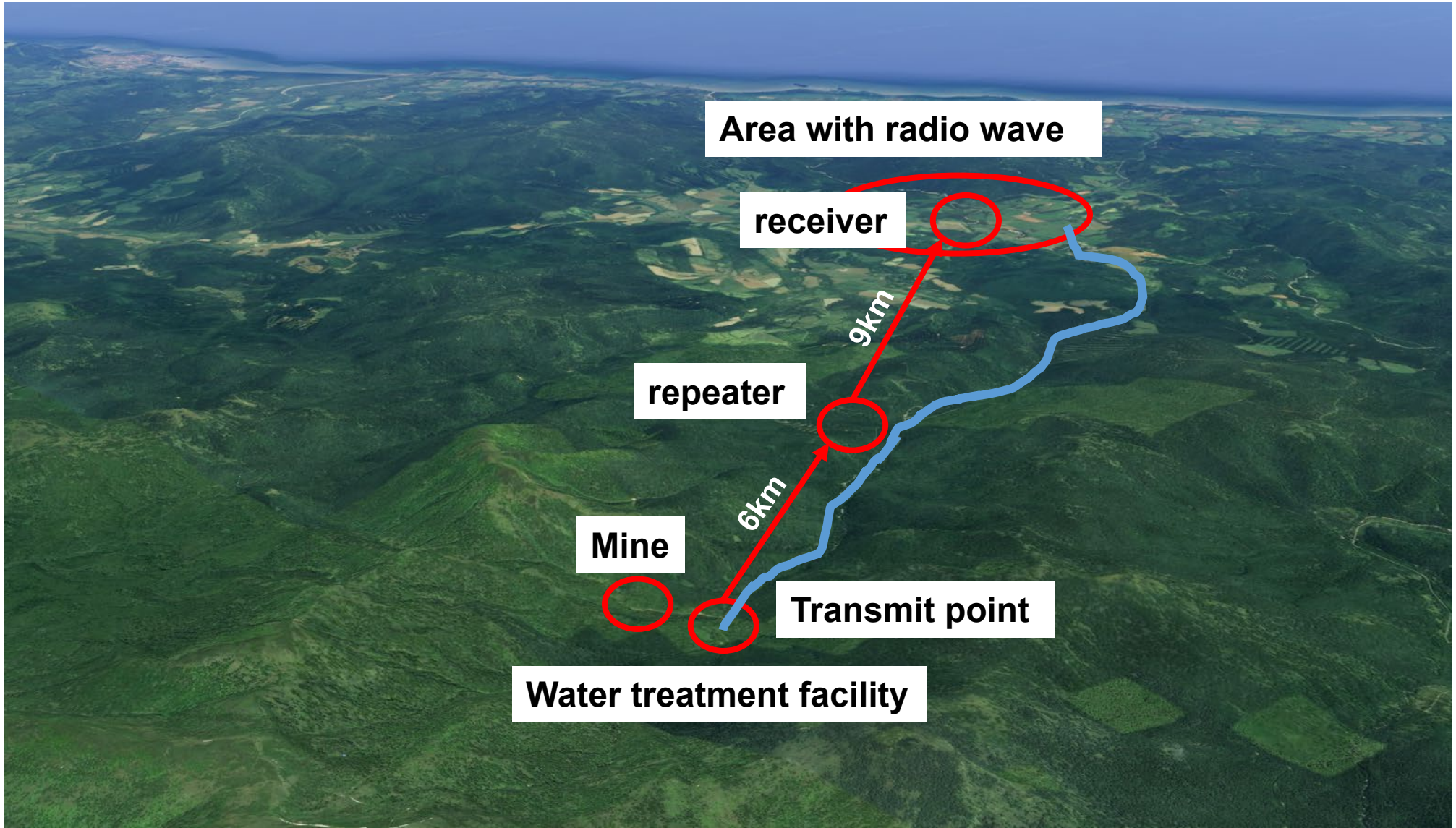


Receiver to Repeater

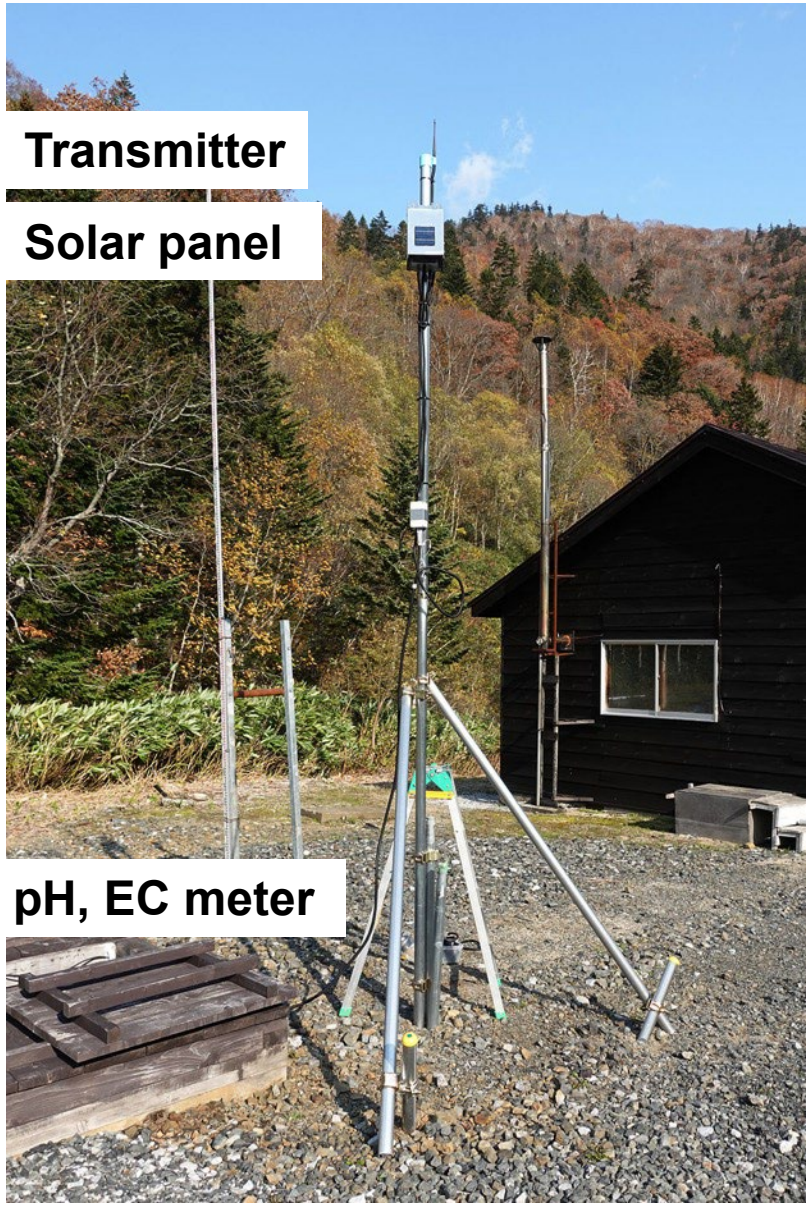


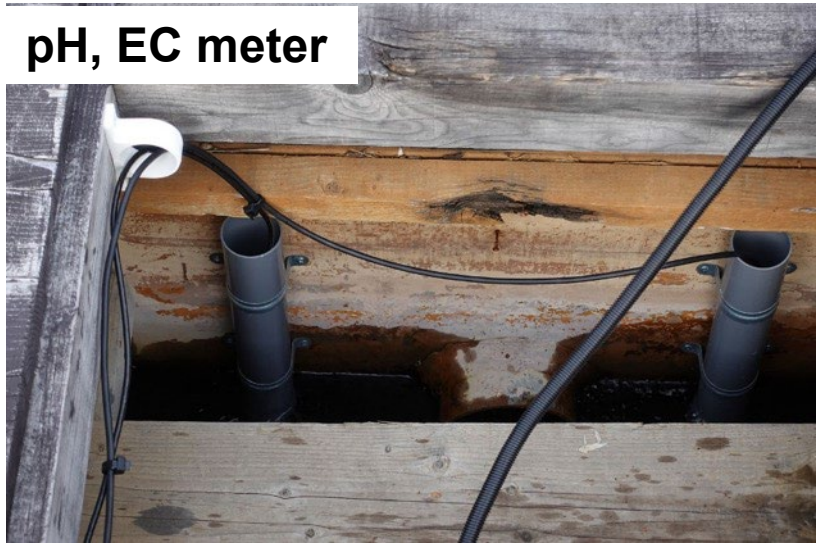
Approx. LoRa communicable sensitivity

Installation point of mine C



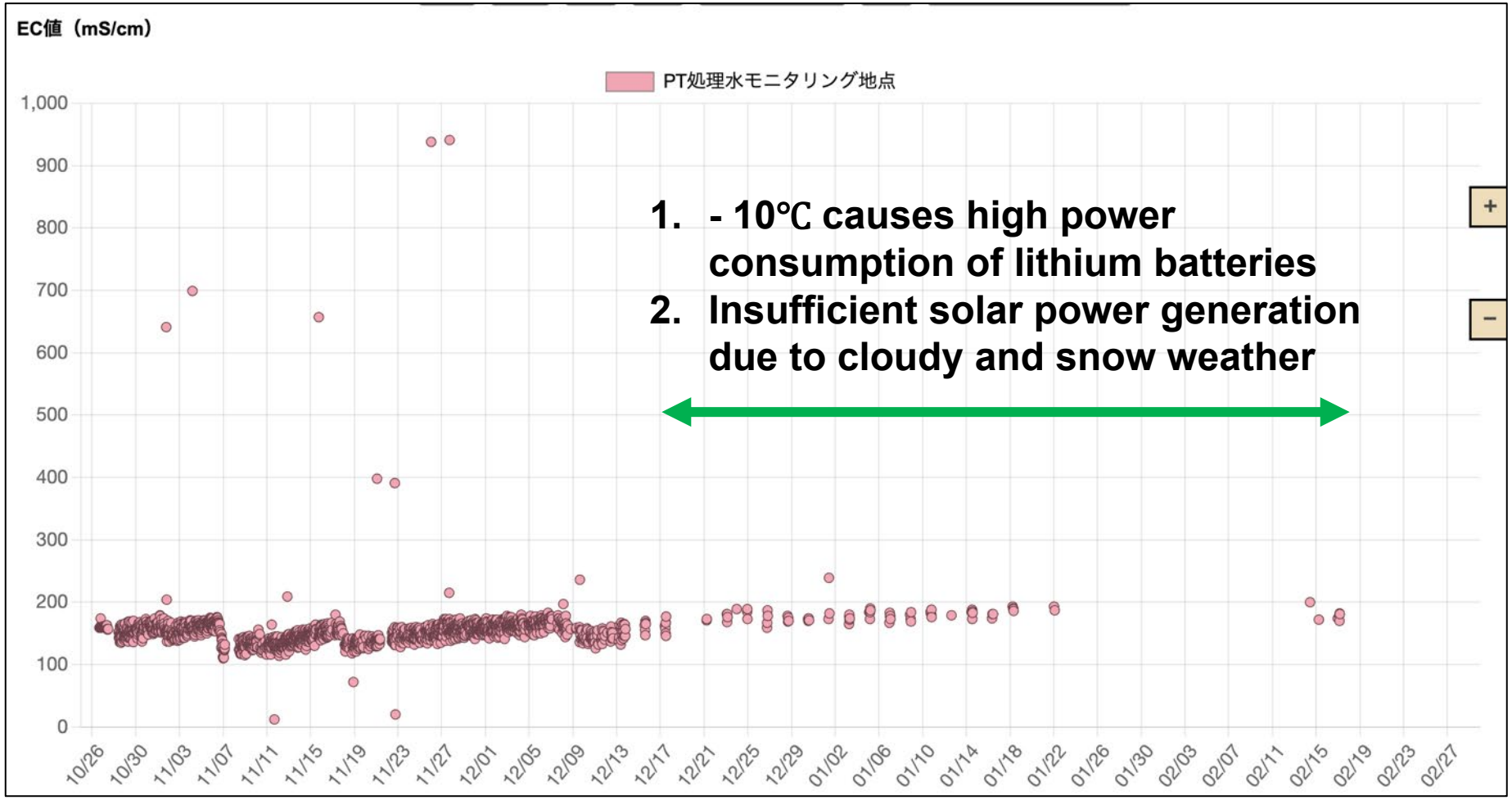
Equipment installation at Mine C.





