City of Phoenix
Water Services Department

Water Remote Facilities
Design Guidance Manual
August 2013

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CHAPTER 1 - PURPOSE AND USE OF GUIDE

1.1 Purpose

The purpose and intent of this Water Remote Facilities Design Guidance Manual (hereafter referred to as "Design Guide") is to provide City personnel and consultants for both Capital Improvement Program (CIP) and Private Development projects with a manual describing equipment standards and general design parameters for the design of water remote facilities including booster pump stations, pressure reducing valve stations (PRVs), well head facilities, and reservoir/storage tanks **that will ultimately be owned and operated by the City of Phoenix**. It is recommended that privately-owned water remote facilities also follow the requirements of this manual because they will need to be upgraded should the City ever be asked or required to assume responsibility for them. This manual provides a framework that the consultant will build upon to satisfy both the City's and the client's requirements. It is to be used in connection with, not in lieu of, the Water Services Department (WSD) Guide Specifications.

The design criteria presented in this manual are intended to serve as a guide to the design of water remote facilities and supplement the design information provided in the City of Phoenix Design Standards Manual for Water and Wastewater Systems. This Design Guide is neither a master document on water remote facilities design, nor is it meant to provide a cookbook approach to design. Project design criteria may be subject to modifications to meet project specific requirements, satisfy code revisions, or address recent changes to requirements and standards.

1.2 Use of the Design Guide

It is the role of the design consultant to use this manual while working in tandem with the WSD staff to arrive at the proper engineering solution for the situation. Any deviation from the design criteria presented in this manual shall be identified by the design consultant and presented to the City for approval during the design effort. Signature by the City of Phoenix Water Services Department Deputy Water Services Director for the Water Engineering Design and Construction Management Division, or his/her designee, of the final plans for the project shall be proof of the City's acceptance of any substitutions agreed to during design. The design consultant will be responsible for the appropriate use of these guidelines, figures, tables, etc., and will be expected to prepare and seal all necessary design calculations, reports, drawings, and specifications for each site.

CHAPTER 2 - PROJECT PROCEDURE

2.1 Design Milestones

All construction drawings for new water remote facilities are subject to reviews by two City departments. The City Water Services Department (WSD) conducts a review seeking compliance with manual standards (Federal, State, County, and City, Process and Operation, and APP requirements), while the Planning and Development Department (PDD) evaluates plans according to building code requirements. The WSD review process for City owned and operated water remote facilities is detailed below. For more information on the PDD review process, please contact PDD at (602) 262-7811.

The WSD conducts four stages of review for all City owned and operated water remote facilities for both developer-funded and CIP funded projects. The intent of the WSD staged review process is to allow the City to provide its expectations to design engineers throughout the design process. The four levels of review conducted by the City are the 30% conceptual design with a Conceptual Design Report, 60% design with a Preliminary Design Report, 90% pre-final design, and 100% final design. The design consultant shall conduct a meeting at each of the stages to review and discuss the City's comments.

In addition to staged design review meetings, the WSD may require additional workshops to discuss detailed design of specific elements (process control strategies and equipment, security, etc.) of the project. The design consultant should discuss these items with the WSD as soon as practical in order to determine the number and extent of these workshops.

All submittals for private developer funded water remote facilities must be delivered to the Infrastructure Record Services counter on the 8th floor of Phoenix City Hall and accompanied by a Water Services Department Plan Submittal Form and the appropriate plan review fee.

All submittals for WSD CIP projects must be delivered to the appropriate project manager on the 8th Floor of Phoenix City Hall.

2.1.1 30% Conceptual Design

A Conceptual Design Report (CDR) shall be submitted to the WSD for approval. The report shall include the project's background information such as location (quarter section, major cross streets, etc.), service area, zoning and land use, population, water demand data, and basis of design. The CDR shall include, at a minimum, a conceptual site layout, major equipment to be used, preliminary pump and system curves, hydraulic analysis with overflow and finish floor elevations, intended operations procedures, design calculations, preliminary control descriptions, and identification of all required easements, licenses, rights-of-way, etc. In addition, the report shall provide an anticipated list of drawings (by discipline) and WSD Guide Specifications sections that will be developed for the project. All assumptions shall be clearly identified and listed.

The CDR must use an area-wide approach that includes the areas adjacent to the proposed project that could be served in the future by the facility. If an approved master plan for the service area exists, the CDR will document how the station will comply with the recommendations of the master plan. If one does not exist, a master plan for the potential service area must be completed and approved at this stage.

Once completed, the CDR must be signed and sealed by a registered professional engineer in the State of Arizona and submitted with six (6) copies to the WSD for review and approval prior to progressing to the 60% Design Stage.

2.1.2 60% Preliminary Design

The Preliminary Design Report (PDR), plans, and specifications are submitted to the WSD for review after the conceptual design report is approved. Comments from the CDR review must be incorporated into the PDR. At a minimum, the report shall contain the following:

a. Design parameters calculated in the hydraulic analysis
b. Preliminary pump flow rates
c. Preliminary system curve
d. Preliminary manufacturer's pump curves for initial and future flows
e. Minimum and maximum flow velocities through the system piping
f. Maximum allowable pump shutoff head
g. Frictional head loss calculations
h. Surge analysis report
i. Hydraulic profile
j. Pipe class rating
k. Intended operations procedure for the facility
l. Pressure loss through the valve (PRVs)
m. Valve operation range (PRVs)
n. Installation requirements (PRVs)
o. Draft Geotechnical Report
p. Draft Environmental Report (if required)
q. Draft Drainage Report or section reviewing site drainage in the PDR
r. Existing conditions and Utility conflict information
s. Other pertinent engineering data developed for the design

The plans should represent approximately a 60% percent completion level of detail in all disciplines. At a minimum, these plans shall include the following:

a. Preliminary civil and electrical site plans
b. Preliminary civil, structural, mechanical, and electrical details
c. Preliminary grading and drainage plan and any offsite improvements
d. Preliminary site plan
e. Existing topography and right-of-way/easements shown
f. Preliminary water main plan and alignment
g. Disinfection system layout and preliminary details
h. Preliminary single line diagram
i. Preliminary control schematics
j. Completed P&IDs
k. Preliminary terminal strip drawings

The specifications should be redlined edits of the WSD Guide Specifications.

The PDR, Preliminary Design plans, and specifications must be marked as to their stage of development and six (6) copies submitted to WSD for review.

2.1.3 90% Pre-Final Design

Once the 60% preliminary plans, specifications, and PDR are approved by WSD, the Final Design Report (FDR) and 90% pre-final plans and specifications can be completed. Comments from the PDR review must be incorporated into the Final Design Report (FDR). The plans shall be complete including all required civil, process/mechanical, electrical, instrumentation and control, architectural, structural, and landscaping plans and details.

Any proposed deviations to material items (manufacturers, testing requirements, etc.) within the WSD Guide Specifications shall be specifically noted and presented to the City for approval at this stage. All Notes to Specifier flags shall be addressed and replaced by appropriate responses.

The Final Design Report must be signed and sealed by a registered engineer in the State of Arizona, and six (6) copies submitted to WSD at the time of 90% pre-final plan submittal.

Key design criteria from the Final Design Report should be included on the General Notes sheet of the Final plan set. These criteria include pump capacity and horsepower, PRV size and capacity, well pump capacity and horsepower, disinfection system design, intended operations procedures, length and diameter of water main lines, generator size, etc. This information must be provided for all phases shown on the drawings. The content of this General Note sheet, as well as the entire plan set, must be discussed at length with the WSD and is subject to its review and approval.

2.1.4 100% Final Design

100% plans and specifications can be completed and submitted for signature once all previous review comments have been resolved. These plans and specifications must be signed and sealed by a registered engineer in the State of Arizona and six (6) copies submitted to WSD. In addition, submit one (1) electronic copy of the plans, specifications, and FDR in .pdf format. Once the plans are signed by the WSD, the PDD building permit review process can begin. The design consultant is responsible for notifying WSD of any PDD proposed changes prior to implementation.

Maricopa County Environmental Services Department will issue the Approval to Construct for all CIP projects. WSD will issue the Approval to Construct – Construction Authorization for private developer funded projects upon approval of 100% plans and specifications. However, construction cannot begin until all applicable building permits have been obtained through PDD.

2.2 Project Phasing

Project phasing must be established at the conceptual design level. The facility design must take into account initial demands as well as build-out demand and attempt to optimize performance for both. Major elements such as the pump size, electrical service, panels, disinfection system, stand by power, telemetry, system piping, etc. shall be sized for the ultimate condition, but serious thought needs to be given as to the expandability of **<u>all</u>** site components in order to allow the capacity of the station to grow as the demand grows. For example, pumps rated at 1800 gpm to service build-out demands will not provide acceptable operating conditions when initial demand only requires 120 gpm.

The design consultant shall provide a detailed discussion of any proposed phasing and the recommended design approach in the CDR. Design of the project will not move forward until the WSD approves the phasing approach.

2.3 CADD Standards

All plans prepared for WSD sites, including those that are privately funded, must comply with the most current version of the City of Phoenix Water Services Department CADD Standards Implementation Plan (CADD Plan). This document consists of three sections: Project CADD Plan, Standard CADD Practice, and Project-Specific AutoCAD Files.

The purpose of the CADD Plan is to ensure consistent documentation, quality, and file structure for all drawings produced. It organizes the drawings, including the submittal dates, and is tailored to include information specific to the project. Compliance with the Project CADD Plan will expedite the electronic transfer of data and minimize drafting effort. The WSD will provide a copy of the basic CADD plan to the designer who will customize the plan for the specific project. The customized plan will be submitted to WSD for review and approval prior to submittal of 60% Preliminary drawings. The City or a consultant hired by the City will examine plans at the 60% and 90% design stage to confirm compliance with the CADD Plan.

2.4 Water Services Department (WSD) Guide Specifications

The WSD Guide Specifications contain specific equipment requirements and technical information not found in this manual. The WSD Guide Specifications must be obtained from WSD for use on all projects pertaining to City-owned facilities. These specifications serve as a guide for the design engineer and must be modified as appropriate for each project (see Section 2.1.1).

2.41 Deviations from City of Phoenix Guidelines:

a. The City of Phoenix Guidelines is intended to standardize the design and ultimately the construction of City of Phoenix owned and operated utility infrastructure. Although City of Phoenix Guidelines provides direction in design, it is still the responsibility of the Engineer to provide the highest level of professional quality design. The Engineer is still charged to utilize creativity and innovation in providing an acceptable cost effective design.

b. All deviations from the City of Phoenix Guidelines shall be identified and noted in the Preliminary Design Report. Resolution and acceptance of any deviations shall be at the discretion of the WSD.

2.5 Public Outreach

For all City projects, refer to the City of Phoenix Water Services Department Public Outreach and Communication Guidelines.

CHAPTER 3 - AGENCIES, CODES, AND PERMITS

3.1 Agencies and Publications

The design of water remote facilities in the City of Phoenix shall comply with all relevant industry codes and standards, a list of which is included in the WSD Standard Specifications. The current version of these documents effective at the time of receipt of notice to proceed with design shall be used as reference for design purposes. In case of conflict between the requirements of this document and any code duly adopted by the local permitting agencies, the code requirements shall prevail.

In addition to the codes and standards referenced above, the following documents or agencies shall be consulted or referenced during design as necessary.

a. ADEQ Arizona Administrative Code, Title 18: Environmental Quality, Chapter 4: Department of Environmental Quality Safe Drinking Water
b. American Water Works Associations (AWWA)
c. Maricopa Association of Governments (MAG) Standards Specifications and Details, edition as approved by City of Phoenix
d. Hydraulic Institute Standards, latest edition
e. City of Phoenix Standard Specification and Detail Supplements to MAG
f. Arizona Game and Fish Department
g. Maricopa County Health Code
h. Flood Control District of Maricopa County (FCDMC)
i. City of Phoenix Design Standards Manual for Water and Wastewater Systems
j. City of Phoenix Zoning Ordinance
k. City of Phoenix Planning and Development Department (PDD) and Street Transportation Department (STD) for floodplain management
l. U.S. Army Corps of Engineers (Corps)
m. U.S. Department of Housing and Urban Development
n. Local zoning, ordinances, codes, development, setback and fencing, landscaping, and noise control requirements
o. Local utility companies

3.1.1 Planning and Development Department (PDD)

In general, the major permitting agency reviewing the project will be the City Planning and Development Department (PDD). The WSD Water Engineering Design and Construction Management Division, with assistance from WSD Water Remote Facilities and Water Distribution staff, is responsible for approving the design, whereas Site Development and Building Safety Sections of PDD is responsible for performing ordinance and code compliance reviews and issuing construction permits and use permits. PDD maintains a process overview of their submittal process, including Pre-application meeting requirements, gate control access requirements, tables and checklists depicting zoning ordinances/summaries, etc. of permitted uses developed by PDD. These ordinances/summaries and checklists are provided as a point of beginning in the permit process to ensure that at least the minimum project information is included in the review set.

For WSD CIP projects at existing sites, the permitting agency will be the Annual Facilities Permit office, or AFP. AFP falls under PDD and is designed to provide streamlined permit reviews for existing facilities. The permits acquired through AFP include a Building Permit, which includes Structural/Architectural, Plumbing, Mechanical, and Electrical, and a Fire Protection Permit. To obtain information on the AFP process, call (602) 262-7501.

The Planning and Zoning Section of PDD administers the Phoenix Zoning Ordinance and regulates planning and zoning requirements through the Site Development and Building Safety Sections. Water Remote Facility site plans must adhere to the design review guidelines and zoning district standards that are outlined in the current Phoenix Zoning Ordinance. The design review guidelines apply to all projects located within the City, while zoning district standards such as wall height and landscaping setback requirements may vary by zoning district.

Once a site plan has been developed, the design consultant should meet with staff at the Site Development counter (Counter 6) on the second floor of the Development Center. Staff will provide an initial review and determine if the scope of works warrants a site plan review and how any site plan should be processed. It may be possible to log site plans in for review and approval without a pre-application meeting. If not, staff will instruct the consultant on how to prepare a pre-application context plan submittal.

Information on the development process, including current fees and review timelines, is available at http://phoenix.gov/DEVPRO/index.html or call (602) 262-7811. If the site is outside City limits, the local jurisdictional development process and codes should be followed.

3.1.2 Fire Department

Fire Department site plan reviews are conducted when plans are submitted to PDD. Refer to the applicable Phoenix fire code for complete requirements regarding fire department site access, water supply, and on-site chemical storage plans. The design consultant shall discuss these code requirements with the City and incorporate any applicable City modifications. To obtain general information on the City of Phoenix Fire Department process and procedures call (602) 262-6002 or visit the Fire Department's website at www.phoenix.gov/fire. WSD will facilitate a meeting with a Fire Department representative to obtain details regarding all applicable design standards upon request.

3.2 Permits and Regulations

The current City of Phoenix Building Code shall govern design and construction of buildings, structures, and equipment. The design consultant shall attend meetings with the appropriate agencies, along with the City's Project/Program Manager, to initiate informal discussions and determine special permitting requirements that need to be incorporated into the design. The design consultant will be responsible for completing the permit application and notification packages and for submitting them to the City for final review and to various agencies for final processing. The efforts of the design consultant will include providing all technical assistance and background studies necessary to meet the requirements of the permitting agencies. The design consultant shall assist the City in follow-up actions with the permitting agencies and shall provide responses to questions directed to the City. All discussions and correspondence with the various agencies shall be coordinated through the WSD.

Original design permits will be kept by WSD with copies retained by the design consultant. The design consultant shall be responsible for incorporating all requirements of the various permits and approvals into the design/construction documents.

3.2.1 Real Estate Acquisitions

All real estate acquisition/easements, etc. must be complete and recorded with the County before the project can be bid. For a CIP project, the acquisition of property rights will be obtained through the City's Real Estate Division. It is the design consultant's responsibility to prepare boundary surveys, site maps, and legal descriptions of the survey, and to assist the Real Estate Division as required/requested. The Real Estate Division will perform the required title search, direct the environmental assessment, appraise the property, negotiate with the property owner, and finally acquire the property or easement.

The acquisition of property rights for lift stations and all associated piping constructed by private developers, including rights-of-way and/or permanent and temporary easements, shall be obtained by the developer at the developer's sole cost and expense. It shall be the developer's responsibility to prepare the required documents, in form and content acceptable to the City of Phoenix, to acquire the subject property rights on behalf of the City of Phoenix. Deeds and conveyance documents shall be prepared and submitted to WSD prior to completion of final construction documents. Upon final acceptance of construction, the City shall record the deed(s) with Maricopa County subject to Phoenix City Council approval. Document numbers for all acquired property rights shall be provided on the final record drawings.

3.2.2 Environmental Permits

Environmental issues can vary widely within a given project. Therefore, during project planning and implementation, careful consideration must be given to the requirements of various federal and state environmental laws and regulations.

3.2.3 Water Quality

If Waters of the United States (in the desert, this includes ephemeral washes) are impacted by a proposed project, a Clean Water Act Section 404 permit will be required from the U.S. Army Corps of Engineers (Corps). A Nationwide permit refers to a general permit that authorizes a specific activity. Depending on the proposed activity and acres of impact, a preliminary jurisdictional delineation is typically performed by the applicant and submitted to the Corps for concurrence. If more than 0.5 acres (current as of this manual update) per jurisdictional wash of permanent impact will occur, an Individual permit will be required. The application process for an Individual permit is much more time consuming in comparison to the Nationwide permit application process. If jurisdictional waters are avoided, a Section 404 Permit will not be required. Contact the WSD with questions regarding any of the 404 permit requirements.

A Section 401 State Water Quality Certification Permit from the Arizona Department of Environmental Quality will be necessary prior to the 404 Permit. The Nationwide permits have conditional certifications already in place, which are effective except for on tribal lands. Individual Section 404 permits will need an individual 401 water quality certification. The Arizona Department of Environmental Quality (ADEQ) has established a general AZPDES permit for storm water discharges from construction sites. This permit was issued on February 28, 2003 and replaces NPDES permits previously issued by the U.S. Environmental Protection Agency (EPA) in 1998. The permit number is AZC2003-001. Coverage under the permit is required for all operators of construction sites that disturb one or more acres (current as of this manual update) of soil through grading, trenching, or excavation. ADEQ should be contacted at (602) 771-4428 for further information.

3.2.4 Biological Evaluation

The U.S. Fish and Wildlife Service and the Arizona Game and Fish Department must be contacted for a list of federally protected plant and animal species that have been documented within the vicinity of the project area. A biological evaluation will address the potential for special status species to occur within the project area.

The Arizona Department of Agriculture must be given a Notice of Intent to Clear Land of protected native plants per A.R.S. 3-904 and 3-905. This notification regarding the intended destruction and/or salvage of native plants must be given at least 20 to 60 days before plants are removed, depending on the size of the project area and the ownership of the project, i.e. private property or municipally-owned property.

3.2.5 Air Quality

Air quality permits and dust control permits are required from the Maricopa County Air Quality Department (MCAQD). In the event that one or both of these permits are waived by these agencies, a waiver letter from the issuing agency (MCAQD) stating that the permits are not required must be submitted to WSD. In either case, designers will be required to meet with MCAQD for determination and required action within the permitting process.

New and rebuilt standby generators must comply with the New Source Performance Standards in Title 40 of the Code of Federal Regulations Part 60, Subpart IIII and the generator manufacturer's emissions certification statement must be included in the application for the air quality permit. Operations and Maintenance (O&M) Plans for the odor control system or any air pollution control device must follow the format established by the WSD Environmental Services Division. All applications require a review and approval by CRAO prior to submission to the MCAQD. Consultants will provide the application and processing fees associated with the development with the permit. Draft permits should be forwarded to WSD Environmental Services Division for review and comments, and the permit negotiations should be lead by WSD Environmental Services Division.

Commencement of construction, as defined by Maricopa County Air Pollution Control Regulations, Rule 100, will not occur until the issuance of a valid air quality permit and dust control permit. The original air quality permit and a copy of the contractor's dust control permit will be submitted to WSD Environmental Services Division. The consultant will log the hours of operation for the standby generator, record the reason for operation of the generator and meet all other requirements listed in the air quality permit. This includes completing the compliance determination (e.g., hydrogen sulfide evaluation) according to the schedule in the air quality permit, testing of rebuilt engines, and other compliance requirements. In addition, the consultant will maintain a daily dust log, complete applicable dust training courses and meet all other requirements for compliance with Maricopa County Air Pollution Control Regulations, Rule 310. All costs associated with the initial compliance activities will be the responsibility of the consultant. WSD will assume the permit administration activities after the acceptance of the lift station.

3.2.6 Cultural Resources

A consideration of cultural resources that might be present in a project area must be part of the planning process. Cultural resources are defined as archaeological sites and canals, historic buildings and structures, traditional cultural places, and other places or objects that are important in our history. A project area may need to be surveyed, monitored, and/or have testing and data recovery completed by an qualified archaeologist in consultation with the City of Phoenix Archaeologist. For all City projects, if cultural resources are identified by the City Archaeology Office's assessment, one of the City's on-call consultants will be contacted by the City Archaeology staff to prepare a compliance/treatment plan so that potential impacts of the project can be mitigated in accordance with the applicable historic preservation laws.

Compliance requirements for a project will vary depending on the scope of the work and level of City, State, and Federal involvement. To determine which levels of compliance are required, or to get answers to any other questions one might have regarding city archaeology policy, the City of Phoenix Archaeologist should be contacted at (602) 495-0901. Guidelines for conducting archaeology in Phoenix can be viewed and down loaded from the web site at www.pueblogrande.com.

For all City projects, City policies regarding preservation and treatment of cultural resources must be followed. If the State of Arizona is involved, the project must comply with the Arizona Antiquities Act (A.R.S. 41-841 through 41-847) and the State Historic Preservation Act (A.R.S. 41-861 through 41-864). The project must also consult with the appropriate State agencies involved, including the State Historic Preservation Office (SHPO). A project with federal involvement will have to comply with Section 106 of the National Historic Preservation Act (NHPA) and consult with the federal agency or agencies involved.

If previously unidentified cultural resources are encountered on a job site, work shall stop within 10 m (33 ft) of the discovery until the City Archaeologist can be contacted and allowed time to make a proper assessment. In the event that human remains or funerary objects are encountered as part of the aforementioned discovery, then the City Archaeologist must be contacted so that the appropriate Native American Tribe(s) and the Arizona State Museum ((520) 621-4795) can be contacted in order to determine the proper disposition of those remains. This includes federal, state and private lands, as per Arizona law (A.R.S. 41-844 and A.R.S. 41-865) and the Archaeological Resources Protection Act of 1979 (ARPA) and the Native American Graves Protection and Repatriation Act of 1990 (NAGPRA).

3.2.7 Construction Permits

An Approval to Construct permit must be obtained from the Maricopa County Environmental Services Department (MCESD) (or WSD County Health Delegate) prior to commencement of construction. In general, if the City is not contributing funding to the project, WSD will issue the Approval to Construct. The engineer must obtain an Approval to Commence Operation from MCESD to initiate testing and operation of the facility when nearing completion of the project. Upon completion of the testing, an Approval of Construction must be obtained from MCESD. The engineer must receive an Approval of Construction prior to receiving final acceptance from WSD. The application packets for both of these permits are located on the MCESD website. If the WSD County Health Delegate is approving the permits, WSD will provide the appropriate application forms. These permits are required for both City and developer-built projects. Copies of both permits shall be submitted to WSD upon receipt.

In addition to the Approval to Construct, PDD requires building and civil permits for various systems, structures, or modifications to the building site. Most of these permits are necessary in order to begin construction. Depending on the scope of the work and the contractor’s means and methods, other permits such as clearing and grading, traffic control, hazardous materials storage, etc. may be required. Since each project is unique, the design engineer is encouraged to contact PDD early in the review process for a listing of permits and associated fees that are anticipated for the project.

For a developer-built project, WSD requires an additional permit for third-party observation of the construction. The fee for this permit is based on the engineer’s estimate of construction costs and is due upon completion of design.

3.3 Utility Coordination

In general, utility coordination for developer-built water remote facilities will be the responsibility of the developer. PDD will require the developer to provide utility conflict notices and resolutions. The developer is required to establish all necessary utility accounts and shall provide a list of the accounts to WSD at the start of construction. Prior to final acceptance, the developer shall provide documentation that all subject accounts have been transferred to the City.

For CIP projects, design consultants are responsible for: (1) coordinating the design with affected utilities, (2) performing utility conflict reviews, (3) establishing and/or verifying availability and service requirements. Design consultants shall coordinate with utility companies through WSD and the Street Transportation Department's Utility Coordination Section (Streets Utilities). All discrepancies found between the utility as-built drawings and field information should be discussed with the applicable utility company. All communication concerning utility conflicts shall be made through Streets Utilities.

3.4 City Review and Permitting Fees

Both WSD and PDD charge fees for all private development projects submitted for review. PDD also charges certain fees for every permit for which an application is submitted. WSD fees are assessed at each stage of review, while PDD fees are assessed on grading and drainage, site plan, landscaping, fire, building plan, and various other applicable project reviews. The PDD also charges permitting fees for an assortment of civil and building permits, as well as other project-specific permits that may be required.

A listing of PDD's current fees can be found at www.phoenix.gov. To get WSD's plan review fees, call (602) 534-5813. All fees are subject to change at any time.

CHAPTER 4 - CAPACITY ANALYSIS

Pump stations and PRV stations are sized based on the amount of flow they are expected to handle; the flows expected at startup, the flows expected at ultimate build-out (if applicable), as well as the flows anticipated during the years between startup and build-out. Well facilities are sized based on the expected production capacity of the well.

To determine the required flow capacity of the pumping station and PRVs, the area to be supplied needs to be determined. For a residential development, it may be merely those homes in the development, (non-agricultural irrigation use is considered residential). For a Master Planned Community, it would be the entire community, residential, commercial, and industrial. Once the service area is established, the land use and zoning also need to be considered, since different land uses represent different flows.

WSD has established water demand factors for various uses. The City of Phoenix – Water Services Department Design Standards Manual for Water and Wastewater Systems, (Chapter 4.2 Water Demands) lists some water demand factors for various land uses. The discharge piping (transmission and/or distribution piping) is designed based on peak day flow plus fire flow. Pump stations and pressure reducing stations shall be designed based on Table 4.1 and Section 4.2 in the City of Phoenix – Water Services Department Design Standards Manual for Water and Wastewater Systems and section X.2 – Peaking factor below.

Pump stations in service areas without storage shall be sized to handle the peak hour of the peak day demand plus fire flow with the largest pump out of service (**firm capacity**). Pump stations in service areas with storage shall be sized for peak day plus fire flow with the largest pump out of service (**firm capacity**).

4.1 Quantity

Once the service area is established, the zoning determined, and any large facilities identified, an estimation of the number of residences and the total area of commercially/industrially zoned land use can be used to establish the total average daily flow expected to be used by the service area, expressed in gallons per day (gpd). If the area under consideration will be developed in phases, each phase needs to be considered separately, as well as totally. This may mean the station will need to be constructed in phases, or at least designed to allow for future expansion, (see Section 5, Hydraulics).

4.2 Peaking Factors

Water demands (excluding fire demands) vary throughout the day, which is known as diurnal fluctuation. The lowest demand generally occurs between 2 A.M. and 5 A.M. Later in the morning (generally between 5 A.M. and 9 A.M., after residences have awakened and prepared for work, school, etc.), the water demand is greater. A peaking factor is used to determine the demand to size the piping and pumping facility. The City of Phoenix applies peaking factors based on average daily demand. As previously discussed, the peak day demand is 1.7

times the average day demand, and the peak hour demand is 2.0 times the peak day demand.

Q_{avg} = Average Day Demand, gpd
Q_{pd} = Peak Day Demand, gpd
Q_{ph} = Peak Hour (of the Peak Day) Demand, gpd
$Q_{pd} = 1.7 \times Q_{avg}$
$Q_{ph} = 2.0 \times Q_{pd}$

4.3 Flow Rates

Several flow rates are required to correctly size the pumping system or pressure reducing valve facility. The pump station's firm capacity must be equal to the peak hour demand plus the maximum fire demand in areas where there is no storage, the peak day demand plus the maximum fire demand in areas where there is storage, and the average daily demand.

The pumps shall be in a combination such that the station can supply a minimum of the total domestic demand, which is peak hour flow, plus the fire flow with the largest pump out of service (firm capacity). The combination shall be such that at lower flows not all of the pumps will be running. The station shall consist of at least one (1) domestic pump that delivers 50% of peak hour demand, one (1) domestic pump that delivers 150% of peak hour demand and one (1) pump that delivers the maximum required fire flow. A second largest pump is to be on in stand-by to meet the firm capacity requirements.

The following outline can be used as a guide to determine the flow demand and assist in obtaining City consent to construct a pumping or pressure reducing valve facility:

a. Determine service area:
   1. Present
   2. Future Expansion (if applicable)
b. Land Use map:
   1. Zoning
      - Current
      - Future
      - Show/Discuss existing/proposed large:
        - Commercial Developments
        - Industrial Developments
   2. Requirements
   3. Related Populations
      - Current
      - Future
c. Table of demand:
   1. Residential (per unit)
   2. Commercial (per 1000 ft^2)
   3. Industrial (per 1000 ft^2)
d. Calculate demand per area (average day, peak day, peak hour)
e. Fire flow requirements

f. Include the above exhibits and calculations in the conceptual design report required by Section 2.2.1.

CHAPTER 5 -HYDRAULICS

5.1 General

The design consultant shall perform a hydraulic analysis of proposed stations/facilities (pump stations, PRV stations, and/or well heads), as well as on any existing stations/facilities that are being upgraded or modified where the upgrades or modifications involve pump replacement, modifications to pumping capacity, pump control and operational adjustments, pump control replacement, changes in total dynamic head (TDH), check valve/control valve closure time adjustments, etc. The analysis should determine the type and size of equipment necessary for efficient hydraulic operation and minimize hydraulic surges during electrical power failures, including normal starting and stopping of pumps. The analysis will also help determine requirements for appropriate pressure reducing valves and appurtenances. The hydraulic analysis shall consist of a steady-state analysis and include a transient (surge) analysis.

In performing the hydraulic analysis, several items must be considered and terms defined. Terms applied specifically to the analysis of pumps and pump systems include:

a. Static suction head (h_s) – the difference in elevation between the supply water level (or pressure) and the centerline of the pump impeller, (the suction head can be positive or negative)

b. Static discharge head (h_d) – the difference in elevation between the discharge water level (or pressure) and the centerline of the pump impeller

c. Static head (h_{stat}) – the difference in elevation between the static discharge water level and the supply water level

d. Friction head (h_f) – the head of water required to overcome the losses resulting from frictional resistance of the flow through the pipe system (both suction and discharge piping)

e. Velocity head (h_v) – the kinetic energy contained in the water being pumped at any point in the system. It is determined from the relationship $V^2/2g$ where g is the acceleration due to gravity (32.2 ft/sec^2) and V is the velocity (ft/sec)

f. Minor head loss (h_m) – the head of water required to overcome the minor losses through fittings and valves in the pipe system (both suction and discharge piping)

g. Total dynamic head (TDH) – the head against which the pump must work when pumping water. It is a function (sum) of the other head terms previously discussed (total static head, suction and discharge headloss, and velocity head)

5.1.1 Calculations of Headloss

The pipe(s) transporting water (transmission or distribution) needs to be considered in terms of diameter (which affects velocity), length, and frictional resistance to the flow (pipe material). Pipes are typically sized to achieve a velocity less than 5 fps, or headloss less than 10 ft per 1,000 feet of pipe. A plan and profile of the pipe must be developed before losses and curves may be determined. Either the Darcy-Weisbach or the Hazen-Williams equations can be used to determine the head loss versus length of pipe or pipe system over a range of flow rates. In addition to the friction losses, minor losses must be considered. Minor losses result from flow through fittings, valves, entrances and exits, etc. In station/facility piping, minor losses can be greater than the frictional losses and must be considered carefully. The frictional losses are added to the minor losses. Once the losses from the pump discharge to the piping system end are determined, the system curve can be generated. Refer to Sanks, "Pumping Station Design" (see Section 18 – References), for additional information regarding hydraulic analysis calculations.

5.1.2 System Head Curve

The system head curve is merely a graphical representation of the TDH against which the pumps are required to operate under various flow rates for the discharge piping system. The head (static head plus the friction and minor losses) required to pump the water to its discharge point (elevation and pressure) is plotted against various flow rates. As defined above, the static head is the difference in elevation between the supply water surface (pressure) and the water surface (or required pressure) at the point of discharge. The supply water surface (pressure) may vary, and the discharge water surface (and/or required discharge pressure) may also vary. Therefore the static head will vary which results in a family of parallel system curves; the maximum system head curve corresponds to the lowest supply water pressure and greatest discharge pressure, while the minimum system curve corresponds to the highest supply pressure level, and lowest required discharge head. Three system curves shall be developed; representing an older pipe, intermediate pipe condition, and a new pipe. For example, if using the Hazen-Williams equation, one curve should be developed using C=90 to represent older pipe, one curve should be developed using C=110, and another curve using C=140 to represent newer pipe. This will display the operating range of selected pumps over the life of the facility.

5.1.3 Pump Curves

Once the system curve is developed, various pumps can be analyzed to determine which pump curves best fit the system curve. Most manufacturers provide pump curves with the TDH, efficiency, and power input plotted against the flow rate; this can be superimposed on the system curve. Multiple pumps may be required to produce the necessary flow at the required head. This exercise is performed for new designs as well as modifications to existing pumping stations/facilities. The pumps shall be capable of supplying, at a minimum, the total domestic demand, which is peak hour flow plus the total fire flow, with at least one (1) of the largest pumps out of service, (referred to as the firm pumping capacity). For an existing pump station modification, a pump test will be required to confirm the operation of the existing pumps. When a pump has been selected, the motor rating (horsepower) and impeller size can be established, which corresponds to the required electrical load for the pumps. Pump curves plotted with system head curves and calculations for each pump installed at the station must be submitted to the City for review. When pump stations are to be expanded in the future by upsizing pumps, the system heads and pump selection procedure needs to be conducted for those future pumps. Therefore facility piping, conduits, control and switchgear cabinets must also be sized for future requirements. Section 6 – Mechanical discusses pump selection.

