Quinault Indian Nation Villages Ambient Air Quality Sensors Project Quality Assurance Project Plan

(Clarity Node-S air sensor monitoring; non-FEM/FRM)

Date: 12/19/2024, Revision Number: 1

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1: Project Plan Identification and Approval

Quinault Indian Nation Villages Ambient Air Quality Sensors Project

Quinault Indian Nation

Division of Natural Resources

Air Quality Program

Version 0 drafted by: Cody Cook-Winscher, using an EPA QAPP template as base.

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2. Definitions:

Assistant Fire Management Officer: An Assistant Fire Management Officer, or AFMO, is a supervisory role that involves planning and executing wildland fire suppression and prevention activities, managing and training fire crews, and coordinating other emergency response activities on public lands. Quinault's AFMO holds this responsibility for the public lands of the Quinault Indian Reservation.

AirNow: A web-based (airnow.gov) source for air quality information obtained from Federal Reference Method/Federal Equivalency Method (FRM/FEM) Monitors, which are more advanced than air sensors and are often used for regulation or litigation (further defined below.) AirNow presents air quality information in the form of a "NowCast" of the AQI. AirNow also includes links to several air quality resources, including interactive, real-time maps of local air quality conditions.

Air Sensor: Air sensor (or simply "sensor") is a simplified way of referring to a class of air quality measurement devices which have the common traits of directly reading a pollutant in the air and being smaller in size and cost than regulatory monitors. Many groups refer to this class of technology as "low-cost air sensors," "air sensor devices," and "air quality sensors." Air sensors cannot be used for regulatory purposes. Though they often prove useful for education, pollution awareness, and health planning, air sensors do not match the precision of federal regulatory air monitors.

Annual Sensor Transfer Collocation Study: An essential Quality Assurance activity of this program, whereby collocation against Quinault's Nephelometer through the sensor transfer method, the continued precision and performance of QIN's four permanent Clarity nodes is verified.

AQI: Air Quality Index. An EPA-developed index for reporting daily (24-hour average) air quality readings and relating them to associable health effects. For more information on the AQI and how it works, please see https://airnow.gov/aqi/aqi-basics.

AQP: The Quinault Indian Nation Air Quality Program, organizationally housed within Quinault's Environmental Protection Department. The AQP is responsible to QIN for monitoring, reporting, and advising on, along with the mitigation of, local air quality conditions.

Clarity[1]: Clarity Movement Co., or just "Clarity" for short, is a United States for-profit corporation which specializes in the design, sale, and management of air quality sensors, including the Clarity Node-S units used in this project.

Clarity Node-S[1]: The Solar-panel equipped model of Clarity's PM2.5 air quality sensor. Seven of these units are utilized in this project.

Clarity OpenMap[1]: Clarity's proprietary device measurements map. The OpenMap platform visualizes $PM_{2.5}$ and Air Quality Index (AQI) data from Clarity's calibrated Node-S air quality sensors, alongside AirNow NowCasts that provide reference monitor readings for comparison. All readings incorporated into this map are real-time.

Collocation-Dedicated Nodes: a term specific to this Quality Assurance Plan, referring to the three additional clarity Nodes provided by Clarity to QIN for the purposes of this program's annual sensor transfer collocation study.

Environmental Justice: the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

EP: The Environmental Protection Department of the Quinault Division of Natural Resources (QDNR, which is defined more specifically below.)

EPA: The Environmental Protection Agency of the United States federal government. Also known as US EPA.

FD [or 'QIN FD']: The Quinault Indian Nation's Forestry Department, a branch of Quinault's Division of Natural Resources responsible the management of forest land and resources on the Quinault Indian Reservation, along with prescribed burning.

Fine Particulate Matter (PM2.5): fine, easily inhalable particles, with diameters that are generally 2.5 micrometers and smaller. For context, the average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle. See: https://www.epa.gov/pm-pollution/particulate-matter-pm-basics.

NAAQS: National Ambient Air Quality Standards. The EPA sets limits for ambient levels of several air pollutants known to be harmful to human health: lead (Pb), carbon monoxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3), coarse particulate matter (PM10), and fine particulate matter (PM2.5).

'Nephelometer'; or, Radiant Research M903 Nephelometer: Quinault's Radiant Research M903 Nephelometer, provided by agreement with the Washington department of Ecology and operated by the AQP is a more sophisticated form of air sensor, which uses heating, and a flashlamp/photomultiplier setup to measure particulate matter by capturing the light scattering coefficient of a sample of air.

NowCast: The real-time weighted average that AirNow applies to the air quality data it provides to Clarity for the reference monitors displayed on the Clarity OpenMap. AirNow uses this weighted average to balance the need to be responsive to rapidly changing air quality conditions with the longer exposure time (24 hours) used in studies on air pollution and health.

Permanent Project Sensors: The four Clarity Nodes installed indefinitely at Quinault's four most populated villages. These are the nodes which collect the data of primary interest to this program's objectives.

$PM_{2.5}$: Particulate Matter with diameter < 2.5 Microns. More generally, "**PM**" alone describes any particulate matter of any size.

QIN: Quinault Indian Nation, and its applicable subsidiaries and ownerships.

QIR: The Quinault Indian Reservation; the bordered and United States-recognized reservation of the Quinault Indian Nation.

QDNR: Quinault Division of Natural Resources, the Quinault Indian Nation governmental branch responsible for the preservation, conservation, restoration and management of the QIR, and treaty resources within the Quinault Usual and Accustomed territory environments and ecosystems, via educational; preventative; and regulatory actions.

Regulatory Reference or Equivalency Method (FRM/FEM) monitor: in the context of air quality monitoring, a regulatory monitor is an air monitoring instrument that has gone through a formal review process and been approved by the EPA as a Federal Reference Method (FRM) or a Federal Equivalent Method (FEM). The data collected by these monitors can be compared to the NAAQS and support regulatory decisions, if the monitor siting, operation, and data handling meet regulatory requirements.

Relocating Collocation Node: a term specific to this Quality Assurance Plan, referring to the single clarity node utilized by this program each year to complete the collocations across the reservation required for the Annual Sensor Transfer Collocation Study.

Rx Burn: Silvicultural burns, commonly referred to as 'prescribed burns,' conducted by the QIN Forestry Department, to ensure safe and healthy forestland maintenance.

1: Disclaimer: Any mention of trade names, products, or services does not imply an endorsement by the Quinault Indian Nation.

3. DISTRIBUTION LIST

An electronic copy of this Quality Assurance Project Plan (QAPP) has been distributed to the individuals listed in Table 3-1: Distribution List and Partner Communities involved in the project. This is revision 0 as of November 5, 2025.

NAME	TITLE; *ROLE IN PROGRAM*	AGENCY	DIVISION	CONTACT INFORMATION
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4. Project Organization and Roles & Responsibilities

4.1 Roles and responsibilities:

The Quinault Indian Nation is responsible for monitoring and protecting the ambient air quality of the QIR. The Quinault Indian Nation's Air Quality Specialist (AQS) is the staff member designated the foremost responsibility in maintaining, operating, accessing, and recording data from, and quality assurance for, the Clarity Node-S air sensors in this project. The AQS, and more broadly the Air Quality Program (AQP), will work closely with QDNR staff involved in Rx burn planning and execution, such as the QIN Forestry Department (FD), to ensure potential air quality impacts of prescription (Rx) burning are considered in the interpretation of sensor measurements, and avoidance of these impacts (if any) are factored into the planning process for future Rx burning. The FD's Assistant Fire Management Officer (AFMO) Fire & Fuels Specialist is involved in much of the process to plan Rx burns on the QIR and is the point of contact for the AQP when one or more sensors in this program indicates concurrent Rx burning may have degraded air quality. The information gathered by this program is used to help inform and improve QIN's Rx burn planning and secondarily to complement Quinault's existing air quality monitoring network. This network includes other air quality sensors and produces cross-QIR air quality measurements used to educate tribal residents of current conditions and recommend exposure mitigation strategies when necessary.

Additionally, when maintenance or closer physical inspection of one of the four permanent project nodes is determined necessary, the AQP will coordinate with the QIN forestry department. QIN Forestry has equipment to help with this vertical access and staff trained in its operation. If re-deployment in a separate site is found as necessary for whatever reason, the new proposed site will be submitted through QIN planning department's development request and approval process. Physical re-deployment will likewise be completed with the assistance of the QIN forestry department's man-lifting equipment.

4.2 Quinault Air Quality Program:

Quinault's Air Quality Program consists of an Air Quality Specialist, who is directly advised by the Environmental Quality section supervisor.

- The QIN Air Quality Specialist will be personally responsible for the coordination of the Program. This includes device deployment; maintenance; data recording and analysis; programmatic Quality Assurance/Quality Control; outreach and education to the QIN FD and tribal public regarding conditions, and revision of programmatic documents.
- QIN Environmental Quality Manager (Kiley Smith): supervise AQS, coordinate with personnel from other QIN Departments on responses to project findings.
- Note that while the QIN AQP is too small of a team to have a dedicated, independent QA program member beyond the Air Quality Specialist, the Specialist will remain committed to following the program's QAPP and objectively applying the QA requirements.

4.3 Quinault Forestry Department:

Quinault's Forestry Department (QIN FD) routinely conducts Rx burning during the autumn/early winter season of each year, to ensure the QIR's forests are effectively managed to minimize the impact of wildfires. The QIN FD will communicate to the Air Quality Specialist when the Rx burning season begins each year, and brief in advance of each individual burn conducted throughout the Rx burning season. The QIN FD has long utilized atmospheric forecasting to help plan Rx burns. However, should the local measurements provided by the Clarity sensors after Rx burns demonstrate that Rx burn smoke is reaching a nearby QIR village, the QIN FD and AQP will discuss potential contributing factors and solutions to improve planning of future Rx burns.

5. Problem Definition and Background

The AQP has long encouraged Quinault tribal members to report air quality issues affecting their neighborhood. The AQP often receives complaints regarding woodsmoke impacting the ambient air quality in Quinault villages, during or shortly after prescribed burning. Prescribed burns, aka Rx burns, are a critical component of safe forest management. Due to commercial logging along with natural accumulation, wood debris unsuitable for sale or harvest (aka "slash") collects on the grounds of forestland. Unfettered accumulation of this debris creates conditions of risk for exacerbated wildfires. Routine burning of slash improves the wildfire resilience and overall health of forests. The smoke plumes produced by these burns must be accounted for, however. To plan Rx burns which, most reliably, minimally affect the air quality of nearby villages, the QIN FD forecasts atmospheric conditions before each burn. However, forecasts are never guaranteed, as weather conditions are always subject to change.

When Rx burn smoke plumes intrude into QIR village airspaces, residents are exposed to a variety of air pollutants negative to human health. Smoke produced by Rx burns, as well as other wood-fueled fires, contains particulate matter with a diameter of equal to or less than 2.5 microns (PM 2.5). PM2.5 is a common air pollutant which can severely affect human health. Children, the elderly, or those with underlying health conditions, especially those affecting the respiratory system, are particularly sensitive to PM2.5 pollution. Fine particles such as these tend to stay in the air longer and can penetrate deep in the lungs. PM2.5 can trigger chronic diseases such as asthma, pneumonia, bronchitis, and more, after short-term exposures. Long-term exposures to PM2.5 can lead to plaque deposits in arteries, which can lead to heart attack or stroke; and adversely impact mental development in youth, and cognition for all ages. Other health-adverse pollutants typically found in woodsmoke include Carbon Monoxide, Ammonia, Nitrogen Oxides, Sulfur Dioxide, and hydrocarbons. This makes woodsmoke, such as the smoke plumes produced by Rx burns, a potential threat to public health on the QIR and a top priority for the AQP to mitigate.

Due to the varied geography and complex airshed of the QIR, localized data is essential to accurately reflect the unique air quality conditions experienced in the QIR's four primary villages. However, only one QIR village has historically had consistent air quality monitoring. Because of this, assessing the severity of air pollution episodes tribal residents experienced -- due to Rx burns or otherwise — has been difficult and often infeasible in the past. Additionally, the lack of a monitoring network has meant that communication around negative air quality episodes affecting QIR villages often relied on the reporting of tribal residents. With this informal structure, the AQP had no guarantee to be made aware of air quality events in their earlier stages of development and therefore was unable to consistently advise the tribal public of exposure mitigation strategies when they were most needed.

Expected project outcomes: understand the frequency and severity of poor air quality episodes in all four primary villages in the QIR. Better understand the source of the air pollution (home heating, Rx burns, or other). Improved outreach during air pollution events leading to better public health outcomes. Inform & support the prescribed burn planning process for Quinault's lands by advising Quinault's AFMO Fire & Fuels Specialist when prescribed burning has unintentionally impacted air quality in a local village.

Applicable data criteria: this project requires representative air quality data collected continuously from the four villages. The data must be accurate enough to differentiate good air quality conditions from moderate, unhealthy, and hazardous conditions.