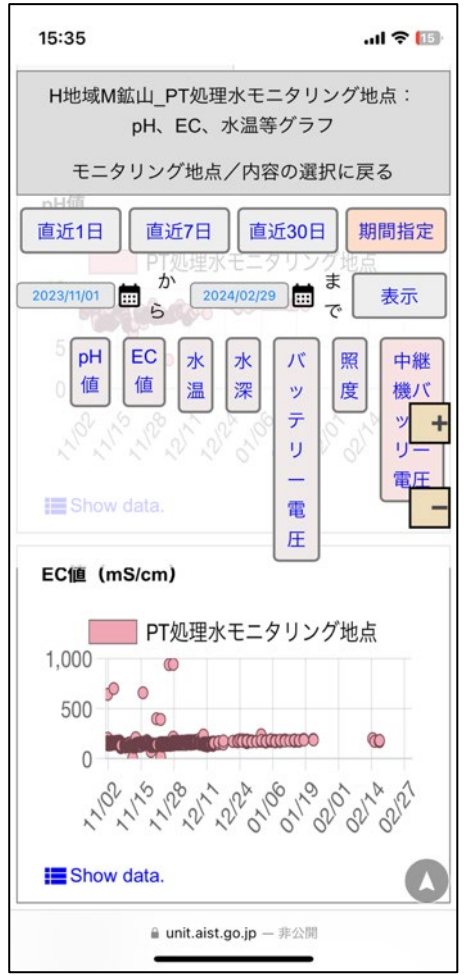
Data of Mine C

EC



1. - 10℃ causes high power consumption of lithium batteries
2. Insufficient solar power generation due to cloudy and snow weather

Smart phone



Nov.,2023 Dec.,2023 Jan.,2023 Feb.,2023

Cost

Initial Cost

- LPWA transmitter, repeater, receiver is within ~~1000~~ 500-800 USD respectively(If we assemble them ourselves).
- Cost of pH meter, EC meter, flow meter is depend on the Model and Performance.
- Travel and labour costs for installation are the highest (depend on the location). But using an installation location search programme, labour costs can be significantly reduced.

