

Workplan for the Development of the AQPI Concept of Operations (CONOPS) Plan

Section 1: AQPI Overview and Status

1.1 Overview of the Advanced Quantitative Precipitation Information System (AQPI)

AQPI is a precipitation monitoring, alerting, and hydrological information system tailored for operational use by water resource agencies and emergency managers as well as other community stakeholders in the San Francisco Bay Area for management of water supplies, and warning of hydrologic hazards such as flash floods, debris flows, or combined sewer overflow events through improved precipitation estimates and enhanced weather observations. The AQPI system features several components. Installation of five weather radars will fill in radar coverage gaps and improve precipitation estimation and short-term nowcasting (<1 hour). To support forecast needs, a data feed blending the High-Resolution Rapid Refresh (HRRR) and Global Forecast System (GFS) forecast models covers days 0-10 in the AQPI web-based display and in the data stream directly to AQPI member agencies. Visualizations are available on the AQPI user portal, and customized data feeds have been developed for Local Partner Agency Committee (LPAC) members to utilize in their operational activities. The system also includes installation of new and aggregation of existing surface measurements of precipitation, streamflow and soil moisture into a decision-support system. The Coastal Storm Modeling System (CoSMoS) provides forecasts of coastal sea level, providing early warning and decision support around coastal inundation hazards. The AQPI system will also incorporate the National Water Model (NWM) to provide streamflow forecasts.

1.2 Overview of AQPI CONOPS Plan

The overarching goal of the AQPI CONOPS Plan is to provide a comprehensive guide to ensure the continued operation and development of the AQPI system for the first five years after the system is delivered at completion of the California Department of Water Resources (CA DWR) award for system development. The CONOPS Plan will be developed over an approximately two-year period, led by the Center for Western Weather and Water Extremes (CW3E) at Scripps Institution of Oceanography. Details of the CONOPS plan goals, contents, and development process are presented in Sections 2, 3, and 4.

1.3 Current Status of AQPI System Components (as of January 31 2022)

Radars

- Two X-band radars operational:
 - Sonoma Water Airport Wastewater Treatment Plant (SCW)
 - Santa Clara Penitencia Water Treatment Plant (STC)
- Three additional radars planned:
 - Rocky Ridge X-band (East Bay, Contra Costa County)

- Sawyer Ridge X-band (SFPUC)
- C-band in northwestern Sonoma County or other suitable site in AQPI area
- Additional radars not part of AQPI that may be tied into system in the future:
 - Two additional X-band radars via FEMA grant (Sonoma, Marin)
 - One X-band radar in Santa Cruz County

Radar displays and quantitative precipitation estimate (QPE) products

- Comparative NEXRAD/X-band web display:
https://psl.noaa.gov/data/obs/sitemap/ScanRadar/scan_radar_dual.php
- Colorado State University, Cooperative Institute for Research in the Atmosphere (CSU/CIRA) X-band radar display: <https://aqpi.engr.colostate.edu>
- Products are available on the AQPI user interface for a 1h and a 15-min quantitative precipitation estimate (QPE) product available on AQPI user interface and a 2-minute precipitation rate product: <https://gsl.noaa.gov/aqpi/>
- CSU/CIRA working on improving QPE products, including blended NEXRAD/X-band QPE products. QPE development products will be hosted on CSU/CIRA website. The blended QPE product utilizes the operational NOAA Multi-Radar/Multi-Sensor (MRMS) product.
- Radar data feeds are currently operational and several agencies are using the feeds to support their operations. The data are available in csv format and focus areas customized to user needs.
- The operational MRMS product does not currently incorporate AQPI radar data, but the possibility of integrating it into the MRMS product in the future could be explored in the Concept of Operations Plan (CONOPS).

HRRR/GFS forecast data feeds

- Visualizations of temperature and precipitation forecasts 0-5 days, potentially to be adjusted to 10 days, available on <https://gsl.noaa.gov/aqpi/>
- Forecasts are hourly for hours 1-18 and every 3-hours out to 3.5 days and every 6 hours out to GFS out to 5+ days.
- Forecast data feeds are currently operational and several agencies are using the feeds and developing visualizations to support management activities. The forecasts are available in csv format and focus areas customized to user needs.