6. Project Description

This grant project will reinforce the QIR's air quality monitoring network with consistent monitoring coverage for its four largest villages with the use of four Clarity Node-S air quality sensors. These sensors and the data they provide will safeguard the respiratory health of these villages' residents in two ways. Firstly, this data will inform the AQP and QIN FD of if, when, and how severely Rx burns impacted the air quality in the villages, keeping in mind the potential for an unrelated air quality event near a village to present a false correlation. This data can provide valuable insight to the QIN FD (including the AFMO Fire & Fuels Specialist which works closest to the AQS for this project), which may help inform planning for ensure future burns do not deteriorate air quality in a nearby village. Secondly, the sensors' data will allow the AQP to detect other air quality events impacting the villages earlier in their respective developments. This way, the AQP may sooner advise residents of these villages on local air quality events and how they can protect their respiratory health through them. Residents are also welcome and readily able to view sensor measurements on their own accord at any time via the Fire and Smoke Map or the Clarity Open Map. Instructions on how to access the Clarity Open Map and view local air quality data from the devices of this project will be provided for tribal residents alongside other outreach communication conducted for this project.

The scope of this project specifically covers the four primary villages of the QIR, for the lifespans of the utilized Clarity Node-S air sensors (approximately 2-4 years), or longer if budgets allow. Four specific tribal villages will each receive one Clarity Node-S air monitor through this project, and are as follows (see Figure 1): Qui-Nai-Elt village, also known as "Q Village," or "Moclips Estates," is located approximately 1 mile Northwest of the mouth of the Moclips river; Taholah, the largest village of the Quinault Indian Nation, with a population of approximately 800, directly borders the southern bank of the Quinault river, where it meets the Pacific Ocean; Amanda Park, a village partially occupying both the QIR and Grays Harbor County's northmost lands, is located directly against the southern edge of Lake Quinault, and; Queets village, which lies against the southwestern corner of Jefferson county, where US Highway 101 and the Queets River meet.

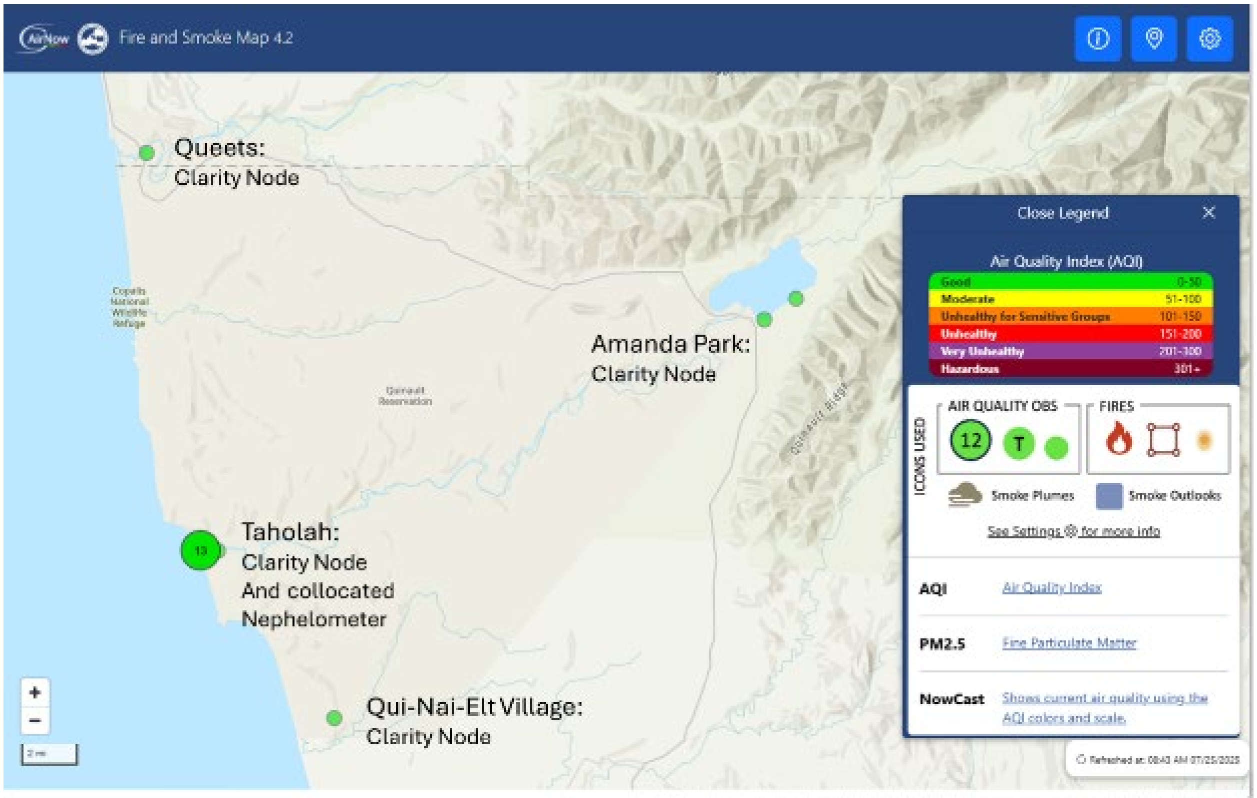


Figure 1: Map showing the Quinault Reservation and the location of the four Clarity Node-S sensors on the AirNow Fire and Smoke Map.

Expectations and use are limited to informal evaluations; data produced in this project should not be considered as definitive measurements to be used for anything other than informational investigations, education, awareness, and continuous feedback to the Rx burn planning process. **Important Note: These air sensors are non-regulatory and the data they collect are not eligible for comparison to the EPA's NAAQS. This equipment is not to be used for confined space evaluations for safety considerations. QIN does not endorse using this equipment to meet any requirements related to health and safety.**

Four Clarity nodes are positioned in Quinault's four largest respective villages to monitor air quality levels. A chief air quality concern being assessed by these sensors is what impact prescribed burns on the QIR have on concentration of ambient pm2.5 in Quinault's villages, on days of burning. Real-time PM2.5 concentration measurements, recorded by these four sensors, will be routinely verified (roughly once every other hour during normal QIN business hours) on days of Rx burning. Should heightened sensor readings coincide with Rx burn activity on the QIR, staff should consider whether the locally elevated PM2.5 levels around those sensors are the result of Rx burning. If it is determined the heightened readings were more likely to be related to the Rx burning than unrelated, whether the smoke intrusion was minor or significant must also be assessed.

To help estimate whether heightened PM2.5 levels in the affected village(s) are in fact resultant from QIN Rx burn activity, staff must consider the location of the Rx burn, which will be provided to the AQP by the FD in advance; the location of the sensor(s) seemingly affected; and wind patterns (verified by tools such as windy (insert link) or (insert NOAA tool.) In determining the significance of expected cases of QIN Rx burn smoke intrusion, staff should consider the five following questions.

- How long did the elevated PM2.5 levels expected to be due to smoke intrusion last in the affected villages?
- How many villages displayed heightened PM2.5 levels which was estimated resultant of QIN Rx burn activity?
- What concentrations were reached during elevated these PM2.5 events?
- How active were the affected area(s) at the time of the PM2.5 events? For instance, were the events late at night when fewer residents were out, on a holiday or associated with a community event, and was this on a weekend or a weekday? Was the weather nice? Etc.

In addition to these considerations, the AQS will discuss with the FD whether other jurisdictions were burning, how much was burned, and if there are any other relevant considerations to this burn's unique smoke impacts. If consideration of these factors and discussion with the FD indicate that QIN FD Rx burn smoke did directly impact air quality experienced in one or more QIR village, the QIN AQP & FD will then discuss the original rationale behind burning in that location at that time, the unanticipated details or inaccurate forecasting which led to smoke intrusion in village airspace(s), and if this burn can offer insight to help future Rx burns to minimally impact the airsheds of QIN's villages.

7. Data Quality Objectives and Indicators

The goal of this project is non-regulatory but directly seeks to improve public health conditions for residents of the QIR by reducing PM2.5 pollution affecting the QIR's four primary villages. If accurate, representative local data indicates elevated PM2.5, the AQS will advise residents of these villages on local air quality events and how they can protect their respiratory health through them. If the data indicates elevated PM2.5 due to concurrent Rx burning, the AQS will work with QIN FD to assess and modify future burning.

7.1: Data Quality Objective(s) (DQOs):

This project's goal of minimizing PM2.5 exposures of the QIR's village residents will be achieved by monitoring ambient air quality and utilizing findings from PM2.5 pollution events to curtail domestic PM2.5 sources. These sources will include Rx burns, as findings inform future burn planning, along with other sources which will be identified and understood over time with this project's data and findings. Reliable PM2.5 readings are critical for this goal, as the outcomes of this project not only have potential to make great positive differences for public health on the QIR but also inform further AQP-conducted outreach to the tribal public. In all cases this outreach will remain educational, advisory, and collaborative—not regulatory. PM2.5 measurements may also contribute to the weight of evidence in determining FARR violations, when local conditions or resident reports suggest a FARR violation may have occurred.

Public outreach and education must be accurately informed with high-quality data. Conversely, outreach based upon low-quality data could inform erroneous conclusions about best practices to reduce PM2.5 production and to avoid exposure. Such misconceptions could delay or counteract the achievement of this program's goal.

Overall, while the AQP will strive to eliminate all extraneous variables which could influence the data produced through this project, moderate uncertainty is acceptable in projects serving research and planning purposes, and unavoidable when using non-regulatory sensors. To counteract the potential uncertainty inherent in using low-cost sensors, staff should consider contexts which may help interpret and understand data. Relevant considerations would include atmospheric conditions of air stagnation or ventilation, known air quality factors currently occurring (ex: local construction, wildfires), and sensor biases. The best judgement of AQP staff when reviewing measurements and considering trends is therefore integral to this program's efficacy.

7.2: Data Quality Indicators (DQIs)

The high-quality ambient PM2.5 concentration data this project requires also necessitates quantitative DQIs which ensure relative statistical certainty in recorded values. Clarity Nodes are considered a "low-cost sensor" under the EPA's definition. This is due to their methodological differences when compared to regulatory-standard Federal Reference (or Equivalent) Method air quality Monitors (FRM or FEM). Due to these methodological differences, low-cost sensors are known to underestimate or overestimate pollutant concentrations when compared to the more precise FRM/FEM monitors. As such, this project has identified several DQIs and methods to achieve them—to ensure measurements gathered through this project are representative of actual air quality trends in the QIR's villages.

Sensor data used for this project must consider and strive to maximally achieve the following DQIs:

1. **Precision** refers to the random error of a given measurement. One way of quantifying precision is by comparing multiple measurements of the PM2.5 concentration in ambient air. Precision can be determined by collocating, and comparing the measurements from, Clarity Nodes & regulatory standard FRM/FEM air quality monitors. International regulatory agencies and Clarity both already have published studies assessing Clarity Node precision via such comparisons with collocated FRM/FEM Monitors. The difference between measurements taken by the Clarity Node sensors, versus those taken by the collocated regulatory monitors, was calculated to determine the general precision of Clarity Nodes. These studies, along with long-term trial and error by Clarity have informed a data correction model – Clarity's Global V2.1 Calibration Model. This model greatly improves data precision and must be applied to all sensors utilized in this project.

   Examples of poor precision and good precision are demonstrated in Figure 1, which shows measurements taken from a Qatar Environment and Energy Research Institute study comparing raw and calibration model-applied data from Clarity Nodes, vs. the data of FRM/FEM monitors. It should be noted that the study applies a different correction factor than what Clarity's own Calibration Model uses; regardless, this study clearly demonstrates the positive impact calibration models can have on the data of a low-quality sensor. The V2.1 Calibration model that currently adjusts Clarity Node measurements produces slightly more accurate data during extreme air pollution but otherwise uses the same methods as its prior version 2.0. Version 2 demonstrates years of precision when it comes to the comparability of Clarity Nodes data with FRM/FEM measurements.