Running cost

- 100-300 USD per year (Transmission of data to the cloud and maintenance of servers)

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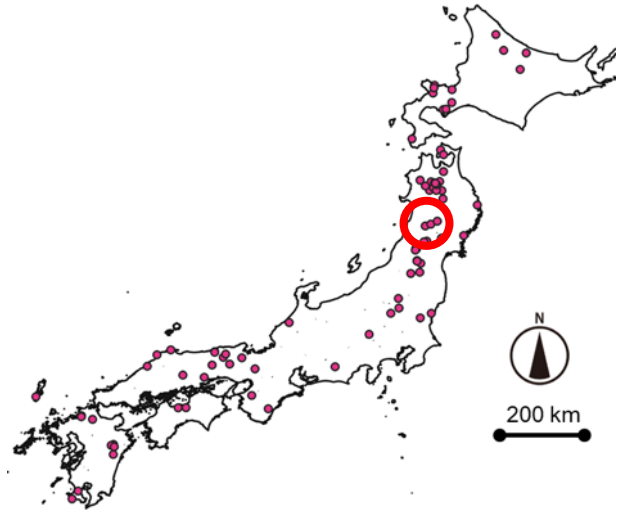
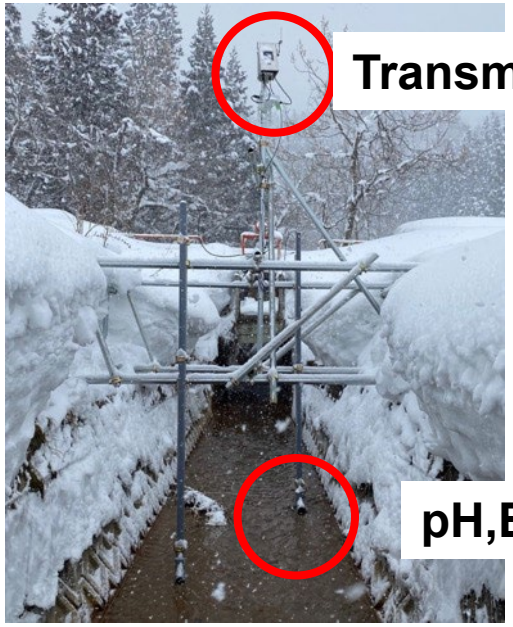
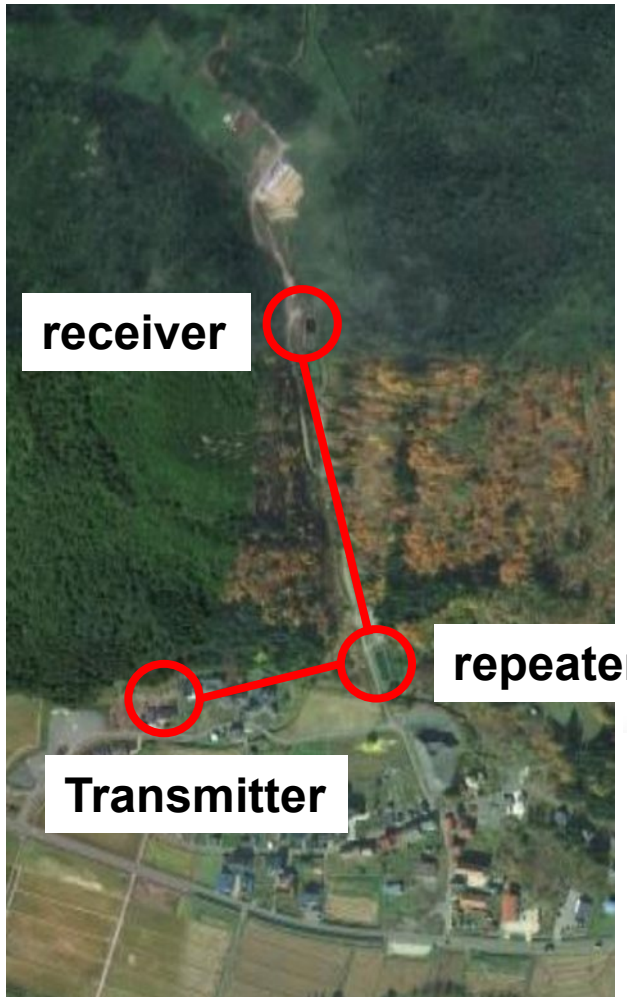
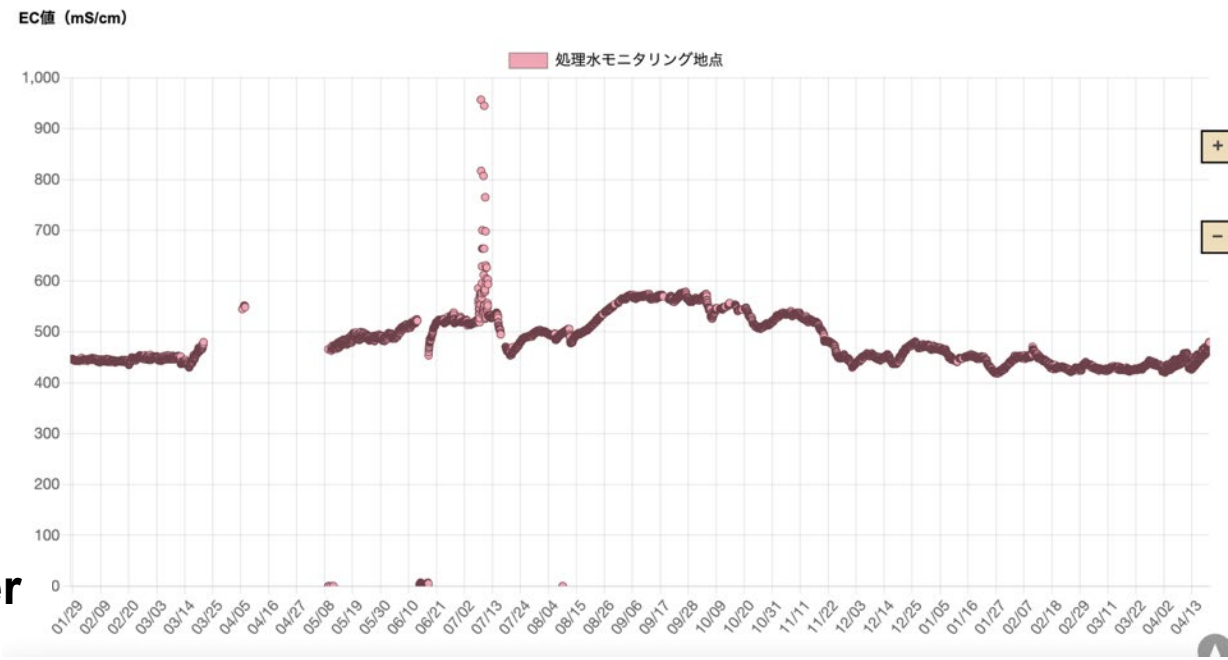
Mine D
Period of operation 1720-1957, produced zinc, lead and copper.







