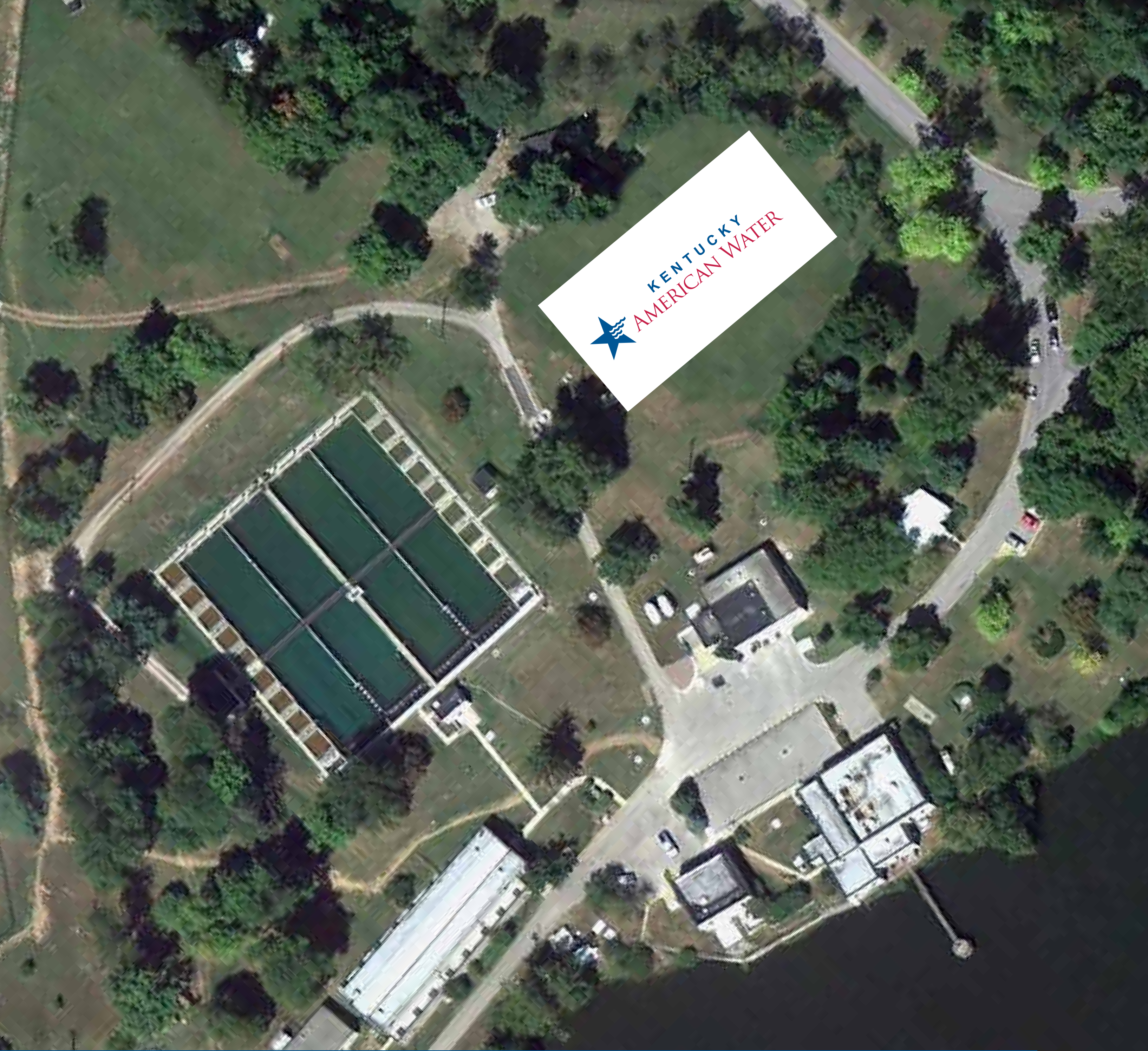

Basis of Design Memo - Draft 2

New Filter Building Design
Richmond Road Station Water Treatment Plant

Kentucky American Water

HAZEN AND SAWYER
Environmental Engineers & Scientists

The design of the Richmond Road Station Water Treatment Plant (RRS WTP) started with the notice of award in January 2014 and extends to July 2014.

There are several key milestones that must be accomplished to meet the completion date of this important project. Hazen and Sawyer prepared a preliminary Basis of Design Memorandum for review by Kentucky American Water (KAW). A meeting was held March 27, 2014 to review the memo and confirm design criteria.

H&S incorporated the design review comments into the drawings and preliminary drawings and submitted a 30% drawing set on April 18, 2014. The 30% design meeting was held on April 22, 2014, which discussed the process design and site/civil coordination. After the 30% meeting, drawings and specifications were updated and submitted to Kentucky Department of Water (KDOW) on May 9, 2014.

A 60% Design Review Package will be submitted to KAW on June 2, 2014. During this time KAW will also solicit bids and award the contract for Construction Manager at Risk. Hazen and Sawyer will work closely with the Contractor for the remainder of the project design. At the 60% design level, documents will be submitted to Lexington-Fayette Urban County Government for permitting. After KDOW permit approval is received, KAW will submit 60% design documents and the target cost to the Public Service Commission (PSC) in late June of 2014.

The 90% design documents will be prepared and provided to KAW for review the end of July 2014. The Final Design Documents will be should be provided to KAW the end of August 2014.

As specified in the RFP, the Notice of Award to the contractor is anticipated in January 2015. Based on our initial estimates, the construction period should be approximately 340 days. Construction is scheduled to be complete by April 2016.

2.1 Kentucky Division of Water (KDOW)

2.1.1 Water Supply Construction Permit

Under Title 401, Chapter 8 of the Kentucky Administrative Code, the Kentucky Department for Environmental Protection, Division of Water (KDOW) will issue a "construction" permit for the construction of the new facilities. The permit application, Form DW-2, has multiple sections for the following:

- I – Project Information
- II – Utility Information
- III – Design Considerations, and
- IV – Fees.

This application, along with plans, specifications and other supporting documents and design calculations, will be submitted. Under 401 KAR 8:101, the Department shall have up to 45 days from receipt of a complete submittal package to issue a preliminary or final approval. It is anticipated that the application for construction permit will include, but not be limited to, the following components:

- New filter complex,
- New CT contact basin,
- New backwash pump station, and
- Relocation of chemical application points

It is anticipated that 60% Design Documents and the Basis of Design Memorandum will be submitted to KDOW so that the review process can begin as soon as possible.

2.1.2 Floodplain Management Permit

It is not anticipated that new construction will take place in the 100 year flood zone area. Therefore, a permit for work in the floodplain will not be required.

2.1.3 Sanitary Sewer Construction Permit

This permit may be required if an extension of sanitary sewer service is included in the project. The time frame to obtain this permit will be 60 days or less.

2.2 Lexington-Fayette Urban County Government Permitting

2.2.1 Site Plan Approval

This process will be required by LFUCG's Division of Planning and Development prior to construction as part of the building permit process. This process is initiated by scheduling an appointment with LFUCG Planning for their Technical Committee Meeting, which meets once per month. LFUCG's Technical Committee consists of representatives from LFUCG's Division of Planning, Engineering, Traffic, and Solid Waste as well other representatives from the Lexington Fire Department and local utility companies. Applicant should allow approximately 60 days for approval.

2.2.2 Building Permit

Required by the LFUCG Division of Building Inspections. Architectural, structural, Electrical, HVAC plans reviewed by the Technical Committee described above. LFUCG currently applies the following codes for these reviews:

- International Mechanical Code 2012
- Kentucky Plumbing Code 2013
- Kentucky Building Code 2013 (2012 IBC with 2013 Kentucky Amendments)
- NEC 2011 Code (AKA NFPA 70)
- National Fuel Gas Code 2009 (AKA NFPA 54)
- International Energy Conservation Code 2009

Two sets of plans shall also be submitted to the Office of the Fire Marshall for fire alarm and sprinkler systems, as applicable to the project. Building Permit issued as part of the development plan approval, in the same 60-day timeframe.

