Mitigation of the Water Crisis within Navajo Tribal Communities through the Sustainable Village Water Systems Model

White Paper

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Prepared by Ohio State's Global Water Institute in partnership with Assist International, Duke University, Suez WTS Systems USA, Inc., and WorldServe International.

Introduction

Assist International, Duke University, Suez WTS Systems USA, Inc., WorldServe International, and The Ohio State University's Global Water Institute (GWI) (herein "our Team"), in collaboration with our funding partners, are working to mitigate the critical water crises and improve public health and agricultural outcomes on Navajo Nation Lands (NN-L). The Navajo Nation is a federally recognized tribe with reservation lands in the states of New Mexico, Arizona, and Utah in the four corners region of the United States. The Nation is one of the largest in the country, with over 330,000 members, 175,000 of whom reside on the reservation.

The COVID-19 crisis has highlighted the fundamental importance of secure access to clean water, sanitation and hygiene (WASH) to ensuring public health. Extended drought and a changing climate already threaten the productivity of agriculture on NN-L, which will only worsen with increasing temperatures and changing rainfall patterns. Water resource use and sustainable management are essential to WASH and agriculture and require both scientifically-based use strategies and sound business models for ongoing operation. Our Team's Sustainable Village Water Systems (SVWS) model combines all of these components – development of secure water access, agriculture, WASH, as well as sustainable business enterprises in agriculture and water services. Rudy Shebala, Ph.D., the Executive Director of the Division of Natural Resources, has helped us to identify several critical water-related needs across the reservation. What follows is a strategic plan to tailor the SVWS model to provide immediate relief for these urgent water needs and long-term support for optimized water resource use, improved water access, optimal agriculture and public health strategies for the NN-L, and creation of water services and agricultural businesses. Our Team is committed to coming together to act now in partnership with the Navajo Nation.

Our plan of action for mitigating the water supply crises and improving agricultural productivity and public health on NN-L involves immediate (Phase I: next 6-9 months) and longer term (Phase II: five year) activities (Appendix A). Our approach includes immediate improvements to water access infrastructure and water resource assessment to facilitate long term planning for optimal water resource utilization, agricultural, and WASH activities.

Phase I: Immediate Plan of Action (6-9 months)

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1. **Survey existing water sources and needs:** In collaboration with the Division of Natural Resources, our Team will conduct a preliminary survey of existing sources of water and their suitability for consumption. This will include a detailed hydrogeological survey and a comprehensive assessment of a wide range of water quality parameters (e.g., salts, metals, organics, naturally occurring radioactive materials). This work will be used to identify the top five areas within the NN-L

with the most urgent water needs and to ensure the safety of domestic utilization of these groundwater resources. This will also allow us to conduct market testing and to establish support on the reservation for deployment of a Sustainable Village Water Systems (SVWS) model adapted to NN-L. A literature review is already underway and field work and sampling can start at the first availability of Dr. Shebala and his team. **Timeline: In-progress with completion by the end of February 2021.**

2. **Repair existing water infrastructure:** Our Team will partner with Navajo leadership to ensure that the existing, but currently out-of-service, water supply infrastructure is operational as quickly as possible, and to provide assistance by hiring professionals capable of helping with repairs as needed. A poignant example would be repairing the broken windmill and livestock troughs within the White Rock Chapter. This work can be coordinated remotely and can start at the discretion of the Division of Natural Resources with or without our Team's on-site participation. **Timeline: starting immediately and completed by February 2021.**

3. **Design comprehensive built-to-need onsite water access (kiosk) systems:** Based on the hydrogeological and water quality surveys, our Team will design water access (kiosk) systems that are complete with onsite water storage units. The storage units will provide better turnaround times for water filling and allow for the flexibility to install suitable water treatment and other infrastructure modules where needed. These water access systems can be paired with both updated or newly installed water wells described in Action Items 4 and 5. In areas where water quality does not meet acceptable standards for drinking, WASH, and/or agricultural needs, a customized water treatment system will be incorporated into these water access systems. An important feature of these water treatment systems is that the design will be configurable for specific uses (e.g., drinking water, WASH, agriculture) or adaptable to enable treatment for different purposes (e.g., large volumes for agriculture or pastoral usage, and smaller but more rigorously treated volumes for drinking water). The comprehensive water quality assessment proposed in this project will ensure that all naturally occurring and anthropogenic contaminants in groundwater will be analyzed and appropriately treated to ensure the sustainability of the water treatment devices and the safety of the Navajo people. System design is in progress and will be adapted to local needs and intended uses following comprehensive onsite assessments of water quality and pumping potential. **Timeline: Standard system design is in progress and the system will be tailored to the water quality needs identified during Action Item 1. We anticipate completion of the final treatment system's design by March 2021.**