5.2 Minimum Requirements

The following information is required as a minimum to perform the hydraulic analysis:

a. Flow rates
   1. Peak Daily
   2. Peak Hourly
   3. Minimum Fire Demand
   4. Maximum Fire Demand
b. System Curve
   1. Peak Daily Flow Rate
   2. Peak Hourly Flow Rate
   3. Minimum Fire Flow Rate Demand
   4. Maximum Fire Flow Rate Demand
   5. Minimum Static Head
   6. Maximum Static Head
c. Pumping rates should sustain:
   1. Maximum Peak Hourly Flow velocity of 5 fps
   2. Maximum Peak Hourly Flow headloss of 10 ft per 1,000 ft.
   3. Maximum Fire Flow Demand velocity less than 10 fps.
d. Manufacturer's Pump Curves
e. Maximum allowable pump shutoff head
f. Frictional Head Loss
   1. Hazen-Williams equation
   2. Darcy-Weisbach equation
   3. Minor Losses
g. Friction factors for various pipe materials
h. Pipe Class rating
i. Steady-state hydraulic headloss and transient (surge) analysis calculations

5.3 Steady-State Analysis

The design consultant shall perform a steady-state hydraulic headloss analysis of the pumping and transmission system to determine the TDH requirements of the pump station or well facility. TDH calculations shall be made for new facility designs as well as existing facility design modifications. The design consultant shall perform a headloss analysis of the pump suction piping and determine the net positive suction head available (NPSHA) for the pumping system. The design consultant shall follow the requirements of the latest edition of the Hydraulic Institute Standards when calculating the NPSHA. The NPSHA shall always be greater than the net positive suction head required (NPSHR) of the selected pump(s) under an agreed-upon, worst-case scenario. In addition, the NPSH margin ratio (number of times NPSHA is greater than NPSHR) must be greater than 2.0 to provide an adequate safety factor. The design consultant shall then determine pumping head requirements, TDH curves, flow velocities, and travel times. WSD shall provide the design consultant the necessary operating criteria of the existing system. The following criteria shall be provided by the design consultant to perform the steady state analysis of a particular system:

a. Minimum and maximum static head analysis.

b. Recommended pumping rates, e.g., flow through transmission mains or distribution piping shall have a maximum velocity of 5 fps or headloss of 10 ft. per 1,000 ft. of pipe.
c. Pipe pressure class rating.
d. Maximum allowable shut-off head.
e. Friction factors for typical pipe materials.
f. 20-year pipe degradation analysis.
g. System curves with associated pump curves
h. NPSHA vs. NPSHR calculations

The City has adopted WaterGEMS as their modeling software. The design consultant shall receive boundary conditions for their use in preparing a hydraulic model for the design of the pump station, PRV station, or well facility.

5.4 Transient Analysis

The transient pressure and flow condition in pipe systems are referred to as waterhammer, which is caused by rapid changes in the flow velocity due to such things as pump startup, pump shutdown, power failure (resulting in rapid pump shutdown), or a valve being closed rapidly, all of which can result in significant pressure changes or surge phenomena, (positive or negative) throughout the pipe. The most severe waterhammer conditions are usually caused by a pump shutdown or power failure. Every pump, transmission main, distribution main, etc. is subject to transient (surge) pressures and conditions. So a surge analysis is required for all new facilities and modifications to existing facilities. Refer to Sanks, “Pumping Station Design” for additional criteria on surge analysis.

The design consultant should model the worst case pumping scenario. Typically the simulation will consist of instantaneous pump shutdown (power outage) during peak pumping conditions. The instantaneous shutdown should account for spin down times of each pumping unit. The design consultant should determine the preliminary pump control valve opening/closing times, critical time (T_c), and the applicable control valve flow factor (C_v). The control valve must be designed with a hydraulically controlled closure mechanism that will provide soft/restrained closure of the valve during power failure and not allow the valve to slam closed. The allowable surge envelope (maximum – minimum surge pressure) for the system should also be determined. The design consultant shall utilize these parameters as the basis for establishing the design of the yard and station piping, including the design of pipe joints (gaskets), fittings, valves, and appurtenances used in the yard, station, and transmission main piping.

Refer to Sanks, “Pumping Station Design” provides a much more detailed discussion of waterhammer analysis and hydraulic transient control measures.

The handling of transients is a site specific issue. Depending on the analysis performed and the results obtained, surge mitigation strategies can vary widely and, depending on the system, be required on both the suction and discharge sides of the pumping units. Typical surge control/protection measures can include a combination of:

a. Attenuation of surge pressure by programmed pump control valve closure.

b. Use of surge relief control valves or surge anticipation valves.
c. Design of pipeline to resist upsurge and downsurge pressures.
d. Selection and location of proper control devices, i.e. air relief/air vacuum valves.
e. Identification of proper start-up, operation, and shut-down procedures for the system.
f. One-way or two-way surge tanks – flow through surge tank is preferred for water quality reasons.
g. Utilize variable frequency drive units on pumps to achieve a ramped or attenuated start-up and/or shut down of the pumping units.

Surge control valves or surge anticipation valves should be included in all facilities. These surge mitigation methods should be included in the design to handle the discharge of water.

As noted, the control valve shall be a dual chamber valve and must be designed with a hydraulically controlled closure mechanism that will permit soft/restrained closure of the valve during power failure. A limit switch should be used to indicate the valve is within 10% of full valve closure before the shut-down sequence of the pump motor is initiated. Surge control tanks may also be required on the discharge and/or suction side of the pump system. The design consultant shall review the pump system and its transient analysis to determine the applicable surge control/protection measures and applicable control valve opening and closure times. (See Sanks, "Pumping Station Design" for a complete discussion regarding fundamentals and control of hydraulic transients.)

When the pump motor is suddenly cut off, pump speed along with flow and velocity in the discharge pipe are quickly decelerated by pressure waves traveling up the pipeline and back in accordance with Newton's second law of motion. When the velocity is reduced to zero, reverse flow through the pump will occur if a gravity operated check valve or an automatic control valve is not installed on the pump discharge line, or such a valve did not close properly. To control and limit these surge phenomena, gravity check valves or pump control valves should be used. (See Chapter 6 – Mechanical for more discussion on Surge Control)

Surge tanks are another method of reducing the surge pressure; the air within the tank compresses and absorbs the transient pressure waves, minimizing damage to the pipeline and pumps. Surge tanks are required on the discharge side of the pumps.

5.5 Project Phasing

If the flow rates to/from the station/facility are expected to increase significantly as time progresses, phasing of the station/facility must be considered. The design of the pumping facility should provide provisions to allow for future expansion of the facility. The suction and discharge piping system, yard piping, and pump manifold shall be designed for future (ultimate) flows. This includes providing adequate space for additional or larger pumps, piping, storage tanks, hydro-pneumatic tanks, and other station equipment, to procuring additional land for station expansion and upgrades. Any buildings housing pumps, controllers, equipment, etc… shall also be sized to accommodate future station expansion.

The following (at a minimum) shall be designed for the future (ultimate flow) design condition:

a. Yard piping
b. Chlorination System
c. Electrical service entrance
d. Electrical conduits, duct banks, etc.
e. Instrumentation and Control System

The pump station, PRV station, and/or well facility shall be sized to accommodate the lowest expected flow rates, as well as the largest anticipated flow rates. The equipment shall either be of sufficient capacity to handle the entire range of initial and ultimate flows or provide suitable provisions for increasing the capacity of the station/facility in the future. The phasing strategy shall be addressed in detail in the Preliminary Design Report.

5.6 WSD Standards

A listing of equipment for surge control/protection to be utilized in the design of pump stations, wells, and PRV stations are provided in Section 6 – Mechanical. Other design requirements and approved manufacturers are provided in the WSD Guide Specifications.

CHAPTER 6 - MECHANICAL

6.1 Referenced WSD Guide Specifications

The following WSD Guide Specifications are referenced in and/or are applicable to this section, though other specifications sections not listed may also be applicable. The WSD Guide Specifications are applicable for all projects where the facilities will be operated and maintained by the City. If the design consultant requests the requirements can be discussed with WSD and a waiver requested.

6.2 General Station Layout

The design consultant shall work with the City to establish a preliminary layout of all pump stations, reservoirs, PRV stations, and well facilities. The layout shall address general space dimensions and use, length and arrangement of station piping, location of valves, flow meters, pumps, tanks, MCC panels, and most major equipment. The capacity of the station and additional process such as disinfection system requirements directly affects the overall size of the station and should be carefully discussed with the City. Capacities of the individual pumps and types of pumps have an impact on the dimensions of the station and thus must be established early in design. It is desirable to optimize the number of pumps at a given facility; installing several small pumps provides flexibility in meeting the range of system demands but increases the land and maintenance requirements. Installing a few larger pumps decreases the land and maintenance requirements but does not offer much flexibility in meeting system demands. Station equipment, piping, etc. shall be oriented in the station to provide convenient and safe access for personnel and any equipment to be able to operate and maintain the site, including the installation and removal of equipment.

For vertical turbine pump station wet well and pump can design, the design consultant must follow the latest edition of the Hydraulic Institute Standards, specifically the section “Pump Intake Design”. This section outlines the requirements for vertical pump design in wet wells such as horizontal spacing between vertical turbine pumps, baffle wall requirements, and intake dimensions to the vertical turbine pumps. For pump can design, this section outlines several requirements such as the suction piping length, suction pipe invert to pump can depth, pump can sizing and flow valve requirements.

6.3 Station Piping

The pump station piping shall be designed so each pump takes suction from either a common wet well or from a suction header using individual and separate suction piping such as a can pump station. The layout of a common wet well or a can pump station shall be designed to meet the requirements of the latest Hydraulic Institute Standards. Suction header piping serving multiple pumps is the typical design arrangement; care must be taken to ensure there is adequate suction head and pressure to satisfy the pumps’ NPSH requirements. The pump station suction header shall be designed to ensure a velocity to the pumps of not more than three (3) fps and shall not create turbulence in the header that could lead to possible cavitation of the pumps. Individual pump suction piping shall also be designed to ensure a maximum velocity of three (3) fps. For vertical turbine can pump stations, the velocity for the fluid between the pump barrel and the pump can shall not exceed five (5) fps and shall follow the latest Hydraulic Institute Standards.

Velocities in any of the discharge piping including the individual pump discharge piping shall not exceed five (5) fps. Each pump shall have individual suction and discharge isolation valves and a dual chamber pump control valve between these two valves. Where appropriate, pump branch connections to the suction header and to the discharge manifold shall be made at approximately 45˚ angles to the centerline of the header and manifold. All manifold outlets shall be flanged with a flanged valve of the same size. In general, if wyes are used to make these connections, the wyes shall be the same diameter as the manifold and header. However, depending on the site and its constraints, the use of reducing/increasing wyes or other reducing/increasing fittings may be necessary. The use of these fittings shall be reviewed on a case-by-case basis by WSD during design. All station piping shall be supported with reinforced concrete saddles or fabricated steel pipe supports and shall be equipped with steel, hold-down straps as required. Pump station, well facility, and PRV station piping shall utilize insulated flange gaskets as necessary to electrically isolate the station piping from the yard/system piping. The design consultant is to provide an adequate cathodic corrosion control system which must be approved by the City.

To facilitate installation, removal, and accommodate slight alignment adjustments in the pump suction and discharge piping, restrained, sleeve-type flexible steel couplings shall be provided at each pump inlet and discharge connection. The restrained couplings shall be located between the pump suction/inlet isolation valve and the pump and between the pump and the dual chamber pump control valve. All pipe connections shall be either flanged or welded joints. The pumps and piping must also be anchored as necessary to prevent movement. See Section 11.16.1 for more information regarding piping systems, as well as the WSD Guide Specifications.

6.4 Pump Systems

The proper application of a particular pumping system requires an understanding of the pump as well as how the pump functions within the particular process system. It is necessary to determine the inlet conditions and understand how these conditions affect the performance of the pump before the pump can be selected. The design consultant shall design pump stations and well facilities with centrifugal pumps. For pump stations, use vertical turbine or horizontal split-case pumps; for well facilities, use in-line vertical turbine or down-hole submersible vertical turbine pumps. The following discussion focuses only on the centrifugal pumping class. If the design consultant chooses to investigate other pump types for a particular design, the design consultant shall discuss these issues in advance with WSD and receive their approval prior to proceeding with the design. Refer to Sanks, “Pumping Station Design” for additional information regarding pump system design.

All pumps, pipes, and valves shall be numbered north to south and east to west, as appropriate.

6.4.1 Pump Selection

In general, pump stations should be designed with consideration of a station’s firm pumping capacity as the initial design decision; the firm capacity of a pump station is the total pumping capacity of the station (domestic + fire flow) with the largest pump out of service, at maximum static levels. In cases where the "domestic" demand is a small fraction of the required fire flows, the fire flow shall determine the firm pumping capacity. A balance can be achieved by allowing the piping/meter system to have a maximum velocity of 10 ft/sec during fire events in an effort to downsize piping for the smaller domestic pumping scenario. In these instances, the design consultant shall carefully review the issue with WSD prior to commencing with design.

Pumps should also be selected to provide stable and efficient operation at average and design conditions. Designers often design pumping stations to be efficient at future maximum flow (design conditions). A more practical design is to select pumps that are efficient at an average of the present day and future design conditions. Pump selection should be made with the pump's best efficiency point (BEP) to the left of the intersection of the pump and system curves. The selected BEP shall not exceed the efficiency of the pump at the intersection of the pump and system curves by more than +/-2%; as the piping system ages, the headloss will increase and push the operating point to the left into the best efficiency point. Three system head curves, one at C=90, one at C=110 and one at C=140, shall be plotted on the proposed pump curve to verify the pump will run efficiently as the piping system ages.

Minimum flow conditions should also be considered in pump selection, especially where variable speed pumps are used. (See Section 11.4.4 for additional VFD discussion.) In general, pumps should not operate at less than approximately 25% of design capacity. If low flow conditions require operation at less than 25% of design flow, pumps should be set for on-off control at these low flows. Alternatively, smaller "jockey" pumps could be used to pump low flows.

The design engineer shall also prepare reduced speed curves of each selected pump utilizing VFD control. These curves provide information relating to the delineation of the pump design (operating) point at various reduced pumping speeds. Curves shall be provided for the following percentages of full speed: 100, 90, 80, 70, and 60. The minimum percent speed at which the pump is capable of pumping should be identified. The design consultant shall also prepare reduced speed curves of each selected pump. These curves will provide valuable information relating to the delineation of the pump design (operating) point at various reduced pumping speeds when variable frequency drives (VFD's) are used. When selecting pumps, operating curves that are relatively flat should be avoided where slight variations in TDH produce significant changes in pump flow. It is recommended that the slope of the curve for VFD control vertical turbine pumps be no less than a ratio where flow vs. head is 4:1. The design consultant shall provide calculations and a pump figure showing the flow vs. head conditions such that it meets or exceeds the above ratio. Also select a pump/impeller near the middle of the operating curve to allow for potential modification during startup or future system demands.

6.4.2 Net Positive Suction Head

The design engineer shall determine the net positive suction head available (NPSHA) for the pumping system. The NPSHA shall always be more than the net positive suction head required (NPSHR) by a margin of 2.0 (number of times

NPSHA is greater than NPSHR) to provide an adequate safety factor. The design engineer shall then determine pumping head requirements, TDH curves, and flow velocities. Sanks, “Pumping Station Design”, describes the method of calculating NPSHA.

6.4.3 Pumping Units

In pump station projects employing reservoirs, the design consultant can select horizontal split case or vertical turbine centrifugal pumps. End suction centrifugal pumps may be considered. The following discussion focuses on identifying the advantages of both types of pumps in pump station design applications.

Typically, the configuration of piping for a vertical turbine pump is as shown in Figure 6-1 or some variation thereof; however, it must follow the latest Hydraulic Institute Standards Pump Intake Design section. Likewise, typical piping for a horizontal split case pump is shown in Figure 6-2. It is readily apparent there are significant differences in the piping layout and hydraulic considerations of each. The design consultant must consider such factors as the preferred location of the intake structure in the reservoir or supply source, site drainage, 100-year flood elevation, station accessibility, operation and maintenance access, effects of varying water supply levels on the pump’s performance, the City’s experience with the type of pump, and of course the City’s pump standard before selecting the type of pumping system and resulting station layout.

Pumping stations shall consist of a combination of pumps to supply a minimum of the total domestic demand, which is peak hour flow, plus the fire flow with the largest pump out of service (firm capacity). The combination will be such that at lower flows not all of the pumps will be running. The station shall consist of at least one (1) domestic pump that delivers 50% of peak hour demand, one (1) domestic pump that delivers 150% of peak hour demand and one (1) pump that delivers the maximum required fire flow. A second largest pump is to be on in stand-by to meet firm capacity requirements.

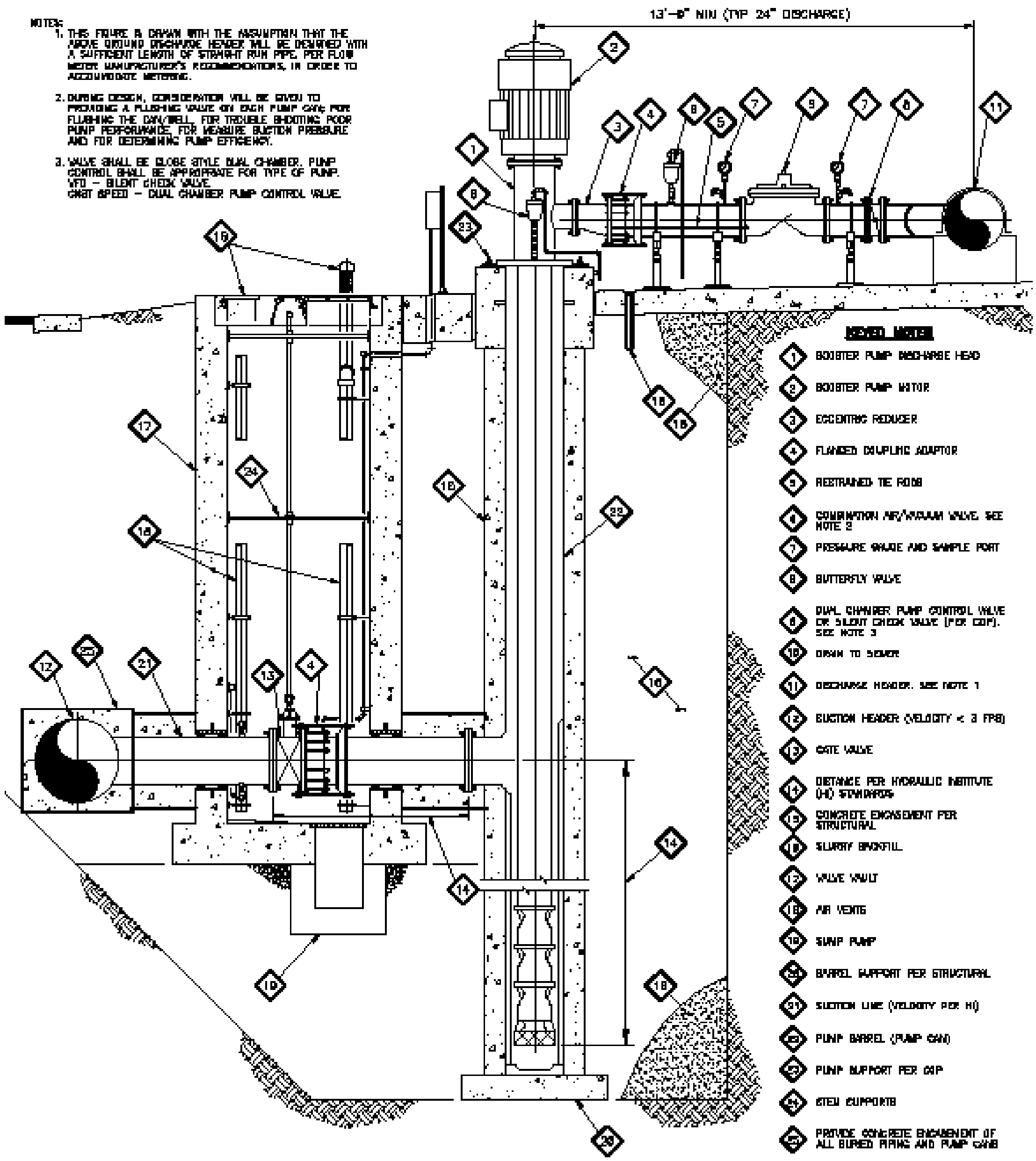


FIGURE 6–1
TYPICAL VERTICAL TURBINE PUMP

Figure 6-1 Typical Vertical Turbine Pump Profile

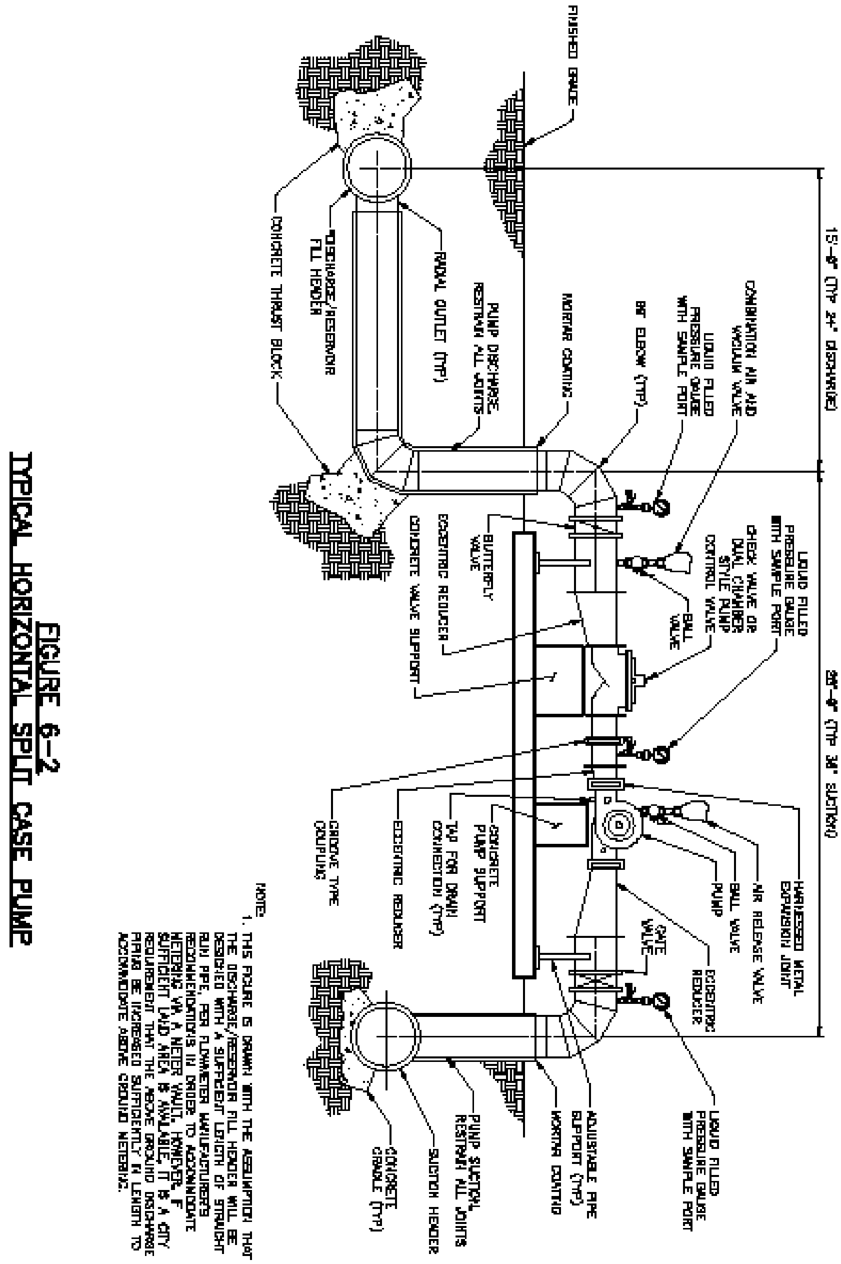


Figure 6-2 Typical Horizontal Split Case Pump

The minimum design criteria used to analyze the advantages of each type of pump include:

a. priming considerations
b. corrosion and abrasion
c. flexibility
d. inspection
e. repair and maintenance
f. durability
g. space requirements
h. noise generation

Table 6.1, identifies advantages of vertical turbine and horizontal split case pumps:

Table 6.1 - Pump: Type Advantages

Vertical Turbine (VT)	Horizontal Split Case (HSC)
(1) Pump efficiency in flows less than 2500 gpm are generally better than HSC pumps	(1) Pump and motor are generally less expensive than VT pumps
(2) Less floor area is required compared to a HSC pump.	(2) Maintenance on the pump is easier because most of the pump's rotating parts are completely accessible by removing the top half of the casing.
(3) Less noise at the operating floor level than HSC pumps.	(3) Easier to install than VT pumps, thus typically have lower installation costs.
(4) Pump suction is always flooded, therefore, the Net Positive Suction Head (NPSH) requirements are generally not a major design consideration.	(4) Inspection, repair, and maintenance costs are generally less than VT because of the easy access to the pump.
(5) Pump priming equipment is never necessary; however air relief from the pump column is required for pump start-up.	(5) Where adequate NPSH is available to meet the required pumping unit's NPSH, HSC pumps are acceptable.
(6) The chance of motor overload is less likely because of adequate horsepower to head relationship.	(6) Head room requirements in the pump station are lower than those for a VT pump. (This makes HSC pumps easier to inspect and maintain.)
(7) Versatile and adjustable in terms of location, pump column length, and the ability to have additional stages readily added to meet significant changes in TDH.	(7) Roller bearings and many other parts are isolated from the pumped fluid and therefore may be made of less expensive materials.
(8) Pressure requirements are easily met by staging.	
(9) More durable, useful life is typically greater, and maintenance requirements are less than those required for HSC pumps.	
(10) Pump motors can be positioned at levels not subject to flooding.	

In general, the selection of the type and configuration of a pump station for a reservoir or in-line header entails careful consideration of many factors such as pump hydraulics, system hydraulics and conditions, water quality, future system requirements, capital cost, pump efficiencies, operation and maintenance costs, intake structure location, and standards of the owner. Both vertical turbine and horizontal split case pumps have many distinct advantages and disadvantages. However, each project has its own peculiarities and requirements that have an important impact on the selection of pumping units for a particular pump station. To assist the design consultant in determining the correct type of pump for a particular pump station design project, the design consultant should consult with the WSD staff to determine the City's minimum pump standards, and the WSD approved pump manufacturer or its local representative for technical data concerning the various types of acceptable pumps.

For wells, a submersible vertical turbine pump is a vertical turbine pump being driven by a close-coupled submersible motor typically mounted below the pump bowls/impellers with the potential for contact with the pumped fluid; by virtue of its name, the submersible pump functions underwater. Submersible pumps are in general more expensive than conventional vertical turbine pumps, and the entire unit (pump motor and pump head) must be either pulled from the pump column/pump can or out of a wet well to be serviced. Where noise is a significant consideration, a submersible pump is quieter because its motor is located within the pumped fluid. When using submersible pumps in pump and well applications, consideration must be given to water temperature. A submersible pump uses the pumped fluid to cool the pump motor. Water temperatures above 80˚ Fahrenheit can overheat a motor leading to motor failure. Depending on the location of the pump station or well, the design consultant shall investigate the use of submersible vertical turbine pumps. If the use of submersible pumps is warranted, the design consultant shall discuss the issue with the City before proceeding further with the design.

6.4.4 Motor Requirements

The prime mover on a pumped system is the means of supplying energy to the pump. The most frequently used prime mover is the electric motor, mainly due to its versatility, compactness, and low maintenance requirements. The speed of a pump is important in the design of a pumped system. For high-speed, above ground vertical turbine pumps, on the order of 15,000 plus rpm, the efficiency of the motor increases significantly with a corresponding increase in speed. However at the typical speed ranges for booster pump applications, i.e.: 1,200 to 1,800 rpm, motor efficiency increases are minimal. Therefore, from a power consumption/efficiency stand point, there is no significant benefit in specifying high speed pumps. The following information identifies additional design considerations for low speed pumps:

a. Abrasion, vibration, and wear of pump parts increase with increased pump speed.
b. The potential for cavitation damage increases with pump speed.
c. Motor noise can become a significant problem as a pump's speed is increased.

In general, the design consultant shall include and verify that in the project design specifications requirements for the pump, drive motor, drive shaft, couplings, supports, gear reducer, fly wheel, variable-speed drive equipment (or constant speed equipment), and specific controls and appurtenances to be provided by a single manufacturer/supplier (typically that of the pump equipment) who shall take unit responsibility for the entire system.

Typically, pumps are installed outdoors, and in dirty or corrosive environments, requiring totally enclosed motors. In addition, motors installed outdoors shall have temperature ratings adjusted to suit ambient operating conditions (+50° C). Motor starting equipment shall be suitable for the type of motor and required voltage. Motor starters will be designed for limiting the inrush current where shocks or disruptions to the electrical supply are likely to occur as a result of pump start-up. Where low starting inrush current is required for constant speed pumps, such as when using engine driven generator sets, wound-rotor motors should be considered as an alternative to squirrel-cage motors. The motors shall be sized such that it will not be non-overloading across the entire full-speed pump curve and not loaded to more than 90% of the rated HP at 1.15 service factor. The City of Phoenix prefers 480V whenever possible but realizes 4160V may be required at certain locations and must be approved by the City.

6.4.5 Drive Equipment

Pumps can be operated at either constant speed or variable speed. Constant speed operation is less costly than variable speed operation, but does not provide much operational flexibility. As a rule of thumb, VFD's should not be used if constant speed pumps are capable of meeting the minimum to maximum flow range and if the pump curve is relatively flat. (A flat pump curve inherently provides large flow changes for relatively small adjustments in head; this is the principal behind the use of VFD's, therefore nothing is gained by using VFD's with flat curved pumps). **The use of VFD's shall only be used with written approval from WSD**.

Pump stations and well facilities pumping into a system with elevated storage tanks do not require VFD's because they typically operate over long periods of time at uniform flow rates. Therefore, constant-speed motors with across-the-line soft start capability shall be used.

The main reason for using variable frequency drive (VFD) units as part of a pump station and well facility design is to provide/maintain constant system pressure during periods of varying demand. Pump stations and well facilities pumping directly into distribution systems without elevated storage require VFD's to maintain a nearly constant system pressure as the system demand changes. Variation in a pump's speed controls the pump's discharge head while the discharge rate is determined by the system demand. As a rule of thumb, VFD's should not be used if constant speed motors are capable of providing the required constant system pressure, and if the system curve is relatively flat.

In general, VFD's are more expensive, less efficient, require more maintenance, and require air conditioned enclosures. All modern variable-speed drives include a speed regulator, whether it is an engine governor or a variable frequency drive VFD controller. The regulator shall be provided with a 4 to 20-ma follower to accept the control signal from the instrumentation system. The speed regulator shall not exceed 3% of range.

VFD's, if required and approved by WSD, shall be provided by the pump equipment manufacturer/supplier. This ensures a unit responsibility for a system that will pump over the required head and flow ranges. The VFD specifications must include a complete description of the power system including any requirements for operation from standby generators. Where standby generator operation is required, complete generator characteristics must be included or referenced in the specification.

In addition to the criteria discussed herein and the WSD Guide Specifications, specifications for VFD's shall address the following:

a. Power requirement as a function of pumping capacity
b. Allowable supply voltage wave form distortion
c. Allowable supply voltage notch area
d. Minimum and maximum allowable power factor over working speed range
e. Minimum allowable efficiency at full speed and load
f. Required operating ambient temperature range
g. Required diagnostic provisions
h. Control and monitoring signal interface
i. Allowable acoustical noise level
j. Adjustable ramp acceleration/deceleration time
k. Characteristics (available short circuit current X/R ratio) of power supply including alternate and standby power supplies
l. Allowable speed regulator error
m. Across the line contactors for operation upon VFD failure
n. Full range of harmonics tests (See WSD Guide Specifications)
o. Equipment to remove harmonics if detected

6.5 Valves

The design consultant shall select materials for valves appropriate for potable water use and prevent corrosion of valve components. To minimize the number of different types of valves used within the pump station, well facility, or PRV station, only valves from those manufacturers and valve types designated in the WSD Guide Specifications shall be used.

All valves shall be shown on the drawings. In addition, valves larger than 6 inches in diameter shall be numbered and shown on the appropriate drawing sheet(s), delineated in a valve/piping schedule, and referred to in the specifications by the valve number. This schedule shall be included in either the design drawing set or the specifications. The valve schedule shall include the valve number, location, service, valve type, class and size, quantity, actual maximum pressure and flow range, actuator service, operating time range, NEMA enclosure, and any applicable remarks such as, voltage, phase, type of connection, linings, coatings, etc. If practical, all valves shall be installed above ground.

All large system valves (16 inches and larger) to be installed below ground shall be housed in either precast or cast-in-place concrete vaults with manholes to permit maintenance of the valve and valve operator. Valves shall be configured for operation without having to enter the vault. Manholes shall be a minimum of 60 inches in diameter with cast iron frame and covers. Vaults shall have a 2'x2'x1' deep sump constructed in the vault floor with two wire mesh covered fresh air ducts in the vault lid.

All valves should be able to handle the flow and pressures produced by the system pumps and all other internal pressures developed by the system. Typically, WSD uses butterfly valves with resilient rubber valve seats located on the valve body for all transmission mains 16-inches and larger, and gate valves for distribution mains 12-inches and smaller. Resilient wedge gate valves can be considered up to 36-inches. Butterfly valves require a vault if they are buried, to allow access for adjusting and maintenance, therefore, the designer must check with WSD prior to designing butterfly valves. Also, WSD typically uses gate valves upstream of all pumps and PRV's due to turbulence issues and pump efficiency. The designer shall discuss valve installation with WSD throughout design for WSD's consideration.

6.5.1 Check Valve

For simple cases involving small to medium sized pump stations with gradually rising discharge piping (no intermediate high points) less than about 1,000 feet long and static discharge heads of less than 50 feet or (25 psi difference between suction and discharge), (such as pumping to a reservoir), a gravity operated check valve will usually suffice. Gravity type check valves shall be either swing check valves or cushioned check valves. Swing check valves utilize an outside lever and weight (or spring) which is set to assist closure before flow reversal occurs; swing check valves must be installed horizontally. Cushioned check valves utilizing an oil-filled dashpot adjustable for rate of closure may be justified in certain cases. Silent check valves shall be used on pump systems with VFD control; VFD manufacturers require silent check valves to achieve the start slow/stop slow condition. For additional protection, by-pass piping and a pressure relief valve may be needed in conjunction with check valves to allow reversing flow to bleed out of the piping; however, provisions must be made to handle bleed water.

Check valves are available in various types, shapes, and configurations, each with its own advantages and disadvantages for a particular application. Because of the wide variety of check valve designs available, the selected valve shall be compatible with the intended application. To assist in selecting valves it is recommended the designer consult WSD and the engineering departments of check valve manufacturers, or their local representative, for technical data concerning the various types of check valves available and those that have been used successfully. These sources have years of theoretical and practical knowledge in the operation and design of check valves including their application. The designer should also refer to the WSD Guide Specifications.