2.2.3 Final Development Plan Approval

A Final Development Plan is required when more than one principal structure is proposed on a lot or a parcel of land. It is our opinion that an approved Final Development Plan will be required for approval for this project. This process can be completed within the same timeline as the site plan approval process.

2.2.3 Land Disturbance Permit

A land disturbance permit will be required by LFUCG's Division of Engineering prior to the start of grading. The requirements for this permit include a Grading & Drainage Plan, Erosion Control Plan, and Storm Water Pollution Prevention Plan (SWPPP). A copy of the executed NOI (Notice of Intent) from the Kentucky Division of Water will be required as part of the submittal to LFUCG. This permit will be acquired by the contractor prior to construction, using the NOI and plans prepared by the design team.

2.2.4 Demolition/Wrecking Permit

Before any building is demolished either in part or in whole, the applicant is required by law to obtain a wrecking permit from the Division of Building Inspection. A wrecking permit is non-transferable and can only be issued to a wrecking contractor or the property owner upon proof of proper liability insurance. Should the property be deemed to have historic significance, the Division of Historic Preservation may impose a delay of up to 30 days so the documentation of the property can be completed before wrecking is commenced. In addition to the demolition permit, an accompanying grading permit of the demolished area must also be obtained.

2.5 Permit Schedule

Table 2.1 is a tentative schedule for the application and issuance of permits. This table will be further refined as the project moves forward.

TABLE 2.1 PERMIT SCHEDULE		
Permit	**Apply**	**Receive**
KDOW		
Water Supply Construction	May 2014	June 2014
Sanitary Sewer Permit	June 2014	July 2014
LFUCG		
Site Plan Approval	June 2014	July 2014
Building Permits	June 2014	July 2014
Final Development Plan Approval	June 2014	July 2014
Land Disturbance Permit	December 2014	January 2015
Demolition Permit	December 2014	January 2015

3.1 Overview

The Richmond Road Station Water Treatment Plant (RRS WTP) is rated at 25 million gallons per day (MGD) with conventional treatment processes. Water is filtered through sixteen (16) filters and directly discharged into a clearwell underneath the filters. A second clearwell exists on-site and is hydraulically connected to the clearwell under the filters. Five (5) finished water pumps, horizontal centrifugal configuration provided with variable frequency drives (VFDs), then pump the finished water into the distribution system. These pumps are installed in the Operations building adjacent to Clearwell No.2. One 50,000 gallon ground storage tank, located on high ground on the plant site, is used for filter backwash. A vertical turbine pump located in the pipe gallery of the filter building is used to fill the backwash tank. There is also an emergency backwash connection on the discharge side of high service pumps.

RRS WTP has the ability to draw from two existing raw water sources, Jacobson Reservoir and the Kentucky River. The raw water source is selected based on supply, water quality and power consumption consideration. Raw water enters the WTP and goes through coagulation, flocculation and sedimentation in the two Sedimentation Basins west of the existing filter building. The basins handle 100% of the flow through the WTP. The settled water flows by gravity to the existing filter building, housing 16 filters. Each filter has a rated capacity of 1.56 mgd and consist of a gravel layer, 6-inches of sand with a 24-inch granular activated carbon (GAC) cap. Fluoride and chlorine are dosed in the filter effluent line before entering a 600,000 gallon clearwell underneath the building. Water flows by gravity to a second clearwell (454,000 gallons), which provides additional storage for distribution system management and to achieve CT values.

The south of the plant contains solids management equipment consisting of sludge holding tanks, washwater holding tanks, filter press building and solids pump station. The spent filter backwash water and filter-to-waste are discharged by gravity to the washwater holding tanks. Solids collected from the tanks are sent to the sludge holding tanks and eventually to the filter press building, while supernatant is discharged to reservoir number 4. Sedimentation basin solids are discharged to the sludge holding tank and sent through the filter press.

RRS WTP has two chemical storage and feed facilities. The plant feeds sodium permanganate at the raw water intake for oxidation. Gaseous chlorine is added pre and post filtration as the primary disinfectant, and gaseous ammonia post filtration to facilitate chloramination as the secondary disinfectant and to assist with compliance with the disinfection by-product rule. Other post filter chemicals include corrosion inhibitor and fluoride.

The proposed facilities consist of a Filter Building (FB), CT Basin (CTB) and Backwash Tank and pumps are to be located adjacent to existing facilities within the current plant landspace. The proposed filters are designed at a filtration rate of 5.0 gpm/ft^2, with a backwash rate of 20 gpm/ft^2. Air scour will be provided at a rate of 2.5 scfm/ ft^2. A new blower is proposed for duty operation, and the existing blower will be relocated to the FTB and equipped with a larger motor. Backwash waste and filter-to-waste piping is provided for each filter and will be connected to the existing solids handling facility.

A new chlorine contact tank is recommended to achieve required CT. The new CT basin will provide 22 minutes of post-filtration chlorine concentration and contact time under the design conditions. Chlorine will be fed upstream of the CT basin at the filtered water control structure. A chlorine boost, ammonia, phosphate and fluoride will be relocated to the new chemical feed vault located upstream of Clearwell No.1. Chlorinators and ammoniators will be replaced as required. Details of these improvements are provided in **Section 5** of the Basis of Design Memo. A process flow diagram is shown in **Drawings G05** of the 60% Completion Documents.

3.2 Water Quality

A summary of raw and finished water quality data from the Richmond Road Station for the years 2013 through 2014 is given in **Table 3.1** below.

Table 3.1 Richmond Road Station Water Quality Data – Jan 2013 through Feb 2014				
Parameter	**Sample Location**	**Average**	**Minimum**	**Maximum**
Residual Chlorine, mg/L (Total Chlorine Residual)	Plant Effluent	3.2	2.1	7.5
Fluoride, mg/L	Raw	0.2	0.03	0.9
	Effluent	1.2	0.8	1.7
Alkalinity, mg/L	Raw	96	34	150
	Effluent	80	22	119
Hardness, mg/L	Effluent	156	70	356
Orthophosphate, mg/L	Effluent	1.1	0.8	1.5
pH	Raw	7.9	7.3	8.9
	Settled	7.6	7.0	8.0
	Effluent	7.3	6.8	7.8
Temperature, °F		57	37	81
Turbidity, NTU	Raw	20	4	406
	Settled	0.5	0.2	1.5
	Effluent	0.1	0.03	0.3

3.3 Hydraulics

The hydraulic calculations for constructing the new filter building, CT basin have been based on existing hydraulic conditions at Clearwell No. 1 and the Sedimentation Basin. There is 26.5 feet of available hydraulic head between the sedimentation basin weirs and normal clearwell operating level.

The hydraulics for the Richmond Road WTP have been evaluated for the current average flowrate of 10 MGD and peak daily flow of 25 MGD. The new filters will maintain a driving head of 8 feet through the filters at maximum flow rate. **Table 3.2** summarizes the hydraulic grade line. A hydraulic gradeline profile is shown in **Drawing G06** of the 60% Completion Documents.

TABLE 3.2 RICHMOND ROAD STATION WTP - HYDRAULIC PROFILE WATER SURFACE ELEVATIONS			
	at 10 MGD	at 18 MGD	at 25 MGD
Clearwell No.1, Normal WSE	978.7	978.7	978.7
CT Basin	990.81	991.33	991.84
High Water Elevation in Proposed Filter	1002.12	1002.12	1002.12
Rate of Flow Valve Position, % Open (clean media)	20%	30%	40%
Sedimentation Basin Effluent Trough	1002.53	1003.26	1004.26
Sedimentation Basin Weirs	1004.7	1004.7	1004.7

4.1 Site Access

The Richmond Road Station Filter Building site is currently accessed from Richmond Road (US 25/421) through the administration building's main entrance. Development of the proposed Filter Building project will not require additional site access.