Nowcast

- CSU/CIRA has developed a radar-based nowcast product at a 2-min, 1 km resolution running out 60 min that is available on the CSU/CIRA AQPI website: <https://aqpi.engr.colostate.edu>
- CSU/CIRA will continue to develop this product and through the no-cost extension and CONOPS phases of the AQPI system, will explore the best location for the Nowcast user interface.

Surface Observations

- Surface meteorological and hydrological instrumentation has been installed. Data feeds from additional instrumentation as well as existing instrumentation operated by Bay Area water agencies have been introduced into the NOAA Meteorological Assimilation Data Ingest System (MADIS) data feed. This allows for the data to be utilized in forecast models and QPE products.
- 20 rain gauges and a few stream gauge sites currently being sited and will be completed by the end of the no-cost extension period.
- Many of these observations are displayed on the NOAA website:
<https://psl.noaa.gov/data/obs/datadisplay/>

CoSMoS Coastal Inundation Forecasts

- USGS has developed the CoSMoS coastal inundation model for the AQPI area. The model provides hourly forecasts out 18h.
- Date of inclusion of CoSMoS data on the AQPI user interface is to be determined but NOAA is actively working on this product.

National Water Model (NWM) streamflow forecasts

- NWM data have been subset and are being received hourly for the AQPI region, though no display has been developed at this time.
- Users can access data/visualizations of NWM output on the NWM page:
<https://water.noaa.gov/map>

Monitoring and Alerting Tools

- Monitoring and alerting tools based on precipitation observations/forecasts will not be available before the end of the development phase, but will be a main focus in the continuing operations plan.

AQPI System Hardware/Software

- The AQPI system hardware and software are currently in transition from NOAA to CSU/CIRA where the system will be operated until a permanent place of operation is determined.
- System hardware consists of five servers.
- Software consists of codes to ingest and process radar data, process and distribute forecast data, operate the user interface, ingest and process surface observations, as well as ingest data required to initialize the CoSMoS model, code for running the CoSMoS model, and codes to display and subset the CoSMoS model for agency use.
- An operation manual for the system is in development to be delivered to CSU/CIRA at the end of March 2022 and will exist as a “living document” at CSU/CIRA until the system is moved to its long-term operating location.

Section 2. Scope and Objectives of AQPI CONOPS Plan

2.1 Scope of AQPI CONOPS Plan

The overarching goal of the AQPI CONOPS Plan is to provide a comprehensive guide to ensure the continued operation and development of the AQPI system for the first five years after the system is delivered at completion of the California Department of Water Resources (CA DWR) award for system development. The no-cost extension currently in effect for the CA DWR award ends December 2023, thus the CONOPS plan addresses operation of the system for the period beginning January 1, 2024 extending five calendar years through December 31, 2028.

The CONOPS Plan will be developed over an approximately two-year period that began in September 2021 ends in December 2023; the timeline and various milestones are described in Section 5.2. Major deliverables include this workplan, the development of a draft CONOPS plan, a technical workshop to present the details of the draft workplan, a technical memorandum describing workshop outcomes, and a final CONOPS plan at the completion of the award period. Sonoma Water has awarded the Center for Western Weather and Water Extremes (CW3E) a contract to complete this process.

The CONOPS Plan will present several scenarios for continued operation of the system. These scenarios will include different tiers of continued operation and development and associated funding requirements. The CONOPS plan will also describe several plausible entities that can take over and maintain the system long-term. For each scenario, information such as feasibility, equipment and maintenance needs, staffing needs, and likelihood of political and financial support will be provided. Information for each scenario will be placed in a framework that facilitates comparisons across scenarios, and evaluation criteria will be developed. The information provided in the CONOPS Plan will support the LPAC in making an informed decision about the continued operations of the AQPI system best suited to their needs.