6.5.2 Pump Control Valves

Pump control valves are typically used at large pump stations or in situations where long transmission mains are required where the pipe profiles typically conforms to existing ground elevations for economic reasons. This normally results in high points in the pipe resulting in the possibility of water column separation at high points in the line during pump shutdown or power failure. The pressures generated when these separated columns come to rest against closed valves or against stagnant columns may be large, and are determined as above. In general, where discharge piping is greater than about 1,000 feet long or contains intermediate high points, where pumping stations are of relatively large capacity, or static discharge heads are greater than 50 feet, pump control valves will be automatically operated. Normal operation of these valves upon normal pump shutdown is to slowly close the valve while the pump continues to run. When the valve is closed, a limit switch then stops the pump motor. Upon pump start-up these valves are closed and then are slowly opened to minimize the rate of velocity changes. On power failure, an emergency hydraulic or other type operator closes the valve slowly; the valve needs to be closed before the water column reverses and damages the pump. The time of valve closure is important; valves should be half closed when the velocity in the discharge piping has dropped to zero.

To protect pumps and piping from surges caused by pump shutdown or power failure, dual chamber pump control valves shall be installed on each individual pump discharge line downstream of the pump discharge flange but upstream of the isolation valve as shown in the typical piping arrangements provided in Figures 6-1 and 6-2. Pump control valves shall be equipped with adjustable hydraulic dampeners and must be coordinated with the results of the systems surge analysis.

Pump control valves shall be per WSD Guide Specifications.

6.5.3 Isolation Valves

The main function of an isolation (shutoff) valve is to maintain the integrity of the operating system and provide positive isolation of the pump and its valving from the piping system for maintenance purposes. Isolation valves shall be located on the pump discharge and suction piping and on PRV station piping, as shown in the typical piping layout depicted in the figures in Section 8. An isolation valve shall also be installed downstream of the main discharge flow meter. Isolation valves may be motor operated in certain applications, if approved by WSD.

Isolation valves 16-inch and larger located upstream of the flow control valve shall be equipped with a small-diameter (2-inch to 4-inch) bypass line and applicable valving. This bypass system provides downstream pressurization of the discharge line to allow easy operation of the isolation valve. Isolation valves shall be either a butterfly or gate-valve design with resilient rubber seats; all butterfly valves shall be installed with the shaft in the horizontal position. Gate valves are preferred for isolation valves on the suction and discharge manifold at pump stations.

6.5.4 Valve Actuators (Operators)

In general, the design consultant shall design and specify electrically controlled operators including manual handwheel operators for upstream (suction) and downstream (discharge) isolation valves and flow control valves, respectively. All electric operators shall be designed for above-ground application and shall be provided with limit switches. Limit switches shall be added to each valve operator for open/close indication. If the valve is a modulating valve then a valve position indicator is also required. Individual pump suction valves shall be provided with handwheels for manual operation and located immediately adjacent to the main suction header flange. Individual pump discharge valves shall utilize AC-reversing-type operators and shall be located immediately adjacent to the pump discharge header flange. The pump station's main pump suction valve shall be motor operated (AC reversing type) in certain applications and located within the pump station building/structure. The downstream pump station main discharge valve shall be manually operated and located downstream of the pump station's flow meter. (If this valve is located outside of the station, it shall be provided with a 2-inch standard AWWA operating nut in a standard MAG valve box.) Valve operators shall be sized to ensure proper seating and unseating of the valve surfaces against the system and/or pumped head.

The types of valve operators most often used are hydraulic, electric, and pneumatic; before valve operators are specified, discuss with WSD. Valves and operators specified for use will be fully adjustable for closure times ranging from t to 4t as a minimum. In some large pumping stations, the use of automatically controlled valves alone may not be sufficient. Extremely long pipe runs or large distribution systems may require relatively long valve closing times resulting in excessive backflow and reverse rotation of the pump and motor; to counteract this, other measures may be required. In these cases the services of a specialist with extensive surge analysis and remediation experience is recommended.

6.5.5 High Pressure Relief Valves

At all booster pump stations a high pressure relieve valve will be required. This valve will be installed on the discharge line and tie to the suction line. This will allow water to be moved back to the lower zone during startup and other times as necessary to operate the facility. The size of the valve and the requirements will be determined and approved by WSD.

6.5.6 Hydropneumatic Surge Tanks

The tanks shall meet all ASME provisions and shall bear the stamp of the National Board of Boiler and Pressure Vessel Inspectors and be in compliance with all paint and primer codes TT-P-86 and AWWA Standards. The tanks must be able to withstand and exceed all designed pressures for the system and be rated for full vacuum (-14.7 psig). Each tank is to be outfitted with all equipment called for in the WSD Guide Specifications. The equipment includes level probe bottle, level probes and relays, level control. Sight glass, pressure gauge, corporation stops, high pressure release valve, air/vacuum relief, check valves, pressure switches, etc. Pressure sensor fittings and compressor fittings shall be outfitted with copper piping and copper or brass fittings. Galvanized fittings are not accepted for use by the City. Surge tanks are required on the discharge piping. The necessity of a surge tank on the suction piping is site specific, which will be determined by the Engineer and a surge analysis as necessary. Surge tanks shall be as specified in the WSD Guide Specifications Division 11240.

6.5.7 Miscellaneous Valves

Air release, vacuum release, or combination air vacuum/air release valves shall be installed at high points as appropriate throughout the station and system piping. These valves are used to prevent air from accumulating inside the piping system thereby reducing pipe capacity, or to prevent damage to the pipe due to vacuum conditions. Each valve shall be specified with the appropriate orifice diameter suitable for the volume of air to be admitted or released. The method to be used for sizing the appropriate air release, vacuum release, or combination air vacuum/air release valves can be found in the applicable manufacturer design guidelines. To allow periodic maintenance on each valve, an additional isolation valve (¼-turn, resilient, rubber seated ball valve) is required upstream of each air valve. These valve assemblies, including the isolation ball valve and associated piping, shall be rated for the maximum design pressure of the system piping.

An air release valve shall be installed on the vertical elbow on the discharge piping prior to any other valve. The air release outlet shall be piped to a sump if the valve is within a building or vault. If the pump is outside, the outlet shall discharge to an "out-of-the-way" location, approved by WSD. In addition for vertical turbine pumps installed in pump cans, the pump can shall have a combination air/vacuum valve to vent the air that accumulates within the pump can.

There are numerous types of valves available in the industry for flow, pressure, and/or pump and hydraulic transient control. Selection of the appropriate type of valve usually depends on its application, type of fluid being pumped, cavitation potential, range of system flow and head requirements, allowable pressure drop across the valve, and client/owner standards and preferences. Control valves commonly used include sleeve, globe, butterfly, and ball valves.

Sleeve valves, when wide open exhibit high head loss across the valve. As a result, these valves cannot be used where system constraints can tolerate only a small amount of control valve head loss. However, sleeve valves exhibit very small cavitation potential, are effective in high pressure drop applications, have a wide range ability, and their diameters can be reduced from the pipeline line diameter due to their capability of accommodating high (30 fps) maximum-flow velocities through a fully-open valve; this feature helps limit their high cost by restricting their size. Sleeve valves are also supplied by a limited number of manufacturers and therefore could be subject to price fluctuations and availability. Sleeve valves are in general a good choice in high-capacity and high-pressure drop applications and are available in diameters of 8 inches to 60 inches.

Globe body valves are frequently used in flow control situations. Similar to sleeve valves, globe pattern valves, when wide open, exhibit high head loss across the valve. Because of their high headloss, they also cannot be used where system constraints can tolerate only a small amount of control valve head loss. The City's standard is to use globe pattern valves in flow control situations. Globe valves are available in sizes of ½ inch to 16 inches and are limited to maximum velocities of 25 feet per second.

Butterfly valves are also frequently used in flow control situations due to their low headloss and low cost. However, their characteristic curve, range ability, and potential for cavitation limit their use. Butterfly valves are a good choice for flow control in situations where valve headloss must be limited due to system constraints. Butterfly valves are available in sizes of 4 inches to 90 inches and are limited to maximum velocities of 16 feet per second.

Ball valves are sometimes preferred over butterfly valves when used in pump control situations because of their good throttling characteristics and low head loss when wide open. Ball valves are generally more resistant to cavitation and have a good characteristic curve and range. A down side to ball valves is their high capital cost – on the order of two to four times more expensive than butterfly valves. Ball valves are available in sizes of ½ inch to 48 inches and are limited to maximum velocities of 30 feet per second.

6.6 Flow Meters

Accurate measurement of flow discharged from a pumping station is critical to the overall operation of the facility. Consequently, a full port flow meter with transmitter must be installed above ground in the discharge header of all pumping facilities to indicate and record the quantity of flow being pumped. A valved bypass line around the meter is required. The size and requirements of the bypass line to be approved by WSD. The flow meter transmitter shall be shielded from the sun by shade canopy.

The selection of the appropriate pump station, PRV station, or well site flow meter(s) and its location depend on many factors which include having adequate station area to allow installation of the selected permanent meter and allowing provisions for providing the manufacturer-specified number of lengths of straight run pipe before and after the meter; having the appropriate piping orientation and configuration for the type of meter selected; and routing the pipe and installing the meter above ground to eliminate confined space issues. The design of the flow measurement system shall consider the required controls based on available land, the station layout, the flow meter manufacturer, and City input. The required distance of straight-run pipe upstream and downstream of a flow meter depends on the type of meter chosen; therefore, the meter application must be designed specifically for each pump station, PRV station, or well facility.

It is imperative flow meters remain full at all times – even when the pump(s) is/are not running. One means to accomplish this is to install the meter and corresponding upstream and downstream piping below the elevation of the rest of the piping; if there is any potential for siphoning, a mechanical means to avoid siphoning shall be installed. The correct number of straight run diameters upstream and downstream of the meter shall be maintained, whatever is used.

During the initial phase of the facility, the flows may be much lower than the anticipated ultimate flows, and a flow meter sized for the initial flows may be too small to accurately measure the greater future flows. Likewise, if a meter is sized to handle the higher ultimate flows, it may be too large to accurately measure the lower flows. The meter must be sized to accurately measure the flows, at all stages. Initially, a smaller meter may be required and replaced later as flows increase.

With respect to well manifolds, pipe diameters are generally small enough and sufficient land is available to comply with the manufacturer's specified number of lengths of straight pipe both before and after permanent meters. The design consultant shall also include design provisions to meter the well's waste pump out line. Per the Intergovernmental Agreement between the City of Phoenix and Salt River Project (SRP), well flow meters shall be as manufactured by Water Specialties.

For wells utilizing flow meters:

a. Water Specialties flow meters for SRP transfer wells are required by the City per the Intergovernmental Agreement for Water Delivery & Use signed between the City of Phoenix and Salt River Project (SRP).
b. Meter accuracy shall be as close to zero as practical but in no event shall error exceed +/- 5% of actual flow or as specified in the Intergovernmental Agreement for Water Delivery & Use signed between the City of Phoenix and SRP.
c. All flow meters shall be: Full port flow meter, Series ML-04-5G, and come as a complete flow meter with a Water Specialties flow tube or spool and a 4-inch dial indicator-totalizer. (The meter shall have an analog rate of flow indicator and totalizer meter head assembly.) A digital electronic meter head assembly will not be acceptable for use.
d. All meter head assembly shall be Water Specialties Series Model ML-I1.
e. Transmitters: All flow meters must have a contact pulse signal (Type TR-12-2) and a 4-20 MA signal (Type TR-16).

Additional City flow meter requirements are included in the WSD Guide Specifications.

6.7 Vaults

Under special circumstances and only when approved by WSD, a valve vault may be used to house the pump suction/discharge line valves, manifolds, and flow meter. Under these circumstances, the vault shall not be deeper than 5 feet and shall be a concrete structure (precast or cast-in-place) with a concrete floor sloped (¼-inch/ft) to a sump. Fiberglass reinforced plastic (FRP) grating with stainless steel hardware shall cover the entire vault. The grating shall be installed in removable sections to allow access to all components in the vault. If the vault access is at grade, the vault/manhole covers shall incorporate heavy-duty cast iron frame and covers designed to H-20 loads imposed by heavy maintenance equipment, chemical delivery, etc. Stainless steel locks keyed to match the City’s standard locks shall be provided to secure the grating when it is in place. Protective aluminum guardrails shall be provided in accordance with OSHA regulations. The guardrails shall be designed with hinged openings such that valve removal may be performed without lifting the valves over the rails. A sump and a sump pump shall be provided as described below. Vaults shall be sized such that a minimum distance of 3 feet clear is provided between parallel piping and between piping and adjacent walls. Provide a six-inch curb on top of the valve vault to prevent storm water surface runoff from entering the vault.

6.7.1 Vault Sumps

As a minimum, a frame- and grate-covered sump shall be provided in the concrete floor of all valve vaults. The purpose of the sump is to collect fluids for proper disposal from incidental maintenance and housekeeping operations, and potential excessive leakage caused by broken or misaligned couplings. Allowable frame and grating materials include Type 316 Stainless Steel, aluminum, or fiberglass; if an aluminum frame and grate is used, it shall be protected from direct contact with concrete. The sump shall be located at the low point of the structure’s concrete floor. The valve vault floor shall be sloped 1/8-inch per foot toward the sump. See also Section 11.7.

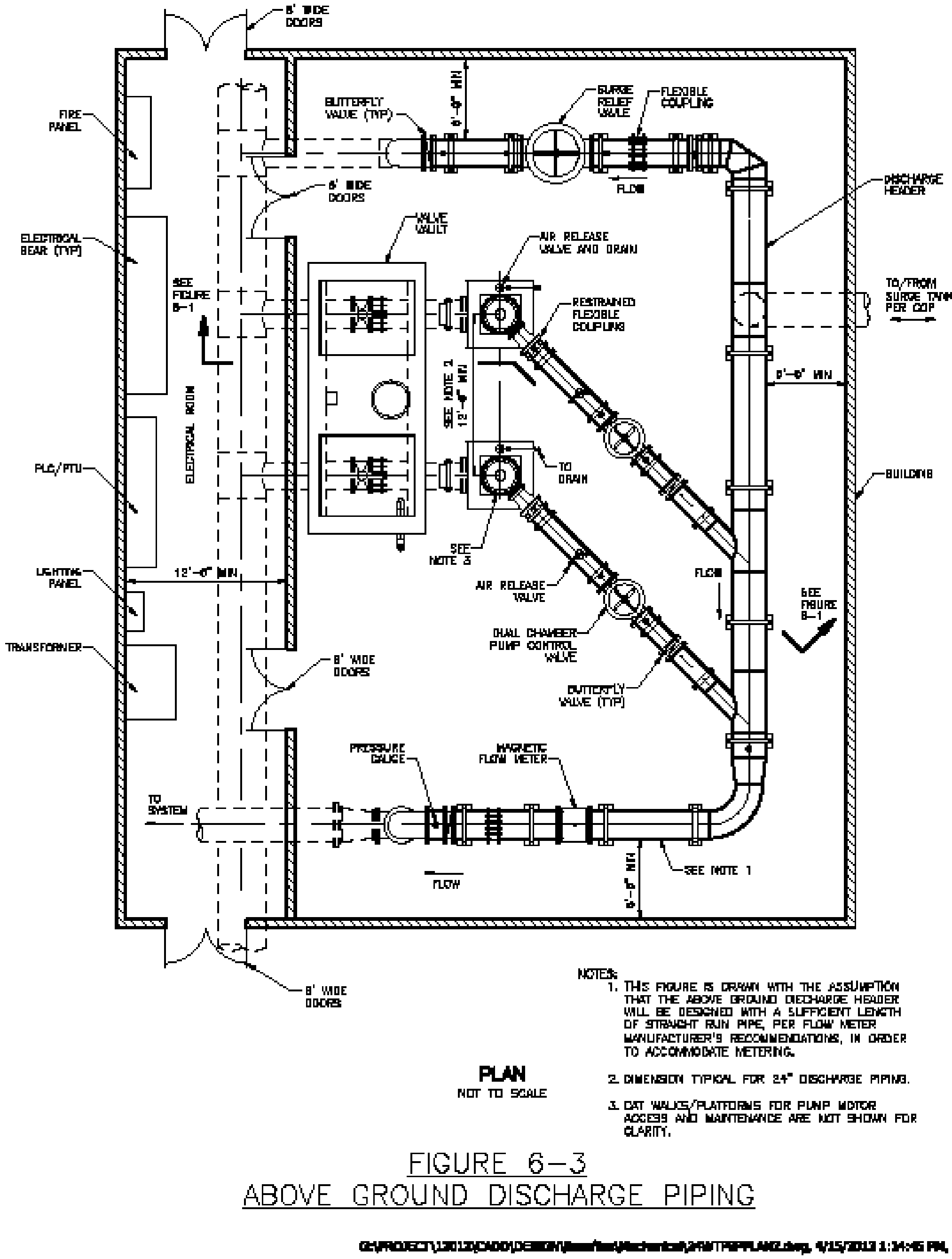


Figure 6-3: Example Plan and Section View of Above Ground Discharge Piping

6.8 Sump Pump

The design consultant shall design a frame and grate covered sump in the concrete floor of all pump station's, well vault's, and PRV station's buildings. The purpose of the sump is to collect fluids from incidental pump and seal leakage, maintenance and housekeeping operations, and potential excessive leakages caused by broken or misaligned couplings, and discharge these fluids to a suitable location for disposal. Grating shall have a checker plate pattern constructed of Type 316 Stainless Steel, aluminum, or fiberglass. If an aluminum frame and grate is used, it shall be protected from direct contact with concrete. The sump shall be located at the low point of the structure's concrete floor. Where footing drains, etc. are required and can not be allowed to discharge above ground, they will be routed to the sump. A duplex, submersible sump pump system shall be designed to handle a minimum flow rate of 50 gallons per minute and pass solids of at least 1½ inches in diameter. The sump pump system shall be designed to ensure it is capable of pumping out a flooded area in 1 hour or less.

Each submersible sump pump shall be hard piped to a common discharge header. A double check valve and isolation valve (plug valve) shall be provided on the horizontal run of each sump pump's discharge line. The sump discharge lines shall be connected to a common discharge header and shall be hard piped to a location approved by WSD. From this point, the handling and disposal of miscellaneous drainages and discharges from a project site fall under strict environmental (EPA and ADEQ) regulations. Therefore, during the pre-design phase of a project, the design consultant shall discuss the issue of miscellaneous drainages and discharges and their disposal with the City. Design options may include routing to and disposal in an adjacent sanitary sewer or storm water drainage system, or to a gravel-filled dry-well (french drain). In any event, this issue must be reviewed with the City during the pre-design phase of the project. As a precaution, the design consultant shall provide a flood alarm switch in the pump station/vault, in the sump below the building/vault/s finished floor elevation, for detection of abnormally high water level in the station/vault. Flood alarm I/O points shall be provided for in the design of the project's PLC. The PLC shall include I/O points for connection to the project's RTU/SCADA system. Refer to Sanks, "Pumping Station Design" for additional information regarding sump design. The sump pump control panel shall meet all WSD Guide Specifications

6.9 Chlorine Residual, Turbidity Sampling, and pH Sampling

To minimize the wasting of sample water, spent samples from the chlorine residual analyzer, pH analyzer, and turbidity analyzer systems shall be returned to the upstream (low-pressure) header or system reservoir. Other options for the disposal of sample water must be submitted to City WSD for review and approval prior to implementation. Sampling systems shall be pressurized using a system supply pump and/or a residual analyzer return pump. (Lift station and reclaimed water facility's analyzed water is returned to site sewer lines only, and carry a total chlorine residual; potable water facilities carry a free chlorine residual).

The chlorine residual analyzer, the turbidity analyzer, and the pH analyzer must be hard wired to the WSD's computer control system through an analog signal.

6.9.1 Chlorine Residual Analyzer

The design consultant shall include a chlorine residual analyzer and sensor system within the pump station. The residual analyzer and sensor shall be installed such that the reading taken will be representative of the chlorine level in the upstream storage reservoir (suction header). This will allow continued sampling of the upstream storage supply system in the event the pump station is out of service. If the chlorine residual reading falls below 0.4 ppm, a chlorine additive system will be activated to return the residual to between 0.8 ppm to 1.2 ppm.

To ensure adequate mixing of the chlorine and potable water, the travel time from the injection point to the chlorine sensor and analyzer shall be 3 to 5 minutes. The engineer shall provide to WSD calculations proving the provided flow rates accommodate the 3 to 5 minute flow time, including the sampling line. If necessary, a static mixer can be installed between the injection point and the sampling port; any other means of mixing shall be reviewed by WSD. (No chlorine gas shall be allowed to pass through any pumps – though with WSD approval, sodium hypochlorite may pass through pumps).

6.9.2 pH Sampling

pH is a measurement of the intensity of the acid or alkaline condition of the water and is important in virtually every phase of environmental/sanitary engineering practice. In the field of water supply and treatment, pH plays an important role in the disinfection capability of various disinfection chemicals; pH can also be affected by the application of various disinfection chemicals. The design consultant shall include a pH sampling probe within the pump station or well facility which shall be located adjacent to the chlorine residual analyzer as noted above.

6.10 Disinfection System

Chlorination for disinfection is a complex process. A chlorination system will be required to maintain the chlorine residual within the reservoir and/or dose water as it leaves by gravity from the Reservoir Facility. The chlorination system shall comply with applicable provisions and recommendations of the following codes and standards:

a. Recommendations of The Chlorine Institute, Inc.
b. Occupational Safety and Health Act.
c. National Fire Protection Association, Annex “D” Standards.
d. City of Phoenix Fire Code.
e. National Fire Protection Association.
f. City of Phoenix Building Code.
g. AWWS C 652 Method 3.

The Engineer shall provide chlorination provisions for reservoirs and/or gravity outlet lines as determined by the COP Water Services Department. Factors in determining the type of chlorine facility will be residential, school, and commercial proximity to the facility. In addition, the Engineer shall follow the COP’s latest standard specifications. The chlorination system will be one of the following types:

6.10.1 Chlorine Gas

Chlorination systems using chlorine gas shall use a chlorine gas container containment system consisting of a scale mounted steel vessel for containing 150 lb chlorine gas cylinders. The System shall use commercially available chlorine gas and shall consist of the following at a minimum:

a. The chlorination system shall be housed in an air conditioned building. The building shall include a fire sprinkler system and be designed to the latest COP building code. The Engineer shall coordinate with the COP Water Services Department for the COP standard layout required.
b. The chlorine cylinders shall be sealed within the containment system.
c. The containment vessel shall include fail-safe valves that are operated by nitrogen gas and electrical power, nitrogen gas supply to fail-safe actuators, vessel weighing system with electronic weight indication, rollers (in vessel interior), pressure relief valve, vacuum/pressure gauge, interior chlorine supply flex hoses, pivots, valves, piping and fittings, and container loading system.
d. Automatic chlorine feeder with controller shall be provided and be manufactured by Wallace & Tiernan.
e. Provide chlorine gas container loader.
f. Chlorine gas container system shall be manufactured by TGO Technologies or as approved by COP. The chlorine gas container weight scale shall be manufactured by Force Flow or as approved by COP.
g. Provide chlorine gas leak detection system that will send an alarm to SCADA in the event a leak is detected.

A standard design template for the chlorine gas system is available from the City of Phoenix and can be requested once the Engineer is ready to start design.

6.10.2 Sodium Hypochlorite Solution

Chlorination systems using sodium hypochlorite solution shall be stored in solution tanks and feed using metering pumps. The system shall use commercially available sodium hypochlorite solution and shall consist of the following at a minimum:

a. The chlorination system shall be housed in an air conditioned building. The building shall include a fire sprinkler system and be designed to the latest COP building code. The Engineer shall coordinate with the COP Water Services Department for the COP standard layout required.
b. Linear polyethylene storage tanks with secondary containment sump.
c. Chemical metering pumps that meet the requirements specified in this section.
d. Sodium hypochlorite solution shall be from 1 to 12 percent sodium hypochlorite.
e. Sodium hypochlorite metering pumps, piping, valves, electrical systems, and controls.

f. All equipment shall be constructed of materials compatible with sodium hypochlorite solution.

6.10.3 Capacity and Points of Injection

The system shall be designed for a capacity of sufficient magnitude to maintain chlorine residual at the injection point of the distribution network of 0.2 to 2.0 mg/L, unless otherwise revised through the COP. Chlorine gas or sodium hypochlorite solution shall be injected at the circulation pump station discharge manifold. In addition, chlorine gas or sodium hypochlorite solution shall be injected at the pump station or reservoir gravity outlet pipe prior to entering the distribution system. A sample shall be taken downstream of each injection point and routed to a chlorine/pH analyzer. Capacity of the chlorination system shall be based on the following;

a. Maximum discharge rate for pump station and/or reservoir gravity outlet pipe.

b. Designed to increase the residual of the total reservoir volume from 0.2 mg/L to 2.0 mg/L in a 24 hour period.

6.10.4 Chemical Solution Piping

Chemical solution piping shall be schedule 80 chlorinated polyvinyl chloride (CPVC) pipe. All isolation valves shall be CPVC diaphragm valves with either union or flanged ends. The Engineer shall coordinate with the COP to determine if buried underground chemical piping shall be double-wall type with leak monitoring system or single wall direct bury. Overhead interior piping shall not be double contained unless the COP Water Services Department requires it for safety and to prevent leaks where personnel or equipment could be impacted. The Engineer shall coordinate with the COP Water Services to determine if exterior chemical solution piping shall be double contained.

6.10.5 Storage Tanks

Chemical storage tanks for sodium hypochlorite storage shall be linear fiberglass reinforced polyethylene designed and manufactured in accordance with applicable ASTM Standards. Storage tanks shall be furnished with inlet, outlet, visual level indicator and transmitter, vent and drain nozzles with an access manhole. Storage tanks shall be provided with a lined containment basin or dike sized in accordance with the (IBC). The containment area shall have a liquid detector with indicator light as well as discrete output to SCADA. Tank size shall be calculated based on 30 days of usable storage volume, not tank volume.

6.10.6 Safety

At a minimum, a combination eyewash/shower that utilizes potable water shall be provided within an envelope of the hypochlorite storage area or gas cylinder storage area, and metering pump system as determined by the more stringent of local regulations or OSHA. System shall be fitted with an alarm annunciated to SCADA and follow the latest COP electrical, instrumentation, and control design standards.

6.10.7 Chemical Injection Using an Eductor

A venture eductor and service water booster pump shall be used for chlorine gas injection. The eductor shall be of polyvinyl chloride (PVC) material. The booster pump shall be sized to create sufficient pressure such that the eductor creates enough vacuum at the suction port and initiates a pressure differential between the inlet and outlet ports greater than the injection point discharge line. The booster pump shall be vertical multi-storage centrifugal type.

6.10.8 Chemical Metering Pump

Chemical metering pumps for sodium hypochlorite solution service shall be peristaltic type and suitable for chemical metering service. The metering pumps shall be manufactured by Pulsafeeder. Each pump shall be complete with base, drive and tubing. Metering pumps injecting into circulation pump station discharge manifold and the reservoir outlet pipe shall be controlled by flow and residual. Accessories shall include calibration column, and all other appurtenances for a complete and functional dosing system. The following shall also be provided:

a. One 4-20 mA analog input for dosage control.
b. One discrete output for common alarm to SCADA.
c. One 4-20 mA analog output.
d. Manual and remote controlled dosage control.
e. Chemical injection quill with appropriate material at the point of injection.
f. At least one installed standby pump.

6.10.9 Sample Lines

Sample lines shall be sized to provide fresh and representative samples to the chlorine/pH analyzers. Sample line sizes and the location of sample points, metering pumps and analyzing equipment shall be coordinated by the Engineer through the COP.

6.10.10 Residual Analyzers

Residual analyzers shall be provided to sample chlorine residual as appropriate for controlling chlorine residual and equipped with 4-20 mA analog output. Chlorine/pH analyzers shall be located as close to the chlorine dose point as possible to reduce the chlorine level lag time.l A chlorine/pH sample shall be taken downstream of each chlorine injection point and monitored by a chlorine/pH analyzer.

6.10.11 Chlorine Residual Sampling

Options for the disposal of sample water shall be submitted to the COP for review and approval prior to implementation. Sampling systems shall be pressurized using either system pressure or a system supply pump and/or a residual analyzer return pump.

6.11 Heating, Ventilation and Air Conditioning (HVAC)

Heating of pump stations, PRV stations and well head facilities is only required to prevent the freezing of equipment or treatment processes with automatically controlled heaters in the equipment areas and on piping systems with a heat trace system per the WSD Guide Specifications. A thermostat controller shall be installed that trips when the room reaches 40 degrees F and turns off at 50 degrees F, or where heaters are used, temperatures should be maintained at or above 40 degrees F. The City of Phoenix has Freeze Protection Guidelines that require a hard wired heat trace system and split foam insulation to piping to pressure switches and transmitters, control lines and pilot controls, and PRVs and control valves.

Ventilation of all buildings is required. Design ventilation rates shall provide a minimum of six complete turnovers of air per hour. Because HVAC design is complex and, therefore, requires a specialist, discussions herein will be general in nature.

Heating, ventilation, and air conditioning equipment shall be of a safe type to provide protection of pumping equipment and accessories, as well as protection of station personnel.

Air conditioning shall be provided for disinfectant buildings. For pump stations with VFD units, an air conditioning (air handling) unit shall be provided. Air handling units shall be designed to prevent maximum room or panel temperatures from exceeding 75 degrees F. Where applicable, the designer shall use multiple, commercial grade, common-size air conditioning units to balance the air flow, rather than use one larger unit.

HVAC and Freeze Protection system requirement shall be defined in the Preliminary Design Report, which shall be submitted and reviewed by WSD. HVAC systems shall be designed by a mechanical engineer, licensed to practice in the State of Arizona.

6.11.1 Applicable Codes and Standards

The ventilation and air conditioning systems shall be designed to satisfy the following codes and standards unless superseded by more stringent requirements:

a. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
b. Chlorine Institute.
c. Clean Air Act of 1990 Guidelines
d. National Electric Code (NEC)
e. National Fire Protection Association (NFPA) 90A
f. Sheet Metal and Air Conditioning Contractors National Association (SMACNA) Standards
g. NFPA 5000
h. Uniform Fire Code
i. Uniform Mechanical Code
j. Phoenix City Code
k. Other local codes, ordinances, and regulations

Because of concern for the environment, the U.S. Environmental Protection Agency (EPA) and local codes may have special requirements and/or limitations regarding equipment or materials used for ventilation systems. The design consultant and its subconsultants shall be aware of these requirements/restrictions and others that may supersede more general industry codes and standards. For example, the use of Freon as a refrigerant has been and continues to be heavily regulated. Electrical equipment associated with the ventilation system shall be UL listed and conform to NEMA Standards.

Buildings must comply with the NFPA 5000 according to the occupancy rating, and NFPA 820. All buildings shall be well ventilated by means of windows, doors, roof ventilators, or other means approved by WSD and PDD and shall be secured against unauthorized access. All building should have proper insulation, as well, to meet current standards. All rooms, compartments, pits and other enclosures below grade for which access is provided, which must be entered and in which an unsafe atmosphere may develop or excessive heat may build up by operating equipment, shall have adequate forced ventilation. The HVAC equipment shall be capable of producing at least six (6) complete room volume changes of air per hour. Rooms containing equipment or piping shall be adequately heated, vented, and if necessary, de-humidified. Where practicable, ventilation should be supplemented by insulating the building, equipment, and piping. Switches controlling forced ventilation shall be located outside such compartments.

6.11.2 Equipment Layout

HVAC ductwork and systems are typically the first mechanical items installed in a building once the structure frame has been constructed. These systems must comply with the NFPA 5000. The ventilation and air conditioning systems shall be designed with adequate space for installation, operation, and maintenance accessibility and with regard for other trades. Air ducts to aboveground piping, louvers, and vents shall be adequately sized to reduce noise generation and transmission. The use of “sound traps”, duct insulation, sound baffles, etc. will be used to reduce the transmission of facility noise. (See Section 13, Noise Control and Abatement, for additional requirements concerning sound attenuation). All vents and louvers open to the outside shall be screened with heavy galvanized wire mesh (maximum opening: ½-inch). The ventilation equipment shall be controlled by a thermostat and an HOA entry switch. Failure alarms shall be hardwired to the main station control panel and to the station’s SCADA System.

Electrical equipment associated with the ventilation system shall be UL listed and conform to the National Electric Code and City Code.

6.12 Washdown Systems

The design consultant shall provide washdown piping with hose bibbs mounted on the interior of each pump station and PRV station, with a minimum of one per wall. The washdown system shall be connected to and metered from the City’s water system. Hose bibbs shall be ¾-inch and conveniently located for station housekeeping service. Each hose bibb shall be provided with a hose rack and a 50-foot, ¾-inch hose.

The design consultant shall ensure all utility water connections to the potable waterlines shall be protected by a backflow prevention/air break system. Utility water piping shall be Type K Rigid Copper pipe. All isolation valves shall be brass body, ¼ turn, ball valves.

6.13 Fire Protection

Fire protection measures for pump stations, well facilities, and PRV stations, i.e., fire hydrants, fire department siamese connections, sprinklers, fire alarms, fire extinguishers, etc. shall be in accordance with PDD, the City Fire Department, the UBC, and the UFC requirements. If a fire suppression system is required, it is recommended the sprinkler system, along with fire and smoke alarms, be provided under a performance specification, with the Contractor obtaining the necessary permits.

All fire alarms shall be designed and installed to report to a SCADA control system; the design consultant shall discuss this with WSD's security group for specifics. The fire detection alarms should have 3 alarm stages – active, trouble, and alarm. The design engineer shall consult with WSD and the City Fire Department to determine fire protection requirements for each facility. Appendix D is a Memorandum of Understanding (MOU) between WSD and the Fire Department discussing an exemption for automatic sprinkler systems for certain electrical control buildings at water/wastewater facilities.

6.14 Pressure Reducing Stations (PRV's)

In general, PRV's or pressure regulating valves are required in areas of the distribution system that can provide source water to a pressures zone operating at a lower elevation. These PRV's are used to control or maintain a zone split between distribution zones when transferring water from one zone to another. For the purposes of this design manual, this section will concentrate on the City's requirement for PRV's located on public distribution mains. These valves will typically be located on their own site or included as a part of a pump station facility.