The existing perimeter of the RRS site, including the adjacent reservoir, is surrounded by security fencing. The proposed Filter Building (FB), CT Basin (CTB), and Backwash Tank are to be located adjacent to existing facilities within this secured area. All construction will be inside of the perimeter of the property and no disturbance of the surrounded security fencing is expected. No additional entrances will be required for this project, although vehicular and pedestrian access to each of the three facilities will be provided through new pavement construction and/or improvements to the existing roadways.

4.2 Site Work, Grading, and Drainage

The proposed FB and CTB facilities will be constructed behind the existing Chemical Building on a gentle hillside with an approximate slope of 10:1 horizontal to vertical. The proposed grading plan will be coordinated with the facility design process to determine whether the new facilities should be benched into the existing slope (finished grade outside of each end of the facilities at approximately equal elevations) or "terraced" into the slope (finished grade on the west side higher than that on the east side). Finished grades outside the proposed facilities will be closely coordinated with the facility design, especially as they relate to access points and windows.

The existing one-lane access road shown at right may be widened to accommodate larger vehicles, and a "roll curb" should be constructed in place of the existing "box curb" on the widened side of the road to allow vehicles to drive over that side without damaging vehicles or the curb).

Paved access to each of the facilities will be provided, including vehicular access for maintenance and operations, and pedestrian access as appropriate.

Surface drainage will be accommodated with minimal or no storm sewer piping, consistent with the existing adjacent facilities. Roof drains will be discharged onto the surface. Runoff will be directed to paved surfaces on the south or west side of the proposed facilities. This portion of the existing site drains across the main plant access road to a concrete flume discharging into the reservoir.

Stormwater best management practices should be incorporated into the project to mitigate impacts to surface water quality, in accordance with local requirements. Based on discussions with LFUCG staff, mitigation of increased volumes of surface runoff should not be necessary due to the negligible downstream impact of the proposed improvements. However, this issue will be confirmed during the permitting process. Stormwater practices will be required to address water quality impacts, and KAW plans to employ green infrastructure practices for this purpose, and possibly to reduce increases in the site's stormwater user fee billings. Rain gardens will be implemented near the CTB and across the road at the reservoir.

4.3 Landscaping and Signage

Most if not all of the existing trees within the project limits appear to be near the end of their useful life. The site setting is a wooded area with a light density of trees. The landscape plan will include plantings around the perimeter of the structures consistent with adjacent plant areas, as well as low-maintenance vegetation for steeper graded slopes. In general, the landscaping requirements will specify preserving existing trees wherever possible.

Signage on site will likely be minimal, and would include directional signs for deliveries and any warning or information signage as may be necessary for plant operations. All signage will be consistent with existing plant signage, especially building identifiers.

4.4 Utilities and Exterior Lighting

Sanitary sewer service is not required for the proposed facilities. Potable water connections for operations and maintenance will likely be required at or near the proposed facilities (to be confirmed during design).

The proposed facilities locations are within open space in the interior of the existing plant site, and numerous existing utilities, primarily underground, cross the site. Utility conflicts appear to involve the following existing plant utilities:

- Process and finished water piping
- Overhead and underground electric
- Chemical feed lines

Maintenance of Plant Operations (MOPO) will be an important design consideration. The existing underground electric lines serve the nearby office building, overhead site lighting, and plant facilities. KAW staff is currently confirming the location of existing water mains in the project area, but existing mapping indicates that lines up to 24-inches in diameter may be impacted. If possible, proposed facilities will be relocated to eliminate major utility conflicts.

Exterior lighting will be installed at locations determined for safe access and as required for proper site security. All site lighting shall be in conformance with the local requirements and consistent with adjacent plant areas wherever feasible.

4.5 Site Security

Security around the existing treatment plant facility consists of chain-link fencing around the site perimeter to provide deterrence from intruders. It is not anticipated there will be any revisions to the existing perimeter fence as part of the proposed plant upgrade work. The existing plant site includes a video surveillance system.

Passive security measures used will include ensuring unrestricted sight lines to all portions of the structure and provisions for security lighting at important locations on site and at the site entrance.

4.6 Erosion Control

Erosion control measures will be employed on the site throughout construction activities to prevent pollution of waterways and the discharge of sediment into the reservoir. In general, erosion control will be achieved through the use of erosion control measures on the site and the preparation and implementation of a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP shall be completed as indicated by local requirements and the Lexington Fayette Urban County Government's NPDES permit. Associated erosion control plans shall clearly indicate temporary and permanent erosion control measures. The erosion control plan sheet shall be combined with the grading plan to show temporary and permanent erosion control measures.

All erosion control measures shall be installed and implemented prior to the beginning of construction. All measures shall be inspected weekly, and after any significant rain event, and any noted deficiencies shall be repaired immediately. Care shall be taken to not disturb the soil on any project site to a larger degree than is necessary. Tracking mud and soil debris off the site shall be avoided and when debris is tracked onto adjacent roadways, it shall be cleaned up at the end of the workday.

The temporary stabilization of disturbed areas is very important in minimizing erosion and sediment transport. All stripped areas not anticipated to have construction take place within 28 days shall be seeded immediately, weather and soil conditions permitting. Finally, immediately after the completion of construction, permanent seeding shall be planted. Once all disturbed areas have been permanently stabilized, temporary erosion and sedimentation control measure may be removed, the area returned to original grade, and any disturbance caused by removal repaired.

5.1 Overview

Kentucky American Water Company (KAW) is undertaking a project to replace the existing filter building with a new filter building at their 25 mgd Richmond Road Station Water Treatment Plant (RRS WTP) located in Lexington, KY. The project also includes a new chlorine contact basin (CT basin) and filter backwash tank and pumps. Detailed information on each of these is provided below. KAW has elected to use the construction manager at risk (CMR) delivery method for the project. The CMR will be brought in after completion of the 60% design to aid in the completion of the design and target cost.

5.2 Filtration

The existing filter building was originally constructed in 1924. Several additions were made to the filter building, the last of which was done in 1953. A 600,000 gallon clearwell (constructed in the 1920's and 30's) is located under the filter building. An inspection and study of the existing filter building and clearwell performed in 2013 (by others) recommended replacement of the filter building with a new filter building. In addition, due to concern about the long-term condition of the clearwell below the filter building, KAW has also decided to demolish the existing clearwell as part of this project.

Proposed filtration will be provided by eight cast-in-place concrete gravity filter boxes. Each filter box will provide a media surface area of 496 square feet with a flow rate of 3.6 mgd and a filter media loading rate of 5 gpm/ft^2. Seven filters will provide a firm capacity of 25 mgd of treatment with one filter out of service for washing or maintenance. The filters are proposed dual media of granular activated carbon (GAC) over sand. Air scour will be provided to enhance backwashing. Individual filter turbidity monitors will be provided, in addition to a combined filter effluent turbidity monitor. Filter-to-waste piping will also be provided and be properly designed with an adequate air gap. A filtered water effluent control vault is proposed on the back of the FTB to provide hydraulic separation from the CT basin. The filter building is shown in **Drawings M100 through M104** of the 60% Completion Documents. **Table 5.1** provides design criteria for the filter boxes.

TABLE 5.1	
Design Criteria for Pressure Filters	
Item	**Design Criteria**
Number of Filters	8
Capacity of Each Filter (mgd)	3.6
Type of Filter	Cast-in-place concrete Gravity filter
Filter Loading Rate (gpm/sf)	5
Total Area per Filter (sf)	496
Depth of Filter Media	
Sand (inches)	12
Granular Activated Carbon (inches)	24
Media Support (inches Gravel)	12
Individual Turbidity Monitoring	Provided
Filter-to-Waste	Provided

5.3 Filter Backwash Systems

The existing filters are backwashed using a 50,000 gallon ground storage tank on higher ground and a parallel 1000-gpm backwash pump. The plant also has an emergency backwash supply connection to the existing high service pump discharge. KAW would like to eliminate the existing backwash tank. In addition, the proposed filters are larger than the existing filters and therefore, new backwash pumps are recommended to properly fluidize and expand the filter media bed. Two pumps will be provided, each sized to fluidize the media during the warmest water conditions. A backwash rate of 20 gpm/sf is proposed for 20% expansion. **Table 5.2** provides design criteria for filter backwash pumps.