4. **Improve efficiency of existing water infrastructure:** Our Team will work with Navajo leadership to identify underutilized water resources. In order to have immediate

impact, one key strategy would be to replace inefficient (or broken) hand pumps with solar-powered electric pumps. Several potential sites have already been identified in the Tonizhoni and Tobewhigani Valleys. Refurbished wells would be optimized through the addition of comprehensive water access systems described in Action Item 3. **Timeline: immediately after completion of Action Item 1 with anticipated completion by April 2021**.

5. **Install new groundwater wells:** Our Team will partner with Navajo leadership to identify areas with insufficient water access or extreme water shortages. In these targeted locations, we will install five new groundwater wells. We expect the need for new wells might encompass health clinics, schools, chapter houses, or other community centers identified by Navajo leadership. Well cost estimates and design will be optimized following the completion of Action Item 1 (estimated costs are detailed in the budget). The newly drilled wells will be equipped with solar-electric pumps (or windmills as appropriate) along with the comprehensive water access systems described in Action Item 3. Potential sites have already been identified in the Tobewhigani Valley and will be confirmed through the surveys in Action Item 1. Where possible, the newly drilled wells will be clustered with existing water infrastructure, but completed to different depths to reduce hydraulic interference among wells and to facilitate rapid permitting and access, etc. **Timeline: immediately following completion of Action Item 1. Well installation to be completed by May 2021.**
6. **Establish an agricultural training plot:** In order to jump-start the critical agricultural component of this project, a training plot will be established immediately upon site identification. The site will be strategically located not only for water access, but also for ease of accessibility and visibility to the target 5 communities. This initial plot will focus on sustainable production of hay, alfalfa, corn, small grains, potatoes, and beans. Trainings and demonstrations will include maximizing water use efficiency through drip irrigation technologies, integrated pest management for minimizing the need for chemical pest controls, management practices that optimize yields while simultaneously regenerating the soil, agricultural equipment operations and maintenance, and agricultural business development. Farm starter kits will also be distributed to jumpstart the training process. **Timeline: Site selection completed by March, plot preparation and planting April – June. Trainings beginning in May 2021.**
7. **Conduct needs assessments around water access, agriculture, public health, and water service businesses:** Our Team will work with Navajo leadership to conduct a thorough community-based participatory needs assessment across NN-L. This will identify needs, opportunities, resources, assets, and limitations related to water, agriculture, public health, and small businesses. The results will be used to collaboratively define specific long-term project objectives, a results framework, and detailed project activity design. The

methodology will include a preliminary assessment with focus groups followed by a community-wide questionnaire, with multiple modes to elicit community inputs. It will complement the hydrogeological, water quality and water infrastructure surveys also being conducted during Phase I.
Timeline: can begin immediately and will be completed by May 2021.

Phase II: Long-term Plan of Action (5 Years)

As part of our ongoing effort to provide sustainable water access across NN-L, our Team will collaborate with Navajo leadership and the Division of Natural Resources to:

1. **Develop an optimized strategy for water resource utilization:** Expand the geographic scope of the preliminary survey of water resources and reservation needs. We will focus on cataloguing and prioritizing the potential to rehabilitate and/or re-utilize existing boreholes.