For PRV facilities, hydraulically operated, direct acting, single seated, pilot controlled diaphragm type globe valves with a pressure-sustaining feature shall be used. PRV's shall be no larger than 12-inches in diameter and no smaller than 4-inches in diameter without WSD approval. PRV station piping shall be a minimum of 6-inches in diameter. A PRV shall be used to provide a maximum differential pressure reading of 40 psi; for pressure drops greater than 40 psi, two PRV's shall be used in line or series. Connecting mains with diameters of 16 inches and less shall have an additional, smaller PRV in parallel with a higher capacity PRV to control lower flows. Larger diameter pipelines, 30 inches through 72 inches, shall have more than one PRV in parallel. Once the design consultant has determined the range of system pressure experienced by the project, development, residence, business, etc., PRV's shall be sized and selected to ensure a regulated pressure range while providing an appropriate supply of water. As with pumping facilities having a firm capacity, PRV stations shall be able to meet the required peak hour domestic plus fire flow, with the largest PRV closed as well as low flow conditions.

PRV stations shall include a valve control system, which includes pilot controls for the pressure reducing and pressure sustaining functions. Pilot controls shall be field adjustable to accommodate any setting in the range of 30 psi to 300 psig, unless specified otherwise by WSD.

PRV facilities shall be located on a dedicated site adjacent to a traveled roadway out of the right-of-way or public utility easement (PUE). PRV's shall be installed above ground unless approved by WSD for easy operation and maintenance and to avoid "confined space" issues. PRV's shall be installed horizontally so the flow arrow matches the flow through the line. Similar to the issue of flexibility and layout for system pumps, as discussed in Section 8.3, Site Layout, expandability, land, and maintenance requirements also apply to PRV facilities. These issues should be discussed and carefully reviewed with WSD to establish the required number of pressure reducing valves and the preliminary layout of the PRV piping/facility. As a rule of thumb, the number of PRV's in a station is a function of the total flow through the station and the recommended flow ranges for 4-inch through 12-inch, hydraulically controlled globe body valves. The facility flow capacity is determined similar to a booster pump station, based on the diameter of the downstream piping and limiting the flow velocity through the station piping to five (5) feet per second. Parallel piping shall allow combined flows through the PRV station. Parallel piping shall incorporate multiple PRV's with and shall be a minimum of 4 inches in diameter, provided the flow velocity through the pipe is not in excess of five (5) feet per second. This piping shall be constructed of ductile iron pipe per Sections 8.8, 11.2, and 11.17.1 of this design manual. The design shall include isolation valves on both the upstream and downstream sides of each PRV and on the bypass piping. Isolation valves shall be either butterfly or gate valves per the requirements of Section 11.5.3, herein. The design consultant shall also include 4-inch diameter pressure gages on both the low-pressure and high-pressure mainlines. Diaphragm seals shall also be included. See Section 11.16.10 – WSD Standards – Pressure Gages.

The City WSD has expressed concerns that if a PRV fails in an open condition, the systems intended to be protected from high pressure are now subject to damage. As a result, the City requires that all PRV stations, facilities, etc. be fitted with an additional PRV on the regulated (low) pressure side of the station, downstream of the station's bypass piping. In this way, if the station fails, the additional PRV will be used to provide temporary protection of piping, business, developments, homes, etc. from high pressure damage.

Depending on control requirements and direction by City Staff, a stand-by generator may be required to serve the PRV station; standby generator systems are typically not required in PRV stations. If power backup is required and the voltage requirements are low, it is recommended the design consultant investigate the use of interruptible power supply (DC) units.

Pressure reducing stations shall be designed to include permanent metering and the ability to field verify their accuracy. Flow meters shall be installed per the flow meter manufacturer's recommendations regarding pipe lengths, orientation, etc., see previous discussions regarding flow meters.

Figure 10-2 shows a typical site layout schematic for a pressure-reducing station. All PRV's shall meet the WSD Guide Specifications.

6.15 Summary

Typically, discharge piping shall be above ground where the valves and meters will be installed. Below ground valve pits or meter pits are to be avoided, except under unusual site conditions and special approval by the WSD. Chemical storage, secondary containment, and chemical feed equipment shall be provided for supplying disinfecting chemicals in a building. Electrical gear, pump controls, SCADA equipment and other equipment shall be required to have a shade canopy. The station shall be provided with block perimeter wall and access gates meeting the Department's security standards and City Fire Department Standards. On-site stormwater retention shall also be provided.

The preliminary design report shall include a site plan (1"=20' scale) showing the footprint location of the facility's structures and components described in the above paragraph and elsewhere herein. The report shall include system head calculations using Hazen-Williams equation for C= 90, C=110 and C=140. To calculate the system head a piping schematic at the station along with a plan and profile of the proposed discharge system is required; the hydraulic grade line shall be plotted on the plan and profile and be presented in the report. The system head curve shall be plotted in graphical format and the selected pump curve(s) plotted on the same graph with the pump operating points clearly identified. Two recommended literature sources regarding system head computations and pump station design are Sanks, "Pumping Station Design" and Karassik, "Pump Handbook", (see Section 19 – References).

The minimum number of pumps required to meet the station's design capacity, plus one more equal to the largest of the required pumps (firm capacity), shall be provided. If the station will be phased, that is, additional and/or larger pumps will be installed over time to meet increasing flow requirements, pumps must be selected for each anticipated upgrade and be presented and discussed in the preliminary design report. Although covered in other sections herein, it is worth noting here that electrical and instrument control conduit sizes and numbers, motor control and instrument control panels, and control building floor space must all be sized for the ultimate pump and station size.

6.16 Equipment

The WSD has identified minimum requirements (design criteria) for pumping facilities, wells, and PRV stations. With only a few exceptions, primary pumping equipment shall be specially selected for individual application/service. Furthermore, the City has established specifications for each piece of equipment, and other aspects of design and construction of pumping facilities, PRV stations, and well facilities. These specifications are the WSD Guide Specifications, and are available from WSD. Those listed design criteria and others associated with piping configurations, pumping units, and pump motor and motor control in pumping facilities, booster pump stations, wells, and PRV stations have been reviewed, discussed with, and approved by WSD.

Listed below are major pieces of equipment found in pump stations, PRV stations, and/or well facilities. **All equipment provided shall meet the WSD Guide Specifications**.

6.16.1 WSD Standards – Station Piping

Buried yard piping:

a. Pipe diameters 16-inches and less: Flanged, ductile iron pipe, AWWA M41, AWWA C110, C111, C115, C150, C151 and MAG 750, shall be encased in polyethylene encasement per ANSI/AWWA C150/A21.50 and MAG 750.5 or prefabricated, cement-mortar-lined and coated, welded steel water pipe, ANSI/AWWA C200.

b. Pipe diameters 18-inches to 42-inches: Prefabricated, cement-mortar-lined and coated, welded steel water pipe, ANSI/AWWA C200, or reinforced, concrete steel cylinder pipe, either (Pretensioned Concrete Steel Cylinder Pipe), ANSI/AWWA C303, and MAG 758 or (Prestressed Concrete Steel Cylinder Pipe), ANSI/AWWA C301 and C304, and MAG 758.

c. Pipe diameters greater than 42-inches: Cement-mortar-lined and coated, reinforced, welded steel pipe, (Prestressed Concrete Steel Cylinder Pipe), ANSI/AWWA C301 and C304, and MAG 758, or Prefabricated, cement-mortar-lined and coated, welded steel water pipe, ANSI/AWWA C200.

All buried piping below concrete slabs or block walls shall be flanged or restrained joint and backfilled with ABC slurry.

Exposed piping shall be one of the following:

a. Pipe diameters greater than 16-inches: Prefabricated Cement-mortar-lined, primed/painted, welded steel water pipe, ANSI/AWWA C200 and AWWA M13.

b. Pipe diameters 16-inches and less: Cement-mortar-lined, primed/painted, flanged, ductile iron pipe, AWWA M41, AWWA C150, C151, C104, and MAG 750.

c. Chemical piping shall be designed per the requirements detailed herein and in the WSD Guide Specifications.

d. Freeze protection with Heat Trace System per WSD Guide Specifications.

6.16.2 WSD Standards – Pump System Components

Design consultant shall provide the following:

Booster Pump Station, Well Head, and PRV Station Piping:

a. Suction piping shall be arranged to avoid high points where air may collect. Where reducers are required in horizontal piping, they shall be bottom eccentric.

b. Discharge piping shall have top eccentric reducers as necessary to avoid high points. Dissolved air has less tendency to come out of solution on the discharge side than on the suction side, but if air pockets are allowed to accumulate, they will restrict flow. Provide a combination of air/vacuum relief valves and pipe to drain away from the pump pad.

c. Pumps shall have isolation gate valves located on the suction and discharge sides at the manifold connections of each pump.

d. Liquid filled pressure gauges shall be provided on the discharge side of each pump as shown in Figure 6-1 on both sides of pump control valve, and shall be specified with diaphragm seals; see WSD Guide Specification.

e. Combination air/vacuum relief valve shall be provided on the suction side of each the pump.

f. Provide piping supports and hold-down straps to keep all weight off of the pump.

g. In booster pump stations, wells, and PRV stations that incorporate the use of a building or other structure, arrange piping to avoid situations where pipes are less than 8 feet above the floor or obstruct passageways or access to valve actuators. Provide hatch and door openings of sufficient dimension to facilitate the removal of both pump/motor, and major equipment.

h. Discharge piping shall include (See Figure 6-3 on pg. 45 for an example plan and section view for discharge piping):
   - End spools (flanged).
   - Spool with NPT tapped outlets or welded coupling with a 90˚ ball valve to accommodate a flow sensor and pressure gage and/or pressure switch.
   - Spool with NPT tapped outlets or welded coupling with a 90˚ ball valve to accommodate an air vacuum/air release valve (if required by design).
   - Dual chamber pump control valve or silent check valve when VPDs are used.
   - Isolation valve (flanged).
   - Eccentric reducer/increaser.
   - Wye fitting (flanged).

i. Pump discharges shall be joined to a common discharge header, which shall include a flow meter with isolation valves. All flow meters shall require a bypass. The design consultant shall pay close attention to the distance (number of straight-run pipe diameters required by the flow meter manufacturer) both upstream and downstream of the flow meter to ensure accurate measurement.

j. A high pressure relief valve shall be provided between the discharge header and suction manifold (as required). The high-pressure relief valve shall be designed to relieve the discharge line back to the suction manifold or reservoir.

k. Design pipeline, joints, fittings, valves, and various piping system appurtenances to resist upsurge and down surge pressures. All facility piping shall be restrained joint type.

l. See Section 11.5 for the types of required isolation valves, check valves, air release valves, combination air vacuum/air release valves, etc. See the WSD Guide Specifications for specific requirements of valves.

m. Below ground yard piping, Ductile Iron Pipe, shall be encased in polyethylene encasement per ANSI/AWWA C105/A21.5, MAG 610, and the Phoenix Supplement thereto.

<u>Pump Motors</u>:
For specific motor requirements, see the WSD Guide Specifications, which take precedence.

a. Prime mover: Electric motor of US, premium-efficiency design, NEMA type, totally enclosed and fan cooled (TEFC), squirrel cage induction type with Class F insulation with Class B rise, designed and applied in compliance with NEMA, IEEE, AFBMA, NEC, HI and ANSI.

b. Electrical motors from 1/2 hp to 200 hp shall be rated at 208/240/480 Volts, 3 phase, 60 Hz.

c. Electrical motors from 200 hp to 400 hp shall be rated at either 480 or 4,160 Volts, 3 phase, 60 Hz. (WSD reserves the right to modify this requirement depending upon design and operation flexibility).

d. If conditions warrant, electric motors larger than 400 hp can also be rated at either 480 or 4,160 Volts, 3 phase, 60 Hz. (WSD reserves the right to modify this requirement depending upon design and operation flexibility).

e. If smaller motors are operating in the same group as larger motors, motors as small as 100 hp may also be rated to match the larger motor’s voltage, i.e.; 480 or 4,160 Volts, 3 phase, 60 Hz.

f. Line-shaft vertical turbine and horizontal split case pumps: minimum motor/pump speed shall be 1,200 rpm.

g. Line-shaft vertical turbine and horizontal split case pumps: maximum motor/pump speed shall be 1,800 rpm. (WSD reserves the right to modify these minimum and maximum requirements depending upon design and operation flexibility).

h. Submersible vertical turbine pumps: nominal motor/pump speed shall be 1,800 rpm. (WSD reserves the right to modify this requirement depending on design and operation flexibility).

i. Motor noise shall be less than 90 dBA at a distance of five (5) feet from the motor. (See Section 13 – Noise Abatement and Control for noise limitations.)

j. The motor torque and locked rotor characteristics will be as outlined in the NEMA standards for Design B and shall be selected to be non-overloading throughout the driven pump’s full speed performance curve.

k. The motor shall be of the solid-shaft type, steel cast, and adapted to a four (4)-piece coupling assembly that will adapt to the bowl shaft assembly.

l. Motors shall be specified for a 50 degree Celsius ambient temperature.

m. Submersible vertical turbine pump motors shall be rated for 60 degree Celsius.

n. Project specifications shall include a requirement for the manufacturer to conduct a vibration analysis and prepare a summary report for submittal to WSD, prior to delivery of the motors.

o. Where used in conjunction with adjustable speed drives, provide electric motors fully compatible with the variable speed controllers. Where used with constant speed pumps, provide power factor correction capacitors with soft start and stop motor starters.

p. Constant speed pump motors 50 hp, 460 V and larger shall be provided with soft starters.

q. All motors except those for variable-frequency drive systems shall have a service factor of 1.15.

r. Variable frequency drive (VFD) system motors shall have a service factor of 1.20 (or 1.15 and derated by 5% of nameplate horsepower and shall be specifically designed for operation with the 5% of nameplate horsepower) and shall be specifically designed for operation with the selected variable-speed drive in the specific application.

s. Motors installed outdoors shall have temperature ratings adjusted to suit ambient operating conditions and be totally enclosed and fan cooled (TEFC), squirrel cage induction type with Class H insulation with Class B rise, designed and applied in compliance with NEMA, IEEE, NFPA, and the NEC.

t. Constant speed pump motors shall not be loaded to use more than 80 rated horsepower.

u. Variable speed pump motors shall not be loaded to use more than 80 rated horsepower.

Pumping Units:

For specific requirements, see the WSD Guide Specifications, which take precedence.

UL/NSF Approval

a. Depending on the site conditions, the design consultant shall specify either a single or two-stage split-case horizontal centrifugal type electric motor-driven pump through a flexible coupling or a vertical multistage turbine, pit, or barrel-mounted, water-lubricated-type pump having impellers of such design that the head-capacity curve is slightly better than what the designed system requires. Pump shall be driven by vertical, solid-shaft electric motors.

b. Pump suction headers: the pump suction supply line shall satisfy a velocity criteria of less than or equal to three (3) feet/second.

c. Individual pumps; the pump suction supply line shall satisfy a velocity criteria of less than or equal to three (3) feet/second.

d. In pump stations, well facilities, and PRV stations incorporating the use of a building or other structure, provide embedded lifting eyes and/or a hoist and rail above pumps and other major equipment including a passageway to facilitate their removal.

e. The pump bowl assembly shall be of close-grained cast iron, Class 30 or better. The bowl assembly shall be fitted with a baffle basket strainer designed to reduce potential vortex formation. The bowl should be spiral cut for proper bearing lubrication.

f. ASTM A193 316 SS and ASTM A194 316 SS nuts and bolts shall be used on all bowl connections. Pump bowl assembly shall be internally coated (lined) with a minimum of (20) mils of porcelain.

g. Impellers shall be ASTM B148, Nickel Aluminum Bronze Alloy C95800, Aluminum Bronze Alloy (no zinc) ASTM B148 C95200 or equal.

h. Pump shaft shall be of ASTM A276 Type 416 SS, with no more than 2000ths of an inch run out. Specify the use of 660 bronze bushings with 3,000ths to 6,000ths of an inch clearance per 1 inch of shaft outer diameter. The use of rubber bushings shall not be acceptable.

i. Shaft bushings shall be no more than five (5) feet apart.

j. Pump shaft seals shall be packed-stuffing box type; provide external seals, ceramic – rotating/carbon- stationary.

k. A drain off around the shaft seal shall be provided.

m. Number of pump cycles or starts per hour will vary depending on the size of the pump motor. Typical limitations on starts will vary due to the load, load torque, voltage applied, ambient temperature, etc. The motor manufacturers should be consulted where there is any consideration for repetitive starting. Excessive motor wear, shortened service life, and starter damage can result from starting frequencies being more than the manufacturer's recommendation.
Maximum number of pump starts range from:
   - 8 to 12 starts per hour for motors 15 Hp and less.
   - 4 to 8 starts per hour for motors 15 Hp to 200 Hp.
   - 1 to 4 starts per hour for motors greater than 200 Hp.

n. The pump casing shall be of close-grained cast iron, ASTM A48, Class 30 or better, free of blow holes and defects, and shall be accurately machined.

o. The motor housing shall be of close-grained cast iron, ASTM A48, Class 25 or 30, free of blowholes and defects, and shall be accurately machined, and shall have UL, FM, CSA, and/or NSF International approval.

p. Impellers shall be dynamically balanced in accordance with the latest edition of the Hydraulic Institute Standards.

q. Pump shaft seals shall require neither maintenance nor adjustment and shall be easily replaceable. The shaft seal shall be component seal type. Rotating metal parts shall be Type 316 stainless steel. A needle valve and pressure gauge shall be installed on the stuffing box inlet. See the WSD Guide Specifications for additional information.

<u>Pump Head</u>

a. The use of cast or fabricated pump heads shall be approved during the early phases of design by WSD.

b. The pump head shall be of heavy-duty steel fabrication with lifting lugs, adapter flanges to fit appropriate pump cans and flanges, and fitted with an external seal with flushing line. Spacers will not be acceptable for use.

c. If steel fabricated heads are being provided provisions for draining the seal (nuisance) water completely from the head will be required.

d. The head shall be provided with a removable sealed access to allow testing of static and pumping water levels. Access shall be provided through a 2 inch minimum diameter pipe with no internal ledges, burs, or obstructions that would cause a sounding wire and head to become snagged. If curves are required in order to facilitate access to the testing tube, long radius bends with a maximum curvature of 45 degrees shall be used. If sound attenuated cabinets are also used to house the pumps, care shall be taken during design to ensure that adequate room is provided within the cabinet for access to the testing tube.

e. The head shall also be adapted with a sweeping 90 degree discharge flange with 1-inch spuds for air relief devices.

f. The top of the head shall be standard NEMA fit with the register to fit the pump motor and with the register fit not more than 8,000ths of an inch clearance.

<u>Pump Cans</u>

a. Water velocity between the largest obstruction in the pump assembly and the can shall not exceed the lesser of the two values, five (5) fps or the requirements of the latest edition of the Hydraulic Institute Standards.

b. Pump cans shall be of a sufficient diameter to avoid short circuiting flow as well as restricting the flow of water into the pump inlet. The City requires cement-lined steel cans with bolt-on flanges and AWWA-specified coatings. The cans shall be of a sufficient depth to accommodate the pump. In order to reduce the potential for pump cavitation, the pump impeller shall be mounted a minimum of 1½ times the diameter of the pump bowl away from the bottom of the pump can. This distance or clearance has been presented in various texts as a function of the pump inlet diameter. Source water flowing into the pump can shall be per the latest edition of the Hydraulic Institute Standards; this prevents short circuit flow when submersible motors are required. It is recommended that the design consultant consult with various experts in the field of pumping to verify the minimum clearance required for their particular design condition.

CHAPTER 7 - RESERVOIRS

7.1 General

This chapter describes the information needed to proceed through the conceptual design report, preliminary design, and final design phases for the construction of both steel and concrete reservoirs. For these applications, a reservoir is defined as a facility that provides operational, emergency, and fire protection storage, as well as regulation and control of potable water. The reservoirs shall provide a minimum design service life of 50 years.

a. It is the responsibility of the Engineer to ensure all requirements within Chapter 6 adhere to the State of Arizona standards and codes. The Engineer is responsible for the final design and contents of this section and shall not absolve the Engineer of the responsibility to design in accordance with all federal, state, and local requirements. The design criteria for steel and concrete reservoirs are governed by the guidelines of this chapter as well as the standards and codes amended by the City of Phoenix.

b. It is the Engineer's responsibility to make reference to and/or utilize industry standards not otherwise directly referenced within this document.

7.1.1 Site Selection

Site selection requires direct coordination with City of Phoenix Water Services Department to ensure the design meets the requirements of the water system master plan for the project as well as the City of Phoenix Water Master Plan. Final selection of the site will be approved, upon review and modification, if necessary, by the City of Phoenix. The list below describes site selection criteria specific to reservoir design. In addition to the following, the Site Civil Design described below must be evaluated:

a. Proximity to existing and future water pump stations.

b. Distribution system hydraulic capacity requirements including overflow elevations.

c. Access to facility including staging plan and construction access.

e. Sit drainage.

f. Future expansion.

7.1.2 Permits – See Chapter 3 for all permitting requirements

7.1.3 Security Features

City of Phoenix Water Services Department will evaluate all proposed project design information for compliance with the department's security standards. The City of Phoenix will determine whether or not the Engineer is required to include security features into the project contract documents for all new facilities or the expansion of existing facilities, as required and described in Chapter 12.

7.1.4 Volume Criteria

Volume criteria will be provided by COP Water Services Department.

7.2 Geotechnical Investigations for Reservoirs

Geotechnical services related specifically to design of reservoirs shall be provided by a Geotechnical Engineer experienced in geotechnical evaluation of water storage reservoir sites. The Geotechnical Engineer shall be responsible for determining the specific foundation design criteria and site conditions as described in these guidelines. In addition the Geotechnical Engineer shall:

a. Evaluate seismic parameters specific to the proposed reservoirs.

b. Provide both geotechnical data and recommendations specific to foundations supporting reservoirs, including appropriate values for lateral support, bearing capacity and modulus of subgrade reaction values for reservoirs supported on large mats.

c. Provide an evaluation of soil corrosivity and recommendations for cathodic protection.

f. Provide backfill and drainage recommendations for soils used as wall backfill for subsurface reservoirs.

e. Provide soil stabilization and/or specific earthwork specifications for soils supporting large reservoir foundations, including stabilization recommendations in the event that subsurface soils become saturated.

7.2.1 Subsurface Vaults

Geotechnical services related specifically to design of deep subsurface vaults shall be provided by a Geotechnical Engineer experienced in geotechnical evaluation of subsurface vaults. The Geotechnical Engineer shall be responsible for determining the specific foundation design criteria and site conditions as described in these guidelines. In addition the Geotechnical Engineer shall:

a. Provide excavation considerations down to the invert elevation of proposed vaults, including an evaluation of possible cemented soil, bedrock, cobbles, or boulders that may be encountered during excavation or at the proposed subgrade elevation.

b. Provide shoring or slope considerations for deep excavations and anticipated minimum setback distances from any existing structures.

c. Provide design values for soil anchors when necessary.

d. Address potential for differential settlement between near-surface structures and interconnected deep vaults, including mitigation measures.

e. Address lateral earth pressures throughout the anticipated depth of deep vaults, including pressures from adjacent structures or anticipated traffic.

f. Address groundwater considerations and any uplift pressures that could occur when vaults with invert elevations below the static groundwater elevation are to be drained.

g. Address compaction considerations for soil adjacent to subsurface walls to mitigate the potential for wall failure from heavy equipment or compaction loads.

h. Provide static and seismically induced lateral earth pressures for anticipated backfill conditions behind subsurface walls.

i. Provide net allowable bearing capacity values for soils supporting deep subsurface vaults including a suitable factor of safety.

7.3 Site Civil Design

General: The Engineer shall provide a Site Civil design for facilities. Also see Chapter 10.

7.3.1 Site Safety

All access, safety, and structural components shall be designed per current OSHA requirements for the safety of City of Phoenix personnel. At a minimum the following safety equipment is required:

1. Ladder cages.
2. Safety climbs
3. Rest platforms.
4. Handrails.
5. Guardrails.
6. Fall protection.
7. Any other appropriate devices to conform to all applicable state and federal requirements for occupational safety and health.

7.4 Structural Design

General: The purpose of this section is to set forth structural and seismic design guidelines for both new reservoir facilities as well as for retrofitting existing facilities. The intent is to establish minimum guidelines as well as reference currently adopted building codes and industry standards. This is intended to serve as an introduction to structural design requirements and should not be construed as an all-inclusive list.

7.4.1 Applicability

This section shall apply to the design, repair and rehabilitation of reservoir facilities, which include the following:

a. Water Retaining Structures: All reservoirs.
b. Buried Structures: All valve vaults and meter vaults.

7.4.2 Reference Standards and Codes

The currently adopted reference standards and code shall be used in the design:

a. American Concrete Institute (ACI).
    1. Code Requirements for Environmental Engineering Concrete Structures and Commentary (350/350R).
    2. Building Code Requirements for Reinforced Concrete and Commentary (ACI 318/318R).
    3. Building Code Requirements for Masonry Structures (530).
b. American Institute of Steel Construction (AISC) Steel Construction Manual.
c. American Water Works Association (AWWA):
    1. Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks (D 110).
    2. Welded Steel Tanks for Water Storage (D 100).
d. International Code Council (ICC):
    1. International Building Code (IBC).
e. Occupational Safety and Health Act (OSHA).

7.4.3 Structural Loads

a. The design criteria presented herein are minimum guidelines. The Engineer is responsible for determining whether or not the minimum guidelines are appropriate for the project.

b. Dead Loads are defined as the load of all material and equipment, which is constant throughout the life of a structure. All roofs shall be designed for (in addition to live and dead loads) a superimposed dead load of 30 psf.

c. Live Loads are defined as the load that a structure is designed to oppose, which includes the constant or ‘dead’ load in addition to any temporary or moving load.

d. The following live loads shall be used at a minimum:

Description	**Minimum Live Load**
Roof Load	More stringent of IBC or local code*
Stairs, Platforms, Walkways	100 psf or per local code
Electrical Equipment Areas	300 psf
Equipment Areas	250 psf**
* Roof Load to include maximum loads due to lifting eyebolts and roof joists.	
** To be verified by equipment information	

e. Wind Loads shall be in accordance with currently adopted code.

f. Lateral Loads shall be designed using soil conditions as defined in the geotechnical report. Hydrostatic pressure shall be included for areas subjected to saturated soil and/or groundwater.

g. Seismic Loads shall be considered in accordance with this chapter.

h. Vibration Loads shall be included where applicable and shall be included based on the equipment manufacturer.

i. Impact Loads shall be considered where applicable.

j. Miscellaneous Loads shall be determined by the Engineer and include but are not limited to the following:

1. Loads due to thermal expansion and contraction.
2. Thrust in pipelines.
3. Vehicular loads on or near structures.

7.4.4 Structural Design Requirements

Reinforced Concrete Structures: The Engineer shall design all reinforced concrete structures per the requirements of ACI 318 and ACI 350R. The following criteria also apply:

a. Minimum Specified Concrete Compressive Strength: 28-day compressive strength of 4,000 psi.

b. Minimum Reinforcing Steel Strength: Yield strength of 60,000 psi per ASTM A 615.

b. Where the concrete is exposed to sulfate containing soils, the Minimum Specified Concrete Compressive Strength shall be increased as required by ACI 318. Cement in concrete exposed to sulfate shall be Type U.

c. Joints: Expansion and construction joints shall be provided to allow flexibility and to adequately tolerate differential movements and shrinkage stress. Joints shall be in accordance with ACI 350R to mitigate cracking.

d. The following types of joints should be considered:
    1. Expansion joints.
    2. Contraction joints.
    3. Construction joints.

7.4.5 Concrete Foundations

The Engineer shall design concrete foundations in accordance with the recommendations of the geotechnical report and in accordance with this chapter. The following items apply to concrete foundations:

a. Mat Foundations shall be designed as a slab on an elastic foundation with construction, expansion, and contraction joints per ACI 350R.
b. Turndowns at slab edges shall be cast monolithically with floor slab.
c. All foundations shall be provided with construction, expansion, and contraction joints per ACI 350R. Only PVC waterstops shall be used. Waterstops at construction joints shall be ribbed. Waterstops at expansion joints shall have bulbs.

7.4.6 Concrete Walls

The Engineer shall design concrete walls considering the following:

a. Cantilever walls with active soil pressure.
b. Walls restrained at the top with at rest soil pressures.
c. Cantilevered Walls shall consider restraint at end walls or cross walls.
d. Construction joint spacing shall not exceed 40 feet.
e. Minimum reinforced concrete wall thickness shall be 8 inches
f. Minimum thickness for reinforced concrete walls greater than or equal to 10 feet high and retaining water shall be 12 inches.
g. Vertical wall construction joints shall align with the floor joints. Construction joints shall utilize (as a minimum) 3/8-inch by 6-inch PVC ribbed waterstop and 3/4-inch triangular sealant grooves. Expansion joints shall utilize (as a minimum) 3/8-inch by 9-inch PVC ribbed waterstop and 3/4-inch triangular sealant grooves
h. Two techniques are recommended to reduce the tendency for vertical wall cracking that results from footing restraint:
    1. The wall shall be keyed into a joint at the tip of the wall footing. In order to minimize water demand from the footing on the fresh wall concrete, the keyway in the footing should be kept wet until the wall concrete is placed.
    2. Additional horizontal reinforcing shall be placed in the bottom 3 feet of the wall.

7.4.7 Concrete Floor Slab

The Engineer shall design concrete floor slabs considering the following:

a. Reservoir floor slabs shall be sloped to provide adequate drainage to the reservoir outlet or sump.
b. Minimum thickness: In accordance with this chapter. (10-inches)

c. Joints: Control joints, construction joints shall be provided in the slab structure per ACI 350R with roof joints aligned with wall joints.
d. Construction joint spacing shall not exceed 20 feet.

7.5 Concrete Reservoir Design

General: The City of Phoenix Water Services Department concrete reservoir standard is one of the following types:

a. Cast-In-Place Concrete Reservoir.
b. Prestressed Concrete Reservoir with cast-in-place core wall, vertical post-tensioned tendons, and circumferential prestressed strands (AWWA D110 Type 1).
c. Prestressed Concrete Reservoir with precast core wall, vertical post-tensioned tendons, and circumferential prestressed strands (AWWA D110 Type III).

7.5.1 Cast-in-place Reservoir Type:

a. **Cast-in-place** concrete reservoir shall be circular in shape and be complete with foundation, walls, roof, roof hatches, roof vent(s), external stairs or ladder, internal ladders, separate inlet and outlet piping, overflow drain, and all associated appurtenances for a complete and functional system.
b. **Design Criteria**:
    1. The following currently adopted version of standards and codes shall govern and shall be used for the design of cast-in-place concrete reservoirs:
        - International Building Code with the City of Phoenix Amendments.
        - Building Code Requirements for Minimum Design Loads in Building and Other Structures, ASCE 7.
        - Building Code Requirements for Environmental Engineering Concrete Structures and Commentary ACI 350 and ACI 350R.
        - National Sanitation Foundation Standard 61 - Drinking Water System Components.
c. **Seismic Loads**:
    1. Seismic Loads shall be in accordance with the requirements of AWWA D110, IBC and ASCE 7.
    2. The City of Phoenix Annual Facilities Program (AFP) Department shall be consulted for verification of the latest seismic zone designation.
    3. Site specific seismic design recommendations, as provided in the geotechnical report, shall be considered.

7.5.2 Prestressed Concrete Reservoir Type:

a. Prestressed concrete reservoir with cast-in-place or precast core walls, vertically post tensioned tendons (or vertical steel diaphragm), and circumferential prestressed strands shall be complete with foundation, walls, roof, seismic cables, exterior protective coatings, roof hatches, roof vent(s), external stairs or ladder, internal stairs, reservoir hand railing (if required), separate inlet and outlet piping, overflow drain, and all associated appurtenances for a complete and functional system. Circumferential prestressed strands shall be tensioned by elongation methods with continuous electronic monitoring and recording. Prestressing by die drawing will not be allowed.

b. **Design Criteria**: The following currently adopted version of standards and codes shall govern and shall be used for the design of prestressed concrete reservoirs:

1. International Building Code with the City of Phoenix Amendments.
2. Building Code Requirements for Minimum Design Loads in Building and Other Structures, ASCE 7.
3. Wire and Strand-Wound Circular, Prestressed Concrete Water Reservoirs, ANSI/AWWA D 110, Type 1 or Type III.
4. Building Code Requirements for Environmental Engineering Concrete Structures and Commentary ACI 350 and ACI 350R.
5. National Sanitation Foundation Standard 61 - Drinking Water System Components.

c. **Seismic Loads**:

1. Seismic Loads shall be in accordance with the requirements of AWWA D110 as amended by the IBC and ASCE 7.
2. The City of Phoenix AFP Department shall be consulted for verification of the latest seismic zone designation.
3. Site specific seismic design recommendations, as provided in the geotechnical report, shall be considered.

7.5.3 Foundation and Reservoir Floor

a. A structural floor or slab-on-grade foundation is required and shall be a minimum of 10-inches in thickness.

b. The concrete floor shall be cast with construction joints spaced at 40 feet on center, when possible. Curing of the floor shall be done with potable water only.

c. A slab-on-grade type floor shall be designed to transmit loads to the subgrade.

d. At a minimum, a membrane liner on the sub-base and covered with an aggregate sub-base; a liner sloped away from the center of the reservoir; and underdrain system and perimeter drains shall be provided. Drain lines shall be routed to a leak detection manhole that has a float switch that activates and sends an alarm to the SCADA system in the event a high level occurs within the leak detection manhole.

e. The Design Engineer shall be responsible for the design of the foundation and reservoir floor according to codes for live and dead loads and for operating requirements and loading conditions during construction. The allowable loads shall be listed in the contract documents.

7.5.4 Reservoir Roof

a. The roof pitch shall not preclude operators from walking on the roof. Fall protection anchors shall be located where operators can attach to anchors before stepping on the above grade roof.

b. A concrete reservoir shall have a cast-in-place roof or roof framed with precast members. If cast in place, the roof slab shall be 10-inches minimum in thickness. In prestressed concrete reservoirs, the joint between the roof and wall shall be separated by an elastomeric bearing pad. Aluminum or dome roofs will not be allowed.

c. For buried reservoirs, the roof shall be designed for H20 traffic load in addition to the weight of the soil above the roof.