TABLE 5.2	
Design Criteria for Backwash Pumps	
Item	**Design Criteria**
Maximum Backwash Rate (gpm/sf	20
Number of Backwash Pumps	2
Backwash Pump Capacity (gpm)	10,000

Total Dynamic Head (feet)	25
Wash Rate Control Method	Variable Frequency Drives

The backwash pumps will be controlled by VFD which will provide better control over the varying head conditions and backwash rates. The design will include air scour for agitation of the media bed prior to backwash water flow. **Table 5.3** provides design criteria for the filter air scour blowers. KAW has an existing blower which will be relocated and used as a stand-by unit. The existing system will require a larger motor (60 hp) to accommodate the new operating conditions.

TABLE 5.3	
Design Criteria for Air Scour Blowers	
Item	**Design Criteria**
Number of Blowers	2
Capacity of Each Blower (scfm/sf	2.5
Design Capacity (scfm)	1,240
Design Pressure (psi)	5.8

5.4 CT Contactor

Under the Surface Water Treatment Rule, the Richmond Road WTP is required to achieve a minimum of 4-log inactivation of viruses and 3-log inactivation of *Giardia* cysts through the physical particle removal treatment processes and disinfection. For plants with complete treatment (coagulation, flocculation, settling and filtration) and meeting filter effluent turbidity standards, removal credits for complete treatment processes are generally assumed to be up to 2.0 log for viruses and 2.5 log for *Giardia*, resulting in a minimum of 2-log inactivation of viruses and 0.5-log inactivation of *Giardia* through disinfection. Inactivation by disinfection will be through exposure to a disinfection concentration over a sufficient contact period, otherwise known as C*T (concentration times contact time), and expressed in units of mg-min/L. Sizing of the CT contactor will be based on achieving 0.5-log inactivation of Giardia since this value is significantly larger than the C*T required to achieve 2-log inactivation of viruses.

One new CT basin will be constructed of cast-in-place concrete with a precast concrete roof deck. The CT contactor is proposed as a two celled rectangular tank with baffling, and a weir at the effluent to keep the contactor full. The two cells are piped to flow in series or in parallel. During normal operation, the positing of the manual valves in the tank and yard will provide for series operation of the two cells. However, repositioning of these valves will also allow for one cell of the basin to be removed from service, for short durations, while the remaining cell can provide C*T. The clearwell is shown in **Drawings M200, M201, M202** of the 60% Completion Documents. **Table 5.4** provides design criteria for the CT contactor.

TABLE 5.4	
Design Criteria for CT Contactor	
Item	**Design Criteria**
Design pH	7.6
Free Chlorine Residual (mg/L at effluent)	2
Design Temperature (°C)	7
Design Flow Rate at 7°C (mgd)	18
C*T Required (mg-min/L)	31.16
C*T Achieved (mg-min/L)	31.25
T10/Td	0.7
T10 Required (minutes)	21.9
Shape of Contactor	Rectangular
Volume of Contactor (mg)	0.28
Number of Cells	2
Volume of Each Cell (mg)	0.14
Side Water Depth (feet)	7.3
Length and Width (feet)	88 X 65
Baffling	Horizontal Serpentine
Length-to-Width Ratio (series flow)	50:1
Length-to-Width Ratio (parallel flow)	25:1

Filtered water will flow by gravity from the Filtered Water Control Vault (FWCV) at the FTB. Chlorine, for free chlorine disinfection, will be applied upstream of the weir at the FWCV. Sample points for residual confirmation will be provided at the FWCV and at the end of Pass 4 or 8 in the CT basin. Additional chemical feeds for water quality, are noted in **Section 5.5**.

A secondary pH and chlorine residual of 7.8 and 1.5 mg/L, respectively, were evaluated through the proposed CT footprint. The maximum flow that could be treated through the basin under these conditions is 13.5 mgd at 0.7 °C.

5.5 Chemical Feed Vault

A new chemical feed vault will be added to the site to feed chlorine, ammonia, fluoride, and zinc phosphate. The chlorine boost point is included to provide the proper chlorine to ammonia ratio for monochloramine formation. Chemical feeds will be flow paced using the flow meter installed upstream of the chemical application points. It is anticipated that the existing feed equipment can be reused due to the proximity of the vault to the chemical feed building. The post-filter chlorine feed represents the furthest relocation effort and may potentially require upgrades to the existing equipment. The chemical vault is shown in **Drawings M050** of the 60% Completion Documents.

6.1 Piping

A schedule of the proposed exterior and interior process piping for the Richmond Road Station Water Treatment Plant is presented in **Table 6.1 and 6.2** respectively. The piping system designations are shown in **Table 6.3.** All major proposed piping at the plant is included in this schedule.

TABLE 6.1
EXTERIOR PIPING SCHEDULE

PIPE	MATERIAL	TYPE OF JOINT	CLASS/DESIGN	RESTRAINT SYSTEM DESIGN PRESSURE *	PIPE
ASC	DIP	RESTRAINED (BURIED) FLANGED (EXPOSED)	CLASS 350	150 PSI	150 PSI
AMS	CPVC (EXPOSED)**	SOCKET	SCH 80	150 PSI	150 PSI
	BRAIDED PVC HOSE IN CASING PIPE (BURIED)	BARB WITH 316 SS CLAMPS	SEE SECTION 15008	N/A	
BWS, BWW, FLW, FTW, BWTS	DIP	RESTRAINED	CLASS 350	150 PSI	150 PSI
D	< 4" PVC	SOCKET	SCH 80	N/A	50 PSI
	> = 4" DIP	PUSH-ON	CLASS 350		
FW	DIP	RESTRAINED	CLASS 350	250 PSI	250 PSI
NPW	< 4" PVC	SOCKET	SCH 80	150 PSI	100 PSI
	> = 4" DIP	RESTRAINED/ PUSH-ON	CLASS 350		
OF	DIP	RESTRAINED	CLASS 350	20 PSI	10 PSI
PW	<4" CPVC (EXPOSED)** < 4" PVC (BURIED)	SOCKET	SCH 80	150 PSI	100 PSI
	< 4" COPPER**	SOLDERED	TYPE K (BURIED) TYPE L (EXPOSED)		
	> = 4" DIP**	RESTRAINED	CLASS 350		

S	PVC	SOCKET	SCH 80	150 PSI	150 PSI
SA	CARBON STEEL	THREADED	SCH 80	N/A	150 PSI
SAN	< 6" PVC	SOCKET	SCH 80	N/A	15 PSI
SAN	> = 6" DIP	PUSH-ON	CLASS 350	N/A	15 PSI
SPD	< 4" PVC	SOCKET	SCH 80	50 PSI	100 PSI
SPD	> = 4" DIP	PUSH-ON	CLASS 350	50 PSI	100 PSI
V	PVC	SOCKET/FLANGED	SCH 80	100 PSI	100 PSI
CASING PIPE FOR AMS, F, HC	PVC	SOCKET	SCH 40	N/A	N/A

TABLE 6.2

INTERIOR PIPING SCHEDULE

PIPE	MATERIAL	TYPE OF JOINT	CLASS/DESIGN	RESTRAINT SYSTEM DESIGN PRESSURE *	TEST PRESSURE
BWS, BWW, FLW, FTW, BWTS	DIP	FLANGED	CLASS 350	150 PSI	150 PSI
AMS, F, HC	PVC	SOCKET/FLANGED	SCH 80	150 PSI	150 PSI
D	< 4" PVC	SOCKET	SCH 80	N/A	50 PSI
D	> = 4" DIP	FLANGED	CLASS 350	N/A	50 PSI
FW	DIP	FLANGED	CLASS 350	250 PSI	250 PSI
NPW	< 4" PVC	SOCKET	SCH 80	150 PSI	100 PSI
NPW	>=4" DIP	FLANGED	CLASS 350	150 PSI	100 PSI
PW	< 4" PVC	SOCKET	SCH 80	150 PSI	100 PSI
PW	< 4" COPPER	SOLDERED	TYPE L	150 PSI	100 PSI
PW	>=4" DIP	FLANGED	CLASS 350	150 PSI	100 PSI
S	PVC	SOCKET	SCH 80	150 PSI	150 PSI
SA	CARBON STEEL	THREADED	SCH 80	N/A	150 PSI
SPD	< 4" PVC	SOCKET	SCH 80	50 PSI	100 PSI
SPD	> = 4" DIP	PUSH-ON	CLASS 350	50 PSI	100 PSI
V	PVC	SOCKET/FLANGED	SCH 80	100 PSI	100 PSI

