IN**DEPTH**

Acoustic Sonar Snow Measurement

This project aims to create a more consistent and simple process in snow pack data analysis for the Natural Resource Conservation Service.

“Manual measurements are still the backbone of the program and will be for the foreseeable future,”

Frank Gehrke, chief snow surveyor NRCS

INDEPTH STRATEGY FOR SNOW ANALYSIS

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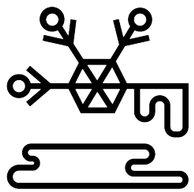
MEASURING SNOW PACK

The snow measurement process in the Western United States is run by the Natural Resource Conservation Service. This government agency deploys multiple processes in order to accurately estimate the amount of Snow Water Equivalent (SWE) that exists in the snow pack throughout the year.

60 Million people on the West Coast depend on melted snow for water. Sampling and measuring the snow water equivalent throughout the western United States gives hydrologists an estimate to how much water runoff will be available. Water agencies, ski resorts, fisheries, agriculture and white water rafting companies all rely on the water forecasts that snow measurement estimates provide.

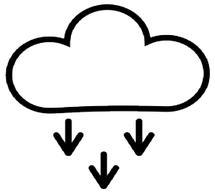
NRCS
Natural Resources Conservation Service

SNOW WATER EQUIVALENT

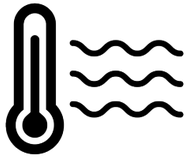


SNOW DEPTH (in)

PRECIPITATION (in)



AIR TEMPERATURE



Understanding snow water equivalent, snow depth, precipitation and air temperature is the foundation of the NRCS Snow Survey.

Core Sample Procedure

NRCS Manual Measurement

The manual snow measurement process consists of surveyrs that travel out to predetermined snow courses in order to take core samples of the snow pack. The core samples provide snow depth, density and ultimately snow water equivalent.

The process for manual measurement is extensive with over 1,400 snow course sites throughout the United States and Canada.

While often reached on foot, some sites require snow machines or even planes and helicopters. Each site consists of 5-10 samples.

The method for manual snow measurement was created in the early 1900's and has not been updated since.

"The goal of the snow survey is to obtain an accurate measure of SWE at predetermined locations: Snow Course"

California Department of Water

Photo by | NRCS

Snow Telemetry Stations

NRCS SNOTEL

Snow telemetry sites are stations that measure multiple snow pack indicators. Including snow depth, temperature, wind, and snow water equivalent.

There are over 800 Snotel sites across the US, and have a standard configuration in remote locations.

While more accurate than manual snow core measuring, SNOTEL stations are expensive and only accurate to the single location they are in.

National Park Service

Aerial Survey

NRCS Aerial Measurement

Recently the NRCS has partnered with NASA to conduct research on monitoring snow pack through aerial flyby methods. The current process is using lidar where planes take a reading of the landscape prior to snowfall and after in order to read snow depth.

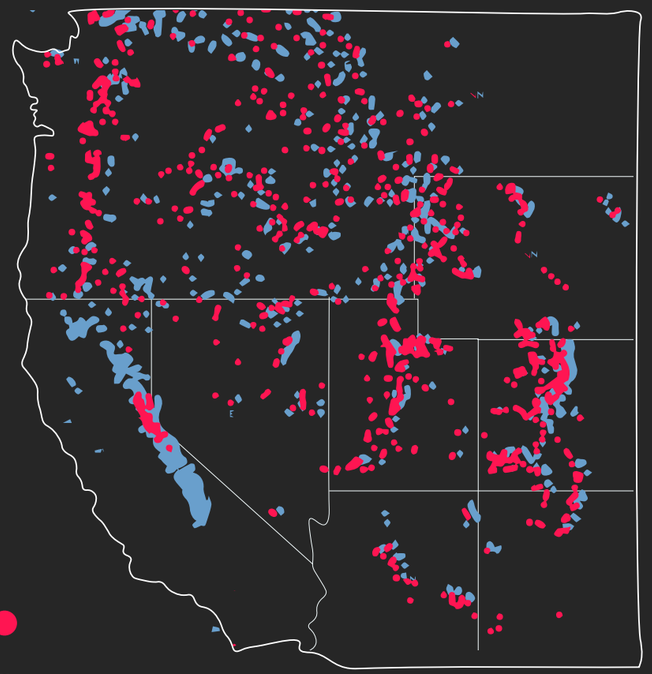
Another method is using large aerial markers that can also be seen from plane and determine depth of snow pack.