7.5.5 Inlet and Outlet Piping

a. The reservoir shall have a main inlet/outlet line that splits into a separate inlet and outlet pipe prior to entering the reservoir.

b. The main inlet/outlet line shall have a magnetic flow meter located within a vault.

c. The separate inlet and outlet pipe shall be routed under the reservoir and be concrete encased with structural rebar.

d. Inlet and outlet piping shall be ductile iron (AWWA C151) or steel pipe, mortar-lined and coated (AWWA C200 and C205).

e. Inlet and outlet piping shall be designed to ensure water circulation inside the reservoir. The outlet pipe shall be routed to the center of the reservoir and the inlet pipe shall be routed to the perimeter of the reservoir, approximately 8 to 10 feet from the side wall. This configuration provides adequate mixing and limits short circuiting.

f. The inlet should be controlled by a butterfly isolation valve outside the reservoir that can be closed for maintenance or inspection. The valve shall be located in a valve vault.

g. The inlet pipe shall have a short stroke, swing style check valve that has minimal head loss. The check valve shall be located outside the reservoir in a valve vault to permit maintenance. If the maximum reservoir level is less than the maximum allowed by a flapper check valve, a flapper style check valve can be installed and located within the reservoir. The flapper check valve can be installed on the end of the inlet pipe within the reservoir and must be supported.

h. The reservoir outlet pipe shall be located away from the inlet pipe to accomplish maximum water circulation within the reservoir. The outlet pipe should be controlled by a butterfly isolation valve located outside the reservoir that can be closed for maintenance or inspection. The reservoir outlet isolation valve shall be located in a valve vault.

i. The outlet pipe shall have a short stroke, swing style check valve that has minimal head loss. The check valve shall be located outside the reservoir in a valve vault to permit maintenance. If the maximum reservoir level is less than the maximum allowed by a flapper check valve, a flapper style check valve can be installed and located within the reservoir. The flapper check valve can be installed at the entrance to the pipe within a sump that permits access for maintenance and removal.

7.5.6 Drain

a. A reservoir drain shall be provided on the reservoir. It shall have an isolation valve located outside of the reservoir in a vault and be piped to a discharge manhole or storm drain vault. The reservoir drain shall be 8-inches in diameter minimum.

b. All reservoir drains must have an air gap.

7.5.7 Overflow

a. The overflow shall be a concrete weir box located on the interior of the reservoir. For fully buried reservoirs, piping shall enter the weir box through the side of the concrete reservoir wall and be completely buried on the exterior. For partially buried reservoirs, piping shall enter through the bottom of the weir box and exit the reservoir wall near the bottom of the reservoir and be completely buried on the exterior. The length of the overflow weir box shall be such that the maximum water elevation over the weir is less than 16-inches at the maximum possible fill rate. Minimum freeboard shall be provided above the maximum water elevation to prevent uplift forces from sloshing during a seismic event as described in AWWA D110. The overflow system must be designed to discharge into a retention basin or wash and must be two times the diameter of the pipe above the surface of the ground to provide an air gap. The overflow discharge pipe shall be sloped for complete drainage and discharge over a drainage inlet or splash concrete pad without causing erosion.

b. The Engineer shall coordinate with the City of Phoenix Water Services Department to determine the overflow level. Reservoirs that float on the system must have the same overflow elevation for that specific zone.

c. Overflow pipe shall be a gravity line and be sized for the maximum possible fill rate.

d. A flap check valve and air gap shall be provided at the discharge point of the overflow drain if it is piped to a drainage retention basin. A grate and air gap shall be provided at the discharge point of the overflow drain if it is piped to a wash. The grate shall be per the City of Phoenix standard detail.

e. The retention basin shall be sized for 100-year, 2-hour storm event plus a one hour reservoir overflow event at maximum fill rate. If adequate space is not available, the Engineer shall coordinate with the City of Phoenix Water Services Department.

f. A flow sensing device shall be installed within the overflow pipe that will send an alarm to SCADA indicating that an overflow of the reservoir is occurring.

g. Verification in writing shall be provided to confirm that overflows will not impact adjacent properties.

h. An energy dissipater may be required to control erosion at point of discharge of the overflow system.

1. The overflow pipe shall be designed to discharge to an energy dissipater at a maximum flow rate to be determined by the Engineer. The Engineer shall design the energy dissipater to ensure that water within the reservoir is protected from cross-contamination with surface water.
2. The energy dissipater shall be designed by the Engineer in accordance with the latest edition of Maricopa County Flood Control District Hydrologic Criteria and Drainage Design Manual.

7.5.8 Reservoir Access

a. Reservoirs shall have a minimum of two hinged, leak proof, spring-loaded, alarmed, aluminum, and lockable hatches. The hatches shall be as follows:
    1. Reservoir access hatch shall be for accessing the reservoir floor area and shall include a stainless steel ladder with a post safety device that shall be less than 10-feet in length that and will connect to a concrete platform and stair system. The concrete stairs shall be per OSHA requirements and include stainless steel handrail.
    2. Additional access hatches may be required and will be determined by the City of Phoenix Water Services Department.

b. The overflow weir box hatch shall be a minimum 36-inch by 36-inch opening. The reservoir access hath shall be a minimum of 48-inch by 72-inch opening.

c. Each hatch shall have a hold open device, hasp lock, intrusion alarm, and security bar.

d. Hatches shall have a minimum 4-inch curb and the cover shall have a downward overlap of at least 3 inches on concrete reservoirs.

e. If the concrete reservoir is buried, the hatch shall be designed for H20 loading and drainage away from the hatch shall be provided.

7.5.9 Roof Vent

a. Roof vents shall be sized to prevent excess pressure or vacuum buildup during the maximum inflow or outflow of water.

b. A minimum of one vent near the center of the reservoir shall be supplied. Roof venting shall be provided with two (2) stainless steel mesh screens to prohibit entry of insects, birds, or undesirable objects. The insect screen shall be #16 mesh and shall be located behind the vent grille.

7.5.10 Roof Access

a. **General**: The Engineer shall provide roof access for reservoirs via ladders or stairs per the requirements herein. All stairs and ladders shall be designed to meet currently adopted codes and standards.

b. **Internal Ladders**: Shall be constructed of stainless steel.

c. **External Stairs**: Shall be provided as required by City of Phoenix. Stairs shall be constructed of hot-dipped galvanized steel or concrete and shall incorporate the following features:
   1. Minimum stairway width of 48 inches.
   2. Minimum tread length of 12 inches.
   3. Maximum riser height of 7 inches.
   4. Non-slip tread surface.
   5. Aluminum rail system that is OSHA-approved that can withstand 250-pound load applied in any direction.

d. All conduits shall be located behind the ladder or stairs for security.

7.5.11 Underdrain System

a. The underdrain system shall protect against uplift that occurs when the reservoir is drained and to detect excessive leakage from the reservoir. An underdrain system shall be provided for all buried and partially buried reservoirs.

b. Underdrain system shall consist of a perimeter ring drain line, an underdrain pipe grid system under the reservoir, and a membrane liner that will contain any leakage from the reservoir and direct it to the leak detection manhole. The membrane liner shall be installed below the underdrain and ring drain piping system to collect water that may have leaked from the reservoir. The piping for the ring drain and the underdrain shall be perforated PVC surrounded by well graded drain rock consisting of processed gravel with 100% finer than 1.5 inches and 100% coarser than the U.S. No. 4 sieve. Water collected from beneath the reservoir and around the perimeter is discharged to a leak detection manhole.

c. The size and configuration of drain rock, polyethylene or PVC sheeting, filter fabric, and PVC perforated piping shall be determined by the Engineer.

7.6 Steel Tank Design

General: The City of Phoenix steel tank standard is ground level, fixed roof, epoxy-coated welded steel tank.

a. Standpipes and bolted steel tanks are not acceptable to the City of Phoenix.

7.6.1 Design Criteria

The currently adopted version of standards and codes shall govern and shall be used for the design of steel tanks.

a. International Building Code with City of Phoenix Amendments.

b. Building Code Requirements for Minimum Design Loads in Building and Other Structures, ASCE 7.

b. Standards for Welded Steel Tanks for Water Storage, ANSI/AWWA D 100.

c. Building Code Requirements for Reinforced Concrete ACI 318.

d. AWWA standard for Painting Steel Water Storage Tanks, ANSI/AWWA D 102.

e. National Sanitation Foundation Standard 61 - Drinking Water System Components.

7.6.2 Seismic Loads

a. Seismic Loads shall be in accordance with the requirements of AWWA D100 as amended by the IBC and ASCE-7.
b. The Geotechnical Engineer shall be consulted for verification of the latest seismic zone designation.

7.6.3 Wind Loads

Load (pressure) asserted on the tank shall be as recommended by ANSI/AWWA D100 on the basis of a basic wind speed of 100 mph or the requirements of the local code, whichever is more stringent.

7.6.4 Roof Design

a. The tank roof shall be structural-steel-supported or a self-supporting umbrella, steel roof having a 3/4-inch vertical to a 12-inch horizontal slope. A knuckle with a 2-foot to 4-foot radius shall be provided at the roof and wall junction.
b. No horizontal structural member shall project below the water line in the interior of tank.
c. No structural members shall project below the water line in interior of the tank.
d. The roof plate that is not in contact with water shall be at least 3/16-inch thick; the roof plate submerged in water during normal operations shall be 1/4-inch minimum.
e. Corrosion allowance is not required for the roof plate.
f. The roof plate construction shall be in accordance with the standard practice of ANSI/AWWA D 100, by continuous fillet weld at the topside only.
g. Full penetration welds shall be used to join the roof knuckle together.
h. The roof plate shall not be seal welded at the support members.
i. The roof supports shall be hot-rolled structural shapes with a minimum thickness of 3/16 inch.
j. Shape, bar, and plate submerged in water shall be 1/4 inch minimum.
k. Lateral bracing of the roof rafter compression flanges shall be required. Friction between rafters and roof plates may be considered unless otherwise restricted by ANSI/AWWA D100.
l. Bolts inside the reservoir shall be Type ASTM A 325.
m. Columns shall be fabricated from steel pipe that is seal welded at both ends. Column base shall be fabricated from steel plate and designed for a maximum allowable soil bearing as recommended by a Geotechnical Engineer. The column base shall not be welded to the bottom plate to allow for rotation during seismic events, but must be restrained from any lateral movement. The base assembly shall be fully coated prior to erection per ANSI/AWWA D 100.

7.6.5 Wall Design

a. The tank wall design shall be in accordance with ANSI/AWWA D100 standard.
b. The design fabrication and inspection requirements specified in ANSI/AWWA D100 will be allowed.
c. The lowest 1-day mean ambient temperature at the tank site shall be generally at 20 degrees Fahrenheit unless a lower ambient temperature is required by the City of Phoenix.
d. Minimum tank wall thickness shall be 1/16-inch greater than the minimum values specified in accordance with the requirements of ANSI/AWWA D 100.
e. The tank wall shall be designed for stability without the requirements of intermediate girders on the inside or outside surface of the wall.

7.6.6 Tank Bottom

a. The bottom shall be lap welded continuously from the top of the plate with a minimum thickness of 5/16 inch.
b. The bottom plate shall be extended a minimum of 1-1/2 inches beyond the exterior of the tank.
c. The joint between the tank wall and the bottom plate shall be continuously welded from inside and outside of the tank wall.
d. The width and thickness of the bottom annular ring shall conform to the requirements of ANSI/AWWA D 100.
e. The requirements of the butt-welded bottom annular ring shall be in accordance with the requirements of ANSI/AWWA D 100.
f. A slope of 1-inch vertical to ten feet horizontal shall be provided upward towards the center of the tank.

7.6.7 Footings and Foundations

a. Reinforced concrete ring footings shall be provided.
b. The top on the ring footing shall be approximately 6 inches above the finished surface.
c. The minimum embedment of the ring footing shall be as recommended by the Geotechnical Engineer, but shall not be less than 2 feet, 6 inches.
d. Ring footings shall be reinforced to resist the lateral soil pressure on the confined earth.
e. The width and height of the ring footing shall be sized for the loads described in section 7.4 (Structural Loads) and the allowable soil bearing pressure recommended in the geotechnical report.
f. The minimum width shall not be less than 1 foot, 6 inches.
g. A compressive strength of 4,000 psi minimum shall be used for the concrete; 60,000 psi yield strength shall be required for reinforcing steel.
h. Concrete cover for rebar shall be in accordance with the requirements of ACI 318.
i. The Alternate Design method is recommended for the design reinforcement. Corrosion protection for concrete shall be as recommended by the Geotechnical Engineer.

j. The ring footing shall be designed and stamped by a structural engineer registered in the State of Arizona.

7.6.8 Allowable Stress

a. Allowable stress for steel plate and structural steel shall be in accordance with the requirements of ANSI/AWWA D 100.
b. Allowable stresses for reservoir concrete footing shall be in accordance with the requirements of ACI 318.

7.6.9 Inlet and Outlet Piping

a. Inlet and outlet piping shall be designed to maximize water circulation inside the tank.
b. Both pipes shall penetrate the bottom plate or lower wall plate (minimum of 12 inches from floor) and shall be separated as much as is practical for circulation. In-line valves shall be the same diameter as inlet/outlet piping.
c. Pipe penetration openings through the bottom plate shall be reinforced in accordance with the requirements of ANSI/AWWA D 100.

7.6.10 Overflow

a. Overflow pipe shall be sized for the maximum possible fill rate.
b. Length of the weir shall be such that the head required to pass specified capacity over the lip of the weir will not result in an uplift force on tank roof. In no case, shall water level rise exceed 6-inches over lip of weir. Weir shall be braced and supported as required. Overflow weir box shall be provided with suitable hinged cover and a hasp to permit locking.
c. Overflow flow pipe shall be steel and be sized for the maximum possible fill rate, with welded or flanged connections. Pipe shall attach to tank shell with suitable brackets spaced at proper intervals. Pipe shall extend from the weir box to approximately 6-inches from bottom of steel ring. To ensure a proper air gap, the overflow system must be designed to dispense not less than two times the diameter of the overflow pipe and shall be above the surface of an overflow junction box. An overflow drain line shall be connected to the overflow junction box, be sloped for complete drainage, and discharges over a drainage inlet, or splash pad without causing erosion to a retention basin or an approved drainage location agreed upon by the City of Phoenix Water Services Department.
d. The reservoir overflow shall be sized such that the height over the weir shall not exceed 6-inches in height.
e. The Engineer shall design the overflow system to ensure that water within the reservoir is protected from cross contamination with surface water, insects, and animal intrusion, etc.
f. Verification in writing shall be provided to confirm that overflows will not adversely impact adjacent properties.
g. A flapper check valve or #16 stainless steel mesh shall be installed on the overflow pipe line.

7.6.11 Drain

a. An appropriately sized drain pipe shall be installed at the bottom of the tank (minimum size 8 inches).
b. If the tank is unanchored, the location of the penetration in the bottom plate shall conform to the requirements of Chapter 13 of the ANSI/AWWA D 100.
c. The drain line may be discharged to a drainage structure or facility common with the overflow pipe.
d. The drain line shall have a isolation gate valve as close to the reservoir as possible.
e. All reservoir drains must have an air gap.

7.6.12 Finial and Roof Vent

a. Finial and Roof vent shall be sized to prevent excess pressure or vacuum buildup during the maximum inflow or outflow of water. Tank finial and vent may be combined.
b. A minimum of one vent near the center of the tank and one vent at the side of the tank near the overflow shall be supplied. Roof vents shall be secured to the tank by bolts not welded. Roof venting shall be provided with two (2) stainless steel mesh screens to prohibit entry of insects, birds, or undesirable objects. The insect screen shall be #4 mesh and shall be located behind the vent grille.
c. Four (4) eye bolts shall also be supplied for tie-offs.
d. Overflow pipe shall not be considered a tank vent.

7.6.13 Reservoir Access and Fall Protection

a. Two (2) 36-inch minimum diameter hinged-type shell manways shall be provided at the bottom shell course. Manways shall be hinged and outward opening.
b. Design of the manway and reinforcement around the wall opening shall conform to the requirements of ANSI/API Standard 650.
c. One (1) vertical steel ladder with safety cage shall be provided. Outside vertical ladders shall be located near driveway rod bottle and a minimum of 3-feet away from roof access hatch for ease of access. Install safety chain at the roof landing and platform entrance.
d. Ladder shall have a 7-foot hinged door located at the bottom. The lock on the hinged door shall be located 4-feet above ground level.
e. A safety cage shall be installed per OSHA requirements on all exterior ladders. The safety cage shall extend to 36-inches above the tank roof.
f. Ladder shall be provided with a ladder safety climb device which shall include a fall prevention system consisting of a fall safety belt and a cable and bar system approved by OSHA.
g. A ladder and platform with galvanized steel grating and railing shall be provided and installed adjacent to the rod bottles. Guardrail shall have a kick plate. Guardrail shall be place around the platform and also around top of tank a minimum of 8-feet beyond the roof hatch and farthest ladder or all the way around the top of the tank.

h. For tank without guardrail around the entire roof top, a retractable device anchoring post shall be installed in center of roof. The anchoring post shall be able to resist minimum 5,000 lbs. concentrated lateral load.

i. Anchoring points shall be added at roof top a maximum of 2-feet from any opening and ladder.

7.6.14 Rod Bottle: Please refer to Guide Specifications and details for rod bottle requirements.

7.6.15 Roof Openings

General: The Engineer shall provide roof openings. Roof openings shall be as follows:

a. Provide one 24-inch roof manway.
b. Provide at least 2 ventilation manways.
c. Provide cathodic protection handholes.

7.6.16 Roof Hatches

General: The Engineer shall provide roof access for reservoirs.

a. Tanks shall have one hinged, leak proof, spring-loaded, alarmed, aluminum, lockable hatches as follows:
   1. Each hatch shall have a hold open device, hasp lock, intrusion alarm, and security bar.
   2. Provide one roof hatch shall be located at the roof access hatch.
   3. Both hatches shall be a minimum 48-inch by 48-inch opening or as approved by WSD.
b. The roof hatches shall have a curb at least 6-inches high.

7.6.17 External Water Level Gage

An external water level gage shall be provided. The gage shall be a guided float type indicator. The interior float shall travel the entire height of the tank. The exterior board shall extend over top half of the tank height and the indicator shall travel 6-inches for every foot of water elevation change. The liquid level indicator shall be a half travel gageboard unit.

7.6.18 Protective Coatings

a. Protective coatings shall be provided in accordance with City of Phoenix Water Services Department Standard Specifications for welded steel reservoirs and all interior surfaces including, but not limited to shell, roof framing, roof plates, columns, floor, piping, manways, and ladders; and painting of all exterior surfaces including, but not limited to shell, roof, manways, ladders (including cage and door), hatches, vents, and exposed piping is required.
b. All interior coatings shall meet requirements of NSF 61 for drinking water service.
c. All parts of steel shall be painted in accordance with the requirements of ANSI/AWWA D 102.

d. Corrosion Control: Corrosion control measures such as cathodic protection shall meet the requirements outlined below.

e. The warranty from defects in material and workmanship shall extend for a period of one (1) year from the date of acceptance of the work. This first anniversary inspection requirement shall conform to ANSI/AWWA D102.

f. Application procedures, safety precautions, and testing of coatings shall be in accordance with the requirements of ANSI/AWWA D102.

g. A NACE certified coating inspector will be required to monitor the entire coating process from surface preparation to finished coating and perform integrity tests on the coatings to confirm proper application.

h. Interior Coating Systems:
   1. Epoxy or polyurethane coating system is required for all interior surfaces including the tank wall, roof plate, bottom plate, and roof support member.
   2. The epoxy shall be a self-priming epoxy coating intended for potable water contact. The epoxy formulation shall use 80 percent solids and zero VOC.
   3. The polyurethane coating shall be self-priming; plural-component lining that uses 80 percent solids and zero VOC.
   4. All welds, rafter edges, top of truss beams, etc. shall be stripe-coated by hand.
   5. Surface preparation shall be near white blast cleaning that conforms to SSPC-SP10. The surface profile shall be 2.5 – 3.5 mils.

i. Exterior Coating Systems:
   1. For exposed exterior metal surfaces of the tank, a coating system composed of epoxy, intermediate epoxy, and polyurethane will be applied.
   2. The epoxy is a polyamide or polyamine, anticorrosive converted epoxy primer containing rust inhibitive pigments.
   3. The intermediate epoxy is a two-component epoxy capable of 4 to 6 MDFT per coat.
   4. The aliphatic polyurethane shall be a two-component acrylic based polyurethane, semi-gloss finish. This paint shall only be used in areas where reflection is not a problem.

7.6.19 Cathodic Protection System

a. General: A cathodic protection system shall be provided for all steel tanks. Cathodic protection system shall be an impressed current system utilizing an ac-powered rectifier to drive a direct current through the system or a galvanic system as determined by the Engineer.

b. Service Life: The Engineer shall design the cathodic protection system such that replaceable components such as anodes have a minimum service life of 25 years when coupled with routine monitoring and maintenance.

7.6.20 Identification

The Engineer shall ensure that the tank is provided with a equipment data nameplate that is 316 stainless steel. The nameplate shall be attached to the reservoir and include:

a. Year the tank was built.
b. The nominal diameter and nominal height, in feet and inches.
c. The nominal capacity in gallons.
d. The design liquid level, in feet and inches.
e. The name of the erector.

7.7 Circulation Systems

a. A circulation pump station shall be designed and shall be one of the following types:
   1. Vertical Turbine Can Pump Station, or;
   2. Horizontal Centrifugal Pump Station
b. Circulation Pump Station selection shall be determined based on suction hydraulics. If the reservoir floor elevation is above the circulation pump station pump pad, the pump station shall be a centrifugal type pump station. If the reservoir floor elevation is below the pump station pad, the pump station shall be a vertical turbine can pump station.
c. The circulation pump station shall have a dedicated pump per reservoir and include a single redundant pump. If there is more than one reservoir there shall be a single circulation pump for each reservoir and a single redundant pump that may be capable to serve all reservoirs.
d. Vertical Turbine and Horizontal Pumps shall comply with requirements of the latest City of Phoenix specification standards.
e. SolarBee or PAX system can be added if desired.

7.7.1 Circulation Pump Systems Design

a. **General**: The Engineer shall include the following in the project design:
   1. Design head and design flow for pump.
   2. Design requirements for the pump, motor, drive (constant or variable speed).
   3. Materials of construction for drive shaft, barrels, couplings, supports, and impellers.
   4. Instrumentation, controls, and appurtenances.
   5. The pump and motor shall be provided by the pump supplier as one system.
   6. The circulation pump station must take suction from the reservoir outlet pipe or from the center of the reservoir bottom.
b. **System Head Curves**: The Engineer shall develop a series of system head curves for pump scenarios, which includes the following at a minimum:

1. Curve for low head condition (high-level in supply reservoir and low-level in receiving reservoir) and high head condition (low-level in supply reservoir and high-level in receiving reservoir).
2. Each System Head Curve shall indicate:
   a. Variation of TDH with flow.
   b. Family of curves for a variety of operating conditions, which include minimum, typical and maximum values for static head, flow, pipe roughness coefficient.
   c. Selected pump(s) and impeller characteristics.
   d. Curves at varying speed if pump speed control is required.
   e. Efficiency.
   f. Net Positive Suction Head Required (NPSHR).
   g. Brake Horsepower.
3. The Engineer shall analyze the System Head Curves at varying operating conditions and shall confirm the following for the selected pump(s):
   a. Pump curve is not "flat" where small change in TDH would result in a large change in pump flow.
   b. Typical operating point on the system curve is near the maximum efficiency point of Best Efficiency Point (BEP).
   c. The pump will operate such that pump shutoff or run out operation is not expected at either minimum or maximum operating conditions.
   d. The pump/impeller combination is located near the center of the pump operating curve.

c. **Circulation Pump Selection**: In general, circulation pump stations should be designed to turn the reservoir over in 24 hours maximum. The City of Phoenix may increase or decrease the reservoir turn over time line however the Engineer is responsible to coordinate with the City and obtain approval from the time period stated above.

d. **Circulation Pump Inlet Configuration**: The Engineer shall calculate the Net Positive Suction.

e. Head Available (NPSHA) for maximum flow at maximum temperature and at minimum flow maximum temperature. The pump inlet shall be:
   1. Designed in accordance with Hydraulic Institute Standards to prevent turbulence, vortexing and jet velocities.
   2. Designed such that the Net Positive Suction Head Required (NPSHR) is less than the NPSHA (where NPSHA is reduced by a minimum of 5-feet to provide a factor of safety):
      1. For maximum flow conditions.
      2. For minimum flow conditions.

f. **Circulation Pump Spacing and Clearances**: In general, pumps shall be arranged to provide convenient access for operation, maintenance, equipment installation, and equipment removal on all three sides. Minimum clearance requirements are as follows:

1. Unless otherwise required by OSHA or NEC, a minimum of 3-foot clearance around equipment shall be provided on at least 3 sides of pump equipments.
2. Equipment, piping, etc. shall be oriented in the pump station to provide convenient safe access for operation and maintenance, including the installation and removal of equipment.
3. A minimum of 3 feet, 6 inches walkway corridor shall be provided between the piping/appurtenances of all pump station walls, stairways, ladders, etc.
4. The Engineer shall indicate any horizontal and vertical clear spaces in contract documents and denote that these spaces are to be kept free of conduit, panels, piping, HVAC, and other accessories.
5. The Engineer shall be responsible for providing minimum vertical and horizontal clearances per the manufacturer's recommendation for all equipment with an additional 12 inches.
6. Vertical obstructions shall be located a minimum of 7 feet, 6 inches above the finished floor.

g. **Circulation Pump Efficiency**: The Engineer shall select pumps such that pumping hydraulic efficiencies are not less than 84 percent at design flows and not less than 80 percent within the full operating range of the pumps. Requirements for lower efficiencies should be referred through the City of Phoenix.

h. **Circulation Pump Station Expandability**: Pump station expandability will be evaluated by the City of Phoenix on a case by case basis:

1. If an additional reservoir is to be installed in the future the circulation pump station shall be planned to be expanded in the future or a second circulation pump station shall be show, the Engineer shall ensure that adequate space is provided to accommodate installation of future equipment.
2. The suction and discharge piping manifold shall be sized for future flows.

i. **Circulation Drive Equipment**: Based on the variation in circulation, if the City of Phoenix decides that the reservoir turn over should be increased or decreased during operation, pump speed control with variable speed drives shall be used. In cases where constant speed motors are used soft start and soft stop features shall be provided.

7.7.2 Circulation Pump Speed Control

The City of Phoenix shall justify use of variable frequency drives (VFDs) for the project. Every project for which VFDs are proposed requires review and approval by the City of Phoenix.

7.7.3 Circulation Pump Station Piping

a. General: The Engineer shall design pump station piping according to the requirements of this section. The general piping requirements include but are not limited to:
   1. Flanges and pressure classes shall be compatible for all piping.
   2. All equipment, piping, and valves shall be provided with sufficient vertical and horizontal clearance for maintenance and removal.
   3. Valves and operator shall be readily accessible and located not more than 5 feet above the finished floor unless approved by City of Phoenix.
   4. All piping shall be adequately supported.
   5. All pressurized piping shall be restrained.

b. Exposed piping within the circulation pump station shall be flanged welded steel pipe or flanged ductile iron pipe in accordance with the following:
   1. Steel pipe shall conform to the requirements of ANSI/AWWA C 200 and design requirements of AWWA M 11 and shall be primed / painted with a primed expoxy coating and fusion bonded epoxy lining system.
   2. DIP shall be minimum pressure Class 150 cement mortar-lined with a primed epoxy coating and cement mortar lining.
   3. All flanged joints shall conform to the requirements of ANSI/AWWA C 207.
   4. Fusion bonded epoxy system shall conform to requirements of ANSI/AWWA C 213.
   5. All materials and coating shall meet requirements of NSF 61.

c. Suction piping shall be designed to minimize long runs and high points. The Engineer shall also provide the following:
   1. Maximum suction piping velocity of 5 fps. Higher velocities are only allowed under emergency conditions unless otherwise approved by the City of Phoenix and as outlined in the latest Hydraulic Institute standards.
   2. Air relief valves at all high points on piping shall be hard piped to a nearby drain.
   3. High quality dampening pressure gauges with an appropriate range.
   4. Reducers of the eccentric type (flat end on top) shall be used upstream of the pump suction.
   5. Isolation valves shall be AWWA C 504 butterfly valve with geared hand wheel operator upstream of each pump suction.

d. Discharge piping shall be designed to minimize high points. The Engineer shall also provide the following:
   1. All joints on suction and discharge piping shall be restrained.

2. Pump discharges shall be joined to a common discharge header, which shall pass through a flow meter located to provide sufficient upstream and downstream pip diameters per the flow meter manufacturer. Maximum discharge header velocity of 8 fps. Higher velocities are only allowed under emergency conditions unless otherwise approved by the City of Phoenix.
3. Air relief valves at all high points on the discharge piping and shall be hard piped to a nearby drain if a drain system is available.
4. High quality dampened pressure gauges with an appropriate range.
5. Reducers of the concentric type shall be used downstream of the pump discharge. Air relief discharge shall be piped to an adjacent drain.
6. Isolation valves shall be AWWA C 504 butterfly valve with geared hand wheel operator downstream of each pump discharge.
7. Discharge manifold to utilize flanged end connections to individual pump connections.
8. Spool with minimum 1-inch NPT welded coupling for steel pipe or manufactured instrument Tee for DIP to accommodate a pressure gauge and pressure switch.
9. Spool with welded outlet for steel pipe or manufactured Tee for DIP to accommodate an air vacuum/air release valve, if required.
10. Provide restrained coupling adapters or flexible couplings at all locations to facilitate disassembly and removal of certain equipment, such as check valves and isolation valves.

e. Flexible Couplings: Shall be provided between pump equipment and rigid connections to mitigate vibration, cushion shock loads, accommodate misalignment, and facilitate disassembly and reassembly. Additional requirements are as follows:
    1. Pump Discharge: couplings located between the pump and discharge check valve.
    2. Provide anchors on pump and piping for longitudinal restraint.

f. Insulation Flanges and Gaskets shall be provided at the transition between dissimilar metals and between the pumps and the piping to mitigate galvanic corrosion.

g. Pump isolation valves shall be AWWA C 504 butterfly valves.

h. Check Valves shall be installed on horizontal piping runs if required. Check valves shall be:
    a. Silent, globe style, non-slamming type.

i. Pump Control Valve with pressure sustaining and check valve feature shall be used on circulation pump stations that are vertical turbine circulation pump stations type. A pump control valve shall be installed on each pump discharge line. The pump control valve shall maintain a constant pressure as the reservoir varies in level.

Pump control valves shall be designed with a hydraulically controlled closure/mechanism that will provide soft/restrained closure of the valve during power failure and not allow the valve to slam shut.

j. Air Release Valves shall be provided at high points and shall be epoxy-coated inside and outside with stainless steel trim.

k. Combination or Vacuum/Air Release Valves shall be provided in locations determined by the Engineer and shall be epoxy-coated inside and outside with stainless steel trim.

l. Manual Valve Operators shall be sized for operating pressures.

m. Pipe Restraints shall be provided and shall include the following at a minimum:
   1. Thrust restraints designed to resist maximum operating pressures and surge pressures.
   2. Anchor rings for all pipes that penetrate walls.
   3. Longitudinal restraint shall be provided through flanged coupling adapters and flexible sleeve couplings.

n. Liquid Filled Pressure Gauges: Shall be standard bourdon-style oil (glycerin)-filled pressure gauges, 4-inch diameter, and 4-inch face. Type 316 Stainless Steel construction. Typical operating conditions should register at the middle of the scale.

o. Provide piping supports and straps to keep all weight off the pumps. The Engineer shall be responsible to ensure that sufficient pipe supports are provided such that no loads are transferred to equipment flanges.

7.7.4 Circulation Pump Motors

a. General: Motors shall comply with requirements of the latest City of Phoenix specification standards.

b. Manufacturers: Acceptable motor manufacturers are:
   1. US Motors.
   2. General Electric (GE).

c. Pump Motor Material: Shall be cast iron with UL, FM, CSA or NSF International approval required.

d. Prime mover: Vertical electric motor of premium-efficiency design, NEMA type, open drip-proof weather protected Type I, squirrel cage induction type with class F insulation and designed for a Class B rise, designed and applied in compliance with NEMA, IEEE, NFPA and the NEC.

e. All rotation changes (phase reversal) shall be made at the motor and not at the MCC.

f. Pump motors shall not be loaded to use more than the rated horsepower with a minimum service factor of 1.15.

g. Drive on each pump shall be a vertical, solid shaft, high-efficiency, high thrust, non-reverse ratchet electric motor. Each electric motor shall be designed to accept the total, unbalanced thrust force imposed by the pump.

h. Electric motors from 5 hp to 400 hp shall be rated at 460 Volts, 3 phase, 60 Hz. (COP reserves the right to modify this requirement depending upon the design and operation flexibility).

i. Ratings for electrical motors larger than 400 hp shall be reviewed by COP.
j. Line-shaft vertical turbine pumps shall be in the range of 900 and 1800 rpm. (COP reserves the right to modify these minimum and maximum requirements depending upon design and operation flexibility.
k. Motor noise shall be less than 90 dBA at a distance of five (5) feet from the motor.
l. The motor torque and locked rotor characteristics shall be specified in the NEMA standards for Design B and shall be selected to be non-overloading throughout the driven pump's full speed performance curve.
m. The motor shall be of the solid-shaft type, steel cast and adapted to a four (4)-piece flanged coupling assembly that will adapt to the bowl shaft assembly.
n. Motors located indoors shall be specified for a 50 degree Celsius ambient temperature.
o. Motors located outdoors with sun shielding shall be specified for 60 degree Celsius.
p. Once the motors have been installed, the specifications shall specify that a vibration analysis and summary report be prepared and submitted to the COP through the Project representative.
q. Where used in conjunction with variable speed drives, provide Inverter Duty Rated electric motors fully compatible with the variable speed controllers that comply with the requirements of NEMA MG-1 Part 31.
r. Motor connection terminals or power distribution blocks shall be provided for motors over 100 horsepower.
s. All motor except those for variable speed drive systems shall have a service factor of 1.15.
t. Motors 100 horsepower and larger shall be:
    1. Totally Enclosed, Fan-Cooled (TEFC)
    2. Equipped with velocity transducers for vibration monitoring with alarm. Velocity transducers shall be as manufactured by Bently, Nevada or equal.
    3. Provided with at least 2 Resistance Temperature Detectors (RTDs) per phase of windings with alarm. RTDs shall be 100-ohm platinum, 3-wire type.