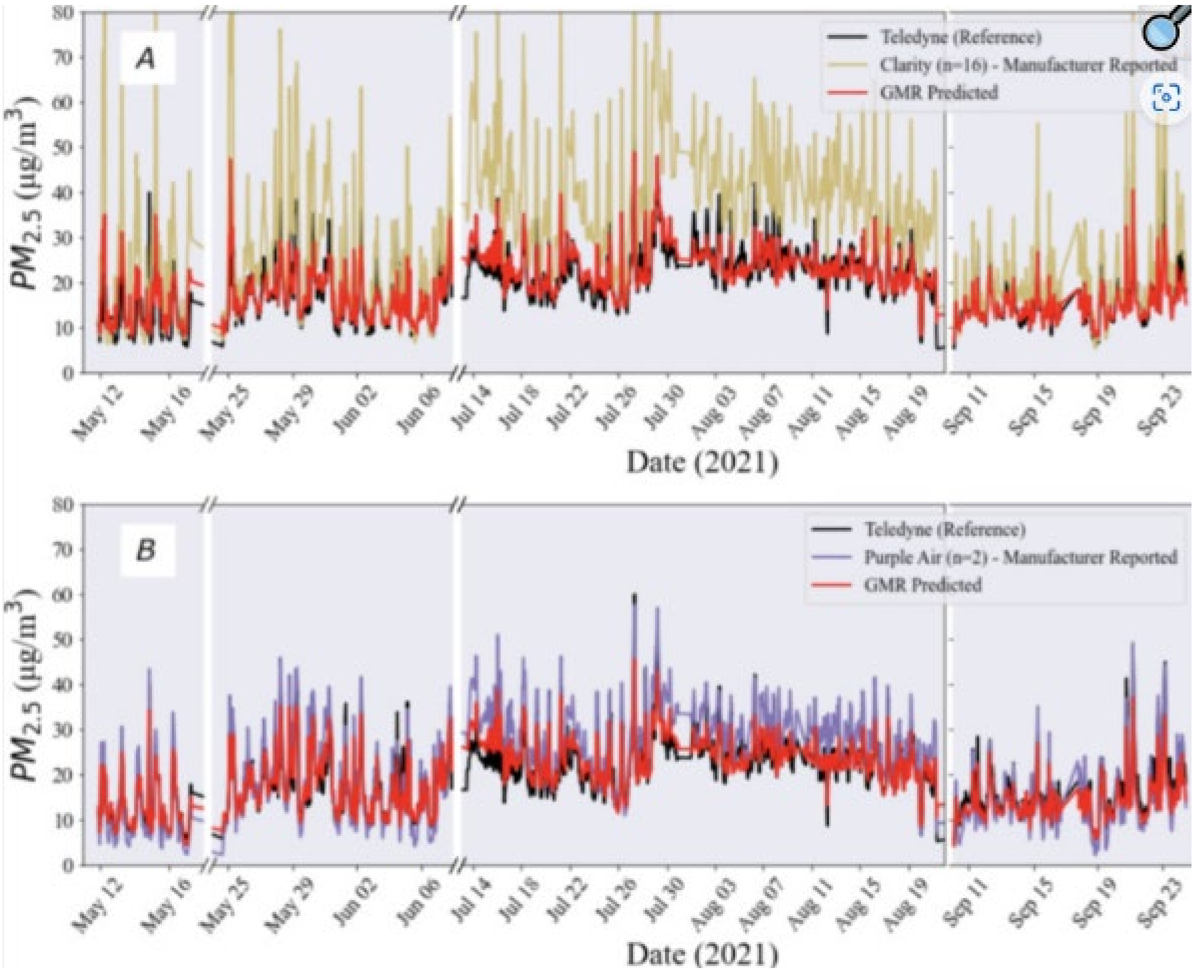


Figure 2: Comparison of 'raw' Clarity sensor measurements; correction model-applied sensor measurements; and a collocated FRM/FEM monitor ("Teledyne")'s PM2.5 concentration measurements. In the top chart, Clarity Node-S sensors (sample size of 16) were compared with the collocated FRM/FEM monitor. In the lower chart, two competitor low-cost "Purple Air" PA-II sensors were compared to the FRM/FEM. Poor precision is evident in both low-cost sensor brands for their 'raw,' uncorrected data. Conversely, both the FRM/FEM data (red) and the respective correction model-applied data from each low-cost sensor (black) align much closer, demonstrating strong precision. All credit for this chart goes to the Qatar Environment and Energy Research Institute, for its 2023 study "Low-Cost Sensor Performance Intercomparison, Correction Factor Development, and 2+ Years of Ambient $PM_{2.5}$ Monitoring in Accra, Ghana".

2. **Bias** is a systematic error in a set of measurements, or a generally consistent difference between the measurements and the true value. While no exact equation or value has been determined which accurately predicts the exact quantitative bias of Clarity Nodes, scholarly studies comparing Clarity

Node sensor measurements with FRM/FEM monitor measurements demonstrate Clarity tend to exaggerate actual PM2.5 concentrations. Figure 3 (and Figure 2) demonstrate this exaggerative bias. Data correction utilizing Clarity's Global V2.1 Calibration Model, however, greatly improves Clarity Node measurements' comparability with FRM/FEM Monitors.

Table 1: Results from collocation study with an FEM GRIMM. Similarly to the study in Figure 2, California's South Coast Air Quality Management District (AQMD) found in their own 2018 study that Clarity Node Sensors exaggerated values when compared to the FRM/FEM Monitor their study employed—especially at lower PM2.5 concentrations. This AQMD study is accessible via the link titled "Clarity Node – Summary Report," at the top of: www.aqmd.gov/aq-spec/sensordetail/clarity-node.

Steady State #	Sensor mean (µg/m³)	FEM GRIMM (µg/m³)	Accuracy (%)
1	31.2	17.3	19.2
2	52.4	43.5	79.5
3	103.0	88.0	82.9
4	161.2	139.3	84.3
5	313.7	279.2	87.7
6	494.7	452.6	90.7

3. **Data completeness** is a measure of how much certain timespans are covered in the collected data. Since PM2.5 levels often fluctuate (e.g., they may be more elevated during inversion events or local burning activities), it is important measurements are received consistently and not intermittently by this project's sensors. Intermittently received, "patchy" air quality data could not be used to accurately analyze trends in concentration.

4. **Representativeness**: For data to be considered representative of general population exposures in each village, sensor siting must meet several criteria. The deployment locations cannot be positioned adjacent to known point sources of air pollution. Locating sensors near these facilities or any other point source of air pollution would bias the collected air quality measurements to disproportionately reflect the air quality experienced by those specifically closest to the facility. Additionally, sensors will be placed within 10-16* feet overhead of a resident-frequented area in the QIR's four primary villages.

   *[Note that the height of 10-16 feet was selected due to Clarity's own recommendations for device elevation when investigating general population exposures.]

7.3: Measurement Quality Objectives (MQOs):

A highly effective method to improve data quality and help facilitate the attainment of this program's MQOs, is Clarity's Global Calibration Model V2.1. This model is an automated data correction model produced by Clarity to improve the quality of data reported from Clarity sensors. When describing the process taken to produce the V2 model (which again, is functionally identical except for extreme air pollution events), Clarity stated the following:

Since the release of V1 of the $PM_{2.5}$ Global Calibration in 2021, our partners have collocated hundreds of our Node-S devices with Federal Equivalent Method (FEM)-grade instruments worldwide. Initially developed to improve performance during wildfire smoke events in the United States, the v1 calibration has proven effective throughout the year and in regions without wildfire smoke. Building on this success, we aimed to leverage a much larger dataset for v2 to enhance accuracy and representativeness further.

This process has created a model which will automatically correct erroneous and anomalous data based upon the findings of these studies, with unique consideration given for air quality trends specific to localities across the globe. An EPA document advising on best practices for PM sensors (EPA/600/R-20/280 "*Performance Testing Protocols, Metrics, and Target Values for Fine Particulate Matter Air Sensors*") lists a minimum data quality target value for low-cost sensor data correlation with FRM/FEM monitors: 70% or greater correlation (R^2 = .7). With opt-in of the calibration model, Clarity Node data achieves an average correlation with FRM/FEM monitors of .79 (R^2 value. This figure has been determined by both Clarity and third-party studies.) The opt-in of this model clearly improves the precision of data produced, and therefore opt-in to this model and completion of the initial calibration period needed to apply the model are required for the purposes of this project.

Long-term data considerations (considering contributing factors such as weather, smoke, nearby sensors, etc.) require a collocation study and the scrutinous, holistic review of program staff to confirm MQOs have been met (data quality issue troubleshooting described in section 11.) Given the value of real-time air quality data and the inherent methodological differences in accessing it, real-time data has a separate set of required MQOs. With distinct MQOs and methodological differences, real-time data is excluded from formal long-term considerations of air quality trends in Quinault's villages, or prescribed burn planning strategy completed with the FAFO Manager. A collocation study is not required to meet Real-time data MQOs, but users of real-time data hosting webpages should verify at minimum that the measurements they are considering demonstrate compatibility with local observable conditions and any immediately collocated sensors. The adoption and implementation of Clarity's V2.1 correction model for this project's nodes is required for both Real-time and long-term MQOs.

Table 2: Measurement Quality Objectives for all Data Quality Indicators:

DQI	**Acceptance/Performance Criteria (Real Time applications of data)**	**Acceptance/Performance Criteria (Long-term considerations from data)**
Precision	Real-Time considerations require some user interpretation of whether data is compatible with real-time observations on the ground, or nearby air sensors. How similar two nearby sensors' air quality measurements may be influenced by local factors which are	R^2 >= .85 between collocation-dedicated nodes and Quinault's Nephelometer (comanaged by Washington Department of Ecology); R^2>= .9 between the main project nodes and collocation-dedicated Clarity Nodes.

	unique to one of the two sensors alone, how close the sensors are to each other, not necessarily the presence of defect. A full consideration of local conditions, any nearby sensors, and the readings of the clarity node in question should be completed to verify the precision of real-time data.	Attainment of these MQOs is supported by the required application of the Clarity Global V2.1 Correction Model and are verified via supplemental data review activities conducted by program staff (ex: the Quarterly Quality Assurance Collocation Studies.)
Bias	The Clarity Global V2.1 correction model must be applied to Clarity Node sensor data, which will help counter the exaggerative bias of Clarity Node sensors.	The Clarity Global V2.1 correction model must be applied to Clarity Node sensor data, which will help counter the exaggerative bias of Clarity Node sensors.
Data Completeness	N/A for real-time considerations.	An hour is considered complete for the purposes of data quality if at least three of the four (75%) approximately 17-minute measurement windows spanning each hour have been properly reported from the sensor and do not present data of questionable veracity. A day is considered complete if 90% of the hours are complete in data (at least 22 of 24 hours) and do not present data of questionable veracity. A quarterly collocation is considered complete when at least 85 (or 78 days for quarterly collocations in Taholah) days considered complete in data from both collocated sensors have been completed and do not include data of questionable veracity. An annual collocation study is considered complete when at least 162 hours of collocation between the sensors have been collected and do not include any data of questionable veracity.

8. Documents and Records:

The most current QAPP will be provided to the sampling personnel (QIN's Air Quality Specialist) prior to sensor mobilization and maintenance. When a new air quality specialist is hired and oriented, the QDNR staff member currently vested with supervisory authority over the AQS will be responsible for providing the AQS the most current version of this QAPP for review. This program's QAPP will be reviewed and updated as necessary by the Air Quality Specialist, who will subsequently present revised versions for approval to their chain of command in QDNR, and the assigned EPA project officer. In revising the QAPP, the Air Quality Specialist will seek advice and input from QIN staff and leadership, community members, and any other relevant stakeholders.

All raw data files and data analysis this project produces retained digitally will be saved into the Air Quality Program's unique file folder for this project's data, located at the following directory path: "H:\QDNR\ENVIRONMENTAL PROTECTION\Air Quality\Sensors & Monitors\ARP\Clarity Nodes\Policy Doc's, Reports". When pertaining to only one sensor, files should be saved into the unique subfolder for that sensor. Supplementary data files and analysis recorded physically (on paper) should be stored in the Air Quality Specialist's office and likewise clearly labeled and organized. It is recommended to use an electronic research log in place of a paper research notebook, however, should staff prefer keeping notes physically with pen and paper, all such physical notes must additionally be scanned or transcribed into digital files.

Raw data files include data reports from routine QA/QC activities (described in sections 12.2 and 12.3). Raw data files must not contain any edits performed by Staff. Any files that contain analysis will be retained separately from raw data files and all analysis will be recorded into the electronic notebook. Analysis may consist of, but is not limited to: graphs, statistical tests, notes, conclusions, etc. Raw data files should be clearly marked with the name of the sensor which produced them (or, for QA/QC reports, the site of sensors collocated), and the month/year of production. Datemarking of the files will be written as: MM-YYYY, with 'M' representing the month and 'Y' representing the year. For example, "*Queets_Collocation 02-2026-05-2026*"; or "*Taholah_Node_09-2026*". For digitally retained data files, this information should be present in the file name. For physically retained data files, this information may be indicated anywhere on the paper of the file or in a note affixed to it. Other data files, analysis, and field notes similarly should include such date and sensor marking, plus a short phrase describing the significance of the file. The date marking on this program's records should also include the exact day if one is relevant (for example: "*Taholah_01-16-2024_RxBurn*"; or "*Q-Village_11-30-2025_condition-notes*") Again, while this project's data records and other files may also be retained physically when preferred; keeping electronic copies of all project documentation is required at minimum.

A unique subfolder, titled "Errors & Bad Data" can be found in each of the sensors' main file folders. All records of device errors, resolutions to the errors (including field maintenance forms when a major device error was corrected during the site visit), and any data determined to have been produced erroneously, or which failed to meet project MQOs must be recorded in this subfolder of the respective device. Files retained in this subfolder which include erroneous data collected must follow the file naming conventions established earlier in this section-- however the short phrase describing the significance of the file must include the abbreviation "EXCL." to reaffirm that the data therein must be excluded from data analysis activities. For the purposes of this project's procedures, all files labeled with "EXCL." in the filename will be regarded as data of unacceptable or unverifiable quality.