While depth is an essential indicator to snow pack it does not give an accurate representation to the amount of water in a given area. Which is why the manual process is still at the backbone of the program.

Photo by | NASA

Problem Space

Manual Measurement Process



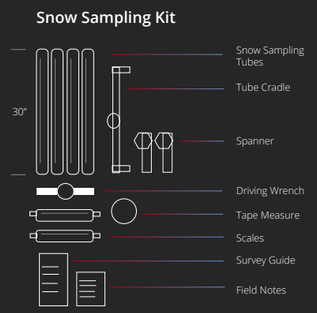
NRCS Map

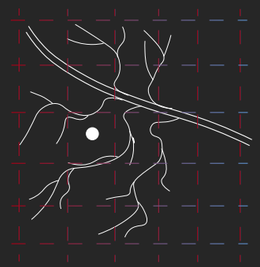
The current manual snow measurement process is time consuming, wide spread and invasive. Targeting this process presents design opportunities for the NRCS to simplify and revolutionize this process that has stayed the same for over 100 years. **This project looks to change the way we analyze snow pack to get a more consistent and easy process.**

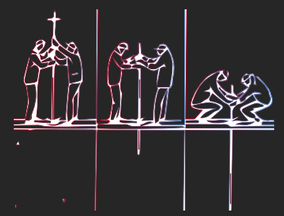
Core Sampling

Manual Measurement Process

1. Assemble Gear → 2. Find Sample Site → 3. Drive Sampling Tube → 4. Measure Depth





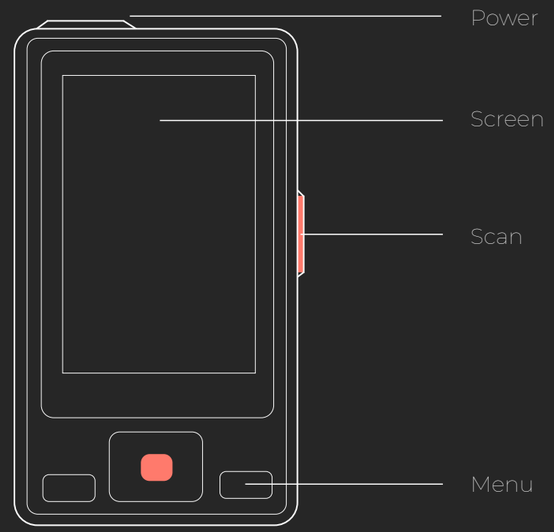


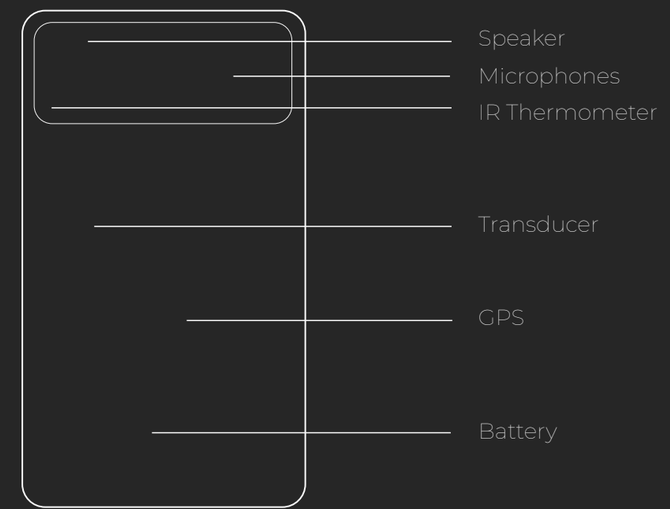
5. Remove Sample → 6. Weigh Core → 7. Record Data → 8. Calculate SWE

INDEPTH Sonar Scanner

Snow pack scanner

inDEPTH is a digital non-intrusive system designed to analyze snow depth, density and snow water equivalent to provide a more accurate, lightweight tool to help predict and monitor changes in climate.