TABLE 6.3 PIPING SYSTEM SCHEDULE DESIGNATIONS					
ASC	AIR SCOUR	FTW	FILTER TO WASTE	S	SAMPLE
BW	BACKWASH	FW	FINISHED WATER	SA	SERVICE AIR
BWS	BACKWASH SUPPLY	HC	SODIUM HYPOCHLORITE	SAN	SANITARY SEWER
BWW	BACKWASH WASTE	NPW	NON-POTABLE WATER	SPD	SUMP PUMP DRAIN
BWTS	BACKWASH TANK SUPPLY	OF	OVERFLOW	SW	SETTLED WATER
F	FLUORIDE	PW	POTABLE WATER	V	VENT
FLW	FILTERED WATER	RW	RAW WATER	D	DRAIN

6.2 Gates

No gates are anticipated in the current improvements.

6.3 Valves

Table 6.4 describes the process application and operator for each type of valve.

TABLE 6.4 VALVES		
Valve Type	**Service**	**Operator Type**
Butterfly Valves	Isolation, Flow Control – Water Service Air Header – Blower Piping	Manual or Electric
Swing Check Valves	Pump Protection	
Ball Valves	Isolation - Chemical Service	Manual

SECTION 7
STRUCTURAL AND GEOTECHNICAL CONSIDERATIONS

7.1 Overview

Structural design of the Filter Building and Chlorine Contact Basin at the Richmond Road Station Water Treatment Plant in Fayette County, Kentucky shall be performed in accordance with the requirements of the 2013 Kentucky Building Code (2012 IBC with 2013 Kentucky Amendments). Since the structural components of the design qualify as process concrete structures used for treatment of water, the design shall be performed in accordance with the requirements of AC1 350 - Code Requirements for Environmental Engineering Concrete Structures to ensure structures are watertight and impermeable with stresses remaining in the elastic stress range to limit the potential for cracking. Loading conditions shall be based on the worst operating scenario to design for static conditions. Design water surface elevations shall be based on the maximum water level possible, not just the hydraulic profile.

A geotechnical investigation will be needed to determine design parameters and foundation requirements for the design of each structure. Based on previous construction at the site, the foundations will likely consist of a reinforced concrete mat slabs supported exclusively by the subgrade. Prior construction on the site has not required deep foundation support. This assumption will require verification by an independent geotechnical investigation conducted by a qualified geotechnical consultant. The geotechnical investigation will address issues including impact of groundwater on design and construction, with consideration of means for resisting buoyant forces due to any elevated groundwater conditions.

7.2 Codes, Standards, References

7.2.1 Governing Code

The strength, serviceability, and quality standards shall not be less than stipulations required by the governing code. The governing code used for the proposed design is the 2012 IBC with 2013 Kentucky Amendments.

7.2.2 Supplemental Design Codes

Selected provisions from the following codes may also be used for the project.

- Standard Specifications for Highway Bridges, American Association of the State Highway and Transportation Officials, Latest Edition
- American Society of Civil Engineers – ASCE 7, Latest Edition
- American Institute of Steel Construction (AISC) – Manual of Steel Design, 14th Edition

7.2.3 Codes and Standards for Specific Materials

Design of specific materials will be performed in accordance with the standards, codes, and specifications adopted by the governing code as listed below.

7.2.3.1 All Materials

The American Society for Testing and Materials (ASTM) standards, as referenced by the governing code or the other codes, standards, or specifications listed herein.

7.2.3.2 Concrete

- Building Code Requirements for Structural Concrete, Publication No. 318, Latest Edition, American Concrete Institute.
- Specifications for Structural Concrete, Publication No. 301, Latest Edition, American Concrete Institute.
- Code Requirements for Environmental Engineering Structures, Publication No. 350 and Commentary, Publication No. 350R, Latest Editions, American Concrete Institute.

7.2.3.3 Masonry

- Building Code Requirements for Masonry Structures, Publication No. ACI 530, Latest Edition, American Concrete Institute.
- Specifications for Masonry Structures, Publication No. ACI 530.1, Latest Edition, American Concrete Institute.

7.2.3.4 Steel

- Specification for Structural Steel Buildings, American Institute of Steel Construction, Latest Edition.
- Code of Standard Practice for Steel Buildings and Bridges, American Institute of Steel Construction, Latest Edition.
- Structural Welding Code, Publication No. D1.1, Latest Edition, American Welding Society.
- Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders, Steel Joist Institute, Latest Edition.
- Specifications for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute, Latest Edition.

7.2.3.5 Stainless Steel

- Specifications for the Design of Cold-Formed Stainless Steel Structural Members, American Society of Civil Engineers, Latest Edition.

7.2.3.6 Aluminum

- Specifications for Aluminum Structures, Aluminum Association, Latest Version.
- Engineering Data for Aluminum Structures, Aluminum Association, Latest Version.
- Structural Welding Code, Publication No. D1.2, American Welding Society, Latest Version.

7.2.3.7 Fiberglass Reinforced Plastic (FRP)

There are no nationally recognized codes, standards, or specifications for the design of FRP. Proprietary design manuals that have been referenced are listed in the section below, Section 7.2.4, References.

7.2.4 References

Engineering manuals, handbooks, textbooks, articles, and technical publications that may be used in design on this project are as follows:

- Reinforced Concrete Design Handbook, Working Stress Method, Publication SP-3, American Concrete Institute.
- Design Handbook in accordance with the Strength Design Method, Publications SP-17 and SP-17A, American Concrete Institute.
- Detailing Manual, Publication SP-66, American Concrete Institute.
- Moments and Reactions for Rectangular Plates, Engineering Monograph No. 27, U.S. Department of the Interior, Bureau of Reclamation, W.T. Moody.
- MSP-1 Manual of Standard Practice, Concrete Reinforcing Steel Institute.
- PCI Design Handbook, Precast/Prestressed Concrete Institute, Latest Version.
- Masonry Designers' Guide, American Concrete Institute/Masonry Society, Latest Version.
- Reinforced Masonry Engineering Handbook, James E Amrheim, Masonry Institute of America, Latest Version.
- Manual of Steel Construction, American Institute of Steel Construction, Latest Version.
- Structural Steel Detailing Manual, American Institute of Steel Construction, Latest Version.
- Design Manual for Composite Decks, Form Decks, Roof Decks and Cellular Floor Deck with Electrical Distribution, Publication No. 28, Steel Deck Institute, Latest Version.
- Diaphragm Design Manual, Second Edition, Larry D. Luttrell, Publication NO. DDM02, Steel Deck Institute, Latest Version.

- Standard Specifications, Load Tables and Weight Tables for Steel Joists and Joist Girders, Steel Joist Institute, Latest Version.
- Design Manual for Structural Stainless Steel, Nickel Development Institute, Latest Version.
- Specifications and Guidelines for Aluminum Structures, Aluminum Design Manual, Aluminum Association, Latest Version.
- Extren Fiberglass Structural Shapes- Design Manual, Strongwell, Inc., Latest Version.