EC



Jan.,2023

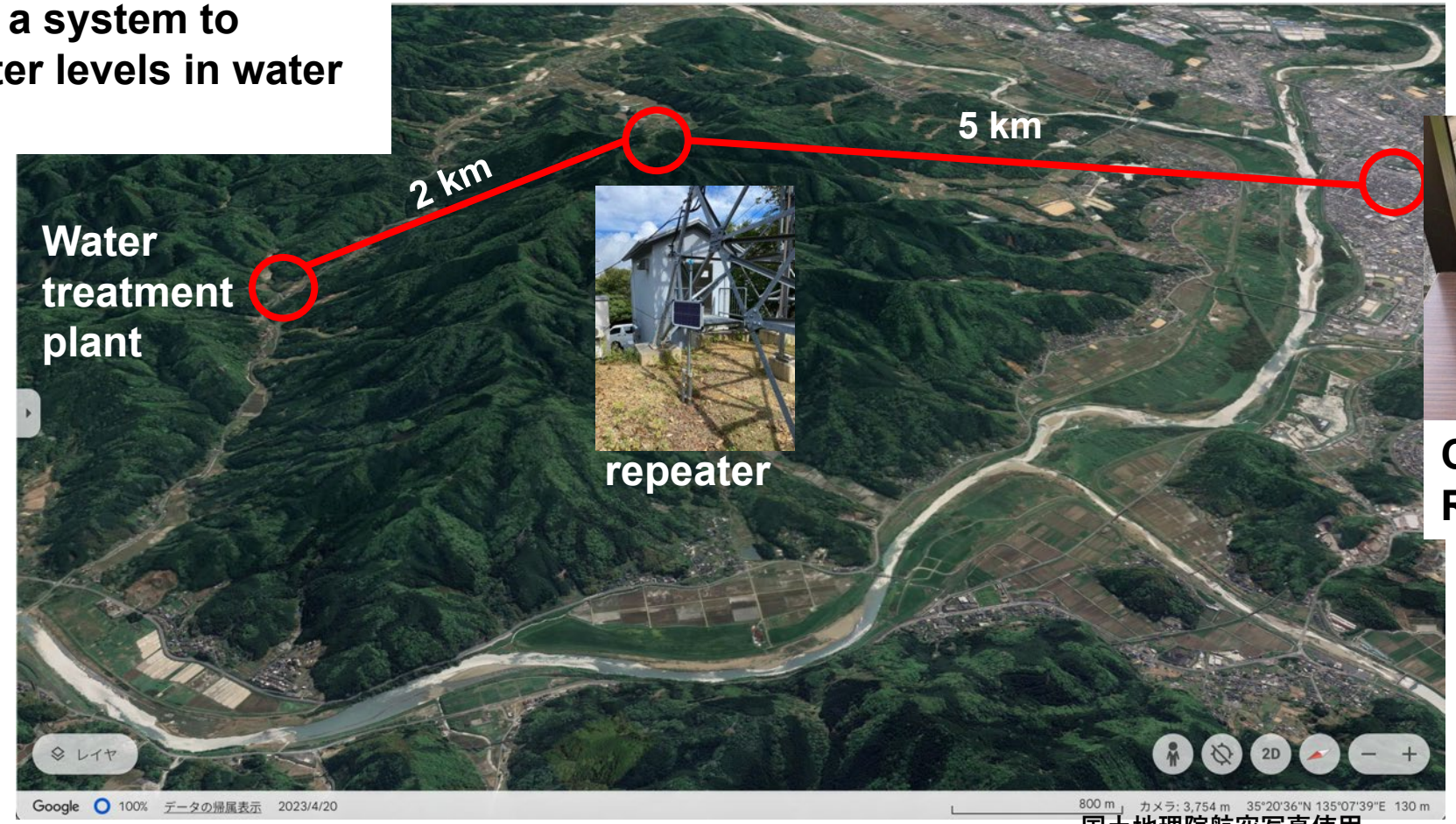
Jan.,2024

Mine D has been remotely monitored throughout the year, with the exception of February-March 2023.