7.7.5 Circulation Pumps

a. General: The Engineer shall specify one of two types of pumps depending on the circulation pump station type:
    1. Vertical multistage turbine, barrel-mounted, water lubricated pump with impellers of such design that the head capacity curve is equal to or slightly better than required.
        a) The pump manufacturer shall be responsible for providing the pump, column, can, and motor.
    2. Horizontal centrifugal pump such that the head capacity curve is equal to or slightly better than required.

a) The pump manufacturer shall be responsible for providing the pump and motor.

b. All pumps and materials shall be UL and NSF approved.

c. Pumps shall be per the latest City of Phoenix specifications.

d. For vertical turbine can pump stations, pump cans shall meet the following requirements:

1. Maximum can velocity shall not exceed 5 fps or as specified in the latest edition of HI.
2. Pump cans shall be of a sufficient diameter to avoid limiting or restricting the flow of water into the pump inlet.
3. Steel cans shall be fusion bonded epoxy lined and coated conforming to AWWA C 213-91. The powder coating product shall be National Sanitation Foundation (NSF) Standard 61 certified material.
4. The can shall have bolt-on flanges to allow for removal.
5. The cans shall be of sufficient depth to accommodate the pump.
6. In order to reduce the potential for pump cavitation, the pump impeller shall be mounted a minimum of 1-1/2 times the diameter of the pump bowl away from the bottom of the pump can. This distance of clearance has been presented in various texts as a function of the pump inlet diameter. It is recommended that the Engineer consult with various experts in the field of pumping to verify the minimum clearance required for the particular design condition.
7. Future expansion provisions such as using larger pump cans, additional pump cans, etc. shall be discussed with the COP.

e. Alarms and Monitoring: Instrumentation and switches for monitoring and alarms to SCADA shall be provided.

f. Factory Acceptance Testing shall be verified by an independent third party Engineer registered in the State of Arizona.

7.7.6 Vertical Turbine Vibration

a. General: The Engineer shall design the pumping facility such that equipment is isolated from vibration and within the vibration limits provided herein.

b. Vertical Pump Vibration Limits: Vertical pump field vibration acceptance limits shall be laterally (horizontally) not more than 3.5 mils peak-to-peak displacement and not more than 0.15 inches per second RMS velocity measured in any direction at the motor base flange. Displacement and velocity measurements shall be unfiltered, and the pump shall be operating at maximum speed and at any flow within the rated range of the pump. Field vibration levels shall also be reported for the thrust bearing at the top of the motor. Acceptance limits for vibration at the motor thrust bearing shall be calculated based on the distances of the motor base flange and the motor thrust bearing above the discharge head soleplate as follows:

Au=3.5 + 6.64 x log10 (D1/Db)
Where: Au = unfiltered displacement, mils peak-to-peak
D1 = distance to thrust bearing, inches
Db = distance to motor base, inches

c. The vibration limit only applies when the pump control valve is fully open. The pumps shall not exhibit unusual or abnormal frequency components on either the shaft or the casing vibration measurements. Normal frequency components are defined as excitations, such as rotational speed or vane passing frequency that are inherent with the mechanical construction of the pump and motor train.

d. Unusual or abnormal measurements taken during performance testing shall be made with calibrated instruments with certification of NBS traceable reference vibration sources.

7.8 Disinfection System – please see Chapter 6

7.9 Testing of Hydraulic Structures

a. Hydrostatic test duration shall be determined by the Engineer and shall be based on ACI 350.1, but shall not be less than 24 hours.

b. Allowable Leakage: Leakage is defined as the quantity of water that must be supplied to the hydraulic structure or any section thereof to maintain the water level within 3-inches of the specified water surface test elevation during the hydrostatic test, plus the amount of water required to fill the hydraulic structure to the specified water surface test elevation at the conclusion of the hydrostatic test, plus precipitation, minus an allowance for evaporation if applicable. The City of Phoenix Water Services Department will determine the water leakage rate allowed, at a minimum, the water leakage rate may not be greater than the following;

1. For concrete structures without lining of interior wetted surfaces, the allowable leakage is 0.025 percent of the volume tested per 24-hour period.
2. For concrete structures with interior wetted surfaces lined with a waterproof material, the allowable leakage is 0.010 percent of the volume tested per 24-hour period.

7.10 Instrumentation and Control

All instrumentation and control shall be provided per City of Phoenix Water Services Department most current Standard Specifications. At a minimum, the following instruments shall be provided:

7.10.1 Level Monitoring

a. The reservoir level shall be measured, locally indicated, and transmitted to a Level Monitoring Cabinet and Programmable Logic Controller (PLC) using a field instrument as discussed below.

b. Reservoir level signal shall be transmitted to the City of Phoenix SCADA system.
c. The level transmitter shall be an ultrasonic-type level instrument.
d. In instances where a circulation pumping station takes suction from the reservoir; the low-level switch activated from the level transmitter signal will be used to protect the pumps from cavitation.
e. Reservoirs shall have a separate high/high level switch.
f. The Engineer shall, as part of the design, develop system hydraulic profiles and include them in the contract documents.
g. As part of the hydraulic profiles the Engineer shall define levels needed for system controls such as reservoir high-high, normal operating band, and low-low water levels.
h. The Engineer shall also include elevations needed for all alarm conditions that will be programmed into the system during startup.
i. In the event some of the alarm conditions are to be provided by suppliers of the equipment, those shall be clearly defined in the contract documents and defined as the responsibility of the Contactor.
j. Underground reservoirs shall have level transmitters and junction boxes in an accessible location for maintenance.

7.10.2 Field Instrumentation

a. Field transmitters may be subjected to temperature in excess of the manufacturer's recommendations and may have to be protected by locating them in the nearby PLC cabinet or by vented metal housing painted white or a sunshade structure. No instrumentation will be allowed in vaults.
b. All reservoir, vault access hatches, and doors, in addition to doors at a building on the site, shall be individually monitored for intrusion by the PLC. The alarm shall be annunciated to SCADA.
c. Instruments shall be protected by lightning protection units at both the field instrument and PLC inputs.

7.10.3 Hatch Intrusion Alarm Switches

Hatch Intrusion Alarm Switches shall be heavy duty industrial grade, NEMA 4X, limit switches with a mechanical arm and roller. Limit switch shall be mounted to the inside hatch wall and arm shall sense hatch location. Alarm switches shall be individually monitored by the PLC and the PLC shall alarm.

CHAPTER 8 - ELECTRICAL SYSTEM

This section provides general design criteria for the design of a pump station, PRV station, and well facility's electrical system. The design criteria presented in this guidance manual are not all inclusive; rather they are intended to serve as a guide to the uniform design of pump stations, PRV stations, and well facilities, and to supplement the design information provided for these facilities in the City of Phoenix – Water Services Department Design Standards Manual for Water and Wastewater Systems, as well as the MAG Standard Specifications and Details, Please refer to the WSD Guide Specifications, Division 16 and Division 17 for specific equipment specifications.

Coordination with the electric utility regarding the electric power supply voltage, transformer ownership, motor starting limitations, and metering requirements are crucial factors in the electrical design of a project and must be initiated very early in the design of the project.

8.1 General Design Guidelines

The electrical systems for pump stations, PRV stations, and well facilities design shall comply with the National Electrical Code (NEC), City code, and all applicable local codes. The electrical equipment will be manufactured in accordance with the standards of the Institute of Electrical and Electronic Engineers (IEEE) and the National Electrical Manufacturers Association (NEMA). The electrical equipment requires a "label" indicating compliance with the standards of the applicable codes, specifically with Underwriters Laboratory (UL) and Factory Mutual System (FM).

The electrical design shall include service entrance sections, switchgear sections, motor control sections, VFD cabinets (if required), standby and/or dual-power systems, conduit and wiring, etc. All electrical equipment specified shall be suitable for outdoor installations, mounted on concrete pads. Only VFD cabinets and MCC panels will be housed in air-conditioned spaces. If larger pumps are to be added in the future and/or the station is to otherwise be expanded, oversized conduits, cabinets, floor space, and additional conduits shall be provided in the initial design and construction to meet the future needs. Each design shall include power demand information for the City of Phoenix to apply for the electrical service from either SRP or Arizona Public Service (APS) power companies, depending on the location of the project.

To ease the electrical draw on a particular system, consideration should be given during design to the requirement for capacitor banks. It may will be necessary to have reduced voltage starters on equipment motors 50 H.P. and larger. The local power company should be contacted and their requirements verified and documented in the design reports.

The electrical transformer and all utility meters shall be located outside of the station wall so the utility meter readers do not have to enter the site. The remote metering shall use CT's – not direct line voltage, that way if the meter is vandalized or otherwise damaged, power is not interrupted to the site.

8.2 City Electrical Inspection Group

To help minimize electrical issues throughout City sites and standardize the City's electrical system to ensure each City facility is compatible, the City will assign (at no cost to the design consultant or developer) an Electrical Inspection Group to review the design, be present during design, construction, and commissioning, and help the City personnel learn the system and perform O & M. The Electrical Inspection Group will provide the design engineer the WSD electrical drawing standards.

8.3 System Reliability

Reliability is the ability of a component or system to perform its designated function without failure. Pump station, PRV station, and well facility power distribution systems shall be designed such that no single fault or loss of the preferred primary power source will result in the disruption of greater than 30 minutes of electrical service to more than one motor control center (MCC) associated with vital components. To satisfy this requirement, the electrical primary power distribution system shall incorporate redundant power sources.

Vital components serving the same function shall be divided as equally as possible between at least two MCC's. Non-vital components should be divided in a similar manner where practical.

8.4 Standby Generator

A standby generator shall be supplied at all stations with an average flow of 10,000 gpd or more to provide power in the event of a power failure. (For stations with average flow less than 10,000 gpd – discuss with WSD the requirements of standby power). The generator shall be of sufficient size to power all necessary electrical equipment at the site. An automatic transfer switch shall be provided for 100 percent of the required load of the station. The generator shall be exercised a minimum of once per week for 30 minutes. Exercising shall be automatic using a time clock. A load bank test representing 100 percent of full load shall be performed during start up and testing of the site.

The generator shall be equipped with noise and air pollution control devices, approved by WSD and PDD. Generators fueled by natural gas are the preferred choice. If diesel is selected, a double-containment, above ground fuel tank shall be used. The fuel storage tank shall contain a minimum volume adequate for 24 hours of continual generator use under full load.

The generator shall not extend above the height of the perimeter wall. If necessary, the generator installation shall be depressed to be below the height of the station perimeter wall; in no case shall the generator installation be depressed more than three (3) feet without approval from WSD. Adequate flood protection measures shall be designed into the depressed generator design to ensure protection against flood hazard. All units shall have sound enclosures and hospital grade exhaust silencers.

8.5 Power System Protection

It is anticipated many pump stations, PRV stations, and well facilities will operate unattended, therefore their power systems shall be provided with protection against single phasing, improper phase rotation, ground faults, and power surges that may come in on the power lines such as from lightning strikes.

Fault studies analyzing the available fault currents shall be prepared for each source of power. Note the normal standby generator can only provide a fault current of three times its full load current or less. Faults shall report to the SCADA system.

A coordination study for selection of proper protective devices shall be performed for each installation. If one of the sources is a generator, special care shall be taken in selecting fault protective devices to ensure their operation when the station is being powered by its alternative power source (generator).

An arc flash analysis shall be performed for each piece of equipment added to an existing facility or installed in a new facility. A placard shall be placed on each equipment control panel providing the results of the arc flash analysis; discuss with WSD the complete requirements for the placard. If an existing facility's electric grid is manipulated in any fashion, even if new equipment is not added, a placard shall be placed on the equipment control panel providing the results of the analysis.

If any work occurs on a facility site that has the potential to affect the grounding grid for that facility, an analysis determining the status of the grid shall occur prior to construction. After completion of construction activities, another analysis to determine the status of the grid shall occur. The grounding grid's status shall not be adversely affected by construction activities.

8.6 Uninterruptible Power Supply

An uninterruptible power supply shall be provided for critical loads where failure of equipment to operate satisfactorily would jeopardize the health and safety of personnel or safety of station systems. Examples include lighting systems, sump pump systems, air supply for pump control valve operation, pressure reducing valve operation, and critical system isolation valve operation, including station SCADA and alarming system, and instrumentation and control systems.

8.7 Equipment Sizing and Rating

Electrical equipment shall be sized to continuously carry all electrical loads without overloading. Equipment and materials shall be rated to withstand and/or interrupt the available fault current with of 65KAIC. All electrical equipment shall have at least a 20% reserve margin for electrical load growth. Electrical power conductors shall be sized according to the heating characteristics of conductors under fault conditions. Temperature rise shall be limited to a maximum of 200 degree Celsius within 30 cycles, in addition to the continuous rating of the conductors.

Electrical power conduits shall be sized for ultimate design conditions. Electrical power conduits shall not be installed in the same duct bank with instrumentation and control conduits.

For conduits installed in concrete or under base slabs, etc., the design shall provide and stub-up at all major equipment and panels at least two spare conduits for every 10 placed. The minimum size of the spare conduits shall be 1-inch diameter. These spares are not for anticipated future expansion but to permit installation of additional ancillary equipment if desired.

8.8 Motor Control Centers and Switchgear

All motor control centers (MCC's) and switchgear shall be provided with a solid state-monitoring device as a minimum. Depending on system requirements, a kilowatt-hour meter and power factor meter are also required. In general, MCC's and switchgear will be provided with Hand Switches (HS) – HOAR's, On, Off, Auto, Remote (SCADA); and Pilot Lights (PL) – On/Off/Fail, Alarm. The Auto position on all HS's shall be provided with "Snap-Action" switch type switches per WSD Guide Specifications. Additional requirements for MCC and Switchgear units are as follows:

a. For outdoor application, the MCC and switchgear shall be weatherproof NEMA 3R non-walk-in type, and shall be fan cooled.
b. Control power panel, transformer, and primary circuit breaker as required MCC accessories or switchgear auxiliaries.
c. Provide one convenience receptacle (duplex two-wire, three-pole grounding type, rated 15-ampere minimum, 120-volt outlet) within each MCC or switchgear panel, unless otherwise noted.
d. Thermostatically controlled HVAC system for each MCC and Switchgear panel.

8.8.1 Motor Control Centers

Additional requirements for MCC units are as follows:

a. Low-voltage motor control assemblies should conform to the standards for NEMA Class II, Type B assemblies.
b. The door of each unit containing a disconnect device shall be interlocked so the door cannot be opened unless the device is in the "OFF" position, thus preventing the unit from being energized when the door is open. All unit doors shall be swing doors with locks and continuous length hinges. All MCC units shall be rodent proof.
c. All indicator lights mounted on the MCC shall be of the push-to-test type.
d. Each wire and conduit shall be identified with a unique number and each terminal strip shall be numbered according to WSD Guide Specifications.

8.8.2 Switchgear

The following items shall be incorporated into the switchgear system design:

a. The construction of the switchgear shall be of the universal frame type using die formed welded and bolted members; panels should be 11-gage steel bolted in place.
b. Bus bars shall be copper, fully insulated, and tin plated at its joints. A full-length ground bus should be provided at the bottom of the switchgear enclosure.
c. Incoming and outgoing switch or circuit breaker sections shall have ample spaces for medium voltage, 133% shielded, jacketed single conductor stress-cone terminations, and lightning arrestors.
d. There shall be a clear indication of switch or circuit breaker position, a high-impact type viewing window for interrupter switches, and status lights for circuit breakers.
e. Each wire and conduit shall be identified with a unique number and each terminal strip shall be numbered according to WSD Guide Specifications.

8.9 WSD Equipment and Material Standards

The City has established standards for the design and construction of pump stations, PRV stations, and well facilities; the designer shall ensure the station/facility conforms to those established standards unless otherwise approved by WSD; the WSD Guide Specifications and the established criteria shall be followed. The design consultant shall also provide the following:

a. Control transformers shall be protected with a maximum 2 AMP fusea maximum of .25KVA.
b. Facility lighting shall be provided with at least one manual/photo-electric operated light. The light switch shall be located next to the access gate in the interior of the facility.
c. Mercury lights are not permitted for use as outside lighting.
d. Task lighting shall consist of simple open PAR lampsweather and dust proof fluorescent lights mounted under an electrical/control equipment canopy or on an equipment panel.
e. Conduits:
    1. Electrical power conduits shall not be installed in the same duct bank with instrumentation and control conduits.
    2. Instrumentation and control wires shall not be installed in the same conduit with electrical power wires.
    3. Spare conduits will be installed as directed by WSD. Additional floor space and pad space shall be provided to accommodate future cabinets, or cabinets shall be oversized to accommodate instrumentation and control components required for the ultimate station size and configuration.
f. The design consultant shall also include in its design of facilities provisions for a shade screen. The shade screen's primary function will be to provide the electrical, instrumentation, and control equipment protection from the sun. (See Section 11.3).

CHAPTER 9 - INSTRUMENTATION AND CONTROL

9.1 General

In the past, process control systems within WSD have been implemented and operated primarily on a site-by-site basis; in today's operating and business environment, this is no longer optimal nor acceptable. The absence of standards and having such varied systems often result in conflicting control systems, uneven implementation, and varying degrees of functionality and success. To eliminate the problems associated with varied systems, WSD has developed "Process Control Standards" independent of specific control system vendor requirements. These standards provide significant insight into the City's current Instrumentation and Control philosophies and presents best practices and materials in the design/build of control systems utilized by WSD. General design guidelines included in the Process Control Standards are to be observed by the design engineer when developing electrical and instrumentation drawings. The Process Control Standards provide contractors minimum design considerations and requirements for proper fabrication of control panels, etc. To obtain the latest edition of the Process Control Standards, contact the WSD Superintendent of Distribution and Collection Engineering Division.

This section provides general design criteria for the design of pump stations, PRV stations, and well facilities' instrumentation and control systems to accompany the Process Control Standards. The design consultant shall also reference the WSD Guide Specifications, Division 17. Division 17 sections are not provided to the design consultant until a meeting with the Superintendent of Distribution and Collection Engineering Division has occurred; the contents of Division 17 are constantly being updated and refined by the City.

9.2 City I & C Inspection Group

To help minimize I & C problems throughout City sites, and standardize the City's SCADA system and I & C to ensure each City facility is compatible, the City will assign (at no cost to the design consultant or developer) an I & C Inspection Group to review the design, be present during design, construction, and commissioning, and help the City personnel learn the system and perform O & M. The I & C Inspection Group will provide the design engineer the WSD P & ID drawing standards.

Appendix C is the City of Phoenix Water Services Department Instrumentation and Control Systems Inspection and Testing Services scope outline. This document outlines the services the I & C Inspection Group will perform during design and construction of the facility.

9.3 General Design Guidelines

The instrumentation and control systems shall comply with the National Electrical Code (NEC) and applicable local codes. The electrical equipment shall be manufactured in accordance with the standards of the Institute of Electrical and Electronic Engineers (IEEE) and the National Electrical Manufacturers Association (NEMA). Where applicable, the instrumentation and control equipment shall require a "label" indicating compliance with the standards of a nationally recognized testing organization, such as, Underwriters Laboratory

(UL), Factory Mutual System (FM), or Canadian Standards Association (CSA). Electrical and I & C design and construction shall also follow the WSD Guide Specifications, specifically Division 16 and Division 17.

9.3.1 Field Instrumentation

Where possible, field instrument transmitters shall be located in air conditioned buildings or protected by sun shades. In some cases instruments should be mounted in instrument cabinets. Instrumentation shall be provided to meet the monitoring and control functions as required by the process, as approved by WSD or directed by the I&C Inspection Group during design.

9.3.2 Local Control

Local control shall include local manual and local automatic control functions. Local controls and instrumentation shall be provided to operate equipment during emergencies, for maintenance purposes or if automatic systems fail. Local controls shall be provided to meet the control functions as required by the process, as approved by WSD or directed by the I&C Inspection Group during design.

9.3.3 Computer Control System (CCS)

The City is in the process of converting the existing HSQ Technology SCADA system to Control System International (CSI) UCOS software and plans to replace existing HSQ RTUs with new Modicon PLCs in the future. Requirements for PLCs or RTU hardware and CCS software programming and interface will need to be determined during design based on the status of the CCS upgrade.

Equipment status and alarms and process instrumentation signals shall be monitored by the CCS. The CCS shall also provide manual and automatic control functions. Instrumentation and controls shall be provided to meet the monitoring and control functions as required by the process, as approved by WSD or directed by the I&C Inspection Group during design. General design guidelines for the various mechanical systems are described below.

9.3.4 CCS Programming

The design engineer will include in the specifications that the contractor shall contract with a City-approved design engineer for CCS programming and testing.

9.3.5 CCS Hardware

A PLC and/or RTU will be required to collect and transmit data to the CCS and perform control logic. PLCs/RTUs will be provided in control panels per City Standards. The PLC/RTU panel will include terminal blocks for field wiring. Field wiring terminated directly to PLC/RTU input/outputs will not be allowed.

PLCs/RTUs will communicate to the CCS via the City's existing multiple address system (MAS) radio system or spread spectrum Ethernet. Radio path studies for new facilities shall be performed by a City approved design engineer.

A backup battery system for all the PLC/RTU equipment, panel, and radio shall be installed.

9.3.6 General Station Alarms and Status

General stations alarms will include the following:

a. Station intrusion (vehicle and pedestrian gates common alarm)
b. Building intrusion (all doors common alarm)
c. Electrical cabinet intrusion (common alarm)
d. Generator Running
e. Generator Fail
f. Transfer Switch in Standby/Normal

9.4 Wells and Booster Pump Instrumentation and Controls

a. **<u>Wells and Booster Pump Instrumentation</u>**: This section applies to both booster pumps and wells. Wells and Booster Stations shall include as a minimum, the following instrumentation:
   1. Flow meters
   2. Suction header pressure transmitters
   3. Discharge header pressure transmitters
   4. Pressure gauge for each pump discharge
   5. Pressure switches as required for local automatic control, interlocks and alarms
   6. Tank level switches as required for local automatic control, interlocks and alarms
   7. Control valve (pump discharge or waste valves) limit switches
   8. Elapsed run time meters shall be provided for each pump on the motor starter

   Pressure switches shall be mounted in instrument cabinets per City standard details.

b. **<u>Well and Booster Pump Control</u>**: Pump controls and instrumentation include both local and CCS controls used to sequence the operation of pumps and alarms for indicating malfunctions in the pumping system. Local controls shall include both manual and automatic functions. Typically, the CCS will include both manual and automatic control of booster pump and wells, however in some cased only CCS manual control is provided. Control functions are based on system requirements, as approved by WSD.

   Local automatic control is typically provided by hard-wired pressure switches or level switches. Additional pressure or level switches will be provided as required for alarms and equipment interlocks.

   Details for the booster pump and well controls (local and remote) will be determined during design and shall be shown on the P&IDs and provided in Division 17 Process Control Descriptions.

c. **<u>Well and Booster Pump Alarms and Status</u>**

   Pump failure alarms must be specific; general alarms will not be allowed. Alarms shall indicate if one or more pumps fail to turn on and a malfunction in the speed controls for variable speed pumps. A station intrusion alarm shall also be provided.

Alarms and status signals that **must** be monitored by the CCS include:

1. Pump failure issues, such as overloads,
2. Low suction pressure
3. High discharge pressure
4. Moisture, motor high temperature, seal water, etc. (individual alarms)
5. Any alarms that prevent pumps from running
6. Surge tank high-high and low-low level alarms
7. Storage Tank high-high and low-low level alarms
8. Control valves failed-to-open, failed-to-close
9. Pump control mode – local, auto, computer
10. Pump running

9.5 Pressure Reducing Valves

a. **Pressure Reducing Valves Instrumentation**: Pressure reducing valves shall be provided with the following instrumentation:
   1. Flow meters – Bidirectional flow meters may be required in some cases
   2. High pressure zone pressure transmitter
   3. Low pressure zone pressure transmitter
   4. Pilot solenoid valves as required for controls
   5. Limit switches as required

b. **Pressure Reducing Valves Controls**: Generally the pressure reducing valves will be hydraulically controlled with no additional local or CCS control. In some cases, one or more PRVs at a station may require additional pilot solenoids to allow remote control of PRVs. PRV controls shall be provided as directed by WSD.

c. **Pressure Reducing Valve Alarms and Status**: The following alarm and status signals shall be monitored by the CCS:
   1. High Pressure Zone high-high
   2. High Pressure Zone low-low pressure
   3. Low Pressure Zone high-high
   4. Low Pressure Zone low-low pressure

9.6 Surge Tanks and Air Compressors

a. **Surge Tanks and Air Compressor Instrumentation**: Surge tanks and air compressors shall be provided, as a minimum, with the following instrumentation:
   1. Surge tank high-high level conductance probe/relay
   2. Surge tank low-low level conductance probe/relay
   3. Surge tank air compressor start (or air valve open) level conductance probe/relay
   4. Surge tank air compressor stop (or air valve close) level conductance probe/relay
   5. Reset conductance level probe/relays and additional interlocks as required

Surge tank level probes shall be installed in a probe bottle. The probe bottle shall be constructed and installed per detailed City standards.

b. **Surge Tanks and Air Compressor Controls**: Air compressors shall be provided with local manual and automatic controls. In automatic mode, air to the surge tank shall be controlled base on water level probes in the surge tank. CCS manual and CCS automatic will not be provided for air compressor control.

c. **Surge Tanks and Air Compressor Controls**: The following alarm and status signals shall be monitored by the CCS:

1. Surge Tank high-high water level
2. Surge Tank low-low water level
3. Air compressor fail
4. Air compressor running
5. Air compressor in auto

9.7 Storage Tanks

a. **Storage Tank Instrumentation**: The following instrumentation shall be provided for storage tanks:

1. Level transmitter
2. High level conductance probe/relay (pre-overflow)
3. High-high level conductance probe/relay (overflow)
4. Low-low level conductance probe/relay
5. Level conductance probes as required for local automatic control
6. Tank fill valve limit switches
7. Tank fill valve pilot solenoids for remote control as required

b. **Storage Tank Controls**: In some cases tank fill valves are provided in the tank inlet. Generally, the valves are hydraulically controlled to prevent tanks from overflowing. In some cases, additional pilot solenoids may be required for CCS control. CCS control may be manual only or control may include automatic control based on tank level. Tank fill valve controls shall be as approved by WSD.

c. **Storage Tank Status and Alarms**: The following status and alarm signals shall be monitored by the CCS:

1. Storage tank high level
2. Storage tank high-high level
3. Storage tank low-low level
4. Tank Fill Valve control mode
5. Tank Fill Valve open and closed position

9.8 Disinfection Systems

Disinfection systems may be double contained gas or sodium hypochlorite systems. This section addresses only double contained chlorine gas systems. Sodium hypochlorite systems will be allowed at certain locations which must be approved by WSD prior to the start of design.

a. **Disinfection Systems Instrumentation**: Double contained gas disinfection systems shall be provided with the following instrumentation:

1. Chlorine residual analyzer (may require more than one)

2. pH analyzer
3. Chlorine gas leak detector
4. Chlorine gas weight scales
5. Eyewash/shower flow switch
6. Gas feed controller
7. Smoke detector and ventilation indicators as required.
8. Pressure gauges

b. **<u>Disinfection Systems Controls</u>**: Gas feed control shall be provided by local gas feed controller as approved by WSD.

c. **<u>Disinfection System Status and Alarms</u>**: The following alarm and status signals shall be monitored by the CCS:

1. Ventilation and Smoke detector alarms as required
2. Chlorine residual high alarm
3. Chlorine residual low alarm
4. Chlorine water booster pumps running
5. Chlorine water booster pump alarm
6. Double containment vessel valve positions (open and closed)
7. Chlorine gas leak alarm
8. Chlorine feed low vacuum alarm

CHAPTER 10 – SITES

10.1 Governing Standards

The governing design standards for civil work associated with pump station reservoirs, well facility sites, and PRV stations shall be in accordance with those standards detailed in this Guidance Manual. However, the City of Phoenix zoning ordinance and PDD standards shall be implemented when developing the design for the facility. The latest editions of these documents govern and take precedence over all other editions. Other documents providing design guidance include:

a. Uniform Standard Specifications and Details for Public Works Construction as distributed by Maricopa Association of Governments.
b. City of Phoenix – Water Services Department Design Standards Manual for Water and Wastewater Systems, January 30, 2013.
c. City of Phoenix – Storm Water Policies and Standards, March 2004

10.2 Site Description

The location of each pump station reservoir, well facility, and PRV station shall be detailed in the design. The design consultant shall provide as a minimum the following information:

a. A vicinity map of the project area. This map should provide enough detail to show the general location of the site with reference to major freeways and roads, including a scale and north arrow.
b. A location map of the project area. This map should provide a more detailed view of the project location and surrounding community. Streets and recognizable features should be identified on the plan, including a scale and north arrow. The site address should be included on the location map.
c. A plan sheet detailing survey control and right-of-way (s) and all public and private easements for the pump station reservoir, PRV station, and/or well facility. The design consultant shall use the City of Phoenix survey datum. The map shall include a scale, north arrow, township, range, quarter section, basis of survey/project baseline, coordinates, benchmarks, monuments, and other existing survey control features including parcel numbers and delineated applicable temporary and permanent construction easements.
d. A key map showing the facility design drawings on an overlay of the project site. It shall include a scale and north arrow.
e. Topographic mapping shall also be provided at a scale of 1 inch = 20 feet for site layout and design (scale shall not exceed 1 inch = 40 feet). Drawing size shall be 22 inches x 34 inches.

10.3 Site Layout

Generally, the City prefers pump station reservoirs, PRV stations, and/or well facilities be centered within the limits of the property. Locating the facility in the center of the site separates the station from the nearest property owners and therefore reduces the likelihood of complaints from neighbors. The addition of landscaping outside the wall surrounding the station further blends the station with the neighborhood. The designer should initially consider this “centered location” for the orientation of the station/facility and adjust or modify accordingly to satisfy maintenance concerns and/or project constraints, etc.

a. **Site layout** shall be designed to allow adequate access to the facility while providing minimal traffic disruption. If a block masonry wall or some type of screen is employed, the wall/screen must be positioned far enough from the right-of-way (out of traffic) to allow the parking of at least one pick-up truck sized maintenance vehicle, while opening the vehicular gate. If a site is located on a heavily traveled roadway, a turning lane for ingress/egress to the facility may be required. This requirement should be discussed with the City of Phoenix Street Transportation Department, PDD and WSD. Main access to facilities on corner lots shall be provided by the street with the lowest traffic volume.

b. **Site access** shall also be designed to provide adequate room for station maintenance activities such as equipment removal using a mobile crane, hoist, or other type of heavy equipment. The design consultant shall avoid locating the maintenance/truck access over the inlet and discharge penetrations into the station to avoid pipe shear loadings at these locations. Access shall be available to at least three sides of the facility/building including any and all access hatches to allow for the installation and/or removal of significant pieces of equipment. The City prefers having two gates to allow drive-through access to stations. If this cannot be provided at the site, a cul-de-sac with a minimum turning radius or looped access road should be provided to facilitate a one-ton maintenance truck’s ability to turn around without having to back up; in most cases however, the fire code becomes the limiting factor in access design. The design consultant shall discuss these code requirements with the City and incorporate any applicable City modifications. It is recommended the designer meet with a Fire Department representative to obtain details regarding applicable design standards.

c. The following issues (as a minimum) should be evaluated and discussed with WSD prior to finalizing the orientation of the pump station reservoir, PRV station, and/or well facility on a project site:

    1. Determine if a building is required to house the pumps, PRV, well head, and/or electrical equipment, versus merely constructing a shade structure only.
    2. Site security is discussed in Chapter 12.
    3. Applicable right-of-way and easement limitations.
    4. Required property line setbacks for construction operations (i.e. cut and fill and site grading), and siting of any buildings, structures, etc.
    5. Site grading and drainage. (Site shall be designed and constructed a minimum of 1 foot above the 100-year flood elevation.)
    6. Flood protection designed for the 100-year flood event; for determination of the Flood Plain contact the Federal Emergency Management Agency (FEMA).

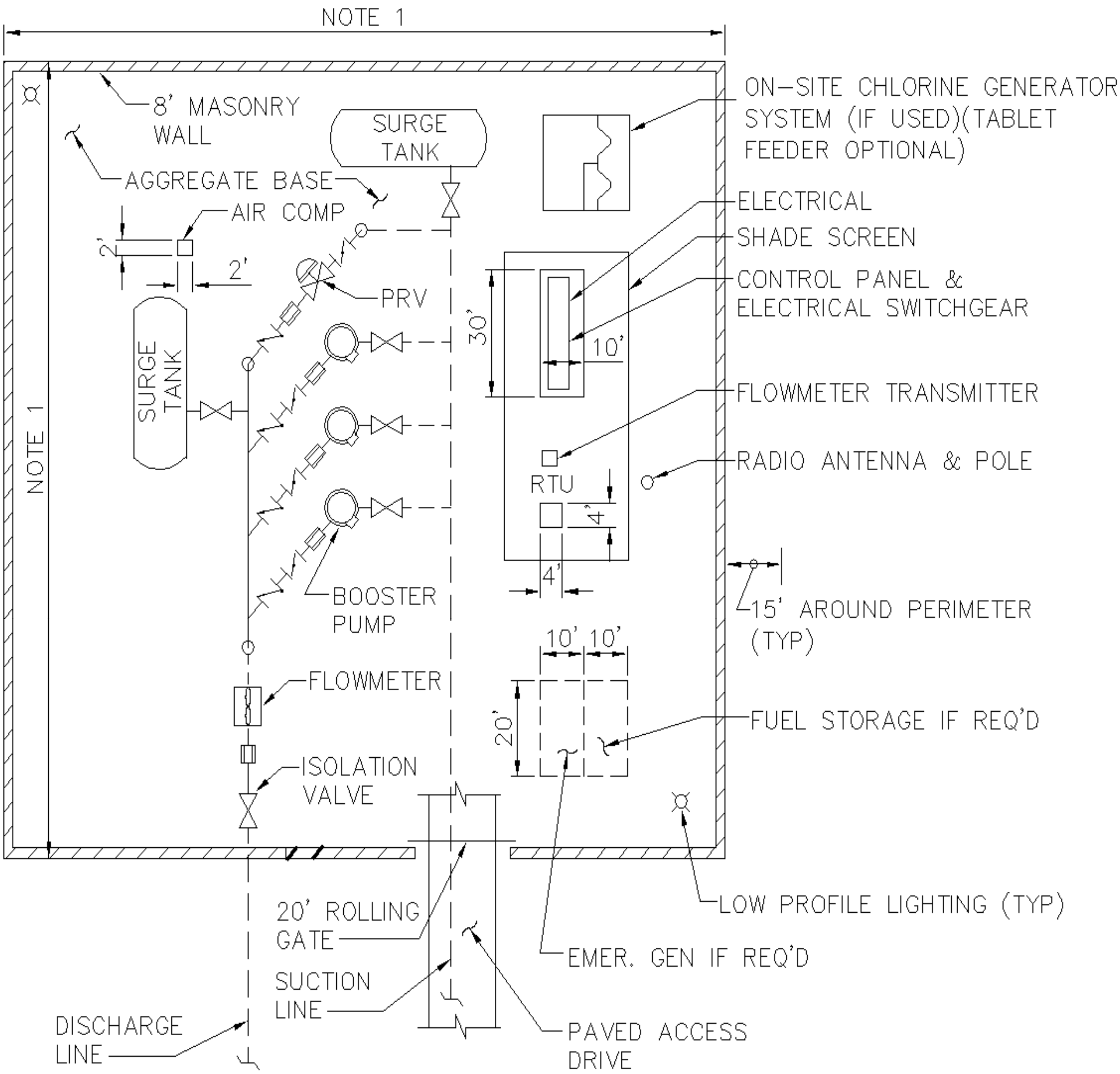
7. Site accessibility for operation and maintenance personnel, delivery/maintenance equipment, and emergency equipment
8. Siting alternatives minimizing exposure of the facility.
9. Irrigation requirements and source water.
10. Landscaping theme and plantings.
11. Permitting:
    - A Clean Water Act Section 404 Nationwide Permit, an Individual Permit, or a Pre-Construction Notice (PCN) will be required from the US Army Corps of Engineers (Corps) depending on the level of impact.
    - Permit to Construct (Corps).
    - A Section 401 State Water Quality Certification Permit from the Arizona Department of Environmental Quality will be necessary prior to the 404 Permit.
    - Cultural Resources.
    - An Arizona Pollution Discharge Elimination System (AZPDES) Individual Permit issued from the Arizona Department of Environmental Quality.

d. **Setbacks** from the site property line to any buildings will be governed by PDD. Station setback from property lines and right-of-way lines shall be provided in accordance with the appropriate City and local standards. Adequate setback shall also be provided to allow for construction operations, i.e. cut and fill operations and site grading. For specific information and determination of a project's setback requirements, the design consultant shall contact the PDD.

e. **Maintenance Activities**: Site access shall also be designed to provide adequate room for chemical delivery trucks and station maintenance activities. Station maintenance activities include equipment removal using a mobile crane, hoist, or other type of heavy equipment. Access shall be available to at least three sides of any facility building including any access hatches to allow for the installation and/or removal of significant pieces of equipment. A four (4)-foot minimum clearance between obstacles must be provided to permit operation of equipment and maintenance activities within the station. In addition, facilities shall have a 12'x12' lockable, metal storage locker on site to house spare parts and related maintenance equipment, unless approved by WSD. Provide sufficient space to place pump on the deck between each pump bay.