7.3 Design Loads

7.3.1 Dead Loads

Dead loads are those resulting from the weight of all permanent non-removable stationary construction, such as walls, floors, roofs, permanent partitions, framing, ceilings, cladding, and equipment bases. Loads from process liquids within the structure and from soil and groundwater outside the structure will not be considered as dead loads. Dead loads will be in accordance with the governing code and as follows:

Dead Loads	
Concrete	150 pcf
Steel and Stainless Steel	490 pcf
Aluminum	169 pcf
Fiberglass reinforced plastic (FRP)	120 pcf
Masonry, CMU, 8” Lightweight	77 psf (grouted solid) 50 psf (grouted at 32” oc) 38 psf (hollow)
Masonry, CMU, 12” Lightweight	118 psf (grouted solid) 73 psf (grouted @32” oc) 55 psf (hollow)
Wood	30 to 40 pcf
Select Fill	130 pcf
Aggregate Base	135 pcf
Pipe Loads	– Design for actual dead loads for pipes > 16” diameter – Where beams may support pipes =<16” diameter, add 1,000 pounds at midspan

7.3.2 Live Loads

Live loads technically include all nonpermanent loadings that can occur, in addition to the dead loads. Live loads are those resulting from occupancy, furnishings, and equipment. Live loads will be used in accordance with the governing code, unless a larger value is listed below:

Area	Live Load
Working roofs	100 psf
Non-working roof loads	As per code, including wind
Office floors	80 psf
Corridors and stairways (process areas)	150 psf
Pipe supports	25 to 100 psf
Electrical control rooms	250 psf
Light storage	150 psf
Heavy storage	300 psf
Grated access platforms and walkways	100 psf
Catwalks	100 psf
Pipe Loads	– Design for actual live loads for pipes > 16” diameter – Where beams may support pipes=<16” diameter, add 1,000 pounds at midspan
Truck accessible areas	HS-20 loading per AASHTO
Liquid Chemicals	Per specified specific gravity
Liquid Loads (all unless specified otherwise)	63 pcf
Lifting Points	– Vertical load = 2 * (heaviest piece of equipment lifted) – Horizontal load = 0.20 * (vertical load)

7.3.3 Equipment Loads

Process area operating floors are designed for the load case resulting in the maximum stresses from the following live load conditions:

- 300 psf on the entire floor area, with no additional load from equipment included
- 150 psf on the areas not directly under equipment, plus actual equipment loads

Equipment loads obtained from manufacturers will be used when available, and other equipment loads will be assumed for the preliminary design. These loads will be confirmed prior to completion of design. In addition to the equipment's operating weight (including any fluids contained), other loads due to moving parts, malfunction, and maintenance will be designed for. Examples of these other loads include but are not limited to the following:

- Loads from rotating equipment will include moment, torque, and lateral thrust.
- Loads from all equipment will include those for required maintenance, such as the removal of large components that may be temporarily placed on the adjacent floor.

The load option, which creates the highest stress conditions, shall be used. The weight of equipment components, which could be placed on or transported across the floor, shall be located to create maximum stress conditions.

7.3.4 Piping Loads

For preliminary design, the live loads listed above will be considered to include the loads from process piping that are supported by the floor below the piping. On floors and roofs that will support process piping suspended below, an additional live load allowance will be included for the preliminary design. This allowance ranges from 25 psf to 100 psf, depending on the size and quantity of piping, anticipated to be suspended below the floor or roof.

Upon completion of piping layout, these allowances will be reviewed for accuracy with the actual pipe configurations for pipes less than 18 inches in diameter, and the actual concentrated loads from pipes 18 inches and larger will be considered.

7.3.5 HVAC, Ducts, Plumbing, and Electrical Raceway Loads

Loads from HVAC ducts, plumbing, and electrical raceways that are suspended from floors and roofs above are typically relatively light and included within the live loads listed above. However, if they do get significant at selected locations, they will be considered prior to completion of design.

7.3.6 Wind Loads

Wind loads on any above grade structures will be in accordance with the governing code and ASCE 7.

7.3.7 Snow Loads

Snow loads will be in accordance with the governing code.

7.3.8 Seismic Loads

Seismic loads resulting from seismic acceleration of the structure dead and live loads, including equipment and piping, will be determined in accordance with the governing code and ASCE 7 as applicable codes for seismic design.

7.4 General Basis for Design

7.4.1 Loading Combinations

The following factored load combinations shall be used in the design of structures. Additional load combinations, which may produce a maximum stress condition, are also to be considered, as appropriate. Note that combinations, which clearly do not govern, will not need to be fully analyzed.

Load Combinations
1.4(D + F)
1.2(D + F) + 1.6(L + H) + 0.5(Lr or S)
1.2D + 1.6(Lr or S) + (L or 0.8W)
1.2D + 1.6W + L + 0.5(Lr or S)
1.2D + 1.0E + L + 0.2S
0.9D + 1.6W + 1.6H
0.9D + 1.0E + 1.6H
D = dead load, F = fluid load, H = soil load, L = live load, S = snow load, Lr = live roof load, W = wind load, E = earthquake load

7.4.2 Safety Factors

Structures are designed on the basis of determining the service loads and obtaining a suitable ratio of material or soil strength to these loads termed a safety factor. Either the service loads are multiplied by a suitable set of load factors and compared with the ultimate strength or the structural material or yield strength is divided by a suitable safety factor.

Safety Factors	
Overturning	2.0
Sliding	1.5
Buoyancy for Groundwater, Design Elevation	1.25
Buoyancy for Groundwater, 100-yr Flood Elev.	1.10

Forces resisting buoyancy shall be a combination of structure dead load, weight of soil directly over footings (considering buoyant soil weight), and the tensile resistance of piles and/or tension anchors (based on allowable load values provided by the geotechnical report), if applicable. Where there are superstructures above grade, the drawings shall clearly indicate at what level of completion dewatering operations can be terminated.

7.5 Serviceability Considerations

7.5.1 Introduction

Serviceability of a structure is defined as its ability to behave under load in a manner that does not adversely affect the intended use of the structure or provide discomfort to its occupants. Harsh chemical environments may require a special coating to protect the concrete. Some processes may also require more concrete cover over the reinforcement than typically provided for the structure as a whole to limit possible structural deterioration. Deflections and vibrations are behaviors of a structure that do not necessarily cause damage to the structure itself, but if excessive can cause minor damage or wear to equipment or discomfort and annoyance to occupants. Structures will be designed to limit deflections and vibrations as stated below such that the intended use and performance of the structures are not adversely affected.

7.5.2 Deflection

Maximum allowable deflections used for design are shown in Table 15-3. An asterisk (*) indicates the deflection limit applies to live loads only.

Maximum Allowable Deflection	
Structures	**Deflections**
Floors, concrete	Per ACI 318
Floors, structural metal framed *	L/360
Grated access platforms *	L/240
Roofs *	L/240
Beams, lintels, or slabs supporting masonry	L/720

7.5.3 Vibration

The design should provide appropriate protection against structural or mechanical deterioration and occupant discomfort from the effects of vibrations. The guidelines stated below will be used to mitigate the effects of vibration.

- The operating frequencies, unbalanced loads, and specific design recommendations from equipment manufacturers will be considered in the design
- To minimize resonant vibrations, the structure supporting the equipment shall be designed such that the ratio of its natural frequency to the operating frequency of the equipment is less than 0.50 or more than 1.50.
- Equipment shall be mounted on concrete foundations rather than metal support systems whenever possible and appropriate.
- Concrete pads or foundations shall be provided with a mass equal to ten times the rotating mass of the equipment or three times the gross mass of the equipment, whichever is greater.
- Vibration isolators or dampeners shall be used on equipment foundations where appropriate.

7.6 Seismic Design

The basis for determining acceleration values and corresponding factors for design are given in the section presenting load criteria. Structures shall be designed according to the governing code and ASCE 7 requirements using the values given in the appropriate code formulas.

Seismic forces due to vertical acceleration result from all dead loads, including the total mass of water above slabs (especially suspended slabs). The direction of force (up or down) shall be selected to create maximum stresses when combined with horizontal seismic forces. The design of foundations resisting overturning must assume that balancing dead loads are reduced by vertical accelerations.

Transitory live loads are not to be used to produce seismic loading nor combined with seismic with the following exceptions. In storage areas, the loading which is anticipated to be in place the majority of the time shall be used but not less than 25 percent of the total live load. Equipment, partition walls, and other fixed items shall be considered as dead loads for determining seismic forces. Seismic loads shall be combined with 75% of the snow load when applicable.