Mine F

- The mine produced iron sulphide and silver; closed in 1955.
- The amount of mine wastewater increased in 2023 due to heavy rainfall. At that time, some mine wastewater was discharged into the river without water treatment

- There was a need for a system to remotely monitor water levels in water treatment facilities.



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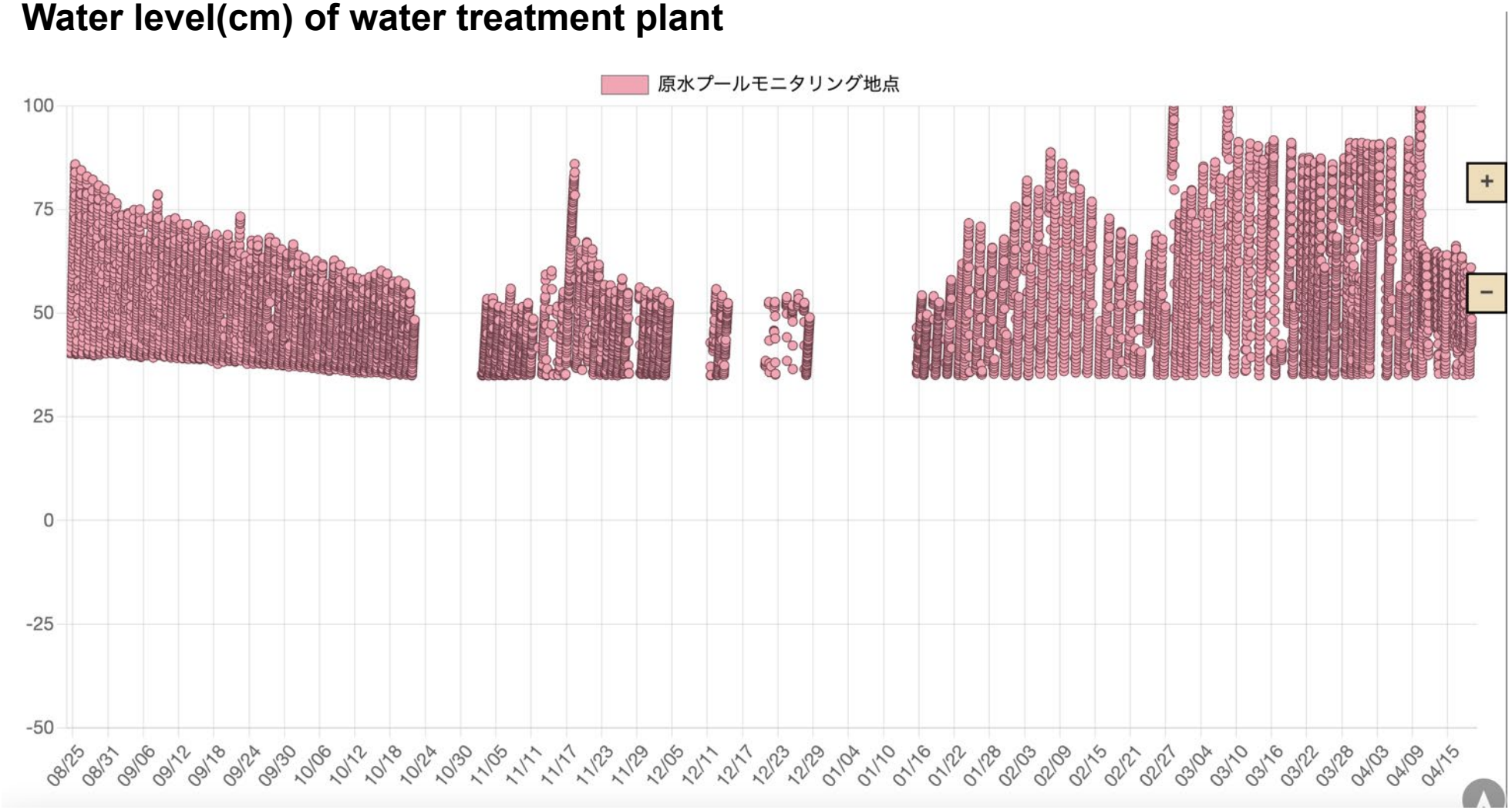
Data of water level at Mine F