2.2 Core objectives of CONOPS Plan

- Ensure the continued operation of AQPI for the next five out-years, while setting up the system for long-term operational success.
- Propose four scenarios for funding the AQPI program over the five-year period covered by the CONOPS plan.
- Propose three scenarios for institutions/agencies that may serve as an appropriate host for the long-term operation of the AQPI system.
- Define opportunities for continued development of the system to further address user needs as well as attract broader community and political support and funding opportunities.
- Provide information that supports the LPAC in decision-making around which scenario is the best fit for LPAC member needs and resources.
- Develop criteria for comparison and evaluation of CONOPS scenarios and provide a comparative table to facilitate decision-making.

- Write the CONOPS Plan in language accessible to AQPI stakeholders to develop a common understanding of the system requirements and capabilities between stakeholders and those operating the system.

2.3 Key assumptions and information gaps that will affect CONOPS plan development

- The system is in the process of moving to CSU/CIRA as an interim host. At the time of preparation of the workplan, it is unknown what challenges or impacts may result from this transition.
- Some aspects of the AQPI system utilize legacy NOAA code as the system was developed to be easily ported into NOAA operational systems (e.g., e.g., MADIS, HRRR, MRMS, NWM, and NWS web delivery). There is potential that many portions of the code base may need to be re-written for the system to be hosted outside of NOAA. This situation is currently being evaluated.
- The CONOPS Plan will assume that all radars are installed and operating when the system is delivered, and that NOAA/CIRA will be providing support for integration of additional radars into system as they come online in the remaining period of the AQPI development phase.
- The CONOPS Plan will assume that development of AQPI has stopped when the system is delivered to CSU/CIRA in March 2022. CIRA may continue development of QPE and Nowcast products.
- The National Weather Service will not be considered as an alternative for the long-term operation of the AQPI system. AQPI radar data is valuable to NWS forecasters, thus the CONOPS Plan will consider mechanisms for the provision of AQPI radar data and QPE in a format compatible with the NWS AWIPS system.
- COVID continues to present challenges around the world in terms of supply chain and disruption, travel limitations for employees of the various agencies involved in AQPI, limitations on in-person meetings, and more. The AQPI CONOPS Plan will be written with the assumption that COVID will no longer present a challenge in the 2024-2028 performance period. It will also assume that COVID does not impact the progress of completing objectives for the remainder of the AQPI development performance period.
- The CONOPS Plan will assume that the AQPI operator hosts CoSMoS for the AQPI region, though USGS collaboration will be necessary to maintain or further develop CoSMoS. USGS will need financial support to assist in activities related to CoSMoS during the CONOPS period.
- HRRR/GFS forecasts: NOAA will continue to operate the HRRR and GFS forecasts long-term, though a transition from the HRRR to the Rapid Refresh will occur when Rapid Refresh is shown to have superior performance (timeline unknown, but potentially the 2023-2024 time period). At that time, adjustments will need to be made to the forecast data feed codes and visualization software to accommodate any change in file format or file naming structure associated with the transition.

Section 3: Elements of the CONOPS Plan

3.1 Topics to be addressed in CONOPS plan

The following topics will be covered in detail in the CONOPS Plan. Input and suggestions on how to address these topics or any missing topics of interest will be sought from AQPI stakeholders and developers.