7.7 Concrete Design

All portions of the structure that are in contact with soil or that contain process liquids (including slabs over process liquids) will be designed using Ultimate Strength Design, per ACI 318 with revised load factors and durability coefficients recommended in ACI 350R

Portions of the structure not included above may be designed per ACI 318 without including the ACI 350R recommendations.

Materials for use in concrete design will be specified to have the following minimum properties:

Concrete Class A1 – Structural: (all applications unless otherwise noted)	
28 day compressive strength (f'c)	4,500 psi
Cementitious Materials	ASTM C150 Type I plus mandatory addition of pozzolan such as Class F fly ash or ground granulated blast furnace slag
Maximum water/cementitious materials ratio	0.42
Air content	4.5% to 7.5%
Concrete Class B: (thrust blocks, encasements, concrete fill)	
28-day compressive strength (f'c)	3,000 psi
Cementitious Materials	ASTM C150 Type I plus mandatory addition of pozzolan such as Class F fly ash or ground granulated blast furnace slag
Maximum water/cementitious materials ratio	0.50
Deformed reinforcing bars (unless otherwise noted)	ASTM A615 Grade 60
Welded wire fabric	ASTM A185

Minimum required amounts of reinforcing would be determined per ACI 318 recommendations depending on the spacing of movement joints provided. Amounts of reinforcing used will be as required for structural strength, but not less than these minimum amounts. Maximum spacing of reinforcing bars will be 18 inches on-center.

Finishes on concrete surfaces will be provided in accordance with ACI 301, and as is appropriate for their use and exposure. Interior exposed walls, columns, ceilings, and beams in habitable spaces will receive a smooth rubbed finish. Interior walls above the water surface of open tanks and any exterior exposed walls above grade will receive a grout-cleaned finish. Floors of tanks and floors in areas likely to be intermittently wet due to washdown or maintenance of equipment will receive a floated finish. Floors in habitable areas intended to be dry at all times will receive a steel troweled finish.

Waterproof coatings will be provided on all walls and slabs in that are in contact with liquid on one side and in a dry habitable space on the other. Concrete sealers will be provided on all floors that are exposed, not intended to be immersed, and have no other type of coating.

7.8 Masonry Design

Masonry will be designed in accordance with ACI 530 and ACI 530.1. Materials for use in masonry design will be specified to have the following minimum properties:

Minimum Properties for Masonry Design	
Compressive strength of masonry (f'c)	1,500 psi
Concrete masonry units	ASTM C90 Grade N Type
Compressive strength of masonry units	1,900 psi
Mortar	ASTM C270 Type S
Grout	ASTM C476
Compressive strength of grout	2,000 psi
Deformed reinforcing bars	ASTM A615, Grade 60
Horizontal joint reinforcing	ASTM A82

Minimum required amounts of reinforcing for seismic loads would be provided in accordance with ACI 530 and ACI 530.1. Amounts of reinforcing used will be as required for structural strength, but not less than these minimum amounts. All cells containing reinforcing will be grouted. Maximum spacing of horizontal joint reinforcing will be 16 inches on-center vertically.

7.9 Structural Metals Design

Structural steel will be designed in accordance with AISC Specification for Structural Steel Buildings – Allowable Stress Design or Load Resistance Factor Design, with modifications as stated in the governing code.

Steel joists will be designed in accordance with the SJI Standard Specifications, Load Tables, and Weight Tables for Steel Joists and Joist Girders with the modifications as stated in the governing code.

Steel decking will be designed in accordance with the SDI Design Manual for Composite Decks, Form Decks, Roof Decks, and Cellular Deck Floor Systems with Electrical Distribution. Diaphragm action of steel decks will be designed in accordance with the SDI Diaphragm Design Manual.

Cold-formed steel structural members will be designed in accordance with the AISI Specification for the Design of Cold-Formed Steel Structural Members, with modifications as stated in the governing code.

Cold-formed stainless steel structural members will be designed in accordance with ASCE 8 Specification for the Design of Cold-Formed Stainless Steel Structural Members.

Aluminum members will be designed in accordance with the Aluminum Association's Specifications for Aluminum Structures.

Materials for use as structural metals will be specified to have the following minimum properties:

Minimum Properties for Structural Metals	
Structural steel shapes	ASTM A992, A572, Grade 50
Steel plates, angles and bars	ASTM A36
Structural steel tubing	ASTM A500, Grade B
Structural steel pipe	ASTM A53, Type E or S, Grade B
High strength steel bolts	ASTM A325 or ASTM A490
Steel anchor bolts and threaded rods	ASTM F1554
Stainless steel shapes	ASTM A276, Type 316
Stainless steel plates and sheet	ASTM A167, Type 304 or 316
Stainless steel bolts	ASTM F593, Type 304 or 316
Aluminum structural shapes	ASTM B308, 6061-T6
Aluminum extruded rods, shapes, and tubes	ASTM B221, 6063-T6
Aluminum plates	ASTM B209, 6061-T6
Aluminum sheet	ASTM B221, 3003

7.10 General Description of Structural Systems

7.10.1 Filter Building

The Filter Building will consist of a reinforced concrete substructure and a steel-framed superstructure. The filters, pipe gallery and access corridors will be contained within the substructure while the filter gallery will be located in the superstructure above. The filters and pipe gallery will consist of reinforced concrete tank walls supported by a reinforced concrete mat foundation. Exterior perimeter walls of the lower level corridors will be constructed using load-bearing reinforced concrete masonry units supported by reinforced concrete spread footings and stem walls. A joist roof system will cover the lower level access corridors. As stated previously, the proposed foundation system and means of preparing the subgrade for supporting the Filter Building will require verification via an investigation conducted by a qualified geotechnical engineer. The interior tank walls of the building will divide the filters into eight separate tanks and support a reinforced concrete slab serving as the main floor of the building superstructure. A braced steel frame, steel joist roof system and metal decking will serve as the primary structural system for the superstructure. Roof insulation and a roofing membrane will be added over the metal roof decking to provide slope for drainage and ensure the water tightness of the system.

7.10.2 Chlorine Contact Basin

The Chlorine Contact Basin will consist of reinforced concrete tank walls supported by a reinforced concrete mat foundation. A center concrete divider wall will separate the basin into two equivalent tanks. Each tank will consist of three partial baffle walls which will separate the area into four parallel channels with a continuous flow path. Precast prestressed concrete hollow core roof planks will span between exterior and interior tank walls to provide cover for the basin. Concrete beams will be added extending over the open ends of the partial baffle walls to support the precast roof members. A concrete topping and roofing membrane will be added over the precast members to provide sloped drainage and ensure the water-tightness of the cover system.

8.1 General

The following section outlines approaches to the architectural design for the expansion of the Richmond Road Water Treatment Facility Improvement Project, including code compliance issues related to occupancy, type of construction, fire resistance of materials and separation requirements, interior finishes, fire prevention and separation, fire protective systems, means of egress, accessibility, interior environment, exterior wall construction, roof construction, and exterior appearance.

8.2 Architectural Code Requirements

Codes, standards, and references will provide the minimum standard for fire resistance, serviceability and quality of materials used for construction. The 2013 Kentucky Building Code, which references and modifies the 2012 International Building Code (IBC) as adopted and amended by the State of Kentucky will act as the governing building code. Accessibility issues will be governed by Chapter 11 of the Kentucky Building Code. Provisions of Kentucky Plumbing Code, the International Mechanical Code, 2009 International Energy Conservation Code and NFPA 70 - National Electrical Code will be applied. Additional federal, state and local codes, standards and references will be coordinated and applied in accordance with the 2009 IBC. A partial list of these codes and standards follow.

- 29 CFR 1910 – Occupational Safety and Health Standards
- ACI 530/ASCE 5/TMS 402 – Building Code Requirements for Masonry
- ACI 530.1/ASCE 6/TMS 602 – Specification for Masonry Structures
- American with Disabilities Act
- NFPA 10 – Portable Fire Extinguishers
- NFPA 13 – Installation of Sprinkler Systems
- NFPA 80 – Fire Doors and Fire Windows
- NFPA 704 – Identification of Fire Hazards of Materials
- UL Fire Resistance Directory

In addition to the State and Federal codes, local regulations additionally impact the design of the buildings and include the local Zoning Regulations. The impact of these regulations includes developed area, parking, landscaping, signage and noise.