Staff must request raw data files from Clarity via the Clarity Dashboard. Data report requests are submitted through the Dashboard's datasources tab (found in the banner on the left edge of the dashboard.) Within the datasources tab, select a data source, and then the "actions" drop-down menu directly above on the webpage will turn blue. Click this blue drop-down menu, then select the option "download measurements" within it. This will pop up a window listing options for your data report. Select the output frequency option of "Minute" to observe all measurements taken by each device, and so the frequency at which measurements were reported can be assessed. For routine QA/QC data collection activities (as described in sections 12.2 and 12.3), ensure the timeframe selected reflects the full length of time since the last routine data report was collected for that respective sensor.

9. Experimental Design

To achieve the goals of this QAPP, as elaborated in section 6, the four Clarity Node-S air quality sensors utilized by this project will respectively be deployed in strategic locations of the four primary villages of the QIR. These locations were identified as reasonably representative of air quality conditions in the surrounding villages, and, where viable, in areas also frequented by respiratory-vulnerable community members.

The AQP will routinely (at least weekly) monitor readings from the Clarity Nodes for negative air quality events. Analysis of these negative air quality events will be conducted, during which the AQP will consider local activities or conditions which may have influenced changes in air quality. During prescribed burn season specifically, the occurrence of local burns will be a prime consideration when negative air quality events are observed in a nearby village. By studying the relationships between local activities with potential to influence air quality (prescribed burns or otherwise) and negative air quality events measured by the Clarity Nodes, the AQP will deepen its understanding of how different activities affect air quality. This understanding will empower the AQP to better safeguard air quality in the future, and the FD to plan prescribed burns with minimized impacts to the air quality of Quinault's villages.

The four strategic locations identified to improve air monitoring coverage in Quinault's primary villages are as follows. The Taholah clarity node will be sited in upper Taholah, behind the Generations building. This building is frequented by tribal seniors and children and is adjacent to the tribe's primary health center. The populations visiting these two buildings are generally among those more vulnerable to adverse air conditions. Additionally, lower Taholah already has air monitoring coverage (Quinault's

Nephelometer.) For the Amanda Park sensor, the decision was made to site the device close to "Pen Rearing," a Quinault fisheries facility. Amanda Park is only partially within Quinault's jurisdiction, and very few residences occupy Quinault's portion of the village. Pen Rearing, meanwhile, is an actively utilized facility for Quinault's fishery, and close to other Quinault-owned businesses on the QIR side of Amanda Park. For the Queets village sensor, ideal placement was determined to be the intersection of Queets Ave. and Riverfront Drive. This is a highly central location of the village, and roughly equidistant to the village's gym, health center, boys' and girls' club, and seniors' buildings—all locations where individuals especially vulnerable to poor air quality might frequent. Finally, for the Qui-Nai-Elt village, Quinault's smallest, a location was identified at the base of a prominent hill. Qui-Nai-Elt village is highly variable in elevation, so this location was selected due to occupying a relative mid-point in the range of elevations the village occupies, to ensure data is maximally representative across the whole village.

In accordance with Clarity's own guidelines (listed in their siting guide, Appendix A), all four nodes are sited within 10-16 feet above ground level, to capture the air quality the general population of each village is exposed to.

10. Sampling Methods Requirements

The Clarity sensors' measurements will be reviewed by the AQP on a weekly basis to locate the presence of negative air quality events. Generally, this will be conducted on Mondays. When the Monday of a week is a day-off or staff are unavailable, this will be done the first subsequent day of the week during which program staff work. Likewise, on the first Monday (or first day staff are working) in each month, measurement reports will be requested and retained as raw data files. These reports provide chronological in-depth detail of a node's air quality measurements. Instructions on the process to request a measurement report can be found in the final paragraph of section 8 of this QAPP. In addition to these more detailed and extensive measurement reports, real-time measurements can be viewed via a similar process in the "datasources" tab of the "Clarity Dashboard," or on Clarity's real-time monitoring map (see Appendix A). The "Clarity Dashboard" is the user interface Clarity provides sensor operators. Given measurement reports are highly information-dense and less accessible, this "datasources" tab, and/or the US EPA Fire & Smoke map (on which the Clarity Nodes' readings are also posted) should generally be used to conduct weekly measurement reviews. Raw data reports, such as those collected for monthly measurement reviews, should be requested from Clarity according to the procedure outlined in the final paragraph of section 8. Quality Control analyses and corrective actions applied to these data reports (to verify MQOs have been and continue to be attained) are detailed in section 11.

The Clarity dashboard also provides a useful tool which can support program staff's weekly measurement reviews and help to stay further apprised of negative air quality events. Air quality "measurement alarms" can be activated via the "communication preferences" tab, present in the menu accessible by clicking the icon shaped as a person in the top right corner of the dashboard. By default, these alarms will trigger and notify operators whenever PM2.5 concentrations surpass approximately 55 ug/m^3 (AQI 150.) However, through the "AQ alarms" tab, accessible from the left sidebar of the Clarity Dashboard, custom measurement alarm thresholds can be set. For instance, the AQP currently has an

AQ alarm threshold of approximately 22ug/m^3 (AQI 75) active for all project sensors. All active and archived air quality alarm rules can be managed via the AQ Alarms tab of the dashboard—see the setup menu for an AQ alarm rule in figure 3. When adverse conditions trigger an AQ alarm for a project sensor, an email titled "New measurement alarms" will be sent by no-reply@clarity.io to the email address associated with whomever is currently designated organization admin for Quinault's Clarity Dashboard account. This email will specify when, where, and how an alarm was triggered.

Figure 3: the menu to establish a new AQ alarm rule. Options available when establishing an alarm rule include selection of pollutant(s), and metric; Calibration & QC status; the pollutant threshold and/or comparison by which the alarm will be triggered; and the datasource(s) the rule will apply to.

The current lowest alarm threshold of roughly 22 µg/m^3 was selected given the substantial population of respiratory-sensitive individuals in the QIR. With this threshold, routine weekly data reviews will be supplemented by immediate notification whenever PM2.5 concentrations approach levels potentially adverse for those most sensitive. This structure and the early notifications ensure the AQP is apprised of degraded air quality conditions while they are still early in development and potential health impacts can be managed more proactively.

The air quality measurements collected in this program are collected automatically by the employed Clarity Node-S air sensors. Clarity Nodes use a small fan to pull in air surrounding the device. This air, along with whatever pollutants it may be carrying, is pulled past the array of sensors. The PM2.5 concentration is detected by a measurement of how much light was refracted within the sample of air. The equipment has a detection range of 0-1000 µg/m^3 and a resolution of 1 µg/m^3. The sensors collect and report concentrations of PM2.5, along with nitrogen dioxide (NO2), temperature, and relative humidity. Please note that while the Clarity Node-S sensors also measure NO2, those data do not contribute to the objectives of this project and thus are not covered in this QAPP.

Clarity nodes require humidity between 10% to 98% Relative Humidity during operations. The Clarity Node-S records data at five or fifteen-minute intervals, depending on the power. Solar Panel configuration is utilized for this project, which delivers measurements in fifteen-minute intervals. However, the Node-S is dynamic and can increase or decrease measurement frequency, depending on user settings and battery charge. The data collected is processed through a propriety algorithm to produce an Air Quality 'rating,' utilizing the format of EPA's standardized AQI rating system.

11. Quality Control Requirements

Quality Control (QC) is the overall system of technical activities that measures the attributes and performance of a process, item, or service, against defined standards to verify the stated requirements are being met. In the case of this project, QC activities are used to ensure uncertainty in the collected measurements can be estimated and is less than the limits of this project's MQOs (see section 7.3.)

In the following section (12 – Data review), staff are directed on how to review raw sensor data produced through this program. As a required step of this data review process, staff must verify the data clearly displays programmatic MQOs were achieved. When review determines MQOs were not met in data produced by a project sensor, the user should practice QC with the following steps to assess the cause and nature of the issue:

11.1: Identifying the QC/QA issue

- Regardless of what flaw(s) staff discover in a sensor's measurements which prevent its data from meeting one or more MQOs, staff should always begin diagnostic inquiry by checking sensor alarms. Clarity Nodes may raise alarms for a variety of reasons. In many cases, these alarms will provide clear indications of what is affecting the quality of that device's data. The presence of alarms can be determined by reviewing "sensor status details" in the Clarity Dashboard.
    - To view active and expired alarms, click the "Devices" menu from the sidebar on the left of the Dashboard. In the list which then expands, click "Nodes". On the page listing each Node, click whichever node is having data issues. With the node selected, click the blue drop-down menu labeled "actions," and then click the option in this drop-down labeled "View Status Details".
    - The meaning and recommended troubleshooting actions for different alarms can be found in Clarity's Common Device status alarms and troubleshooting guide.
    - If such alarms are found, consider the following factors to determine how problematic the source of the alarm might be: how many alarms were raised, how long they were active, what were the listed causes (if any), and might it require device maintenance. Also, consider whether the issue has prevented MQO attainment before, and if the issue could hint at deeper device issues that may prevent MQO attainment again unless resolved? With consideration of these factors and any others that help indicate the potential scope and severity of the source of the alarms, staff should determine and enact the most appropriate corrective action. A list of potential corrective actions starts near the top of the following page.
    - In the event a device presents active alarms in coincidence with data quality issues, but staff are unable to determine via the above strategies how the alarms might connect to the data quality issues, support@clarity.io should be contacted for guidance.
- When measurement frequency is found to not meet this project's data completeness MQO, and coinciding device alarms are not identified, staff should assess the device's connectivity with mobile broadband networks. To view node connectivity, click the "Devices" menu from the sidebar on the left of the Clarity Dashboard. In the list that expands, click "Nodes". On this page, check the column named "signal strength."
    - When the device in question is listed as having a weak signal, the signal may improve 'on its own,' over time. However, in cases where a node consistently has a poor connection strength, staff should consider whether the problem is the node's ability to connect, or the strength of the network itself at the node's current location. Abnormally weak signals and/or outages in the network could include a local power outage or damaged cell tower affecting service.
    - If the device demonstrates a longer-term pattern of communicating measurements late or experiencing periods of lost service, the current site of the relevant sensor may not have adequate service for this project's data completeness needs.
- When sensor measurements do not seem plausible in comparison with actual observed or experienced conditions on-site; or in comparison with measurements from other PM2.5 sensors located immediately nearby:

    - Staff should first check for the presence of device alarms through the process explained in this list's first item. If device alarms are not and were not active when the questionable measurements were produced, staff should conduct a site visit to determine the presence of any physical problems affecting the device.
- When the Clarity Dashboard does not give clear insight into the problem affecting the sensor, staff should physically inspect the QC-questionable sensor. Staff should arrive at these site visits prepared with the tools necessary to resolve common issues. For instance, staff should bring tools needed to re-secure the sensor should its mount have failed, and tools to clean the inside/outside of the sensor should debris have accumulated.
    - Tools recommended to have on-hand for any diagnostic site visit are: a ladder, or other means of accessing the sensor in its elevated location; a flathead and a Phillips-headed screwdriver (or power drill with both drill bits); spare hose clamps OR outdoors rated zip ties; metal shears when using hose clamps (to trim excess); exterior paintbrush or similar brush tool with semi-flexible, semi-rigid bristles; compressed air (or a handheld vacuum cleaner with flexible hose); and weather-proof clothing as-needed.
    - Inspect the sensor inlets on the base of the sensor for debris. If these issues are not present, also verify the solar panel is securely connected to the Node and does not appear damaged.
    - Repairs made, issues noted, and any other pertinent information for sensor maintenance going forwards must all be recorded in the Clarity Node Inspection/Maintenance Field Sheet (appendix B)

11.2: Troubleshooting the QC/QA issue

Once the reason(s) one or more MQOs are not being met by a sensor is/are determined, the user should practice QC with a **corrective action** applicable to resolving the presumptive or known root cause. Staff should use best judgment with consideration of the overall guidance of this QAPP when determining the appropriate corrective action for the situation. The following are examples of corrective actions for common device issues (this list is non-exhaustive. Other issues may impact data quality.):

- If there appears to be physical debris present, clean the sensor with compressed air. A vacuum hose may also be effective.
- When a clarity node consistently struggles with signal strength and a solvable root cause cannot be identified, the struggling node should be relocated to a location which proves to have consistent, at least moderate strength service that sensor can access. To avoid losing air quality data coverage of the locality, the new location should be a different location with better cell signal within or immediately near the same village. If the device does not connect despite being tested in a known consistent service area, staff should reach out to support@clarity.io for a replacement device. If the device does connect and consistently deliver data once again, this indicates its original site has insufficient signal strength, and the device should be relocated. See the corrective actions list beginning on the next page for best practices when relocating devices.