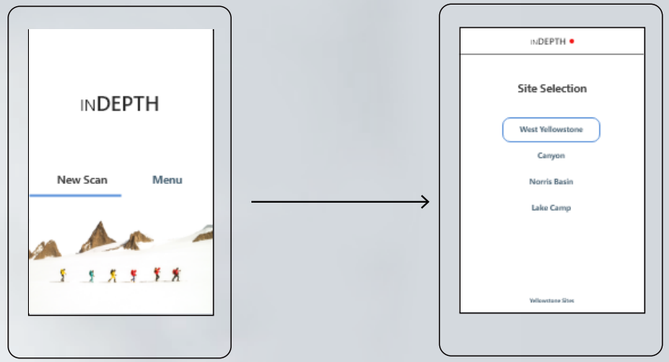




Device Interface

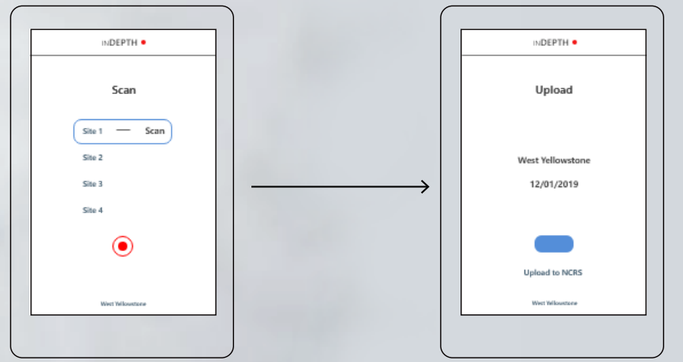
Device Interface

The device interface allows site selection and scanning technology to allow easy recording and mobile interaction.



1 **Home Screen**
Two option menu

2 **Select Site**
Select snow course to scan

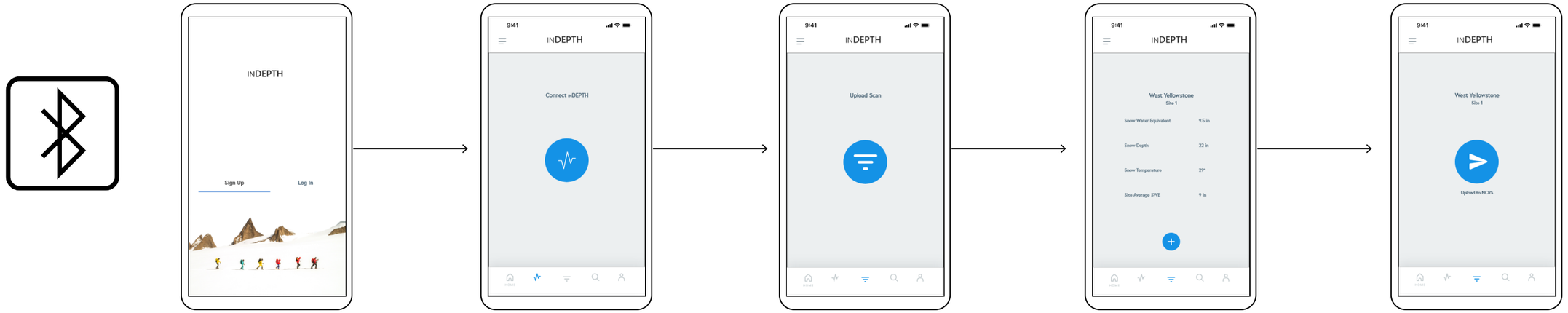


3 **Scan**
Scan the snow pack

4 **Upload**
Send data to smart phone

Device Interface

Mobile Interface



1 **Home Screen**
Two option menu

2 **Connect Device**
Pair your inDEPTH device to connect data

3 **Upload Data**
Upload the recorded data from the device

4 **Add Data**
Add comments and additional snow pack data

5 **Upload to NRCS**
Add the data entry to the database of snow data

Pairing with a mobile device allows further information gathering and upload to the NRCS database in an attempt to digitize snow course data..