Key strategies to optimize water resource utilization will include:

a. Optimize water treatment modules to enable water recovery from saline aquifers (e.g., parts of the Entrada and Coconino sandstones).

b. Identify and rehabilitate existing boreholes that are suitable for long-term use.

c. Match areas with high water availability to water intensive industrial activities (e.g., agriculture).

d. Evaluate wastewater streams (e.g., water wells drilled for coal mining, oil, and gas wastewater) to develop optimized treatment strategies to enable wastewater reuse.

e. Improve wastewater treatment and reuse strategies to enable drip irrigation and support the raising of food, livestock, fodder (e.g., wheat, hay), and/or textile cash crops (e.g., cotton, hemp).
Timeline: This work is in progress with expected completion by May 2021.

2. **Install new groundwater access points:** Establish 300 new groundwater wells and access points through a combination of newly drilled and rehabilitated boreholes. These

wells will be equipped with solar-electric pumps (or windmills as appropriate) and will be in areas of the greatest remaining need. In addition to health clinics, schools, chapter houses, and other community centers, we will focus on opportunities to develop sustainable agricultural business enterprises. Overall, we expect to create new or enhanced water supplies for more than 150 rural communities throughout NN-L. **Timeline: This work will begin in March 2021 and be completed by the end of 2025.**

3. **Optimize the impact of comprehensive water access (kiosk) systems:** Each new groundwater access point will be equipped with comprehensive water kiosk systems like those described in Action Item 3 in the *Immediate Plan of Action Section* above. We will leverage this infrastructure to develop rural 5G internet connectivity, solar powered electric charging systems, and recycling and compost stations. **Timeline: This work will begin in June 2021 and be completed by the end of 2025.**

4. **Develop sustainable agriculture training modules, demonstration farms, and in-person extension training:** In coordination with Navajo leadership, Ohio State Extension, and our corporate partners, our Team will develop a comprehensive agriculture training and implementation program. The needs assessment (Action Item 7 in *Immediate Plan of Action* above) will identify the crops that farmers want to grow, methods and technologies they wish to pursue, and inventory current activities and assets. It will also be used to solicit inputs on broader agricultural goals and objectives, e.g., increased consumption of home-produced crops, improved dietary diversity, and increased agricultural income. The assessment will also determine existing limitations and barriers to achieving these objectives, e.g., difficulties with accessing credit, knowledge gaps around new technologies, or uncertainty stemming from price or input risk. All relevant stakeholders will be engaged including farmers, farmer cooperatives, tribal leadership, universities and vocational schools, Navajo Nation Extension, and business representatives. The outputs from the needs assessment will inform the development of a series of training modules, e.g., best agricultural practices for water-restricted, high mountain desert environments, agricultural business plan development, and marketing. We will also establish scholarships for Navajo residents to complete degrees in this area at Ohio State. In parallel, during this time five locations in which we will develop Demonstration and Training Farms will be identified by targeting strategic places to provide ease of access to the most farmers. Siting will also account for the ability of farmers to access new water infrastructure for agricultural purposes. Demonstration and Training Farms will be prepared for planting, including prebiotic treatment and installation of drip irrigation systems. In anticipation of the growing season, all appropriate farm equipment and tools will be purchased by or donated to the project and stationed at each of the Farms.

Over the course of the project, on-going farmer field schools will take place in which Ohio State Extensionists will lead train-the-trainer programs in partnership with Navajo Nation Extensionists and Navajo students completing graduate degrees at Ohio State. Farm starter kits will be distributed to participating farmers. There will be ongoing engagement with the Ohio State Extensionists throughout the year via WhatsApp chat groups, email, and/or telephone. **Timeline: Development of training materials will begin in January 2021. Preparation of the Demonstration and Training Farms will begin in April 2021. In-person training modules will begin in June of 2021. Training materials and an online platform will be updated continuously, while in-person site visits will continue on a quarterly schedule through the end of 2025. Student recruitment will begin in Fall of 2021.**

5. **Develop a public health train-the-trainers and outreach program:** Improve community health through a train-the-trainers and outreach program targeting WASH and nutrition, in collaboration with Ohio State's College of Public Health. The

needs assessment (Action Item 7 in *Immediate Plan of Action* above) will identify community needs and wants around public health outcomes such as reduced incidence of water-related bacterial infections (e.g., shigellosis, campylobacteriosis), improved nutrition education (e.g., to reduce incidence of adolescent malnutrition, diabetes and obesity), and improved WASH practices in community institutions. The assessment will also gauge community desire to engage in discussions around sanitation and hygiene, and, if appropriate, comfort with different types of sanitation technology. This input will allow us to collaboratively develop optimal training strategies for WASH and nutrition on the NN-L. Topics could potentially include safe water quality characteristics, best practice waste management for water source protection, reducing risk for contamination of drinking water, specific WASH needs for healthcare facilities, schools, and other community centers, improved nutrition for reduction of obesity, cardiovascular disease and type 2 diabetes risk, as well as optimal maternal, infant, and child nutrition.