- Other common physical issues sensors may experience include the unplugging of their solar panels, or problems with how the sensor is mounted (broken zip ties, etc.) If any such physical issues are discovered which could be fixed with simple maintenance by AQP staff, they should be resolved during the site visit.
- For more advanced issues or device damage which staff are unable to diagnose or resolve with the above methods, email support@clarity.io with a description of how the issue presents itself, affects the data, and what is known about it at that point. This email account provides dedicated support to users of Clarity Nodes under warranty (Clarity's two-year "subscription" warranty.)
- Additionally, if a critical defect is discovered for a device still under warranty, Clarity support will facilitate its replacement. Clarity will first assess the problem to verify replacement is necessary, and should they decide it is, they will ship a replacement to the AQP free of charge and provide a return label for the defective unit.
- If funding is present and department approval is provided, devices experiencing critical defects post-warranty may also simply be replaced with a newly purchased device and warranty.
- For issues which occur multiple times, staff should consider whether a revision or new addition to this QAPP or accompanying program documents (such as those listed in this QAPP's appendix) would aid the prevention of this issue going forwards. In such cases, both these documents may be revised with the approval of QDNR leadership, including at least the AQP's supervisor and the QDNR division director.
- Preventative maintenance is an assured method to reduce the frequency of data quality issues. Regular site visits to check on the sensors and address issues are highly encouraged as staff have capacity for them. At a minimum, these site visits should be completed quarterly.

11.3: Recordkeeping of QA/QC issues and affected data

As preventative maintenance fixes and QC Issues are identified and resolved, staff will record notes on the conclusive or hypothetical root cause(s) for the data issues, and their respective solutions to help advise future device QC. These notes will be retained, titled, and clearly distinguished according to the naming and recordkeeping conventions described in section 8. These notes may be kept physically or digitally according to staff preference, but minimally must be scanned into each sensor's unique file folder in the Air Quality directory (which can be found at the file folder path listed in the second paragraph of section 8). All site visits and physical sensor maintenance activities must be recorded in the Clarity Node Inspection/Maintenance Field Sheet (appendix B.)

Once the QC/QA-affecting issue has been identified, and resolved (or resolutions attempted), and recorded, staff must review data produced during the timeframe during which the QC/QA issue impacted the affected device(s). Any data produced during the occurrence of the QC/QA issue must specifically be assessed to verify those data still attained this project's MQOs. Any data found not to meet an MQO of this project (as listed in section 7.3), or determined highly improbable given observable ambient conditions, must be marked as QC-invalid in retained data records. To indicate a data file as QC-invalid, type the abbreviation "EXCL" (for 'exclude') into the filename, and save the file into the respective sensor's "Errors & Bad Data" subfolder. See section 8 for more naming conventions and recordkeeping protocol.

11.4: QA/QC Timetable:

The following Timetable provides an outline of QA/QC activities conducted for this project on an ongoing, routine basis. The following activities and their associated corrective actions can be found in further detail in the preceding lists of this section.

Table 3: QA/QC Timetable

QA/QC Activity	Frequency	Intent / Notes
Checking Clarity Node readings are being successfully transmitted to the Fire & Smoke Map and do not demonstrate stark disagreement between any project sensors and other, immediately collocated sensors	**Weekly at a minimum**. Encouraged daily when QIN villages are immediately threatened or impacted by air quality issues of any origin (ex: wildfire smoke, local fires.)	Ensuring the air quality conditions at QIN villages are publicly accessible on a routine basis and to ensure the AQP can give air quality guidance and mitigations as needed, utilizing the Fire & Smoke Map's correction factor-adjusted data.
Clarity Dashboard device status details review	**Weekly at a minimum.** Encouraged daily when QIN villages are immediately threatened or impacted by air quality issues of any origin (ex: wildfire smoke, local fires); when one or more project sensor(s) have been affected by known issues; or program staff find the device(s) to be exhibiting aberrant behavior	Staff should verify all project-utilized nodes are successfully connected and transmitting readings with no errors. This can be checked via the clarity Dashboard's status details page. In the second half of page 19 of this QAPP are instructions on getting to the device status details page.
Data report review	Monthly	Deeper level of review of recent device data, including trends the data may indicate regarding air quality and air pollutant trends over the last week.
Collocation-dedicated sensor transfers	At least once each quarter, roughly 90 days between relocations.	One of this project's collocation-dedicated sensors will move every quarter, between the permanent project nodes, until it has collocated with all four permanent project nodes (at which point the first portable collocation-dedicated node will join the site of the nephelometer, and one of the other collocation-dedicated nodes will begin quarterly cycling through collocations

		with the four permanent project nodes. This collocation process is integral to verifying sensor drift is not a significant factor for any of the clarity sensors. This would render the measurements they produced as unusable for this project.
On-site (physical) inspection of all permanent and collocation-dedicated clarity nodes	At least once each quarter, roughly 90 days apart at the least frequent	Verifying the physical condition and installation of the four permanent project nodes is integral to confidence in the data this project generates, and to identifying potential device issues early.
Annual Collocation Study between all Collocation-dedicated Nodes and Quinault's nephelometer	162 hours of collocation producing data acceptable in quality, starting in early January of each calendar year.	Continuous comparison of the collocation nodes' data in with the data produced by Quinault's M903 Nephelometer.
Data review, synthesis, & reporting for the annual collocation study results	Upon the completion of each annual collocation study.	The most comprehensive consideration of local air quality data collected through the recent year of project operation. The report produced is also submitted to the EPA & synthesized into a more readable version to retain in AQP records for future staff, should they wish to understand local air quality trends previously observed.

12: Data Review and Verification

To ensure this project's sensors are reporting data acceptable for this project's MQOs (as described in section 7.3), and to develop insights into air quality trends across the QIR, staff will conduct three routine data review activities for each sensor utilized in this program. The three routine data review activities respectively are: reviewing measurement data available on the Clarity Dashboard on a weekly basis; downloading and reviewing full data reports monthly; and an annual calibration-verifying QC study completed via sensor collocation (employing the "Sensor Transfer" strategy.) The exact timing of the former two review activities will follow the frequencies explained in Section 10. Likewise, their records will follow the naming/labeling conventions described in Section 8 of this document. When any of these review activities raise questions of validity or quality in the data recorded, staff must consult sections 11.1-11.3 to determine the potential root cause(s), appropriate corrective actions, and whether any data must be marked QC-invalid and excluded from long-term considerations of this project.

12.1: Weekly Data Reviews:

The weekly data reviews conducted using the Clarity dashboard serve the purpose of keeping staff apprised of current conditions and trends in the four villages covered by this project's sensors. These reviews are less demanding and replete with data review requirements. This is because they are supplemented by the more in-depth monthly data report reviews and annual sensor transfer collocation studies (described below), which both contribute to Quality Assurance verification. NOTE: three additional clarity nodes uniquely provided to the AQP by Clarity, are operated in collocation with the four permanent project sensors to help demonstrate the project's sensors are operating comparably with each other, and Quinault's Nephelometer air monitor. These nodes and their role in QA/QC procedure is described further in section 12.3. For the purposes of weekly data reviews, the AQP should verify these devices are producing near-identical readings with the permanent project clarity nodes they are collocated with and are not producing intermittent or questionable data. These factors and the performance of these three devices should likewise be considered during each weekly review, to identify and resolve any erroneous device behavior as soon as possible.

12.2: Monthly Data Report Reviews:

The monthly review of each sensor's full data reports should be completed a calendar month apart plus or minus 2-3 days or less. However, if extenuating circumstances prevent staff from collecting a data report for a portion of the prior month, be sure to include the portion of the prior month which was not yet reflected in a data report, in the new report being requested. Multiple datasources can be reflected in one data report, however when completing any data review activities it is recommended staff request and download a unique report for each sensor individually, as single reports covering multiple sensors can be dense and difficult to parse.

Before analyzing any monthly review data reports, staff must verify there are no data records reflected in the timeframe the report covers which must be excluded from the analysis. To verify this, Staff must review the "Errors & Bad Data" folder of the unique AQP H: drive file folder tree. All data files in the respective sensor's Errors & Bad Data folder which include "EXCL" in their filenames, and which are dated within the timeframe covered in that monthly data review, must be opened and reviewed for exclusion. Confirm the start and end time(s) of all collected data listed in EXCL files. Now, open the data report spreadsheet(s) downloaded for this month's data. Locate all the measurement data which were listed in the EXCL files and thereby identified as questionable or affected and delete those data from the monthly report. This can be done most efficiently by holding the control key and clicking the row numbers for all rows containing data that were also identified in the EXCL files (row numbers are on the left edge of the screen in excel. Each row reflects one measurement.) Once all data referenced in the applicable EXCL files are selected, right click on any of the currently selected rows and select the option "delete" from the menu that pops up. See section 8 for more details on documenting and recordkeeping protocol.

Once all erroneous and questionable data has been removed from the monthly report, staff must review the data report scrupulously. The calibrated PM2.5 mass concentration measurements in column 'BV' of each report contain the data relevant to this project's goals. Columns E, F, BT, BU, and BW through CZ also provide useful supplementary info: the start and end times of each measurement; status information for the sensor's calibration; PM2.5 measurements obtained through other methodologies; and measurements collected of temperature and relative humidity. While these columns may help to understand device behavior when troubleshooting, column BV's PM2.5 measurements are what staff should review from each data report when considering air quality trends, insights, and whether the device seems to be functioning properly or might not be, due to questionable measurement data.

12.3: Annual Sensor Transfer Collocation Study:

Annual Collocation Sensor Transfer Study Overview

The annual Collocation Sensor Transfer Study for this project's sensors will be ongoing, repeating each year and starting on January 1st. For the completion of this most involved QC activity, Clarity has provided QIN with three collocation-dedicated clarity nodes. Two of these nodes stay collocated with a different, more advanced and precise form of air sensor—a Radiant Research M903 Nephelometer operated by QIN in collaboration with Washington Department of Ecology. Meanwhile, the third would move between the nephelometer and the sites of the permanent project nodes over the span of four quarterly collocations.

The third collocation-dedicated Clarity node will be with each permanent project sensor on the reservation, following a consistent clockwise pattern. These quarterly collocations last approximately 90 days (except winter quarter, lasting approximately 83 days.) Some flexibility from the intended schedule of these collocations to the degree of five days at most per quarterly collocation in the event of absences and holidays, is acceptable. Longer deviations from the intended schedule (which is most precisely outlined in figure 7), however, will require pushing the subsequent dates of the study process back, as needed to compensate for the specific amount of lost time. Routine checks on the physical condition of each of the four permanent project nodes will also be completed during these quarterly collocation swaps. The collocation-dedicated node selected to collocate with all four permanent project nodes over the span of each year of this project is referred to as the "Relocating Collocation Node". Which specific collocation-dedicated node takes on this role should change year-to-year, providing each of the three collocation-dedicated nodes a turn as the relocating collocation node in every three years the project operates.

Once the Relocating Collocation Node has traveled across the QIR to the four permanent project nodes' sites and completed a quarterly collocation with each of the four sensors, it will rejoin the other two collocation-dedicated nodes at the site of QIN's nephelometer. The nephelometer and three collocation-dedicated nodes will now spend a week (at minimum, 162 hours free of erroneous behavior from any of the four collocated devices) in collocation. Generally, this will be the first or second week of January, except when the project had encountered prior delays that had pushed this date forward. After this week is completed, analysis of the data from that year's collocations should begin. Simultaneously, a different one of the three collocation-dedicated nodes should move to its first permanent project node to collocate with, starting a new cycle of collocations as part of the next annual study process. The same one or two collocation-dedicated node(s) should not be used to complete this cycle multiple years in a row, as this can influence disproportionate wear and tear on the node(s) relocated more frequently.

The data from the week of collocation between all collocation-dedicated nodes and the nephelometer will be analyzed to confirm the continued precision of this project's permanent sensors. Further, the quarterly collocations between the relocating collocation node and the permanent project nodes should be analyzed. This process is completed to verify the four permanent project sensors continue to produce accurate measurements and have not developed performance issues or bias overtime. The specific approach to collocation this project will utilize is described in EPA's enhanced air sensor guidebook on page 69 as "Sensor Transfer." Our Sensor Transfer approach is equivalent to the example provided in the guidebook, except that our nephelometer is not a reference instrument, though thanks to its more advanced methodology it is more precise than the low-cost clarity sensors (See figure 4.)

Key	Collocation Strategy			
S sensor R reference instrument S sensor transfer ✓ yes ~ somewhat X no $ cost 🔧 maintenance	**Periodic All Sensors** All air sensors operate next to a reference instrument for short periods before and after the study and/or periodically.	**Continuous Subset** Some air sensors are continuously operated next to a reference instrument while others are deployed to other locations.	**Reference Transfer** A reference instrument visits each air sensor for a short period(s).	**Sensor Transfer** An air sensor collocated with a reference instrument, with known performance characteristics, visits each sensor location for a short period(s).
Continually check sensor performance	X	~	X	X
Capture a wide range of weather & pollution conditions	~	✓	~	~
All sensors tested at the same time	✓	~	X	X
All sensors tested against reference instrument	✓	✓	✓	X
All sensors tested at their sites	X	X	✓	✓
Additional equipment costs	$	$	$$$	$$
Frequent operator maintenance	🔧🔧	🔧🔧	🔧🔧🔧	🔧🔧🔧

Figure 4: a chart from the EPA's Enhanced Air Sensor Guidebook (page 69, figure 3-9) which outlines the sensor transfer method—the collocation strategy this project is employing for its annual collocation studies-- along with alternative collocation strategies.