- Technical components of the system: define all components of the system and their roles in operations, status as of CONOPS Plan writing, hardware needed to operate the system, and other considerations for continued system operations.
- Required software and technical support: describe the software needed to operate each component of the system as well as technical staff expertise needed and security considerations.
- Labor, equipment, and materials requirements: for the various funding scenarios presented, define the labor, equipment, and material needs and estimated costs. This includes defining the various types of staff expertise need for operation and expansion of the system.
- Strategies for repair and replacement of AQPI system components: establish a maintenance plan and a schedule for replacement of components during the five-year CONOPS period. Anticipate repairs that are likely to be needed for the system as well as a “worst-case” scenario for repair/replacement needs. Establish a potential expense range across these scenarios as well as a plan for executing repair/replacement (e.g., where to source parts, where to acquire appropriate expertise, reasonable timelines for repair/replacement).
- Develop a table that describes anticipated annual expenses associated with operations and maintenance of the system over the five-year period.
- Radar sites: provide a description of each radar site including its access procedures, communications and power sources, details of ownership and/or lease agreements, and other relevant information including transitioning temporary arrangements to more permanent ones.
- Work with AQPI stakeholders to develop a framework for upgrades and enhancements of the system’s capabilities and suggestions for future developments of the system to further serve stakeholder needs or to broaden the use to other users.
- User interface: provide a methodology for further development of the AQPI user interface, including how to integrate products developed across various groups/agencies and designing for improved user experience.
- Outreach/communication protocols: outline a plan for continued communications to media, social media, elected officials, and public to promote the benefits of the system. Develop a protocol for communicating new developments in the system across these various groups.
- Decision-making and governance: create a plan for how decisions related to the operations of the AQPI system will be made during the five-year CONOPS period and define parties responsible for making these decisions.

- Determine ownership of AQPI system assets and primary or shared responsibilities in managing these assets including liquidation of assets if the project does not continue.
- Create a description of how the system will be transitioned to and implemented at the selected agency or institution where it will be operated long-term from its current, interim location at CSU/CIRA.
- For each of the four proposed funding scenarios, describe the funding needed, potential funding sources, and approaches to take to secure resources from proposed funding agencies.

3.2 LPAC member agency requirements for continued operations of AQPI system

Requirements for the AQPI system vary across agencies depending on the characteristics of their infrastructure, agency responsibilities, and values at risk. Based on interviews and feedback from NOAA engagements with LPAC members, the following summarizes common requirements across agencies. As the CONOPS Plan is developed and AQPI components are finalized, the CONOPS Plan developers will work with LPAC members to evaluate emerging requirements for the system as well as ideas for future developments of the system.

- Data feeds of HRRR/GFS forecasts, QPE products, and other AQPI data in formats that are compatible with water agency operations and workflow (e.g., csv/ascii formats) and available for a user-specified region and spatial/temporal resolution
- Technical support for LPAC members in developing data feeds for AQPI data to flow into operational models and/or support to process and visualize AQPI data for agency-specific needs
- Case studies and real-world examples of AQPI in action so that agencies can determine how to best utilize the system for decision-making needs
- Ability to set thresholds of interest for precipitation and streamflow and have alerts triggered when they are exceeded or forecast to be exceeded
- Improved precipitation forecasts across timescales
- Forecast precipitation data at high spatial and temporal resolution (1km, 15 min); operational products (HRRR) have an 18-hour forecast lead time
- Ability to incorporate GIS layers (e.g., watershed shapefiles, location of points of interest or values-at-risk) into AQPI displays
- Mobile-friendly interface for viewing AQPI radar data or other data while in the field
- Coastal inundation information to be provided by CoSMoS; user interface characteristics to be determined
- Soil moisture information

3.3 Roles of each AQPI developer or stakeholder organization in CONOPS Plan development

CW3E/SIO/UCSD: Leads the development of the CONOPS Plan. Consults with AQPI system developers to assemble information on the technical characteristics of the system needed to develop the CONOPS Plan. Consults with LPAC members on requirements during the CONOPS period, future developments of interest, and any other questions that may arise.

NOAA PSL/GSD: As the lead developers of the AQPI system, NOAA will provide information on the technical aspects of system components and system operational requirements to CW3E CONOPS Plan developers. NOAA will provide input and feedback throughout the development of the CONOPS Plan to help ensure long-term success of the system.

CSU/CIRA: As the lead for radar design, deployment, and visualization/products, CSU/CIRA will provide information on all aspects of radar maintenance, operations, and new product development for the CONOPS Plan.

USGS: Provide information on status and methods for continued operations of the CoSMoS model for the CONOPS Plan.

Sonoma Water: As the administrator for the CA DWR grant supporting AQPI and the CONOPS Plan development award to CW3E, Sonoma Water will provide administrative oversight for the development of the CONOPS Plan. Sonoma Water will also provide first review of each component of the CONOPS Plan development process to ensure it is on track to meet stakeholder needs.