Trainings will be sensitive to resource limitations on NN-L, such as access to healthcare providers, transportation challenges, and availability of grocery stores. Training will be conducted with Navajo public health personnel and community representatives, and will include specific training modules with healthcare facilities and schools. Nutrition training modules will also be coordinated with the existing Nutrition Education and Obesity Prevention Program and Women, Infants and Children (WIC) Program on NN-L. We will also establish scholarships for Navajo residents to complete graduate degrees in public health at Ohio State. **Timeline: This work will begin in June 2021. In-person training modules will begin in September of 2021. Training materials and an online platform will be updated continuously, while in-person site visits will continue on a quarterly schedule through the end of 2025. Student recruitment will begin in Fall of 2021.**

6. **Develop sustainable water well drilling business enterprises:** Faculty from Ohio State's College of Engineering, College of Arts and Sciences, Fisher College of Business, and Extension will work with our Team and Navajo representatives to provide training on the necessary scientific and business background to develop sustainable groundwater resources after this project has been completed. One key strategy for this will be providing scholarships to Navajo residents to complete degrees at either Ohio State or Duke University. Training topics would include groundwater basics such as aquifer selection, well design, placement and drilling, water level testing, and water quality. In addition, we will train the local communities to develop a citizen-science approach to continuously monitor water quality. To facilitate this, we will provide the community with water conductivity meters and training that will provide a cost-effective, first-order assessment of changes in water quality and allow prioritization for ongoing water quality testing. Along with raising funds for a mobile water drilling rig, this training will lead to the formation of a sustainable, Navajo-owned water well-drilling business, which could become a franchised operation, and open the door for sustainable water resource development on NN-L. **Timeline: Work will begin in June 2021 and continue through the end of 2025. Student recruitment will begin in Fall of 2021.**
7. **Implement a sustainable strategy for rural water management:** The needs assessment (Action Item 7 in *Immediate Plan of Action* above) will identify existing water

service enterprises on NN-L, comfort with different models for water services, and opportunities to develop water service businesses. These inputs will allow us to collaboratively develop an optimized strategy for sustainable management of water infrastructure and service provision by adapting the Sustainable Village Water Systems private operator model, developed by a cohort of our Team in Tanzania, to best suit NN-L. The private operator model (which could be developed into a franchised operation) provides sustainable water access by creating business enterprises for infrastructure operations and maintenance, extended technical support, and remote monitoring, where revenue is generated by water sales. An operator training manual suitable for the water infrastructure on NN-L will also be developed, and training will be conducted for interested community members on water infrastructure operations and maintenance. Training will also be provided as desired on business skills associated with water services and/or water quality testing businesses. **Timeline: This work will begin in May 2022 and continue through the end of 2025.**

Operational Construct

A dedicated Project Management Professional (PMP) will oversee and coordinate project activities across partners and administer strict timetables for project implementation and completion. A project liaison will be appointed from each partner as a point-person for communicating with the PMP on behalf of their entity. In addition, a Secretariat will oversee strict adherence to budgets, and ensure smooth movement of funds across the project. The PMP, Secretariat, and 5 project liaisons from the partners will hold monthly meetings via Zoom to share updates, troubleshoot, and discuss lessons learned. The PMP will then share a short monthly report capturing partnership inputs with all project stakeholders. Below are the specific roles and responsibilities of each partner.

Navajo Nation: All activities will be coordinated and approved by the Navajo leadership. They will be responsible for providing access, setting priorities, and coordinating participation of communities.

Assist International: Assist International will be a project implementer and be responsible for managing the repair of broken infrastructure, design and installation of comprehensive water access (kiosk) systems, optimization and installation of treatment systems, and key components of the measurement and evaluation (M&EL) program.