Annual Sensor Transfer Collocation Study Setup

The specific procedure to complete the Annual Sensor Transfer Collocation Study process is as follows. Clarity has provided Quinault with three Clarity Nodes specifically intended to aid in the completion of this Quality Assurance collocation study. Two of these three nodes (referred to throughout this section as "collocation-dedicated nodes"), are collocated with a more advanced and precise air sensor at the site of the Taholah School (600 Chitwin dr., Taholah 98587). Quinault's Radiant Research M903 Nephelometer, provided by and operated in collaboration with the Washington Department of Ecology, is housed at this site. See Figure 5 for the precise location. Three criteria must be met in the installations of the collocation-dedicated nodes at this site: the solar panels face southwards (or, a permanent alternative power source is identified and connected to all three nodes); the Nodes are not readily accessible to vandalism; and the Nodes are mutually within 5' of the air intake of the Nephelometer while also not being within 1' of each other.

When installing or inspecting a collocation-dedicated node, a padlock must be opened to access the alcove wherein the Nephelometer is housed. Should AQP program staff need to recover the padlock code, Ecology's Calibration & Repair Lab (360-407-6030) can provide the code (and other useful information regarding the Nephelometer program, when needed.) When leaving, take care to re-lock the padlock, as shown in figure 6. Specifically, when locked: the chain should loop through the vertical poles that make the inner edges of both sides of the gate, with the padlock itself then locking through both a link of the chain and the other padlock (a second lock for maintenance staff to access tools stored in the alcove.) Figure 6 clarifies the exact location of the Nephelometer air intake, around which the three collocation-dedicated nodes will be installed. Regardless of precisely how the collocation nodes are installed, it is imperative staff verify the installation is completely secure, even to harsh weather. Steel hose clamps and UV-resistant zip ties are examples of securements which can help achieve this.

Figure 5: Aerial view of Taholah School (600 Chitwhin Dr, Taholah, WA 98587), with the precise location of Quinault's *Radiant Research RR903* Nephelometer indicated by the red rectangle.

Figure 6: Exterior view of the enclosure which houses Quinault's Nephelometer. The area where Quinault's Radiant Research M903 nephelometer's air intake is located is circled. The installation of the collocation-dedicated Nodes here would likely be easiest to complete by fastening the Nodes to the top of the chain link fence, on the interior side of the fence, in a row adjacent to the Nephelometer's air intake, spaced by a foot or so each. NOTE: roughly 10 feet of horizontal space not pictured lies between the two photos stitched together for this figure.

Once the two collocation-dedicated nodes collocating with the Nephelometer are installed alongside the Nephelometer's air inlet, ensure their configurations on the Clarity Dashboard reflect the location of Taholah School, and they each have an activated datasource. To setup the configuration & datasources for the collocation-dedicated nodes, click the "Devices" option in the sidebar on the left side of the Dashboard. In the drop-down which then expands, click "Nodes". On the page listing each Node, click a node from your list of devices that will be used for collocation (they will be at the bottom of the page in the "inventory" section.) At this point, a drop-down menu button labeled "actions" will illuminate blue. Click on this "actions" menu, and then the "configure" link in the menu. A step-by-step interface with instructions will now pop up, which guides staff through naming the new datasources and marking their locations (again, please select the precise location of the collocation study, in the southeast corner of the Taholah School.) Be sure to give the new datasource a name which clearly indicates its purpose of collocation and its physical location. Repeat this process for the other two collocation-dedicated nodes.

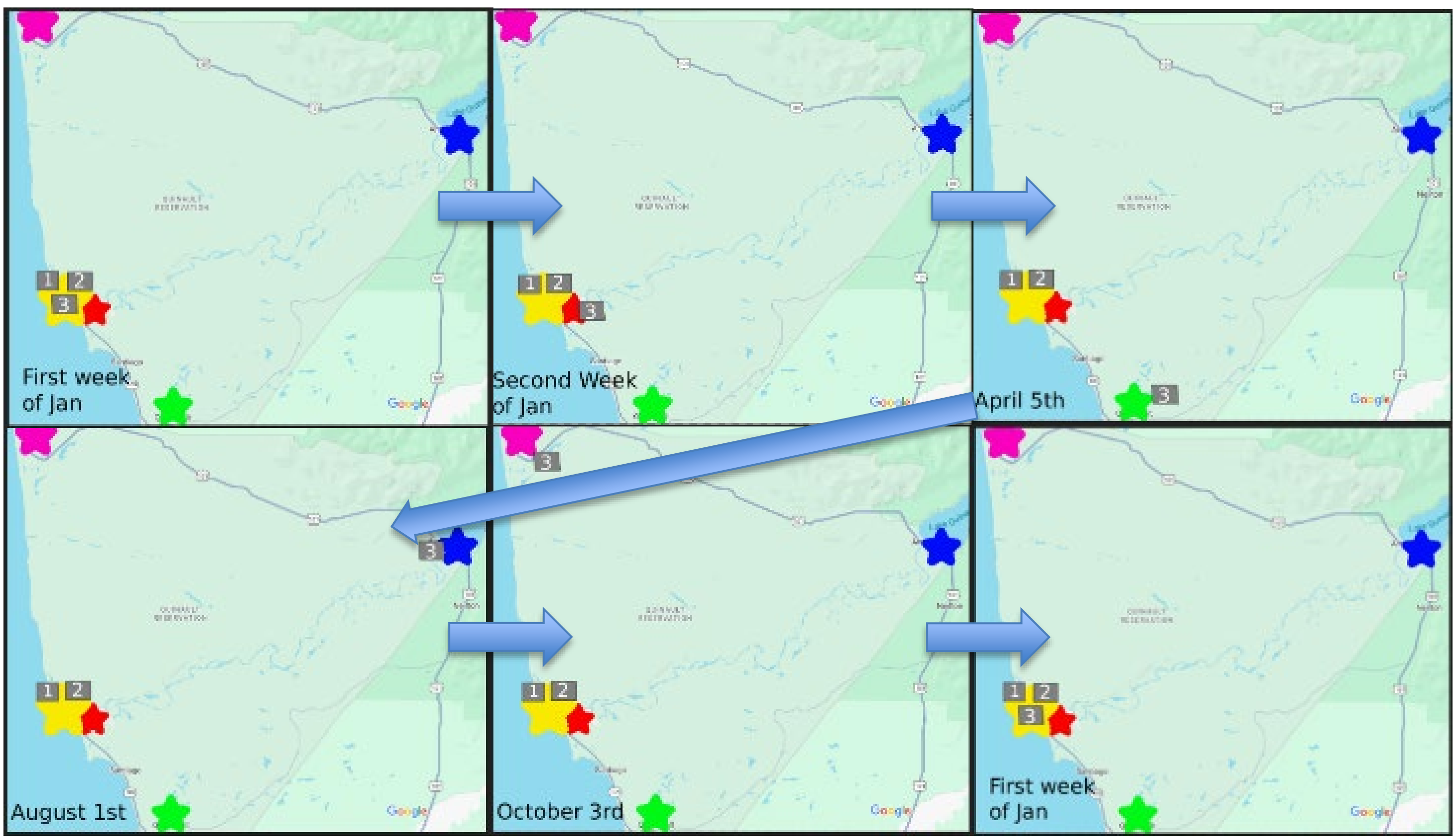
Once this is completed, these two collocation-dedicated nodes will remain in collocation with the Nephelometer for approximately the following year as the third collocation-dedicated node completes quarterly collocations with the four permanent project nodes. This process may be longer than a year, when needed to accommodate staff absences or excused holidays and still collect the minimum required amount of data. The third collocation-dedicated node will relocate to the site of the permanent Taholah node, to begin collocations with each of the four permanent project nodes over the following year. This node will be known as the “relocating collocation node.” Each of the three collocation-dedicated nodes should respectively have a year to take turn being deployed as this “relocating collocation node” over every three years the project operates. This will prevent only one or two of the collocation-dedicated nodes from disproportionately experiencing wear from frequent relocations.

Before moving any node from one site to another, its current datasource must be paused. To pause the current datasource, open the Clarity Dashboard and select the Devices section from the left sidebar. Select the nodes tab. Click the “actions” dropdown menu and select the “stop recording data” action therein. This will pause the datasource from attempting to collect further measurements. The node which was associated with the datasource should now display in the “Inventory” section of this page. Now, a new datasource will need to be established or reactivated for the node’s new collocation site. When a node serving the same data collection purpose (collocation, or data collection) has operated in the same location previously, it will have left an inactive datasource which can be reactivated for the new node occupying the site. To configure a relocating node with an inactive datasource, navigate to the datasources tab of the Clarity Dashboard. At the bottom of the page, “Stopped Datasources” will be listed. Click on the site-applicable inactive datasource. The actions drop down menu will now turn blue. Click on the actions menu and select the “resume” option to reactivate the datasource. A menu will pop up, with a drop-down list of your currently available nodes. Select the node you are trying to configure and then click confirm. When an appropriate inactive datasource is not available, see the instructions for activating a new datasource, beginning on the prior page.

The relocating collocation node first collocates with the permanent Taholah Clarity Node each year, for 83 days (winter quarter), followed by 90 days collocating with each of the other three respective permanent project nodes. When the relocating collocation node and a permanent project node disagree, staff should follow section 11’s recommended QA/QC activities to identify which node has lost precision, and to bring the two nodes back into alignment. To accommodate errors or QC fixes such as these, staff absences, and excused holidays, the quarters may be at most 5 days shorter than these listed quarterly durations. Figure 7 provides an example of an acceptable timeline for a study’s collocations, along with the precise intended schedule staff should follow when availabilities allow (see the orange text.) In the event a medical absence, device error, or other unavoidable barrier arises and delays a sensor transfer of the study by over 5 days, all subsequent transfer dates of the study should be adjusted forward as necessary to ensure the minimum required duration of each collocation is attained. Keep in mind this may also affect when the next annual sensor transfer collocation study begins. When critical dates of the collocation study process are delayed, staff must record the new dates in the program’s H:Drive folder and inform other program staff of the change, to avoid possible confusion.

Once the relocating collocation node has completed its collocations with all four permanent project nodes, it will rejoin the other two collocation-dedicated nodes back at the site of Quinault's Nephelometer. At this point, a week-long collocation study of those four sensors must now be completed and reviewed. Staff should select a week during which they have the availability necessary to routinely (at least three times a day) verify the sensors are performing effectively. If errors occur in any of the collocation-dedicated nodes during the study process (including significant "disagreements" between any of the project sensors and the nephelometer), consult section 11's Corrective Actions (be sure to mark erroneous data for exclusion as 11.3 directs.) In rare occasion, errors affecting one or multiple of the sensors collocated may incur delays sufficient to prevent the completion of 162 hours of quality-acceptable data by the end of a full calendar's week of collocation. Should this occur, the end of the collocation must be extended as necessary to ensure the required minimum of 162 quality-acceptable hours of data can be collected.

(January 1-Jan 7)* **(Jan 7-April 1)*** **(April 1-August 1)***



(Aug. 1-October 1)* **(Oct 1-Jan 1)*** **(Jan 1-Jan 7th)***

Legend	Pink Star = Queets Permanent Clarity Node Blue Star = Amanda Park Permanent Clarity Node Green Star = Q-Village Permanent Clarity Node Red Star = Taholah Permanent Clarity Node	Yellow Star = Quinault Nephelometer Gray boxes = collocation-dedicated nodes 1, 2, 3

*NOTE:	The dates overlaid upon the diagram are purely examples of acceptable dates by which to complete the sensor relocations necessary in an annual collocation transfer study. Meanwhile, the orange text above and below the diagram outlines the precise schedule of the study, which is intended and should be followed when circumstances allow. The intended date range of the study is listed above and below the figure in orange. 5 days of delay from any of these dates are acceptable at most. All days beyond 5 during which a date of the study is delayed (due to staff absences, device errors, or holidays will equally push back the following collocation dates of the study.

Figure 7: An example of a full cycle of collocations in the Annual Collocation Sensor Transfers Study process, with clarifications regarding the acceptable limits of flexibility for the sensor transfer dates.

While the 3 collocation-specific nodes do not directly provide measurements used for the consideration of this project's findings or recommendations, they play an integral role for verifying whether the project's permanent sensors continue to produce data of acceptable precision. Critically—is the data of the permanent project Clarity Nodes within the acceptable DQI of .85 R^2 correlation with the data of QIN's nephelometer? The procedure to complete the collocation between all three collocation-dedicated nodes and the nephelometer is described in the following section.