Water level(cm) of water treatment plant



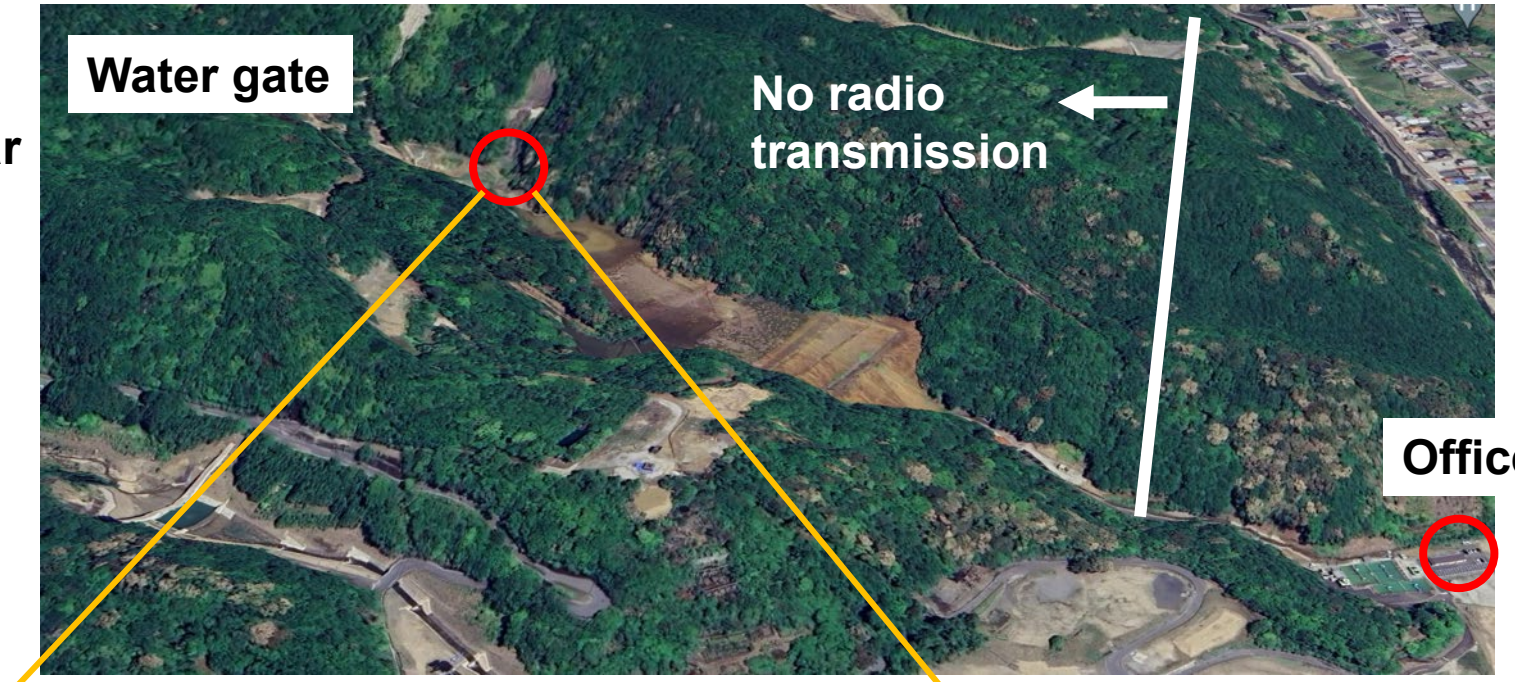
- **Mine E has been remotely monitored throughout the year.**
- **Some periods of missing data, but due to WIFI connection settings in city halls.**

Aug.,2023

Apr.,2024

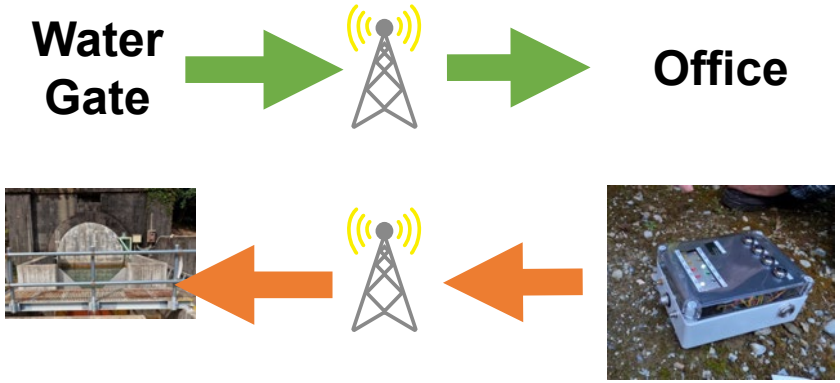
Mine A:
The challenge of two-way directional communication

- The mine produced Cupper and Sulphide; closed in 1972.
- As it takes about 20 minutes by car from the office to the water gate.
- There was a need to check the situation and remotely control the operation of the water gate.