Duke University: Duke will be responsible for select water quality analysis (e.g., salts, naturally occurring radioactive materials), evaluating the potential for reuse of impaired water resources, including wastewater generated from energy development activities and water treatment facilities, and key components of M&EL.

The Ohio State University, Global Water Institute: The Global Water Institute (GWI) will be responsible for conducting field surveys and resource assessments, developing various train-the-trainer and sustainable business enterprise modules, monitoring water quality (e.g., metals, organic contaminants), helping to develop optimal mitigative strategies to treat poor water quality, and siting new water wells. GWI will also develop and lead training modules for water well placement, water quality assessments, optimal water use and reuse, WASH, nutrition, public health, and agriculture, and training and operation of the Sustainable Village Water Systems model (i.e., private sector operator model) optimized for the Navajo Nation. GWI will take a leadership role in recruiting Navajo students to undergraduate and graduate

educational opportunities at Ohio State and Duke University and in conducting the monitoring, evaluation and learning program.

Suez WTS USA, Inc.: SUEZ is a worldwide leader in designing, manufacturing, operating, and maintaining water treatment equipment and facilities for the benefit of local communities, industries, and citizens of the world. SUEZ will provide expertise to fully understand the scope of the water challenges, comprehensively engineer and execute sustainable solutions, and support the systems lifecycle from initial operation through training and digital tools and monitoring.

WorldServe International: WorldServe International will lead fundraising and be responsible for managing the installation of solar pumping units, well drilling, and rig acquisition. WorldServe will lead coordination of the project strategy and manage the logistics of operations with Navajo leadership regarding project development.

Implementation Plan and Timeline

Improved and Sustainable Water Access

The activities proposed here are planned to provide relief for the most critical water needs on NN-L as quickly as possible.

Our Team has already begun work on conducting preliminary surveys of water sources and water quality. The information from this survey will be essential to designing site-specific water quality treatment systems, optimizing existing infrastructure, and siting new water wells in Phase I.

Our Team is also ready to begin immediate work on repairs to existing infrastructure to return out-of-service water systems to operation by the end of the year.

The implementation plan includes ongoing activities that will be carried out through the end of 2025 to provide sustainable water access across the Navajo reservation.

Ongoing activities will include developing an optimized strategy for water resource utilization that will match multiple sources of water across NN-L, including that of poor quality and wastewater streams, to the best suited use. This work will begin before the end of 2020 and be completed in 5 months, by May 2021.

New water wells and distribution points will be installed in areas of severe water stress that have not already been addressed and will include comprehensive water systems with storage and water quality treatment. This work will incorporate knowledge from the water surveys and optimized water strategy, and so will begin in 2021 and continue through 2025.

Agricultural Training Program

The activities proposed here are designed to provide an optimized agricultural strategy for the realities of life in a water-restricted, high mountain desert based on a comprehensive assessment of needs across the NN-L. The assessment will take place during Phase I while water resources are being secured. Outputs from the assessment will be used to develop training materials and identify optimal locations to site Demonstration and Training Farms, beginning in Spring 2021. This will come in two forms, including increasing capacity of existing Navajo personnel and communities, as well as providing graduate education for Navajo scholars (at Ohio State). Preparation of the Farms and in-person training will begin in Spring 2021, with training continuing through to the end of 2025.

Public Health Training and Outreach Program

Ohio State public health faculty and Extension Service will meet with the Navajo Leadership and public health professionals to collaboratively develop a train-the-trainers and outreach program focused on WASH and nutrition. This

will come in two forms, including increasing capacity of existing Navajo personnel and communities, as well as providing graduate education for Navajo scholars (at Ohio State). A comprehensive needs assessment will be conducted in Phase I, followed by development of training materials. In-person training will begin in September 2021. Training materials and an online platform will be updated continuously, while in-person site visits will continue quarterly through the end of 2025.