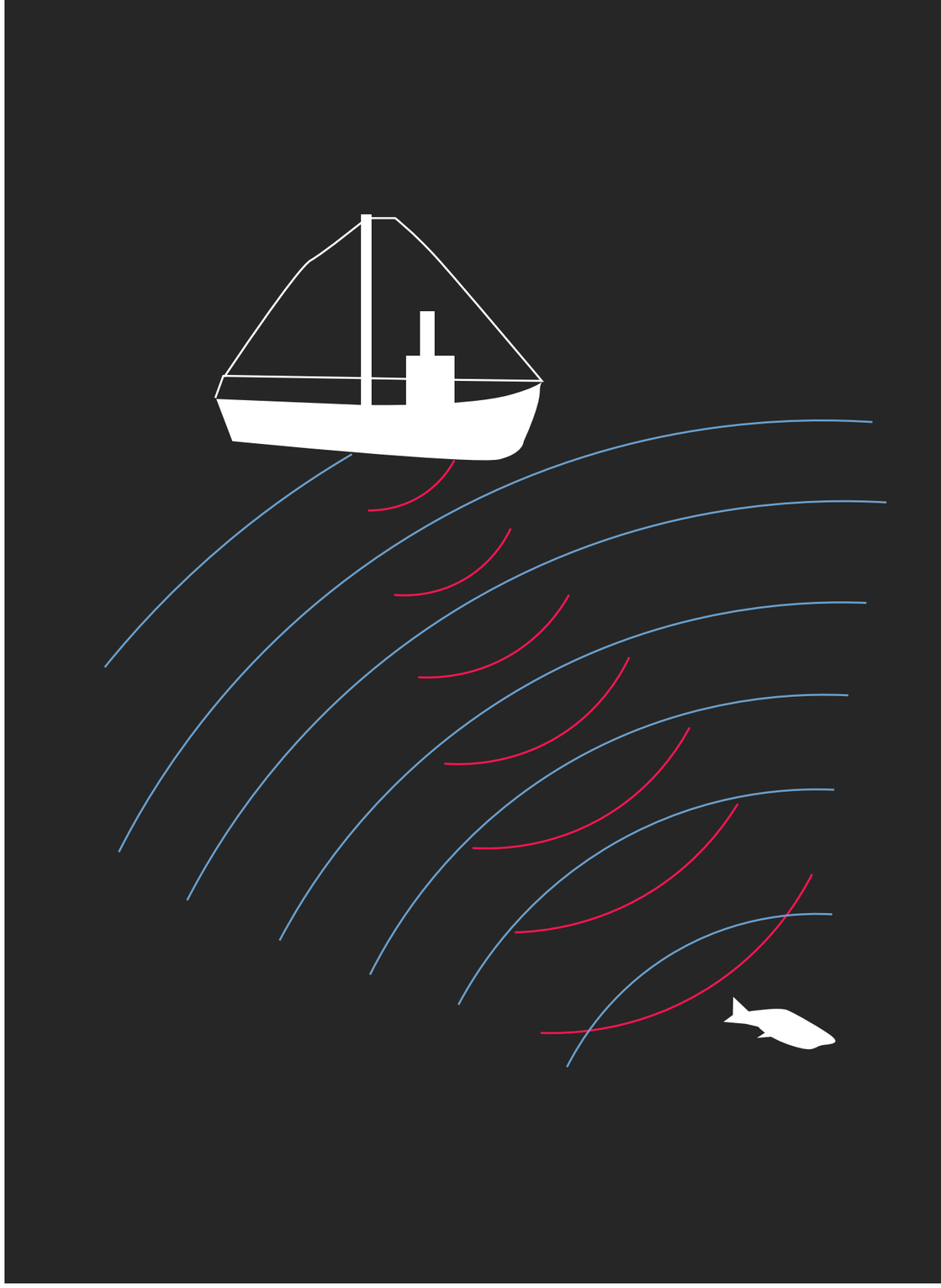
Technology

SAS2 Acoustic Sonar

The inDEPTH hand-held device uses a SAS2 acoustic sonar to measure snow pack depth and density.

The device uses a sonar transponder to send sit-coupled acoustic waves that are sent into the snow pack and reflect data of the layers present back to the device. This technique uses a modified version of the Biot-Stoll theory of sound propagation through porous media to obtain acoustic measurements of snow and images of the snow pack.

In the same way fish finders on boats can register fish from their density, inDEPTH can read different snow layers.