Conducting the Annual Sensor Transfer Collocation Study

Once all three collocation-dedicated nodes have produced the minimum-required 162 hours of data (which are free from errors affecting or casting doubt upon data quality), these measurements must be used to calculate correlation with Quinault's Nephelometer. If the measurements from the respective permanent project nodes and collocation-dedicated nodes correlate with R^2 values of .9 or greater; AND the measurements produced by the collocation-dedicated nodes correlate with the measurements of Quinault's Nephelometer at R^2 values of .85 or greater: the permanent project nodes will have met the precision DQI.

To determine these correlations and whether the project's DQI have been met, staff should calculate the precise correlation between two data sets at a time (two sensors' measurements at a time.) Before you can calculate the correlation between the sensor data sets, you first need to ensure the datasets reflect the same timeframe, and both present data in the form of hourly-averaged measurements. This will ensure both datasets contain the same number of measurements to calculate correlation and contain only measurements from the span of the collocation study.

The simplest and least time-consuming way to obtain the needed datasets for all sensors involved in the collocation with Quinault's nephelometer is to download hourly-averaged PM2.5 reports for the data produced by the sensors during the collocation. This data can be accessed and downloaded from the Clarity Dashboard and Washington State Department of Ecology webpage (for the Clarity nodes and Quinault's Nephelometer, respectively). The process to download hourly-averaged PM2.5 reports from the Clarity Dashboard is explained in section 12.1. Follow section 12.1's guidance to download the datasets needed, except be sure to select the output frequency option of "hour", (contrary to section 12.1's suggestion of "minute" averaging.) Be sure to select only the timeframe of the collocation study for all the Clarity Nodes' data reports downloaded. Repeat this process until a data report has been downloaded for each node included in the Collocation Study. Save these reports in the "Annual Collocations" sub-folder of the AQP's H:drive file folder holding the other files retained from this program. Follow the naming conventions listed in section 8 for the downloaded reports.

To download an hourly-averaged PM2.5 report for the Nephelometer, go to the Washington Department of Ecology's Air Quality Map (https://airqualitymap.ecology.wa.gov/) and navigate the map to Taholah. Click on the green bubble in Taholah (representing the Nephelometer). This will pop up a chart displaying data collected from the Nephelometer over the last 24 hours. Just above the chart are three buttons: click the "Reports" button. This new page allows you to download hourly-averaged PM2.5 data reports from Quinault's Nephelometer in several formats (direct link: https://airqualitymap.ecology.wa.gov/site-report/56 .) By default, the selected report type is "Hourly AQI Report." However, for Quality Assurance activities like this collocation study, PM2.5 concentration measurements, and not AQI, should be selected. To change the default report type, click the drop-down bubble "Report Types" near the upper left-hand corner of the webpage. In the drop-down, select the option "Hourly Data Report." Figure 8 displays the settings staff should select before downloading this data report (except the exact start and end dates, which should align with the exact start and end dates of that year's Annual Sensor Transfer Collocation Study.)

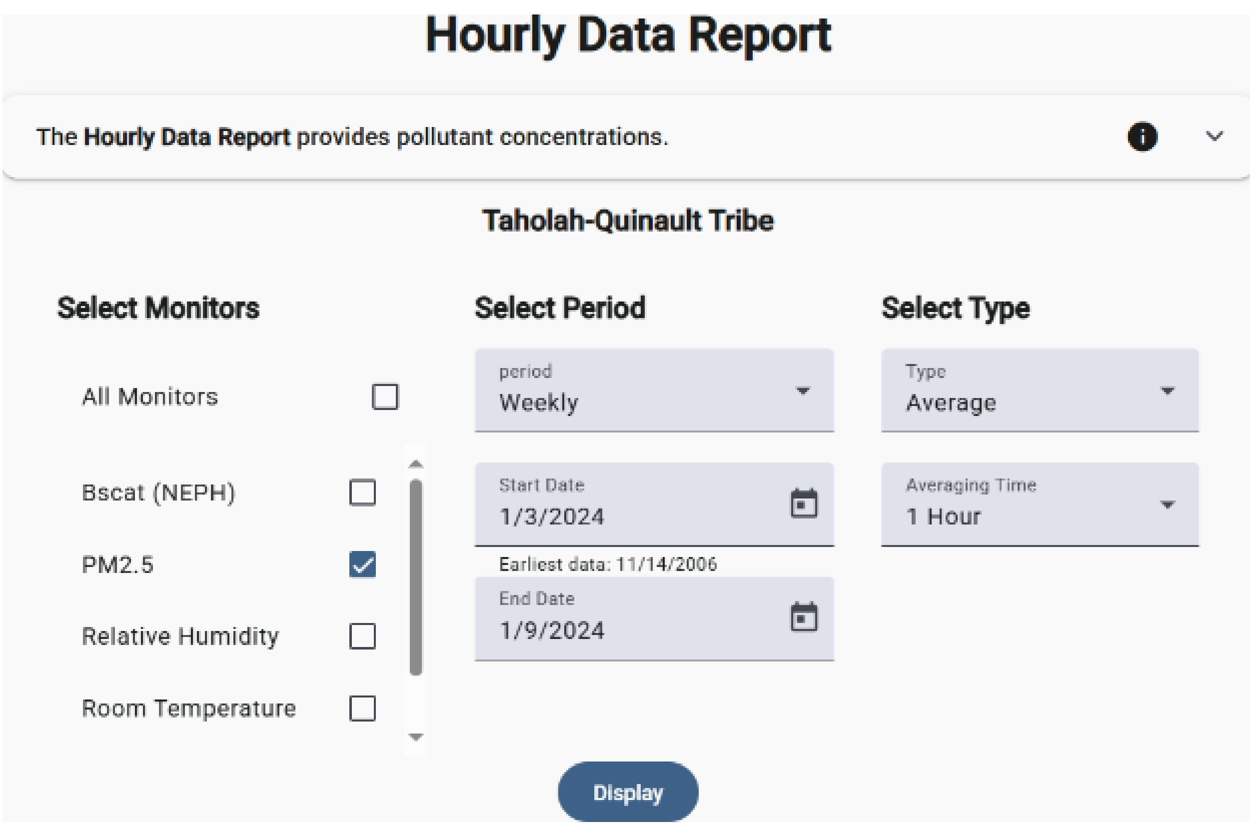


Figure 8: When downloading data from Quinault's Nephelometer for the week of the Annual Sensor Transfer Collocation Study, be sure to select the same settings as are displayed here (not including the start and end date. Again, those must align with the start and end of the collocation study.)

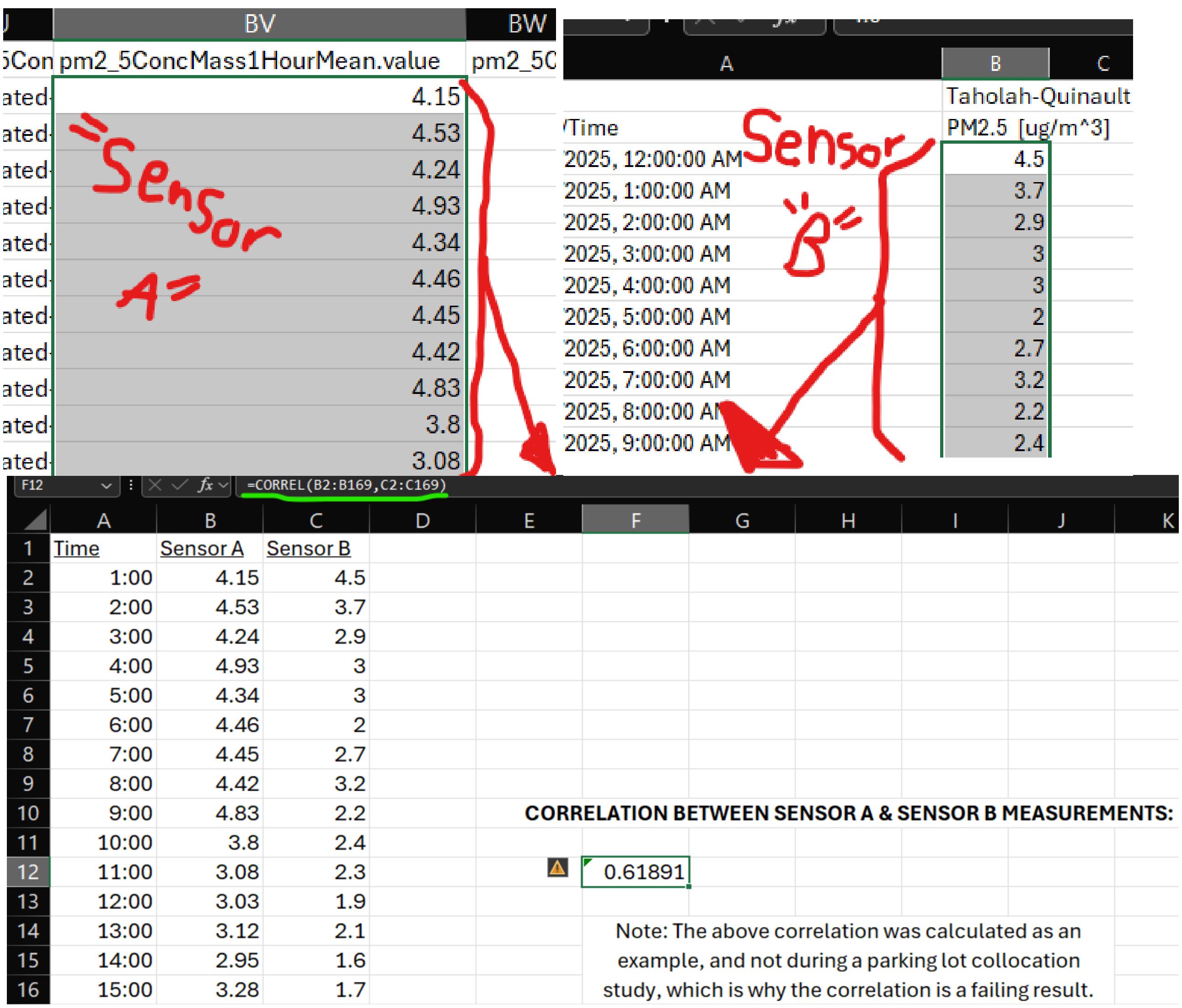
Once the proper settings have been selected, click the “Display” button just below the report options. A new set of buttons will now appear in place of the “Display” button: click the button titled “download as CSV.” You should now receive a notification in the top-right corner of your browser’s window, asking what you would like to do with the newly downloaded data report. Select the option “Save As” and save the report in the aforementioned “Annual Collocations” sub-folder of the AQP’s Clarity Nodes program H:drive file folder. Again, follow section 8’s naming conventions.

The data produced by each of the collocation-dedicated sensors employed in the study must be reviewed to ensure any quality-affected or questionable data produced during the study has been deleted from the reports downloaded. Review all “EXCL”-designated data files produced during the duration of the study for the collocation-dedicated sensors and verify the start and end times of those files’ listed measurements. Open the data report spreadsheets for all sensors which produced data listed in EXCL files from the duration of the study, locate the rows containing the data which was identified for exclusion in the EXCL files, and delete all rows of affected data from each applicable report. Once all rows containing affected data have been highlighted, right click on any of the currently selected rows and click the option “delete” from the menu that pops up. See section 8 for more details on documenting and recordkeeping protocol. Complete this for all collocation-dedicated node data reports which will inform this annual collocation study. Review for the Nephelometer’s data is still necessary, however, generally all QC-questionable data and data produced during instances of error in the nephelometer is not reported to the Nephelometer’s listing on Washington department of Ecology’s air quality map by default. However, should highly unlikely or impossible readings have been produced by the Nephelometer and delivered to the Washington Ecology Air Quality map nonetheless, follow the same process to remove the data from the final downloaded spreadsheet, and be sure to notate the questionable data by the appropriate procedure of the Nephelometer’s monitoring program.

While there are more than two datasets in total, and correlations between more than two variables are mathematically valid, the correlations described in the MQOs are specifically intended to be two-variable correlations. Therefore, all correlations calculated for this Annual Sensor Transfer Collocation study and its accompanying quarterly collocations should contain only two sensors’ data per each correlation calculated. The screenshots below demonstrating the process to calculate correlation will refer to Sensors “A” and “B,” as an example of a correlation between two sensors. The simplest and most efficient method to calculate the correlation between two datasets involves using Excel’s CORREL function to immediately compute the correlation. The relevant hourly-averaged calibration-applied PM2.5 concentration data in Clarity Node measurement reports is found in column BV. For the Nephelometer’s measurement reports, you can find the relevant measurement data in Column B. Open a blank excel page and copy-paste the PM2.5 hourly concentration data collected for the duration of the collocation study (the entire column of relevant data) for the sensors being correlated into two adjacent columns in the new excel sheet. See Figure 8 on the following page for a visual example of the process.