Water Services Business Training

Training will be provided on the necessary scientific and business background to maintain the development of sustainable groundwater resources after this project has been completed, including through the creation of a Navajo-owned water well drilling franchise. This will come in two forms, including increasing capacity of existing Navajo personnel and communities, as well as providing graduate education for Navajo scholars (at Ohio State or Duke). This work will begin in June 2021, following the installation of water access systems that can be used as case studies, and continue until the end of 2025. An Operator Training Manual and training program will also be developed for operating water supply small businesses, to ensure sustainable operation and maintenance of water supply infrastructure. This work will begin in May 2022 and continue until the end of 2025.

Monitoring, Evaluation and Learning

The project will employ a rigorous monitoring, evaluation and learning (ME&L) plan to: (i) track progress toward achieving the project's objectives; (ii) provide evidence-based decision making and adaptive project management; and (iii) evaluate the project's overall effectiveness and the impact of major activities. The major components of the ME&L plan are:

1. Community-based participatory needs assessment, which will be used to develop the theory of change, results framework, and impact assessment surveys.
2. Ongoing project monitoring and reporting.
3. Project impact assessment and evaluation.

The needs assessment (see Action Item 7 in Immediate Plan of Action above) will identify the existing pathways through which community and individual activities and practices lead to outcomes of interest to this project. Together with the project objectives, a theory of change will be developed that conceptually describes how the project activities are intended to lead to initial outputs and outcomes, and how those outputs eventually lead to the project objectives. Using the theory of change, a results framework will be developed that formalizes the explicit pathways through which project activities will lead to the specified project objectives, based on collectively agreed upon assumptions.

Ongoing monitoring and reporting will be undertaken throughout the project life cycle to track the progress of activities. Updates will be shared with all project stakeholders, including Navajo leadership, implementing partners and funder stakeholders, at predetermined intervals.

Performance indicators will be established collaboratively with Navajo leadership and the project partners for each of the major activities. Performance indicators are well-defined metrics of progress toward the project objectives. They are measurable, and annual targets will be established for each indicator, with data disaggregated by gender as appropriate. Monitoring of indicators will be done by the implementing teams.

A monitoring and reporting matrix will be developed to organize the monitoring and reporting process. This matrix will specify the data to be collected for each indicator, sources of information, data collection methods and frequency, responsible entities for data collection, and frequency of reporting.

Reporting and communication protocols will include the process for ongoing community engagement during the lifetime of the project. The protocols will establish the methods to be used (e.g., notices posted at meeting places, informal meetings, text messaging), the responsible entity/entities for receiving and responding to community inputs, and timelines for providing responses back to communities.

The theory of change and results framework will be used to develop baseline, midline and endline household surveys to be conducted throughout the project for impact assessment. The final endline survey will be carried out 18 months after the completion of project activities to evaluate the long-term impact of the project.

The project activities will be staggered over the 5-year project period utilizing a stratified phased rollout design. A phased rollout is commonly used in programs where simultaneous interventions across the program area are not feasible due to the broad geographic coverage and time restrictions of project activities. In this project, implementation will be particularly limited by the logistics of transporting equipment across the large areas represented by the targeted 150 rural communities, the time needed for borehole drilling and water kiosk installations, and the ability of project partners to establish agricultural training programs within 150 communities spread over large areas.

Project activities will take place within 4 regions across Navajo Nation Lands. Within each region, chapters will be designated for early, intermediate, or late intervention if possible. Early intervention chapters will have activities beginning at the start of the project (after the needs assessment is completed, at the 6 month mark), activities in intermediate chapters will begin approx. 24 months after project initiation (i.e., beginning of year 3), and activities in late chapters will begin approx. 42 months after project initiation (i.e., midway through year 4). By the end of the project timeline, all communities will have received all intervention activities.

The phased rollout design will allow for longitudinal comparisons of changes within each community, as well as difference-in-difference comparisons between communities. By using this difference-in-difference approach to impact evaluation, we can use pre-intervention communities as controls for post-intervention communities, to measure the impact of interventions on both pathway indicators and ultimate project objectives. We will also be able to measure exposure effect, as in some locations' midlines will allow us to quantify impact at multiple points after roll-out. We expect to see progress towards objectives improve over time, once the project is rolled out in any given location.