   Site layout shall provide adequate access for various chemical and fuel deliveries to the storage areas in the facility. Chemical and fuel deliveries typically involve the use of large tanker/container trucks to deliver the material. The delivered product is typically stored in aboveground storage tanks with secondary containment within the station boundaries. Adequate space shall also be provided for chemical equipment and feed pumps. If a building encloses chemical/disinfection storage, provide an outside fill connection with a spill basin below. Also, provide adequate space to accommodate a vehicle for drive-up delivery.

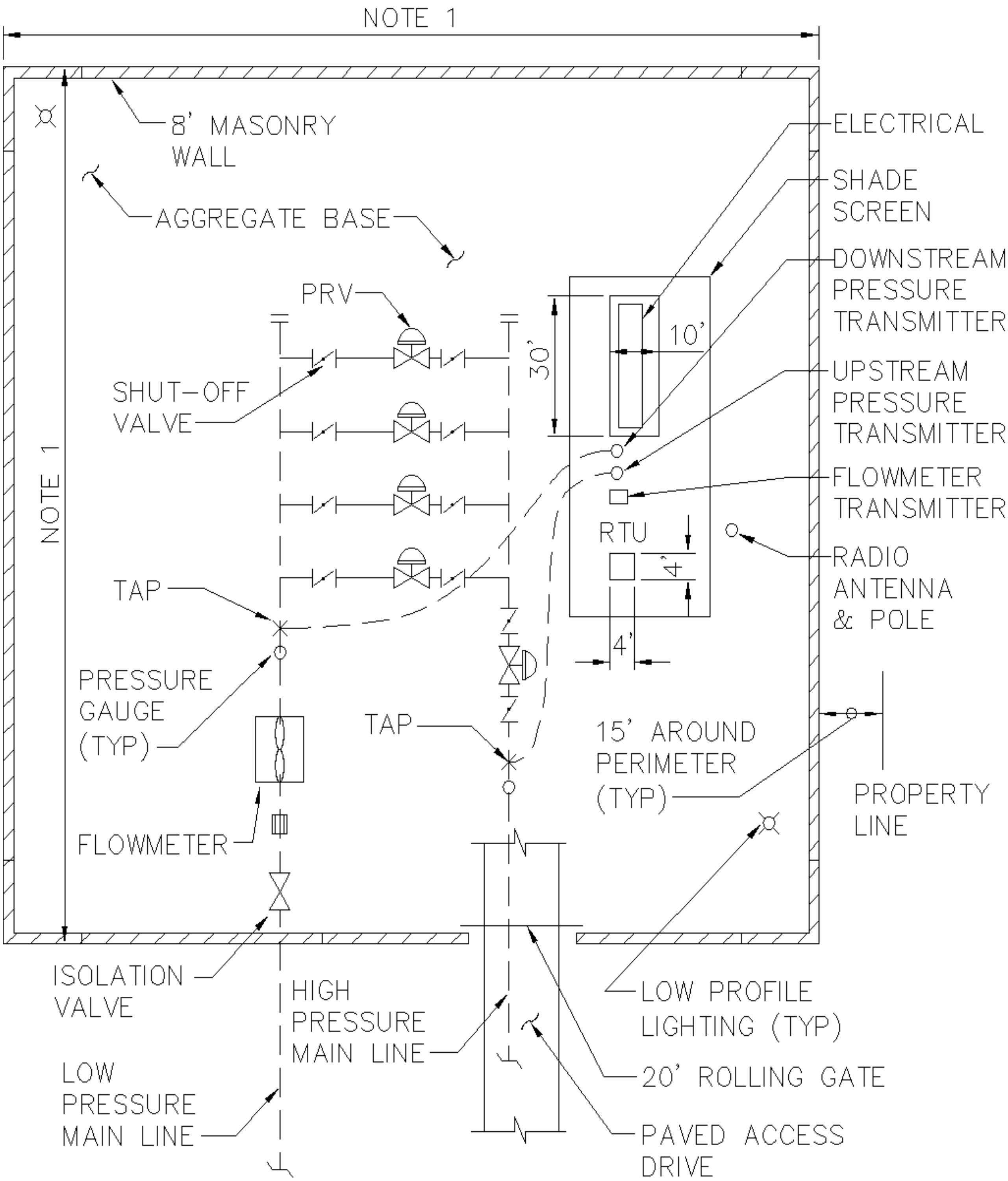
Typical site layouts and/or schematics for booster pump station reservoirs, chlorination facilities, PRV stations, and well facilities are included in this design guide. See Figure 10-1 for a typical site layout schematic of a booster pump; Figure 10-2 for a typical site layout schematic for a Pressure-Reducing Station; and Figure 10-3 for a typical well facility layout.



NOTE:

1. ON COMBINED BOOSTER PUMP PRV SITE USE 80'x100' FOR FACILITY DIMENSION AND 100'x130' OVERALL DIMENSION. FOR 30 MGD CAPACITY AND LESS USE 80'x120' FOR FACILITY DIMENSION AND 110'x150' OVERALL DIMENSION.

Figure 10-1 Typical Booster Pump Station Site Layout



NOTE:

1. FOR LINE SIZES 42" AND LESS, USE 50'x50' FOR FACILITY DIMENSION AND 80'x80' FOR OVERALL DIMENSION. FOR LINE SIZE 48" AND LARGER, USE 100'x150' FOR FACILITY DIMENSION AND 130'x80' OVERALL DIMENSION.

Figure 10-2 Typical Pressure Reducing Station Layout

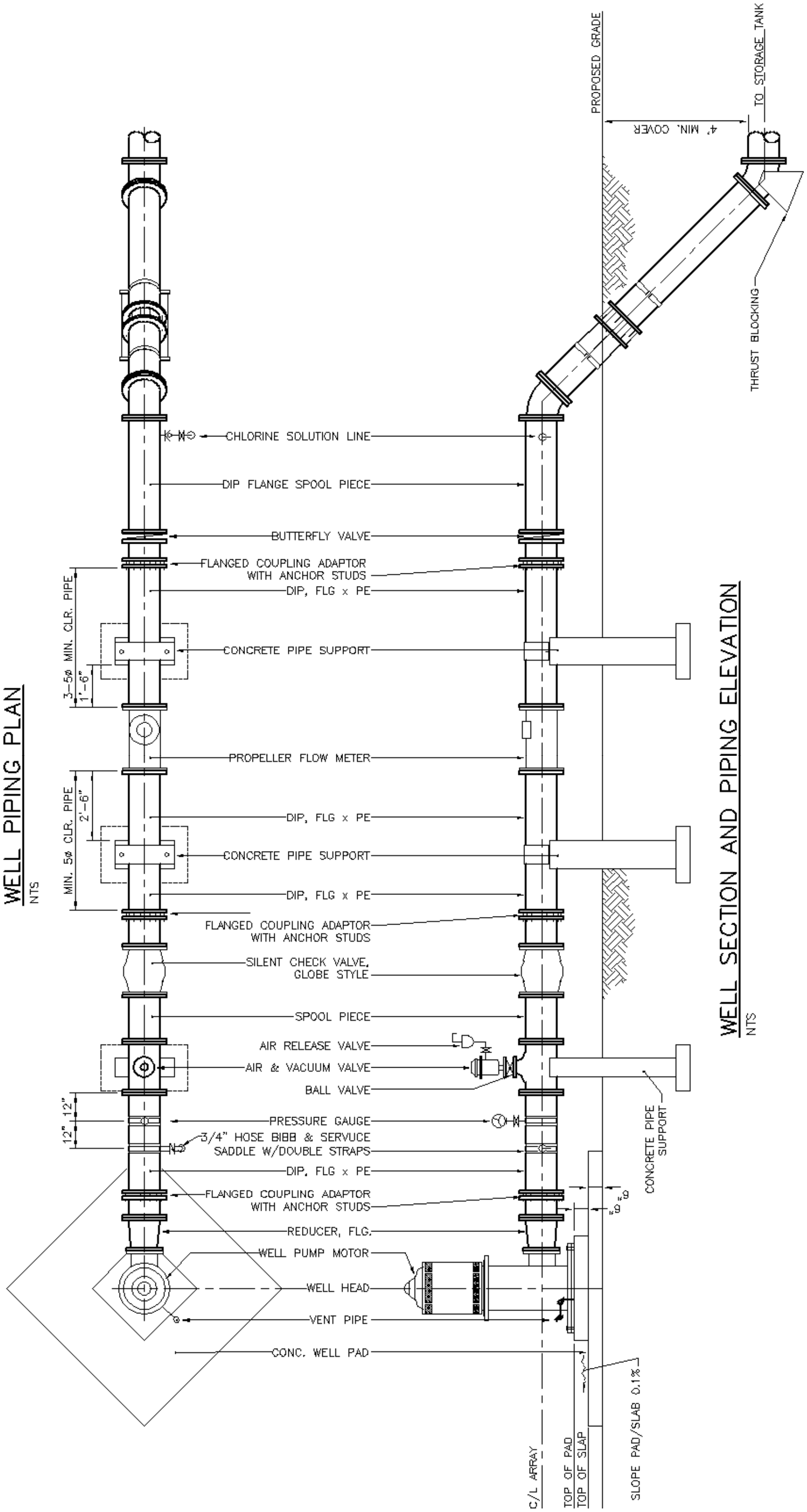


Figure 10-3 Typical Well Facility Layout

10.4 Survey Control

The horizontal and vertical datum to be used for design surveys and mapping shall be consistent with the City of Phoenix requirements. The horizontal datum is a local ground-distance-based system based upon NAD 27. The vertical datum shall be based on the City of Phoenix Datum (NGVD 29). Design-level surveys are to be performed by Global Positioning System (GPS) or conventional total station traverse survey methods. If performed by GPS, the horizontal accuracy of survey results shall meet or exceed the Federal Geodetic Control Committee (FGCC) Third Order Class 1 Standards. If surveys are performed by conventional total station traverses, the horizontal accuracy shall meet or exceed 1:10,000. Vertical accuracy shall meet or exceed FGCC Third Order Standards. Additional survey requirements, submittal of record of survey reports, site control, base map files, field-established survey points, ground contours, access permits, utility location/identification requirements, etc. shall be discussed in detail with the City.

10.5 Floodplain Determination

The design consultant shall obtain maps of the facility site detailing the elevation or existence of the 100-year floodplain elevation. Information on flood zones may be available from sources such as the City of Phoenix Street Transportation Department - Floodplain Management, U.S. Army Corps of Engineers, or county or local flood control districts (i.e., Flood Control District of Maricopa County), or may have to be developed for the specific project.

10.5.1 Site Elevation Requirements

The design consultant shall design finished floor, slab, and hatch opening elevations, etc. to be at a minimum of one foot above the adjacent ground elevation. On sites within the 100-year floodplain, the finished floor, slab, and hatch opening elevations, etc. shall be a minimum of one foot above the 100-year floodplain elevation, or shall be protected to such an elevation. Equipment pads, electrical pads, etc. shall be a minimum of 6 inches above the finished floor/slab/ground elevation.

10.5.2 Permitting

Permitting of the project site can have a significant impact on the orientation of the station facilities within the limits of the site. For example, the 404 Nationwide Permit (Section 404 of the Clean Water Act), issued by the Corps of Engineers, authorizes the Corps to issue permits for the discharge of dredged or fill material into the waters of the United States at specified disposal sites. The crossing, grading, re-grading, modification, etc. of drainage washes fall under this permit because drainage washes contribute to the flow of navigable waterways of the US. It is recommended the design consultant retain the services of a permitting subconsultant to acquire this and other federal permits.

10.5.3 Storm Water Discharges

The Arizona Department of Environmental Quality (ADEQ) has established a general AZPDES permit for storm water discharges from construction sites. This permit was issued on February 28, 2003 and replaces NPDES permits previously issued by the U.S. Environmental Protection Agency (EPA) in 1998. Coverage under the permit is required for all operators of construction sites that disturb one or more acres of soil through grading, trenching, or excavation. (The permit

specifies various requirements for different types of operators.) The owner of the site can be ultimately held liable for any failure of the operator or operators to comply with the permit terms and conditions, even if the owner is not required to obtain coverage under the permit as an operator. In addition, there is a high potential for lengthy delays to a project if permit requirements are not planned for and addressed early in the planning and design stages of a construction project. Therefore, the following information is intended to provide general guidance for compliance with the new general AZPDES permit; is not intended to be an all-inclusive guidance summary. WSD and the design consultant shall refer to ADEQ's website for a description of the general permit and detailed guidance compliance at:
http://www.azdeq.gov/environ/water/permits/azpdes.html

a. **WSD** (When City controls the project specifications)
   1. WSD shall determine if the construction site will discharge to impaired or unique waters. If yes, ADEQ requires submittal of both the Notice of Intent (NOI) and the Storm Water Pollution Prevention Plan (SWPPP) for review; the SWPPP must specifically identify Best Management Practices (BMP's) and other controls that will minimize the discharge of pollutants from the site.
   2. WSD shall submit copies of the General Permit, its Fact Sheet, blank NOI and Notice of Termination (NOT) forms, and blank Waiver Certification forms. Guidance for compliance can be downloaded from ADEQ's website at:
http://www.adeq.state.az.us/environ/water/permits/stormwater.html#const.

b. **Submittal of NOI's** for all operators of the construction site shall be submitted to:

Arizona Department of Environmental Quality
Water Permits Section/Stormwater NOI (5415B-3)
1110 West Washington Street
Phoenix, Arizona 85007

   1. As a permittee and as the construction site owner, WSD is responsible for ensuring SWPPP's implemented for City construction sites are effective and remain so until submittal of the NOT's. Inspections must be performed, structural controls kept in good order, and records maintained as required by the permit. The SWPPP must be amended if changes in design, construction, operation, or maintenance result in effects on the discharge not previously addressed by the SWPPP or, if inspections, monitoring, or investigations determine that the SWPPP is ineffective.
   2. WSD shall ensure copies of the permit, the NOI, and the authorization letter from ADEQ are included in the SWPPP, and the SWPPP is available at the project site (or an approved alternative location).

c. **Consultants/Developers/Contractors** (Those having day-to-day control of on-site activities)

1. Ensure the SWPPP meets the minimum requirements of Part IV of the Permit and identifies the parties responsible for implementation of control measures identified in the plan.
2. Ensure the SWPPP is implemented prior to the start of any construction activities that may result in soil disturbance (e.g. grading, trenching, and excavation).
3. Ensure the NOI's are complete and accurate. Discharges are not authorized if the NOI is incomplete and/or inaccurate; this is true even if ADEQ does not provide a notice the NOI is incomplete or inaccurate. Unauthorized discharges are subject to enforcement action.
4. Ensure submittal of NOI's for all operations of the construction site. NOI's are to be submitted to:
   Arizona Department of Environmental Quality
   Water Permits Section/Stormwater NOI (5415B-3)
   1110 West Washington Street
   Phoenix, Arizona 85007
5. Unless other arrangements have been made with PDD, copies of the NOI's must also be submitted to PDD.
6. It is the responsibility of the operator (Consultant and/or Contractor) having control of the day-to-day on-site activities to ensure SWPPP's implemented for City construction sites are effective and remain so until submittal of the NOT. Inspections must be performed, structural controls kept in good order, and records maintained as required by the permit. The SWPPP must be amended if changes in design, construction, operation, or maintenance results in effects on the discharge not previously addressed by the SWPPP; or, if inspections, monitoring, or investigations determine that the SWPPP is ineffective.
7. Ensure copies of the permit, NOI's, and the authorization letters from ADEQ for all operators are included in the SWPPP, and the SWPPP is available at the project site.
8. Ensure no operator's activities renders another party's pollution control ineffective. All operators must implement their portion of a common SWPPP or develop and implement their own SWPPP.

10.6 Grading and Drainage

In general, site grading shall be made at a sufficient slope to promote conveyance of drainage away from the station and into existing and/or new retention/detention facilities. However, care shall be exercised to ensure the gradient is not too steep to cause excessive site erosion.

Retention and/or detention basins should be located outside the station's perimeter wall to maintain a compact wall footprint. This will decrease the cost of wall materials and maximize the distance between the station wall and surrounding properties. The City requires the retention and/or detention basins and landscaping external to the station be maintained by the development, unless the station is City owned. Wall openings allowing storm water to drain from inside of the station to a retention basin should be designed with consideration to site security. The designer must not specify wall openings that are large enough to permit human entry into the station.

The design consultant shall prepare a Grading and Drainage Plan for the facility site in accordance with Phoenix City Code Section 32A, PDD, and City of Phoenix Storm Water Policies and Standards Manual, March 2004. Additional grading requirements for reservoirs and other facilities are included in later sections of this report.

10.6.1 Report Content

a. **Geotechnical Evaluation** reports shall contain the following information at a minimum: (Note to reader: this may be redundant to a previous chapter and can be removed if necessary)

1. Review of available previous studies performed on or adjacent to the subject site, and a discussion of the findings.
2. A scaled plan showing the location of the borings or test pits.
3. Boring logs showing drilling equipment used, depth drilled, surface elevation, depth to groundwater observed during drilling and measured at least 24 hours after completion of drilling, and complete soil descriptions per ASTM D 2488. Boring logs should also list the logger or geologist observing the drilling, and list any special surface or subsurface conditions observed.
4. Depths to cemented soils or caliches and hardness and degree of cementation, if encountered, and drilling rates.
5. Site description including existing structures, roadways, and subsurface improvements, if known, special geologic or drainage features, site relief, vegetation, and description for adjoining parcels.
6. Results of laboratory testing, including a description of the test method(s) performed.
7. A summary of the subsurface materials encountered, including any artificial fill, cemented soils, expansive or hydro-collapsible soils, and corrosive soils, and thickness of existing pavement sections, if appropriate, including asphalt concrete and aggregate base thicknesses.
8. A summary of anticipated loads and types of structures proposed.
9. Site class per Table 1613.5.5 of the International Building Code.
10. Representative latitude and longitude coordinates in decimal degrees to four decimal places for the purpose of determining the site seismic acceleration.

b. **Geotechnical Parameters**: The following are minimum geotechnical parameters to be addressed:

1. Lateral active and passive soil pressures, including static and seismic pressures for walls, manholes and vaults, include a pressure diagram.
1. Lateral at-rest soil pressure.
2. Total and differential settlement for each type of foundation system.
3. Design allowable bearing capacity for each type of foundation system.
4. Minimum footing width and embedment.
5. Recommended foundation system.
6. Modulus of subgrade reaction for design of mat-type foundations, when applicable.
7. Coefficient of friction for mat-type and spread footing foundations.
8. Allowable axial capacities, both compressive and uplift, for drilled shaft foundations including group factors for drilled shafts in groups where deep foundations are anticipated.
9. General construction recommendations for drilled shaft foundations including anticipated excavation methods, slurry or casing recommendations, and a recommendation for non-destructive shaft integrity testing (CSL or PIT) where deep foundations are anticipated.
10. Post-tensioned foundation recommendations, where applicable, based on the City of Phoenix Amendments to the IBC.
11. Design criteria for thrust blocks.
12. Groundwater considerations.
13. Recommendation for a rippability study, if warranted, where cemented soils or bedrock are encountered.
14. Slope stability analysis as deemed necessary where existing or proposed steep slopes are to be utilized on site.
15. Corrosive soils and mitigation criteria.
16. Considerations regarding concrete and steel reactivity.
17. Expansive soils and mitigation criteria.
18. Collapsible soils and mitigation criteria.
19. Locations and extent of fissures and mitigation criteria.
20. Location and extent of faults and mitigation criteria.
21. Document potentially contaminated soils and groundwater, and note on the boring logs at the appropriate depth interval.
22. Horizontal seismic coefficient.
23. Site coefficients for mapped spectral response accelerations at short period and 1-second period, FA and FV.
24. Mapped spectral accelerations for short period and 1-second period, SS and S1.
25. Potential for liquefaction and mitigation recommendations.
26. Seismically induced lateral earth pressures, include a pressure diagram.

27. Concrete mix design criteria based on soluble sulfate content of soils.
28. Exterior concrete flatwork recommendations.

c. **Groundwater**: The Geotechnical Engineer shall evaluate and provide considerations for the following groundwater conditions where applicable:
1. Dewatering during construction.
2. Permanent dewatering, if required.
3. Target dewatering elevations.
4. Anticipated dewatering induced settlements for any existing structures.
5. Anticipated seasonal groundwater level fluctuations.

d. **Site Preparation and earthwork**: The Geotechnical Engineer shall provide recommendations for the following:
1. Excavation constraints (rock, caliche, blasting, etc.) relative to the site and considerations for any specialized types of equipment if anticipated.
2. Earthwork specifications including over excavation depths, testing methods and frequencies, maximum lift thickness, moisture conditioning recommendations, and estimated range of soil shrinkage values.
3. Subgrade stabilization recommendations where soft, wet, or unstable soils are anticipated to be encountered including recommendations for geogrid and/or filter fabric and imported stabilization rock as deemed appropriate.
4. Recommendations shall be made regarding the specific geotextile product as deemed appropriate for the anticipated soil conditions.
5. On-site and imported structural fill criteria, including maximum or minimum values as applicable for soil gradation, plasticity, swell, solubility and chemical composition.
6. Identification of unsuitable soils and removal and disposal recommendations.
7. Stability of temporary excavation slopes, with maximum allowable slope ratios.
8. Stability of permanent fill and cut slopes, with maximum allowable slope ratios.
9. Benching recommendations for fill slopes.
10. Mitigation of cut/fill transitions beneath improvements as applicable.
11. Pavement design for both flexible and rigid pavement for design ESAL values of 1,100, 7,160, 33,130, and 121,000, which correspond to Traffic Index of values 4, 5, 6 and 7, respectively.
12. Anticipated site drainage measures regarding finish grades adjacent to foundations and considerations for sub drains where applicable.

13. Protection of existing structures where earthwork is to be performed adjacent to any existing improvements, including safe setbacks for new excavations.

10.7 Paving, Curb & Gutter

The design consultant shall design the paving, curb and gutter, sidewalks, driveway entrances, etc. per the requirements of MAG Uniform Standard Details for Public Works Construction including the City of Phoenix Supplements. Driveway entrances into all facilities shall be paved with asphalt similar to City of Phoenix Supplement to MAG Standard Detail No. P-1255. The access road must be twenty (20) feet wide and paved from the street to the station gate at a maximum slope of 10%. The interior of the facility shall be surfaced with a 4-inch, 3/8" compacted aggregate base. Paved access for service vehicles to major station components shall be provided. Maricopa County dust control requirements must be followed.

10.8 Yard Piping

In general, the design consultant shall select piping systems appropriate for the type of fluid being conveyed and in accordance with MAG Standards/City of Phoenix Supplement, the WSD Guide Specifications, and the City of Phoenix – Water Services Department Design Standards Manual for Water and Wastewater Systems. Piping systems should be designed based on the loads imposed; linings, coatings, and cathodic protection may then be selected as required. As part of the design, the design consultant shall prepare a piping schedule delineating pipe materials, diameters, type of service, coatings, linings, fittings, field test pressures, etc.

Yard piping is considered as any and all piping within the property limits of the station. Any buried piping below concrete slabs or block walls shall be restrained joint and backfilled with ABC slurry. Above ground piping shall be adequately supported with WSD approved pipe supports.

Welded joints are the preferred method of connection outside the station. Welded joints shall conform to the requirements of ANSI/AWWA C206. Steel pipe, ductile iron pipe, and concrete cylinder pipe shall be provided with blind flanges, test fittings, or bulk heads for hydrostatic testing. If so desired or required to connect to existing piping systems, the design consultant can propose alternate pipe and/or restrained joining systems.

Thrust restraint for exposed piping, bends, fittings, valves, etc. shall be achieved through the use of flanged fittings. The thrust restraint system for buried yard piping, bends, fittings, valves, bulkheads, etc. shall be restrained by using City-approved joint restraint devices compatible with the type of pipe selected. (Joint requirements for various pipe materials are include in the MAG Standards.) The use of concrete cylinder pressure pipe, steel pipe, and ductile iron pipe shall adhere to the restraint length calculation provided in AWWA M-9, M-11, and M-41, respectively. If welded joints are used, no additional thrust restraint is required. However if tying into an existing system, it is recommended a thrust block or some other restraint system be utilized to secure/restrain the existing pipe/fitting. The length of the restraint system shall be shown on the design drawings and complete supporting data on the restraint system design shall be submitted to the City for review and approval.

Where yard piping is to be installed in corrosive soil or dialectically hot soil, additional protection may be required based on the recommendation of an experienced corrosion protection specialist. These systems shall be discussed with the City and shall conform to the applicable ANSI, AWWA, and ASTM standards.

The design consultant shall coordinate the design of the station piping and yard piping with the design of new adjacent piping systems and/or existing adjacent piping systems. The design consultant shall coordinate the type of pipe, horizontal and vertical alignment; pipe thrust restraint, closure locations, connection method and sequence, cathodic protection requirements, linings and coatings, etc. with adjacent piping system designers and the City.

The design of all pump station reservoirs, well facilities, and PRV stations both new and existing shall include isolation valving and piping added to the yard piping design by each design consultant. Isolation valving and piping of all pump station reservoirs, PRV stations, and well facilities shall be provided to minimize disruption to the system when pumps or equipment are out of service or not operating as designed. Multiple reservoirs shall be piped such that each reservoir can be operated independently, in parallel, or in series.

10.9 Utilities

The design consultant shall be responsible for coordinating all utility requirements for the facility, including power, telephone (if required), water, etc. A ¾" minimum potable water line must be designed to enter the station. The WSD can provide assistance with identifying a potable water source. A public fire hydrant shall be located outside of the station (preferably on low pressure line) if none exists within 200 feet of the entrance gate. Any design associated with water services shall follow the requirements of the MAG Uniform Standards for Public Works Construction, including the City of Phoenix Supplements and the City of Phoenix – Water Services Department Design Standards Manual for Water and Wastewater Systems. Power, telephone, and other private utilities shall be coordinated with the respective utility company in the area. The electric transformer, electric meter head, and other utility meters shall be located within the confines of the facility enclosure.

10.10 Geotechnical Evaluation

General: Geotechnical services related to the designs of pump station reservoirs, PRV stations, and well head facilities shall be provided by a geotechnical consultant experienced in geotechnical evaluations of below-grade retaining walls and footings, vertical sound walls, foundations and underground structures, and partially buried and at-grade structures. The geotechnical/soils engineer must obtain right-of-entry or permission in writing from the landowner prior to entering or accessing any property. Photographs depicting the site conditions prior to, during, and subsequent to the geotechnical investigation shall be submitted to WSD and PDD with the Preliminary Design Report. Upon completion of the geotechnical work, i.e. soils boring, excavation, etc., the property shall be returned to its previous condition. The geotechnical consultant shall be responsible for determining the following site conditions and specific design criteria.

a. **Site Conditions:**

The geotechnical consultant shall be responsible for providing an evaluation of the site to determine the minimum number and the depth of exploratory soil borings required for design of any station structures, related piping, etc. During the soil boring operation, the geotechnical engineer shall examine, visually classify and log each of the soil borings, and obtain samples for material classification. The geotechnical consultant shall conduct (at a minimum) the following laboratory testing on selected soil samples:

1. Gradation and grain-size analysis.
2. Modified proctor, direct shear tests, and Atterburg limits.
3. Sulfates, pH, chloride, and total salts.
4. Dry density and moisture content determinations.
5. Soil permeability.
6. Soil stability and excavation method and means.

Single point soil resistivity tests shall also be performed on these samples for in-situ and saturated conditions.

b. **Design Parameters:**

The site evaluation carried out by the geotechnical consultant shall address the following minimum design parameters:

1. Total and differential settlement.
2. Minimum footing embedment.
3. Recommended foundation system.
4. Active and passive earth soil pressure.
5. At-rest soil pressure.
6. Design soil bearing capacity.
7. Natural groundwater elevation (if applicable).
8. Presence of corrosive soils and expansive soils.
9. Excavation side slopes that cannot be exceeded without sheeting, shoring, and bracing.

10.11 Noise Control and Abatement

General Design Guidelines: Noise levels from pumps and ancillary equipment can have a negative effect on neighbors as well as City personnel. Neighbors are affected by transmitted noise that extends beyond project (station) boundaries, whereas station noise can have a negative effect on the health of City personnel. Maximum noise levels in working environments are regulated under the federal Occupational Safety and Health Administration. The OSHA requirements and regulations shall be included in the design of all structures to establish the working environment's maximum noise levels. Station noise discussed herein applies to both structures and enclosed compounds.

Noise can come from a wide variety of sources but is mostly limited to noise generated from large equipment. These sources can include pump motors, HVAC systems, standby generator units, blowers, and fans. A significant contributor to noise can also come from operation and maintenance activities; noise generated from these activities usually contains variations in tone or frequency. These variations typically have a greater annoyance impact on the surrounding community than simply the decibel level.

Noise control measures at pump stations and well facilities should focus on equipment selection, use of structure sound barriers and sound traps, acoustical shrouding and/or enclosing equipment, wall batting, and acoustical architecture to attenuate the sound wave forms. Construction of these facilities can also contribute significantly to noise levels resulting in human annoyance. Though construction is temporary, provisions should be included in the design specifications to ensure the contractor obeys all local noise ordinances. One way to mitigate construction noise is to restrict the contractor's work hours to specific times during the day/evening and/or require the use of temporary noise barriers.

a. **Reference Standards and Codes**

The following standards and codes shall be followed:

1. Latest OSHA updates.
2. Latest update of the Phoenix Zoning Ordinance, Section 627.
3. Most current design requirements as established by the City of Phoenix Planning and Development Department (PDD) (General Notes); see Appendix A. These general notes are provided to assist the design consultant in understanding elements of the City of Phoenix PDD review and submittal process as well as to provide additional design criteria. These are not to be confused with the General Notes (and key design criteria information) that are required on the Final plan set.

b. **Design Issues**

PDD and the Phoenix Zoning Ordinance have established requirements regarding noise. According to the PDD General Notes (which shall be included in the construction documents), "No noise, odor or vibration will be emitted so that it exceeds the general level of noise, odor or vibration emitted by uses outside of site." This is interpreted by WSD as noise emitted from a pump station, PRV station, reservoir or well facility shall not exceed a value of 50 dB at the project property line, when measured on an "A weighted" sound level meter according to the procedures of the EPA. However, if the project is located in an area with a designated zoned use of A-1 or A-2 (light industrial), according to Phoenix Zoning Ordinance, Section 627, Chapter 6, E, 3, and Section 628, Chapter 6, D, 3 "The average noise level, measured at the property line, shall not exceed 55dB (1dn) when measured on an "A weighted" sound level meter and according to the procedures of the Environmental Protection Agency." Table 10.1, Typical Criteria for Background Noise, has been provided for information purposes only; it should be used as a reference for comparing typical background noise levels for indoor and outdoor areas. This table has been reproduced in its entirety from the Design of Municipal Wastewater Treatment Plants, Volume 1, 1991, 2nd edition.

Table 10.1 Typical Criteria for Background Noise

Space Type	Noise Level dBA
Indoor	
Conference Rooms, offices	42
Lobbies, laboratory, work areas	47 - 56
Light Maintenance shops	52 - 61
Work spaces – communication required	56 - 66
Work spaces – no communication required, but with no risk of hearing damage	66 - 80
Hearing protection required	85
Outdoor	
Quiet residential	40 - 50
Average residential	50 - 60
Commercial	55 - 65
Industrial	60 - 70

The completed pump station, PRV station, and/or well facility design must comply with the established PDD and Phoenix Zoning Ordinance noise requirements as discussed in the preceding paragraphs.

If buildings are used in the design, main sources of station noise are anticipated to emanate from HVAC supply and exhaust systems and the use of standby emergency generators. Fan selection, duct sizing and configurations, and inlets and outlets shall be carefully designed to ensure noise emissions are minimized. It is required that fans/blowers be mounted within a building to reduce noise and discharges equipped with appropriate sound traps.