LPAC member agencies: LPAC members will be invited to review provide feedback on the components of the AQPI CONOPS Plan development (workplan, draft CONOPS plan, workshop technical memorandum). LPAC members are encouraged to provide input about their requirements for AQPI during the CONOPS period as well as future developments they would like to see for the AQPI system.

National Weather Service: As an AQPI stakeholder, the NWS will provide input on their requirements for the AQPI system during the CONOPS period so that the system can be utilized for forecasting efforts. NWS will also advise on technical aspects of the system to help avoid confusion between NWS messaging and AQPI information. NWS will be contacted for input by the CONOPS developers and invited to participate in review of CONOPS documents.

Section 4. Comparison of CONOPS alternatives

4.1 CONOPS alternatives evaluation methodology

The CONOPS Plan will present several alternatives for funding and long-term operations scenarios. The Plan will include information formatted in a way that allows for a comparative analysis of the alternatives to assist LPAC members in evaluating the alternatives.

Each alternative will be described in detail and a summary of the key characteristics of each alternative will be presented in a table to facilitate comparisons across alternatives. The concept of the table is similar to the tables one might consult to make comparisons across health care plans, where several characteristics of interest to the consumer are presented and the cells of the table contain summaries of how each plan addresses the characteristics. The

AQPI CONOPS alternatives characteristics described in this table will include cost, labor requirements, equipment requirements, maintenance needs, technical feasibility, potential for future system enhancements, likelihood for financial and political support, any foreseen challenges or limitations, and key decision points, among others. The LPAC will be consulted about specific characteristics they would like to see in the table to facilitate their evaluation.

4.2 Criteria for selecting a CONOPS alternative

The criteria for selecting a CONOPS alternative from the proposed scenarios will depend on LPAC member agency needs and priorities. As the CONOPS Plan development moves forward, engagement with LPAC members will be critical to identify these criteria. As priorities are identified, it may be possible to assign weights to each characteristic in the CONOPS alternatives comparative table and subsequently rank how each alternative performs for that characteristic based on LPAC priorities. This would allow for assignment of a value to each CONOPS alternative, providing a straightforward way to intercompare alternatives. Discussions between LPAC members and AQPI system developers and subject matter experts will also be critical in assisting the LPAC in evaluating alternatives. This can be achieved through smaller working group meetings, and will be a focus of the discussions at the CONOPS Plan workshop.

Section 5. Approach and timeline to complete CONOPS plan

5.1 Approach to CONOPS Plan development

The technical aspects of the CONOPS Plan (e.g., equipment, system design, data feeds, software and code structure) will rely heavily on operation and maintenance manuals and other documentation provided by NOAA, as well as CSU/CIRA experience as the system temporarily transitions to them. The CONOPS Plan will begin with this information, and any gaps in information or additional information needs will be requested from NOAA and incorporated in the Plan.

Discussions with LPAC members addressing requirements and visions for the long-term operation and governance of the system will also be key in the CONOPS Plan development and will take place both in scheduled meetings (e.g., monthly LPAC meetings or technical working groups) as well as informal discussions as needed. CONOPS Plan development will also utilize information NOAA has assembled from their interviews and working groups with LPAC members. LPAC members will also be consulted on what future developments they would like to see for the system.

The CONOPS Plan developers are considering four scenarios for funding and operations. Once technical aspects of the system and LPAC expectations for long-term system operation have been established, the CONOPS Plan developers will refine these scenarios as needed to meet user and technical requirements. Once these scenarios are clearly defined, options for potential funding sources will be assigned to each scenario. The CONOPS Plan will be developed and reviewed following the timeline below.

5.2 Schedule for CONOPS Plan development

There are several key deliverables in the CONOPS Plan development: a workplan, a draft CONOPS Plan, a workshop on the CONOPS Plan draft, a technical memorandum on the workshop outcomes, and the final CONOPS plan. The following figure illustrates the timeline for completion and the periods for input and feedback for each of these deliverables.