Baseline surveys in early intervention communities and midline surveys are critical to this difference-in-difference strategy. They also allow us to examine mechanisms behind the ultimate impact of each program, particularly mechanisms that build over time. The midline surveys additionally allow us to evaluate how early and intermediate interventions are influencing outcomes, allowing us to reevaluate programmatic activities if needed.

If project rollout deviates from the initial plan by necessity, in some instances the surveys may only be able to identify correlative, but not causal, impacts. Such results will still be valuable in determining project impact, but we will be clear as to which type of results is expected on a case-by-case basis.

Households will be chosen for survey via a stratified sample design, with geographic intervention areas serving as strata. Sampling will be based on a census list of households in each region obtained by Navajo Nation, and power calculations will determine sample size for each region. We may over-sample key population groups of interest (e.g., livestock-focused households, agriculture-focused households, households in low water availability areas, or households with poor soil fertility). Surveys will be divided into modules, and the individual within the household who has the most expertise

in each area (e.g., most involved with agriculture, food choices or childcare, or fetching water) will be the respondent for each module.

Consent from all participating households will be obtained, and the entire survey will be approved through the Ohio State Institutional Review Board before we begin. As is standard, we will pilot and test our baseline survey before it is conducted, in order to ensure quality of questions/responses. We may pilot parts of the midline surveys too, where new questions are being added.

As appropriate for the project objectives being considered, we will supplement large-scale surveys conducted in person through facilitators with shorter, rapid surveys done via telephone or text message. This information could allow rapid response or program alteration in the face of immediate, urgent needs, and might also be integrated into the larger evaluation dataset. This information will not be part of the formal impact assessment conducted via the difference-in-difference method but will be key to informing our understanding of why certain impacts existed or deviated from expectation.

Qualitative data will also be gathered from small sub-samples of both pre-intervention and post-intervention survey communities, through focus groups and key informant interviews. This qualitative data, like the rapid small-scale surveys, will help us to interpret and learn from our quantitative analysis. It will also be used to iterate details of the project activities to ensure maximal impact.

Finally, time-varying satellite data will be integrated into the dataset, including geographic data on rainfall, temperature, and greenness (NDVI/GDVI). Metrics of economic improvements (e.g., solar panel installation, household expansion) may also be gathered via administrative data rather than surveys. These data will allow us to consider the role that other factors may play in mediating project outcomes.