The emergency generator, if located within the structure, shall be equipped with hospital grade exhaust silencers and inlet and outlet louver appurtenances to minimize nuisance noise. If, however, the generator is located outside of the station building or within a compound, it is recommended the generator be shrouded in its own soundproof enclosure. (Acoustical generator enclosures are readily available from a host of generator manufacturers). On shrouded units, the design consultant shall include the use of hospital grade silencers to control generator exhaust noise. Depending on the required decibel level, multiple silencers may have to be arranged in series to achieve the desired decibel level. The generator may be located within a secondary containment area to lower the generator below the height of the station wall and reduce noise produced by the equipment. The containment shall not be depressed more than three (3) feet below grade and four feet of clearance between the equipment and containment walls must be provided. A six inch curb must also be provided around the containment to prevent stormwater runoff from entering. Adequate flood protection measures shall be designed into the depressed generator design to ensure protection against flood hazard.

c. **Noise Mitigation Design Standards**

The City has established these standards for the design and construction of pump station reservoirs, PRV stations, and well head facilities; the designer shall ensure the station design conforms to these standards unless otherwise approved by WSD. The WSD Guide Specifications and those criteria identified within this manual shall be followed. Those listed design criteria and others associated with either controlling or dampening noise levels in pumping facilities have been reviewed and discussed with representatives of the WSD:

1. Maximum Noise Level:
   - According to Phoenix Zoning Ordinance, Section 627, Chapter 6, E, 3 for land zoned as A-1 and Section 628, Chapter 6, D, 3 for land zoned as A-2 use: 55 dB at the project property line.
   - According to WSD, for all land zoned other than A-1 or A-2 use: 50 dB at the project property line.
2. Select station equipment that meets OSHA requirements for 8 hours of continuous exposure.
3. Standby emergency generators shall be provided with hospital grade exhaust silencers see WSD Guide Specifications.
4. Within facility buildings and enclosures, the exhaust systems of standby emergency generators' shall be covered with high temperature insulation (inner layer shall be rated for 1,800 degrees Fahrenheit; outer layer for 1,000 degrees Fahrenheit). Insulation shall be calcium silicate with Type 304 stainless steel strapping, bands, and appurtenances.
5. White vinyl coated, quilted, acoustically absorptive fiberglass batting (cloth) shall be used to line the interior walls of the standby generator room and other high noise areas.
6. As an alternative to batting, slotted acoustic concrete masonry units can be substituted for standard masonry units in the construction of a building. Factory-installed, sound absorbing elements are provided in masonry unit cores. Finish and color shall be as selected by the City.
7. Sound traps on ductwork systems, generator radiator, and intake louvers shall be constructed of Type 304 Stainless Steel sheets. Seams shall be locked formed. Dividers shall be fabricated of perforated 304 stainless steel sheets, cavities filled with an inert, moisture- and vermin-proof acoustical absorbent material.
8. Acoustical equipment enclosures shall be specified for individual pieces of equipment or pumps located in enclosure compounds. These enclosures shall be constructed from acoustical quilts, modular acoustical

screens, or as recommended by the equipment manufacturer.

d. **Groundwater**

If applicable, the geotechnical consultant shall evaluate and provide recommendations for the following groundwater conditions:

1. Design groundwater elevation.
2. Construction dewatering.
3. Soil permeability.
4. Design of underdrain systems, including drain rock or modified footing/floor slab design to guard against uplift.
5. Moisture protection (membrane vapor barrier).
6. If groundwater levels will impede construction, a groundwater consultant shall be employed to prepare a dewatering plan to be incorporated into the construction documents.

e. **Site Preparation**

1. The geotechnical consultant shall provide recommendations for the following:
2. Temporary excavation slopes.
3. Structural/permanent fill and cut slopes.
4. Fill and backfill materials and compaction.
5. Granular base gradation requirements.

f. **Pipelines and Pavement**

1. The geotechnical consultant shall provide recommendations for the following:
   - Excavation slopes and shoring.
   - Cut or fill side slopes and temporary slope faces shall be protected per the recommendations of the geotechnical consultant.
   - Slope faces: Permanent slope faces shall be provided with slope protection. If shotcrete or gunite is not utilized, side slopes shall not exceed a steepness of 4:1 (H:V) side slope. If shotcrete or gunite is utilized, side slopes shall be a minimum of 4:1 (H:V) to a maximum of 1:1 (H:V), but only if acceptable to the project's geotechnical consultant.
2. The geotechnical consultant shall refer to MAG Standards and the City of Phoenix Supplement and make recommendations for:
   - Trench width.
   - Bedding material and thickness.
   - Pipe zone and trench backfill.
   - Compaction requirements.
   - Pavement design for both flexible and rigid pavement for anticipated traffic, vehicle types, and loads. (The minimum pavement design shall be 3 inches of asphaltic concrete (AC) over 5 inches of aggregate base course (ABC).)

3. For requirements concerning construction within the street right-of-way, the design consultant shall refer to the City of Phoenix Street Transportation Department supplement to MAG Standards.

g. **Seismic**

The geotechnical consultant shall address the seismic parameters detailed in the most current City codes. The City of Phoenix is located in Seismic Zone 2A. As a minimum, the following design parameters shall be determined:

1. Average shear wave velocity as determined by the "subsurface soil profile concept."
2. Seismic refraction survey including time/distance plots and site plan (indicates the existence of shallow bedrock conditions).
3. Maximum credible earthquake for known major faults.
4. Potential for liquefaction and recommendations.

h. **Corrosion Potential and Chemical Testing**

The design consultant shall retain the services of a corrosion specialist subconsultant to perform an analysis of the project site. The corrosion specialist shall review the site and evaluate the magnitude of induced AC current potential on the project site. Sources for stray current include: unshielded buried power cables, overhead power lines, and existing utilities utilizing impressed current as a form of cathodic protection. The corrosion specialist shall perform chemical tests and corrosivity analyses on the project site and provide recommendations regarding protection of facility components and piping to be installed in these soils. Analyses and tests shall include at a minimum, the following:

1. Test soil for pH, chlorides, and sulfates.
2. Measure soil AC potential for stray electric currents.
3. Measure soil resistivities.
4. Conduct utility interviews.
5. Evaluate the corrosion potential for buried station pipes and pipelines.
6. Recommend pipe and pipeline coatings and cathodic protection measures.

i. **Geotechnical Reports**

Geotechnical reports prepared for design purposes shall be prepared in accordance with acceptable standards of practice, such as those below:

1. The soils report and soil boring logs shall contain only a description of the investigation made and the results of the laboratory tests performed. Soil data, testing results, and investigations made should be kept separate from summaries and recommendations.
2. In general, the geotechnical report should be written to address the design through the design consultant. No comments or directives should be made addressing the contractor nor should any be implied that might suggest direction to the contractor, i.e. expected excavation,

methods of construction, materials, etc. If the design consultant requests the geotechnical report comment on these issues, it must be specifically stated in the report those sections pertaining to expected excavation or methods of construction were made to clarify design issues.

3. Site observation and test results regarding soil permeability shall be included in the geotechnical report.

CHAPTER 11 - ARCHITECTURE AND LANDSCAPING

11.1 Architectural Guidelines

The design consultant shall meet with WSD, PDD, and the appropriate village planning committee (if applicable) to discuss the appearance and physical attributes of the facility, establish architectural criteria and landscape requirements, and facility layout and design, for the pump station, PRV station, and/or the well facility designs. Selected criteria shall focus on internal and external features of the facility as well as the surrounding facility/neighborhoods, including input from the neighborhood during open-house meetings. The City meetings will be used to create an efficient yet functional design incorporating City requested features and equipment requirements.

11.1.1 External Features

External criteria shall incorporate the theme of the surrounding community into the aesthetic design of the station or well facility. Form, style, materials of construction, the use of wrought iron fences, concrete masonry unit (CMU) block walls, gates, etc., including the use of colors and finishes, should reflect the theme. The underlying intent of the external architectural treatment of a facility is to have it blend in with the surrounding community/neighborhoods while maintaining a level of security. Established City standards, preferences, and guidelines for materials, building layout, site security, and appearance should also be discussed and integrated into the design.

11.1.2 Internal Features

Internal design features focus on the location and configuration of the selected processes within the station footprint, size of major pieces of equipment and their interdependency on adjacent mechanical and electrical systems, and their operation and maintenance. Environmental concerns and special requirements such as noise limitations, lighting requirements, security, HVAC requirements, personnel ingress/egress, maintenance/repair requirements, equipment clearances, and safety requirements shall also be identified and incorporated into the design.

11.1.3 Lighting

The lighting design shall satisfy the operational, safety, and security needs of the facility. Interior ambient light levels shall be established for optimum safety and efficiency. Task lighting is lighting designated to relate to a specific task location and orientation, i.e., MCC panels, SES panels, etc. Where necessary, separate guidelines shall be established for specific tasks and areas, such as lighting at instrument panels and/or chemical feed/storage locations. As a minimum, task lighting shall provide a lighting level of at least 20 foot-candles. Interior of buildings and enclosures shall be provided with four-foot fluorescent lights.

Facility lighting shall be provided with at least one light with a manually operated switch. The light switch shall be located next to the access gate in the interior of the facility. Exterior lighting criteria shall be established to accommodate all necessary nighttime operations and assure a reasonable level of security for the facility. At the same time, exterior lighting criteria shall avoid illumination levels that are a nuisance to the surrounding community per the requirements of Shielding and Filtering Outdoor Lighting (“Dark Sky”), City Code Section 23-

100. Wall-mount lighting shall be used in stations less than or equal to 130 feet by 80 feet, while pole-mount lighting is required in larger stations. Wall lights shall be mounted 24 inches above the finished grade or ground floor, and top of poles shall be lower than the top of the perimeter wall.

a. **<u>Facility (Outside) Lighting</u>**:
   1. CMU block walls: use wall mount H.P.S. lights on stations less than or equal to 130 feet x 80 feet. Lights shall be mounted 24 inches above finish grade/ground floor.
   2. Use pole mount H.P.S. lights on stations more than 130 feet x 80 feet. Top of pole shall be lower than the elevation of the top of the wall.

b. **<u>Inside Lighting</u>**:
   1. Interior of buildings and enclosures: use 4-foot fluorescent lights; vapor proof, 2 lamp, with a T-8 ballast.
   2. Task lighting is lighting designated to relate to a specific task location and orientation, i.e., MCC panels, SES panels, etc. Task lighting shall provide a minimum lighting level of 20 foot-candles (fc).
   3. Task lighting shall consist of simple open PAR lamps mounted under an electrical/control equipment canopy or on an equipment panel.

11.2 Gates and Perimeter Wall

The City prefers having two gates to allow drive-thru access to pump stations. If only one gate is provided, there must be enough room for a fire engine to turn around within the station. The height of all station perimeter walls shall be 8 feet, which may require a variance from the zoning department. The access gates shall be the same height as the perimeter wall and have 20 feet opening width to allow for fire engine and chemical delivery truck entry. Locks and alarms are required on all gates, and gates must be secured or braced to eliminate false alarms caused by wind or rattling of the gate doors. Bracing should be placed on the inside of gate doors to avoid climbing surfaces on the outside of the station. Gates must also be wired for card and/or keypad access to be used by City employees. Wiring must be placed inside the station within conduits, and access conduits and wires ran to both inside and outside card reader locations. At each gate, site grading shall be either flat or sloping away from the station.

Other general gate provisions:

a. Gate material will be discussed on a case-by-case basis depending on the location and neighborhood requirements.
b. Rolling gates are required to be automated and must open to full width.
c. The facility entrance (traffic gate) shall have a twenty (20)-foot-wide, panel-style, rolling access gate. Traffic gate material of construction will be discussed on a case-by-case basis depending on the location and neighborhood requirements. As a minimum the gate shall be constructed of wrought iron.
d. Man (pedestrian) gates will not be permitted at any of the City facility sites.

e. Driveways must be paved. The station shall have a paved access road at least 20 feet wide with a maximum slope of 10%. A 45-foot-radius turn around as measured from the centerline of the access road shall be provided if the access road exceeds 50 feet in length
f. The interior of the facility shall be surfaced with a 4-inch, compacted aggregate base.
g. Access for service vehicles to major station components shall be provided.
h. The Fire Department will use a Knox box to gain access through the station gates; a Knox padlock locking bar system is required at the entry gate. If the facility is not within the City of Phoenix boundary the use of a Knox box will have to be coordinated with the responsible Fire Department for the area
i. Gates must be automated if they are too heavy to be opened manually. This requirement will be determined by WSD.
j. A sign must be posted on the station's entry gate. Standard signage includes identifying the station and/or well number, address, and emergency telephone numbers. See WSD for sign dimensions, etc.
k. Additional signage shall include "No Trespassing" signs. See Figure 11-1 for the City's standard "No Trespassing" sign detail.
l. Gates shall be designed to be hung from isolated support posts independent from the site walls.
m. Gates shall be positioned 3-inches above finish grade. If the gate position is recommended to be otherwise, permission must be obtained from WSD.

11.2.1 Walls

Walls shall be designed with consideration for the following:

a. The wall shall be compatible with the surrounding environment, including landscaping and zoning requirements. (A zoning variance may be required.)
b. An Eight (8)-foot-tall screen wall with a lockable traffic entrance gate enclosing the facility. The wall shall be compatible with the surrounding environment, including landscaping and zoning requirements. (A zoning variance may be required.)
c. Before the type of block surface can be selected for each particular project, the design consultant shall meet with the City to discuss on a case-by-case basis, the location of the project and neighborhood requirements. Walls are typically constructed of concrete masonry unit (CMU) block. The type and size of the CMU block must be presented to the City for review as part of the design reports.
d. Once the type of wall has been selected and approved by the City and the community, the design consultant shall work with the City and the community to finalize such design items as color of the paint applied to the block or wrought iron, type of block, finish/stain, wrought iron fencing mixed in with the block construction, etc.
e. The use of stucco on CMU block is not acceptable to the City.

f. CMU block shall be manufactured with a standard gray color; integral colored block is not allowed. Depending upon the architectural theme of the project, the block shall be painted or stained a specific color after the wall is constructed. Prior to painting, an acrylic-bonding agent, compatible with the selected finish coat, shall be applied to the block.

f. All CMU block walls are to be painted or stained. If no paint or stain color is identified by the design consultant, the City will select the color from color samples provided by the design consultant.

h. Wall footings shall be continuous with the floor slab.

i. Vertical wall construction joints shall align with the floor joints. Construction joints shall utilize (as a minimum) 3/8-inch by 6-inch polyvinyl chloride (PVC) flatstrip water stops and ¾-inch triangular sealant grooves.

j. Two techniques are recommended to reduce the tendency for vertical wall cracking that results from footing restraint:
   1. The wall shall be keyed into a joint at the top of the wall footing. To minimize water demand from the footing on the fresh wall concrete, the keyway in the footing should be kept wet until the wall concrete is placed.
   2. Additional horizontal reinforcing shall be placed in the bottom 3 feet of the wall.

NO TRESPASSING

IN ACCORDANCE WITH
A.R.S. 13-1504

SIGN SIZE = 12” X 42”
TEXT SIZE = 3” LARGE, 2” SMALL
FONT STYLE = TIMES ROMAN BOLD
WHITE BACKGROUND
BLACK LETTERING

Figure 11-1 City No Trespassing Sign

All locks and keys for station ingress, general access, equipment panels/cabinets; enclosures, access hatches, etc. shall be coordinated with City security standards. Follow the Phoenix Fire Department’s requirements for gate and lock details; each site must be evaluated for compliance with security measures on a case-by-case basis.

11.3 Shade Canopy

The shade canopy's primary function will be to provide electrical, instrumentation, and control equipment protection for the sun. The shade canopy shall consist of the following:

a. Frame-Structural steel tubing per WSD Guide Specifications

b. Canopy Material - High-density polyethylene knitted fabric which meets flammability standards. The canopy may also be constructed out of metal with approval from WSD.

The canopy size with layout and details must be clearly shown on the drawings (overall site plan or electrical site plan) with dimensions to the property line. A table noting the building (shade canopy) classification as required by the current building code.

11.4 Landscaping

In projects where landscaping is required, the design consultant shall utilize the services of a registered landscape architect (RLA). Landscaping materials, plantings, etc. shall be provided in accordance with local codes and ordinances, and with the most current edition of the American Nursery Association Standards.

Applicable local codes and ordinances include:

a. "Hillside Ordinance," Section 710 of the Phoenix Zoning Ordinance
b. "Landscape Standards and Guidelines," City of Phoenix
c. Low Water Using Plant List Phoenix AMA
d. Arizona Department of Water Resources
e. City Water Conservation Ordinance

Landscaping plans are reviewed through PDD. Specific issues regarding landscaping and site security around the facilities must be addressed at the Pre-Application Meeting. The design consultant with the RLA shall review all landscape design concepts including irrigation system design criteria with the City. Required landscape design concepts are provided in the following sections.

11.4.1 Plant Inventory and Re-Vegetation Design

The RLA shall prepare an on-site inventory (vegetative plan and de-vegetative plan) of desired native plants within each facility, staging areas, storage areas, piping alignment, etc., for potential salvage and reuse per the City of Phoenix supplement to the MAG Standards. The RLA shall provide recommendations for the following:

a. Notice of Intent to Clear Land, written and delivered to the Arizona Department of Agriculture.
b. Plant inventory (by species, number, and location) and salvage plans.
c. Compliance with Section 710 of the Phoenix Zoning Ordinance, (Hillside Area Development).
d. Specifications for site restoration.
e. Compliance with restoration or re-vegetation requirements imposed by ADEQ to satisfy 401 certification conditions.

11.4.2 Plantings and Ground Cover

Landscape planting shall be indigenous plant species appropriate for the region. All species shall be selected for ease of maintenance, hardiness, and drought tolerance. Because Phoenix is a desert community, plant selections should serve as an example of aesthetically pleasing, yet reasonable techniques of resource management and water conservation wherever possible. In areas where ground cover is a City requirement, it is required that graded, decomposed, crushed granite be used. Color and size of materials and plantings shall be carefully selected to emphasize and strengthen the facility's relationship with the surrounding environment.

The RLA shall consider the safety and security of the pump station, PRV station, and/or well facility when specifying plant species and locations. Landscaping materials must not aid in gaining access into the station/facility. Trees shall not be planted in the proximity of the facility's perimeter wall or structures (within 6 feet), keeping in mind the mature height of the tree. Only low-growing or insubstantial trees and shrubs may be planted near facility walls. No landscape planting will be planted on the interior of the perimeter wall. The interior of the facility shall be surfaced with a 4-inch base, 3/8" compacted aggregate base.

Permanent slope faces shall be provided with some sort of slope protection. If decomposed granite is used, the minimum side slope shall be 5:1 (H:V), but only if acceptable to the project's RLA.

11.4.3 Irrigation System

Irrigation system design criteria shall harmonize with the public image of the client as a responsible resource management organization. As such, irrigation water should not be visibly wasted to evaporation, but rather efficiently and unobtrusively delivered to the point of use through underground piping (i.e. drip system) and operated by a controller system. Refer to the City of Phoenix Supplemental to MAG Standard Specifications and Details for specific provisions for the construction of irrigation systems, including trenching, piping, backflow preventer assemblies, valves, fittings, emitters, controllers and wiring, etc.

11.5 Structural Design Requirements

General Design Guidelines**:** This section identifies the codes, standards, and design aides that shall be used in the design of structural components of pump stations, well facility structures, and PRV stations for the City. This is intended to serve as an introduction to structural design requirements and should not be construed as an all-inclusive list. A Conceptual Design Report, Preliminary Design Report, and a Final Design Report shall be prepared by the design consultant to support each design project. The following structural design requirements shall be included as part of the project's CDR, PDR, and Final Design Report.

11.5.1 Reference Standards and Codes

The following standards and codes shall be used in the design:

a. The latest edition of the building code.

b. The latest edition of ACI for Environmental Engineering Concrete Structures (ACI 350R).

c. The latest requirements for reinforced concrete (ACI 318) and commentary (ACI 318R) as contained in the UBC.
d. Latest requirements from Occupational Safety and Health Administration (OSHA).

11.6 General Service Design Loads

Each structure shall be designed to safely support the imposed live and dead loads. Loading combinations and live load reductions shall be according to the requirements/limitations set forth in the building code. All live and dead loads used for the purpose of design shall be developed for the intended use or occupancy of the particular structure.

The following general service design loads shall be used in the design of pump station and well facility structures. These loads include dead loads, live loads, impact and vibration loads, wind loads, earthquake loads, hydrostatic loads, lateral soil loads, and applicable miscellaneous loads.

a. **<u>Dead Loads</u>**: In addition to the dead load of the basic structural elements, the following items, at a minimum, shall be used:
   1. Piping 12 inches in diameter and smaller shall be treated as uniformly distributed loads. Typical values are 20 pounds per square foot (psf) for extensive piping and 10 psf for light to moderate piping.
   2. Piping larger than 12 inches in diameter shall be considered as concentrated loads.
   3. Pipeline thrust under maximum pressure conditions.
   4. Earth: 120 pounds per cubic foot (pcf), or as recommended by the geotechnical engineer.

b. **<u>Live Loads</u>**: In addition to dead loads, the following loads shall be used:
   1. General roof live loads, walkways, platforms, and stairs shall have a minimum (unreduced) live load of 100 psf. Additional consideration shall be given for the type, size, and weight of specific equipment, and maintenance of equipment, in determining the actual design live loads and concentrated loads. Requirements are as follows:
      - **Mechanical and electrical rooms**: Equipment weight + 100 psf.
      - **Stairs and walkways**: Use the greatest of 100 psf or 1,000 lbs.
      - **G rating**: Use a concentrated load of 300 lb/ft with less than ¼-inch deflection.
      - Use HS20 load per AASHTO for **truck loading**.
   2. Electrical and pipe space areas can be estimated by using 150 psf or more as determined by actual equipment.

c. **<u>Hydrostatic Loads and Lateral Soil Loading</u>**: The values for lateral soil pressures and soil-bearing pressures for below-grade structures or parts of structures shall be designed in accordance with the geotechnical report(s)/geotechnical engineer.

1. Buried reinforced concrete structures shall be designed for hydrostatic forces imposed by the presence of groundwater. The design of these structures shall include resistance to uplift forces.
2. For buried hydraulic structures:
   Use high operational water level without backfill (33% overstress).
3. Lateral soil loading shall include active soil pressures for yielding walls, at-rest soil pressures for non-yielding walls, and surcharge pressures due to a minimum soil cover of 2 feet or equal to the actual depth of the soil cover above the structure.
4. Seismic soil pressures.

11.7 Seismic Design Criteria

Each structure shall be designed in accordance with the latest edition of the building code and per site-specific seismic design recommendations given in the geotechnical report(s). For minor isolated structures where a site-specific study may not be performed, the appropriate provisions of the building code shall be used to determine seismic forces. Seismic forces resulting from dead loads shall be determined using the appropriate ground acceleration and in accordance with the building code criteria.

11.8 Structural Design Criteria

Reinforced concrete shall be designed for both strength and serviceability. The strength design method and the working stress method (alternative design method) are acceptable for reinforced concrete design. Reinforced masonry block shall be designed based on the working stress analysis method.

Pump stations, PRV stations, and well head facilities with onsite structures constructed of reinforced masonry block shall be designed based on the working stress analysis method.

a. <u>Materials</u>

1. Hollow concrete masonry units: Grand N-1, Type 1 moisture-controlled units made from concrete with a compressive strength at 28 days of at least 2,000 psi based on the net section, made from normal weight aggregates (ASTM C33). Size: 8-inch by 8-inch by 16-inch concrete block.
2. Masonry reinforcement: ASTM A615, Grade 60.
3. Concrete for water bearing structures shall be constructed with 4,000 psi concrete. The concrete mix design will be determined on a case-by-case basis by the project's structural engineer and delineated in the project's Contract Documents.

b. <u>Joints</u>

Expansion and construction joints shall be provided in accordance with ACI 350R to allow flexibility and to adequately tolerate differential movements and shrinkage stress. Strength design method shall employ load factors and strength reduction factors.

Load factors for each structure shall be in accordance with ACI 318-83 Code.

c. **<u>Floor Slab</u>**

Floor slabs shall be designed with consideration for the following:

1. Minimum 3,000 psi concrete.
2. Station (and any vaults) floor slabs shall slope for drainage at a minimum of 1% along the longest distance and sloped to a sump.
3. A perimeter drain shall be formed along the inside perimeter of the floor slab. Dimensions of the perimeter drain shall be 3-1/2 feet wide by 3-1/2 feet deep. The perimeter drain shall be sloped to the sump location using non-shrink grout fill.

CHAPTER 12 – SECURITY

12.1 Remote Facility Security Requirements

WSD has developed minimum security standards which are required to be installed at all new sites. The minimum standards include the following:

a. A block wall minimum height of 8’ measured from the existing ground on the exterior of the site.
b. An access gate the same height as the block wall.
c. Intrusion alarm contacts on all panels, gates, and doors with communication to Security Management and SCADA.
d. Low level lighting.
e. All landscaping to be reviewed by WSD and at a minimum no trees shall be planted within 10’ of the perimeter wall.

Due to the sensitive nature of site security, this guidance manual provides only a brief discussion of the topic and presents some basic information. Each project must be evaluated on a site-by-site basis by WSD as part of the design process and specific remote facility security requirements will be established at that time. For additional information relative to Remote Facility Security, designers should contact the WSD to request a meeting to discuss specific security requirements.

CHAPTER 13 - START-UP AND COMMISSIONING

The start-up of booster pump stations, PRV stations, and well facilities are a highly complex process requiring the combined technical expertise of the Contractor, manufacturers, subcontractors, the design engineer (or other appointed representative of the Developer/Owner), and Owner. Start-up is the responsibility of the Contractor and shall include the City's engineer or the developer's engineer/consultant, working closely with personnel from WSD Engineering and Operations as well as the third party inspection firm if applicable. In order to ensure a smooth project start-up and commissioning, a plan will be required to be submitted with the conceptual design report. The start-up and commissioning plan must be reviewed and approved by personnel from WSD Engineering and Operations prior to receiving design plan approval. Refer to the WSD Guide Specifications for more details and the most current requirements. The start-up plan shall include the tasks necessary for operations and maintenance (O&M) manuals, start-up, testing, training and commissioning, and a schedule showing each task. To assist in the development of a testing program that will meet the requirements, refer to the City of Phoenix Equipment Setup/System Testing Guidance Manual. Once start-up and commissioning begin, the design consultant shall conduct a complete and thorough start-up check to avoid damaging equipment, malfunctions, and future operational problems. The commissioning shall demonstrate proper operation of all mechanical equipment, electrical controls, emergency power and warning displays, and shall be witnessed by the Owner (or appointed representative of the Owner). Division 1 of the WSD Standard Guide Specifications provide requirements and specifications for putting equipment in service, as well as O&M manuals, start-up, testing, training and commissioning requirements.

Provisions for project O&M manuals, start-up, testing, training and commissioning must be included as a tasked item in the developer consultants' scope of services. This includes requirements set forth by the City that developers must ensure their engineers have included in their project scope of services provisions for Project Start-Up and Commissioning.

O&M Manuals, start-up, testing, training, and commissioning of a project is generally the period of project development that occurs at the end of the construction phase. Project O&M manuals, start-up, testing, training, and commissioning shall commence only on entire systems that are complete, ready to run, and useable, i.e., after all station alarm points and functions (including remote telemetry functions) have been methodically verified and tested by the contractor, without failure. This is considered the Equipment Start-Up prior to testing the equipment 24 hours per day for a period of seven (7) consecutive days, see below – Pre-Demonstration Period. This seven (7) day period is prior to the start of the 30 day commissioning period. Some equipment may require a Pre-Demonstration Period that is less than 7 days as approved by WSD.

All I & C inspections shall be witnessed by the City or a City appointed I & C inspector. The inspector(s) shall witness all loop checks and field instrument calibration of all equipment. The loop checks and field calibrations shall be performed by the Contractor. The Instrument Calibrations will consist of verifying the devices function within their full ranges and set points, plus completion of the calibration reports identified in the project specifications. The loop checks consist of:

a. Witnessing the functionality of the field instrument through any control panels and the logic in the Computer Control System
b. Controlling the signatures on the Computer Control System testing signoff sheets identified in the project specifications.

Calibration forms are found in Division 1 of the WSD Guide Specifications.

13.1 Start-up

The Instrumentation and Controls Inspector will develop four punch lists during the project. They are listed as follows:

a. **Pre-Installation Punch List**: This inspection is to insure that the equipment conforms to the submittals and the specifications before it is to be installed. This is to avoid any rework that may be required at the manufacturer's facility. The inspection will be conducted when the equipment arrives on site. The Instrumentation and Controls Inspector will conduct a visual inspection of the equipment and develop the punch list. All issues that are listed that inhibit the installation of the equipment will need to be resolved before installation. All issues that do not inhibit installation will need to be resolved before Final Acceptance. The items from the Factory Test will be carried over to the Pre-Installation Punch list if in the opinion of the Instrumentation and Control Inspector that they can not be resolved at that time.
b. **Pre-Startup Punch List**: This inspection is to insure that the equipment is physically ready to be started up, tested, and witnessed by the Instrumentation and Controls Inspector and the Construction Administrator. The Instrumentation and Controls Inspector and the Construction Administrator will witness all loop checks for the control systems and sign off on all documentation required in the specifications. The items from the Pre-Installation Punch List will be carried over to the Pre-Startup Punch list if in the opinion of the Instrumentation and Control Inspector that they can not be resolved at that time.
c. **Pre-Commissioning Punch List**: This inspection is to insure that the systems are ready for commissioning. The inspection will include all equipment associated with the system. The Construction Administrator will determine the extent of the system. The Instrumentation and Controls Inspector and the Construction Administrator will witness the commissioning and sign off on all documentation required in the specifications. The items from the Pre-Startup Punch List will be carried over to the Pre-Commissioning Punch list if in the opinion of the Instrumentation and Control Inspector that they can not be resolved at that time.
d. **Final Punch List**: This inspection is to insure that all items from the previous punch lists are resolved and to document any items that require resolution before the City issues final acceptance.

13.2 Testing

As a part of the design of all pump stations, PRV stations, and well facilities, the project specifications shall include provisions for the contractor to perform equipment start-up and testing per the approved start-up and commissioning plan, the City of Phoenix Equipment Setup / System Testing Guidance Manual, and per Division 1 of the WSD Guide Specifications. The Contractor shall initially start-up and place all equipment installed into successful operation according to the manufacturer's written instructions and as instructed by the manufacturer's field representative. All system and subsystem components must be tested and proven operable before they can be started up for continuous operation. Start-up and testing shall be in accordance with the following definitions:

a. **Project Classified System (PCS):** A defined portion or part of the project, consisting of an arrangement of items, such as specific equipment, structures, components, piping, wiring, materials, or incidentals, related or connected so as to form an identifiable, unified, functional, operational, safe, and independent system.

b. **Equipment Start-Up and Testing**: This is the initial testing (turning on) of equipment prior to running the 7 Day Test. Equipment can include pumps, meters, etc.

c. **Pre-Demonstration Period – 7 Day Test (Performance Testing)**: The contractor shall perform an operational test of the facility for 24 hours per day for a period of seven (7) consecutive days. The Contractor will start up and successfully operate the facility without failure of the system. The 7 Day Test shall commence after initial construction and installation activities have been completed, during which the Contractor, with assistance from the equipment manufacturer's representatives, performs a sequence of facility reviews. The Pre-Demonstration Period shall not exceed seven (7) consecutive days and shall include manual and automated operation of pump stations, PRV stations, and well facilities. If a failure of any kind is encountered during the 7 Day Test, the fault will be rectified and the 7 Day Test will start again, commencing on Day 1, and continuing for 7 consecutive days with no failures. Start-up is considered complete when the station operates for seven continuous days without any failures. Some equipment may require a Pre-Demonstration Period that is less than 7 days as approved by WSD. Prior to beginning the 7 Day Test, the Contractor shall discuss and schedule with WSD; WSD will provide an inspector to witness the 7 Day Test for the City.

d. **Demonstration Period – Project Start-Up and Project Commissioning**: Following the successful outcome of the 7 Day Test, the Contractor will start up and successfully operate the facility, without failure, 24 hours per day for 30 consecutive days, in the presence of a City representative. Its purpose is to test the functional integrity of the mechanical equipment, electrical equipment and components, and of the control interfaces of the respective equipment comprising the facility as evidence of Substantial Completion. The Demonstration Period is considered the Start-Up and Commissioning phase of the project. The contractor must provide all equipment maintenance during the commissioning period. The City appointed I & C inspector will be responsible for the operation and response to alarms.

e. **Substantial Completion**: Establishment of the project's Substantial Completion by the City is based on the City's ability to use the entire project for the purposes intended while the remaining activity of the Contractor will not interfere with such use. Substantial Completion will only be declared when the entire facility operates as specified, not just portions of it. A requirement of Substantial Completion includes, but not limited to, all necessary construction inspections performed and successfully completed by PDD and the City of Phoenix Fire Department. See WSD Standard Guide Specifications Division 1 for further requirements establishing substantial completion.

f. **Final Completion**: This final stage of a project is satisfied only when the following have been completed by the Contractor and approved by the City:

1. Project punchlist completed and accepted by the Engineer
2. Commissioning has been completed
3. "Environmental Review Checklist" (see Appendix B) has been completed by the designer and accepted by the City
4. Certificate of Occupancy has been issued by PDD
5. Passing bacteriological test results are received
6. Passing pressure and leakage test results have been received
7. Maricopa County Approval of Construction (AOC) has been issued
8. Project's Operation and Maintenance Manuals and project record drawings have been submitted and accepted by the City
9. Private developer projects being turned over to the City must complete and have signed by the City, a developer's agreement. This agreement identifies elements such as ownership transfer, etc. Without this signed agreement, issuance of the project's Certificate of Occupancy will be withheld by PDD
10. Land transfer from developer to the City, water/sewer accounts switched from developer to the City

13.3 WSD Guidelines

To obtain general information on the WSD process and procedures, the design consultant shall visit the City of Phoenix website at www.phoenix.gov and contact the City of Phoenix Water Services Department.

The Contractor must document testing procedures by completing and signing required forms found in the WSD Guide Specification.

13.4 Training

The manufacturer shall instruct City Operations and Maintenance personnel on the operations and maintenance of all mechanical and electrical equipment placed in pump stations, PRV stations, and well facilities. The Contractor shall provide the services of factory-trained maintenance specialists to instruct City staff in the recommended operation and the preventative maintenance procedures of equipment, which shall consist of a combination of classroom and field training, including "hands-on" demonstrations of operation and maintenance of the equipment. See the WSD Guide Specifications for further training details and requirements. Training shall not commence until all Operations and Maintenance Manuals have been accepted and approved by WSD. See WSD Guide Specifications.

13.5 O & M Manual Preparation

No system, unit process, or any piece of equipment shall be started for continuous operation (including the 7 Day Test) without Operation and Maintenance Manuals being turned over, accepted, and approved by the City. These manuals consist of Operation and Maintenance Data to be used by City personnel for all equipment and systems, valves, and related accessories, instruments and control devices, electrical gear, and spare parts lists in accordance with the WSD Guide Specifications.