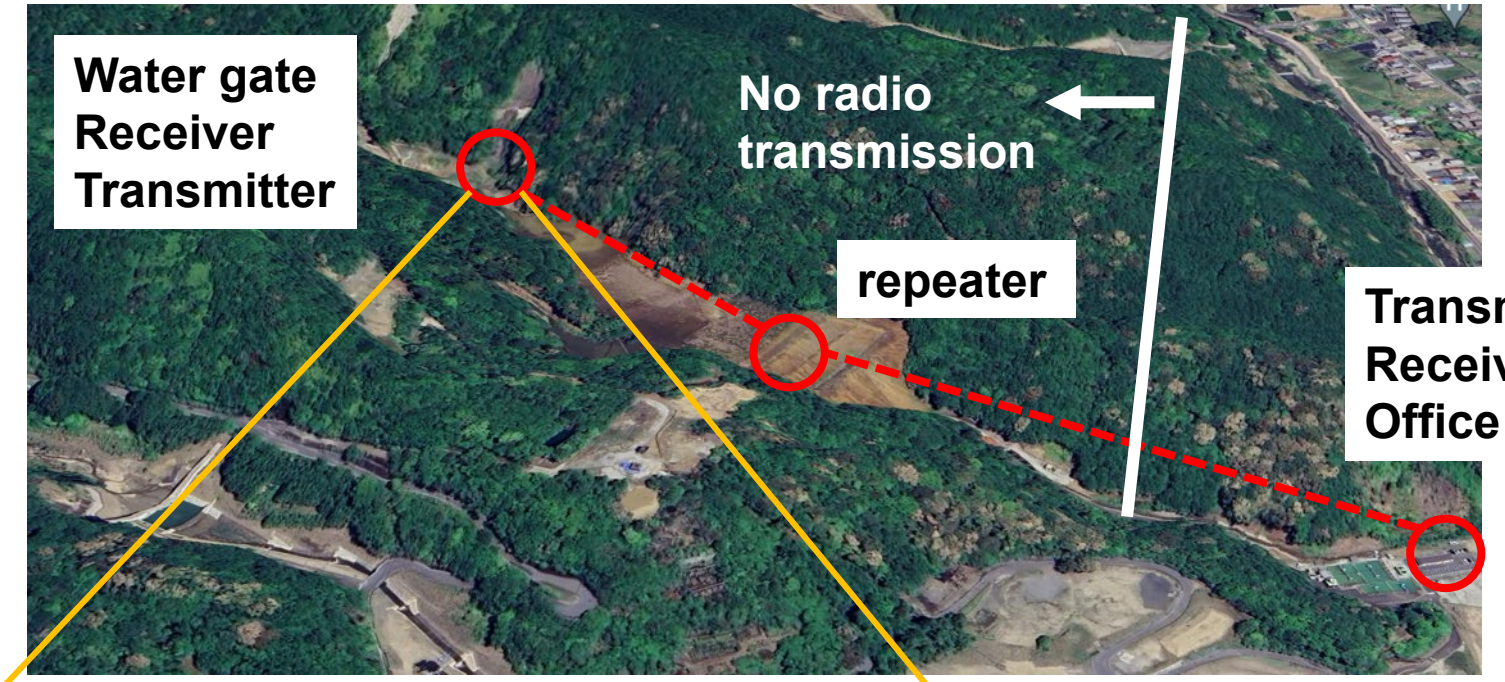


Mine A
The challenge of two-way directional communication

Monitoring
- Status of water gate (opening voltage, various lamps ON OFF)
- Flow rate



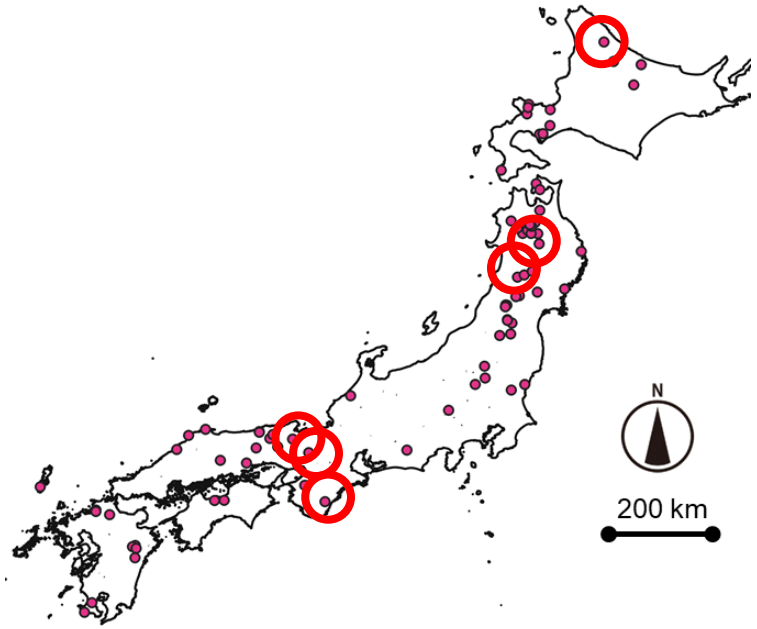
Operation
- Command (sluice gate opening rate 2% open, 2% closed, 10% open, fully closed)



Remote controler of water gate opening/closing

Summary

- An low power remote monitoring system using LoRa were developed to save labour in the management of legacy mines that have no electricity and/or radio waves.
- At 6 mines in Japan, developed remote monitoring system were installed and water quality and other data were continuously transmitted to points between 1 km and 15 km away from the mine.
- It was suggested that these technologies could be used to provide inexpensive remote monitoring as well as two-way communication operations in non-electromagnetic areas..



Acknowledgement

This study was partially funded by METI (Ministry of Economy, Trade and Industry). We would also like to thank the JOGMEC and mine management person for their support in setting up the remote monitoring.

Thank you for you attention and have a nice evening.

Contact address
t.yasutaka@aist.go.jp