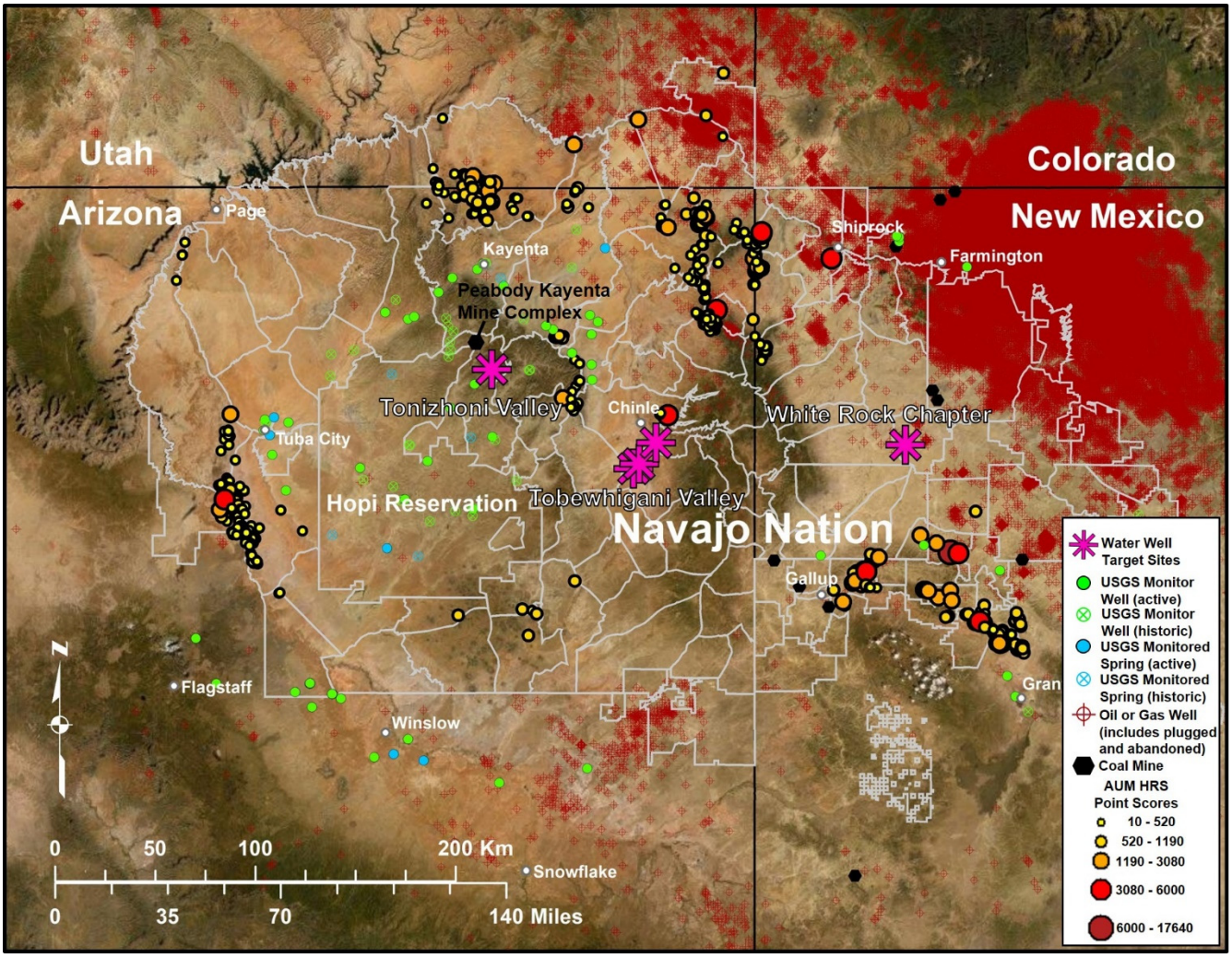
GWI, in partnership with Assist International, will take responsibility for quality assurance of ME&L activities and liaise with Navajo leadership and communities, as well as the implementing partners. GWI will take the leadership role in publishing and disseminating project learnings, providing opportunities emanating from this project for researchers and organizations, and providing technical assistance in applying best practices for strengthening water access, agriculture, WASH, nutrition, and business capacity related to water services and agriculture. However, all partners will have the opportunity to participate in publications and will have access to early program monitoring data and qualitative feedback in a timely manner in order to improve the program and maximize grant writing fundraising potential.

The ME&L team will hold fixed weekly videoconference meetings to enhance communication and coordination amongst the group and assess progress, while field visits will occur on a biannual basis to assess performance. Quarterly virtual review meetings engaging all partners will be convened for lesson learning and sharing of best practices, while in-person review meetings including all partners will be convened annually. Mid-term and end-of-project evaluations will be conducted to assess if the project has achieved intended outputs, outcomes, and results.

Appendix A

Activity	Year 1													Year 2	Year 3	Year 4	Year 5
	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21				
Immediate 180-day Plan																	
1) Preliminary survey of existing water sources																	
2) Repair existing water infrastructure																	
3) Design of comprehensive water access system																	
4) Improve efficiency of existing infrastructure																	
5) Installation of 5 new wells																	
6) Establish an agricultural training plot																	
7) Baseline needs assessment																	
Long-term (Five-year) Plan																	
1) Develop optimized strategy for water resource utilization																	
2) Install 300 new groundwater wells and access points																	
3) Optimize impact of comprehensive water access systems																	
4) Develop sustainable agriculture training modules, demonstration farms, and conduct in-person training																	
5) Develop Public Health training and outreach program																	
6) Develop sustainable water well drilling business enterprises																	
7) Implement sustainable strategy for rural water management																	
Monitoring and evaluation																	

Timelines for Phase I (Immediate) and Phase II (Five-Year) Plans



Map of Navajo Nation with targeted sites for the installation of drinking-water wells, abandoned uranium mine (AUM) hazard risk scores (HRS), USGS groundwater and spring monitoring stations, and industrial development.