The above process should first be completed two more times to determine the correlations between the three respective collocation-dedicated Clarity Nodes and Quinault’s Nephelometer (three unique collocation node-to-nephelometer correlations.) For each new dataset, you will need to either replace the previously correlated collocation-dedicated node’s column of data in the excel sheet made to calculate the correlation, or create a duplicate excel sheet for each correlation. If all three collocation-dedicated nodes produce a correlation factor of .85 or above (R^2 value) with the Nephelometer's measurements collected during the collocation study, the collocation-dedicated nodes will have thus demonstrated sufficient comparability with Quinault's Nephelometer. Use the correlation results document listed in appendix C of this document (and saved as a template Annual Collocations" sub-folder of the AQP's Clarity Nodes program H:drive file folder) to document the results of the Study. Record into this file the specific correlation factors calculated here. Be sure to indicate which datasets produced which correlation factors. Follow the naming conventions of section 8, specifically indicating that the file represents an annual sensor transfer collocation study, and the year that study occurred.

Now, the above process should be repeated yet again, four more times: to verify each of the four permanent project nodes produce a correlation factor of .9 or above with each of the relocating collocation nodes during their respective quarterly collocations. If all the permanent project nodes produce a correlation factor of .9 or above with the relocating collocation node during their quarterly collocations with it, the Annual Sensor Transfer Collocation Study will have produced a passing result for Quality Assurance purposes. Record all correlation factors calculated here into the annual study results form provided in appendix C. Specifically label which two sensors produced which correlation factors.



Time	Sensor A	Sensor B
1:00	4.15	4.5
2:00	4.53	3.7
3:00	4.24	2.9
4:00	4.93	3
5:00	4.34	3
6:00	4.46	2
7:00	4.45	2.7
8:00	4.42	3.2
9:00	4.83	2.2
10:00	3.8	2.4
11:00	3.08	2.3
12:00	3.03	1.9
13:00	3.12	2.1
14:00	2.95	1.6
15:00	3.28	1.7

Figure 8: An excel file demonstrating the "CORREL", or correlation formula in Excel, and the correlation factor (in the green-underlined cell) that it calculated. In the red circle at the top of the screenshot, see the CORREL equation which was entered to calculate the correlation factor between example "Sensor A" and "Sensor B" data sets. =CORREL prompts the equation for whichever cell you are currently typing in, and two cell ranges go in parenthesis, to instruct the equation which two data sets you are comparing for correlation. BE SURE TO SEPARATE THE TWO CELL RANGES BY A COMMA, OR ELSE THIS FUNCTION WILL NOT OPERATE.

Once the data collected via the study has been reviewed to confirm the DQI were met, the next collocation-dedicated node to act as the relocating collocation node must be taken down and redeployed at the site of the permanent Taholah node. However, before physically taking down this node, remember to ensure the datasource set up for the node's stay at the Nephelometer site is paused with the "stop recording data" function in the Clarity dashboard. When this is done, promptly reinstall the node in collocation with the Taholah Clarity Node, and reactivate the previously used correlation datasource for that site, and assign it to the relocating collocation node. The other two collocation-dedicated nodes will remain alongside the Nephelometer for at least the following year. Do not move them until their respective turns to act as relocating collocation node arrive.

12.4: Important Considerations for all Data Review Activities:

Staff should consider for all three of these data quality reviewing activities whether the measurements presented seem feasible considering local conditions. Data used for non-regulatory purposes such as education/outreach, or mitigation of air quality issues (such as Rx burn or wildfire woodsmoke intruding village airspaces) as is the case for this project, should be verified by such comparison. For instance, when a device is reporting poor air quality, can you see or smell smoke or other issues in the locality which may be affecting air quality? Or conversely, are there air quality issues at the sensor's location which the node does not seem to be accurately portraying in its readings?

Given the AQP's multiple responsibilities, staff may not always be able to travel to sensor sites to confirm conditions align with measurements. When staff are concerned that device measurements do not seem realistic for observed or probable conditions, staff have a few more strategies to help verify sensor measurements align with local conditions. Firstly, staff may compare Clarity sensor PM2.5 measurements with measurements from other collocated PM2.5 sensors. A competitor low-cost sensor brand, Purple Air, submits sensor readings from its devices to the US EPA Fire & Smoke map (on which Clarity sensors and their readings are also displayed.) This allows for convenient comparison between the Clarity Sensor measurements, and measurements from alternative low-cost sensors located immediately nearby. As of November 2025, this map displays purple air sensors located in close proximity to Quinault's Clarity Nodes in Taholah, QuiNaiElt, and Amanda Park villages (see Figure 4.) The AQP also has plans to deploy a purple air sensor in Queets in the near future, so a Purple Air sensor's readings may be considered in comparison to Queets' Clarity Node as well. Finally, forecasted air quality conditions displayed on EPA's interactive Airnow air quality map, can be compared with the measurements of local sensors. However, remember that local air quality events may have led to different measurements than what was forecasted. Staff should use best judgement and scrutiny when considering whether a local event may have affected air quality, leading to any unexpected measurements.

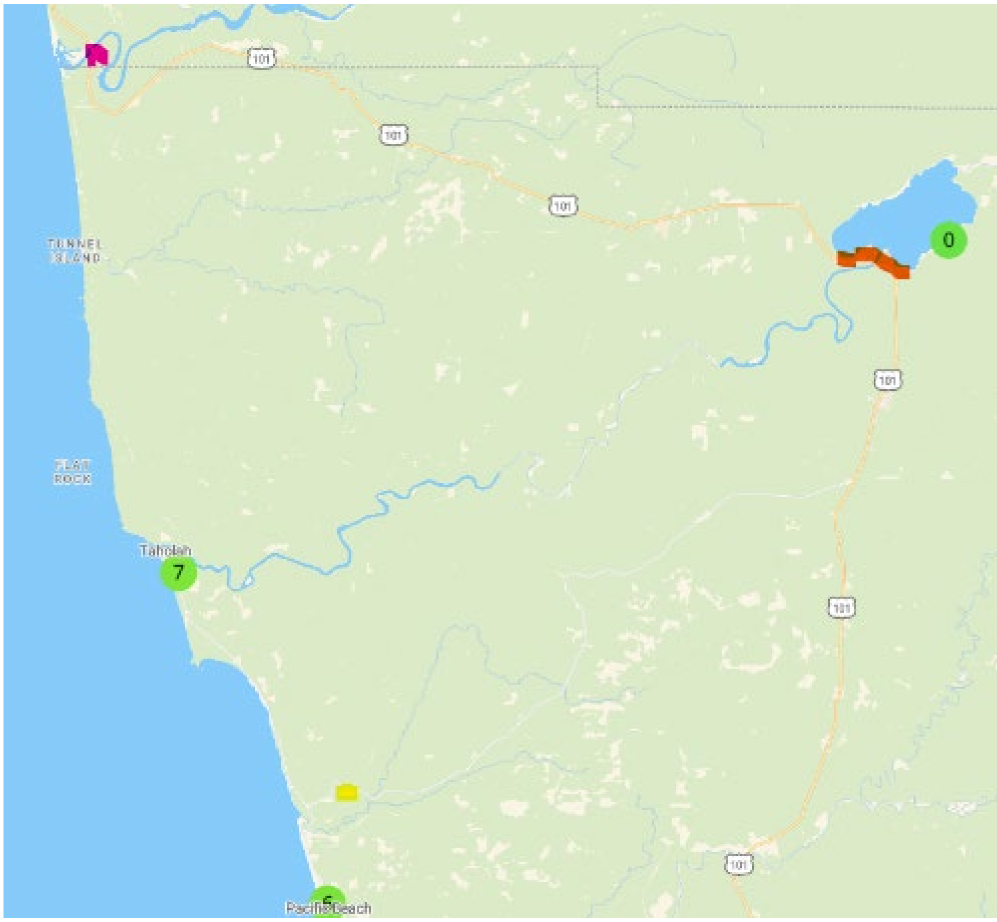


Figure 9: View from [Purple Air's sensor measurements map](). Taholah village is marked on the map by default, however the other three villages were not, so they are highlighted in this screenshot (Queets: pink, Amanda Park, red, QuiNaiElt, yellow.) Note how all the villages except Queets have nearby collocated Purple Air sensors.

It's important to remember that neither the low-cost sensors visible on Purple Air's map, nor EPA's air quality forecasting on their AirNow map are exact determinations of air quality. Still, significant deviations between clarity sensor measurements and the conditions presented by either of these resources for the same locations may indicate a project sensor is experiencing malfunctions or other issues. When such significant disagreements between project sensors and local conditions or measurements from other local sensors or forecasts are noted, staff should first verify that these sensors are tracking on the same averaging frequency and collecting measurements of the same metric (for instance, AQI compared to AQI, and not AQI compared to pm2.5.) When the two relatively nearby sensors recording measurements at the same averaging frequency and with the same air quality unit of measurement significantly disagree, staff should give special attention to the measurements of the sensor which has been behaving unexpectedly. If the sensor continues producing anomalous or unlikely measurements for another full day from when the questionable measurements were first noted, staff should investigate this issue with the steps described in section 11 – Quality Control.

Data for any periods during which a sensor is found to have been malfunctioning; obstructed; or failing to meet project MQOs must be excluded from any considerations of this project's conclusions or recommendations. Specifically, these data must be labeled "EXCL" and retained in the appropriate Errors & Bad Data folder for the respective sensor, when entered into digital records (see section 8.)

Appendix A: Additional Resources

Resource Description	URL:
Clarity Node-S Specification sheet, produced by the manufacturer to describe basic device functionality and specifications.	https://click.clarity.io/hubfs/Marketing%20Assets%20-%20PDFs/Product%20and%20Specification%20Sheets/Node-S%20Specifications%20Sheet.pdf
Clarity Node-S Deployment Guide	https://click.clarity.io/knowledge/deployment-node-s-cellular
Guide for utilizing Clarity's Device Status Page	https://click.clarity.io/knowledge/understanding-the-device-status-details-page
Guide for viewing and understanding Clarity Node-S provided Air Quality data (also produced by the manufacturer.)	https://click.clarity.io/knowledge/viewing-and-understanding-your-air-quality-data
US EPA Fire & Smoke Map, which displays live hourly averaged and quality-controlled air quality measurements from local sensors, along with wildfire activity and smoke plumes.	https://fire.airnow.gov/
Clarity's proprietary measurements map. All Clarity devices actively reporting will display their air quality readings on this navigable map. Note that ONLY Clarity sensors display on this map.	https://openmap.clarity.io/
Guide to deploying Clarity Nodes, written by the manufacturer.	https://click.clarity.io/knowledge/deployment-node-s-cellular
Guide to site-selection for Clarity Nodes,	https://click.clarity.io/knowledge/siting-guide
Clarity Node Sensor alarm interpretation and troubleshooting guide.	Common Device status alarms and troubleshooting guide
Interactive map displaying sensor measurements from Purple Air, a competitor low-cost sensor which has sensors collocated to most of our deployed Clarity Nodes. Useful for comparison.	US EPA PM2.5 by PurpleAir
EPA's AirNow air quality forecasting map, which also can be used to compare projected air quality conditions with measurements reported from project sensors.	interactive Airnow air quality map
Clarity guide to understanding data report column names, or "metrics," as they call them.	Metrics dictionary - API Guide
Additional context for interpreting Clarity Data Report data classifications.	Metrics in measurements - API Guide

Appendix B: Clarity Node Inspection/Maintenance Field Sheet

Sensor Location Name (Ex: "Queets")	
Clarity Node Serial no.	
History:	
Date sensor(s) deployed:	
Calibration completed?	
Any maintenance or troubleshooting prior?	
Does the sensor beep to indicate both power-on and device connected, after being restarted?	<u>Power-On (long, single beep):</u> Y / N <u>Connection Successful (Two short beeps, the second being higher pitched):</u> Y / N
Sensor deployment:	
Deployment date:	
Address or latitude and longitude of sensor	
Deployment height	
Any obstructions near the sensor?	
Picture taken that shows sensor and surroundings?	
Sensor registered and set to public?	
Sensor maintenance	
Sensor showing up on the EPA Fire & Smoke Map & the Clarity OpenMap?	
If no to the above question, please list the most recent days the sensor displayed on either map.	
Site visit date, issue, and whether the issue was resolved:	
Problem identified/takeaways:	

Appendix C: Collocation study results template

Annual Collocation Study & Quarterly Collocations Correlation Results Form			
Sensors Correlated	**Correlation Factor**	**Passing?**	**Notes**
Nephelometer & Collocation Node 1 (ID #:________________)			
Nephelometer & Collocation Node 2 (ID #:________________)			
Nephelometer & Collocation Node 3 (ID #:________________)			
Relocating Collocation Node (ID#:______________) & Taholah Node			
Relocating Collocation Node (ID#:______________) & QuiNaiElt Node			
Relocating Collocation Node (ID#:______________) & Amanda Park Node			
Relocating Collocation Node (ID#:______________) & Queets Node			
In the event of a failing result, list the planned timeline to complete QA/QC activities to identify the cause of failure and redo a collocation study (attach a second page if necessary):			