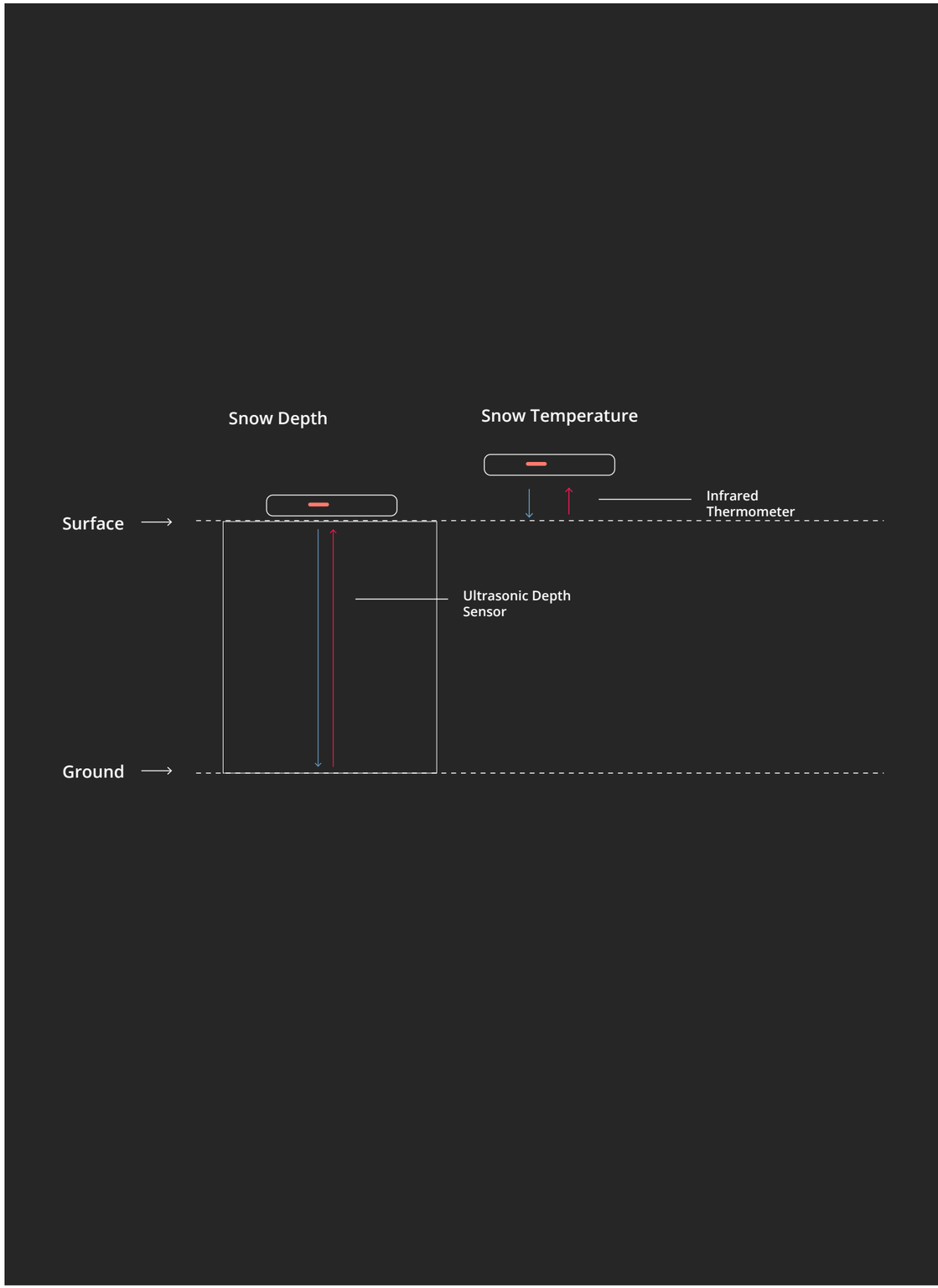
Snow Depth and Temperature

Ultrasonic and Infrared

The inDEPTH device uses an ultrasonic snow depth sensor that works by measuring the time required for an ultrasonic pulse to travel to and from a target surface.

The device also measures the snow temperature using infrared, which allows for a temperature measurement from a distance without contact to the snow pack.

Using depth and temperature the inDEPTH device can more accurately estimate snow water equivalent.

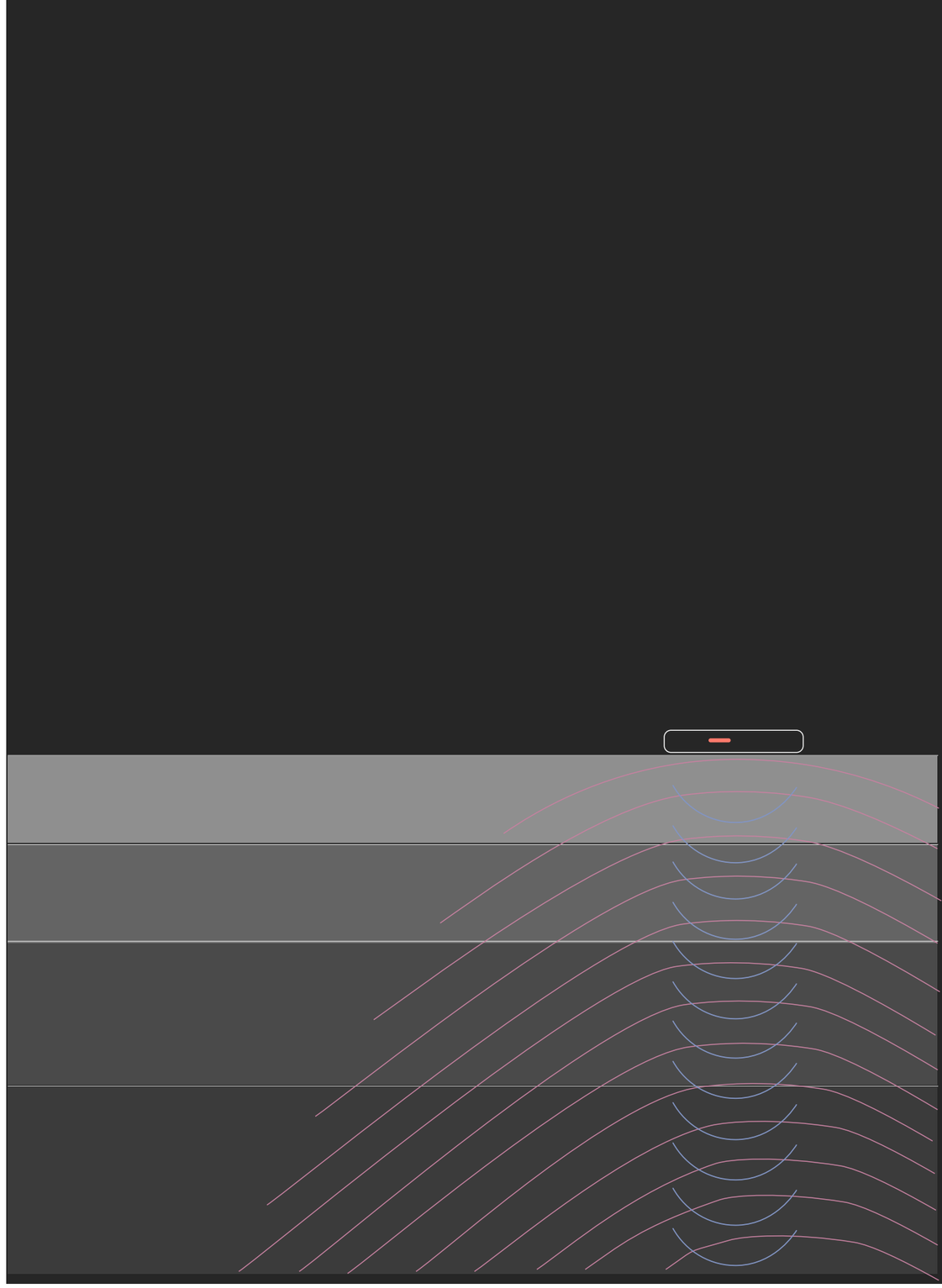


Snow Density

Bio-Stoll equation

SAS2 Developed by N.J. Kinar and J.W. Pomeroy uses an electronic sensing system to measure density. Using a modified version of the Biot-Stoll theory of sound propagation a formula was developed to measure different snow density's using acoustic sonar.

These methods of measurement and technology combine to create a non-invasive acoustic sonar measurement device that could be implemented with the NRCS throughout the west coast.



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