8.3 New Filter Building

The primary occupancy and use of the new administration and chemical building will be Low Hazard Factory Industrial (F-2). The building will be two stories with a pipe gallery on the lower level with filter gallery and filters on the upper floor. The building will be occupied by employees and escorted visitors. The plant may be open to the public via regular tours for community groups. Tour routes will need to be established as the route will be required to have accessible elements include access, toilet facilities, guards, etc. which will meet the accessibility requirements of the Building Code. If tours are provided to levels above or below the entry level an elevator may be required to allow code compliant access to the upper floor. Toilet facilities may be required depending on how tours are staged.

The building will be designed to provide adequate egress from the building and each room. Exits will open directly to the exterior, exit passageway or stairwell. Exits will be located as remote from each other as possible. One stair connecting the floor will be housed within a fire rated enclosure and exit directly to the exterior. A second stair will be provided for egress and may or may not be enclosed within a rated enclosure. Illuminated exit signage and emergency lighting shall be placed throughout the buildings. Fire extinguishers will be located throughout the building and will be compatible with the contents of the room.

The travel distance within a space or floor having one exit shall not exceed 75 feet. Travel distance to the nearest exit from any point in the building shall not exceed 300 feet. Travel distance shall take into account travel around fixed pieces of equipment. Equipment and rooms shall not create common path of travel in excess of 75 feet. Paths of travel shall not proceed from a room of low hazard to a room of higher hazard.

The Accessibility Code requires access to buildings by people with physical limitations. Water treatment facilities have several areas that are not considered accessible spaces due to the hazards present. The buildings will be designed with an accessible entrance and include handicap parking spaces, and accessible corridors at the filter operating floor.

Interior finishes will include painted concrete masonry units and steel. Floors will be sealed concrete. Ceilings will remain open to the structure above and be painted. Finishes within tour routes may vary and include epoxy floor and base, painted concrete masonry, acoustical ceiling system to minimize noise during tours, and possible upgraded lights.

Exterior walls will be non-loadbearing masonry and utilize an insulated cavity wall design. The cavity wall design will consist of an interior wythe of concrete masonry, and an outer wythe of brick. A continuous insulation and drainage cavity will be formed between the wythes to enhance energy performance. The cavity will include an air barrier applied to the exterior face of the concrete masonry, 1 ½ to 2 inches of rigid insulation, and a 1” airspace. The cavity will drain through a series of weep vents above the through-wall flashing. A mortar net will be used at the base of the wall to ensure open drainage. The walls will be reinforced to resist loads as required by the 2012 IBC.

Roof shall have a minimal slope of 1” per 12” and drain to gutters along the outside edges of the roof. Where possible, the slope will be obtained with sloping structural members. Rigid roof insulation shall be placed above the structural substrate and a self-adhered underlayment placed above the insulation. The roof covering shall consist of a standing seam metal roof system with a Kynar based coating system. The roof will be detailed in accordance with the manufacturer's recommendations for a 25 year total system weathertightness warranty. Walkways will be provided to roof mounted equipment from the roof access points.

The exterior appearance will utilize a brick façade and harmonize with the existing structures. As the existing facilities have several different architectural treatments the administration building will draw elements from the different buildings and to help develop a unifying aesthetic. Multiple colors of masonry may be used as well as windows and openings that complement the proportions of the building and the existing buildings.

8.4 Chlorine Contact Basin Roof

Roof shall have a minimal slope of ¼" per foot and drain to edges of the clearwell. Slope will be obtained with sloping structural members. The roof covering shall consist of a fully adhered single ply membrane. The roof membrane will have a high Solar Reflectance Index. The roof will be detailed in accordance with the manufacturer's recommendations for a 15 year total system warranty. Walkways will be provided to roof mounted equipment from the roof access points.

SECTION 9
HVAC REQUIREMENTS

9.1 General

The following section outlines approaches to the HVAC design for the renovation and expansion of the Richmond Road WTF Improvement Project, including dehumidification of the filter pipe gallery and operating floor, cooling of the electrical rooms and exhaust heat rejection in the backwash pump and blower rooms. American Water Company HVAC Standards as well as other applicable codes and standards will be observed.

9.2 New Filter Building

In the filter pipe gallery space relative humidity will be controlled by multiple portable mechanical refrigeration type dehumidifiers. These units do not require additional ductwork, but will require providing a local drain to accommodate removal of condensate. Insulation on gallery piping will also be provided to minimize pipe surface condensation. Electric unit heaters (corrosion resistant construction for moist environments) will be used in the filter pipe gallery to maintain the space during heating season above 50 degrees.

In the filter gallery, an air handling unit (gas-fired) will be used to provide an average continuous rate (3 air changes per hour) of ventilation with heating to maintain the space during heating season above 60 degrees.

The electrical room in the Filter Building will be kept below the maximum rated temperature of the electrical gear and control panels through filtered outside air intake and exhaust ventilation.

9.3 Backwash Pump Station

Equipment associated with the backwash pump station will be installed in exterior conditions without the need for a building.

10.1 Electrical Requirements and Modifications

The new filter building will include a dedicated electrical room for housing electrical and control equipment in a climate-controlled, clean, dry, non-corrosive space. The electrical room is proposed to be served by a single 480-volt, 3-phase power feed terminating at power distribution equipment to serve the required filter building, chlorine contact basin, and backwash pump station loads. The treatment plant has multiple utility service drops installed at the plant site for various expansions or modifications. It is proposed that the utility source for the new filter building originate at an existing service-entrance equipment if feasible to avoid the necessity of another metered service. Service-entrance equipment manufacturer, model, vintage, expandability, and a practical estimate of maximum load must be evaluated prior to establishing an existing service as the source for the new filter building. Electrical room will include a a main circuit breaker for single point disconnection of utility power.

In addition to multiple utility services at the plant, multiple standby emergency generators have also been installed at the plant. After evaluation and discussion with plant personnel, it is proposed to replace the existing 250KW generator just west of Chemical Building No. 2. The generator is over 20 years old. It is proposed that it be replaced with a generator of sufficient capacity to serve its present load (Chemical Bldg. No. 1, Chemical Building No. 2, and the Electrical Control Building) plus the new filter building and chlorine contact basin loads. Inside Chemical Building No. 2, the emergency power main disconnect switch and distribution panel will be replaced due to corrosion. The new disconnect switch and distribution panel will be installed in the same location as the existing and will distribute emergency power to the existing loads via re-used feeders as well as the new filter building loads. Emergency power from Chemical Building No. 2 will terminate at a single disconnect switch in the filter building electric room. This disconnect and the main utility circuit breaker will provide a single disconnecting means to isolate all new loads from an electrical power source if necessary. Both utility and generator power will feed an automatic transfer switch.

The load side of the automatic transfer switch will feed a fused disconnect power panel fused with current-limiting fuses that in turn will feed multiple panelboards and motor controlling equipment. In discussion with plant staff, it was agreed to use this design approach in an attempt to minimize arc-flash categories to all field equipment that operations and maintenance personnel would most frequently engage. Additionally, the series rating of downstream circuit breaker panels will allow for smaller, less expensive panelboards to be used as the current-limiting fuses will prevent the panelboards from enduring extended destructive fault currents.

A 208/120V dry-type step down transformer and panelboard will be provided for lighting, receptacles, instrumentation, and other miscellaneous power needs in the filter building. An outdoor, 240/120V packaged power supply will be provided for the few single-phase loads at the chlorine contact basin. .

Variable frequency drives (VFDs) will be provided for modulating backwash flow rate. Instead of a motor control center, VFDs will be housed in wall-mounted or floor-mounted stand-alone enclosures to provide optimum flexibility in maintenance or replacement. VFDs will include input reactors to reduce harmonic effects on the power system and minimize susceptibility to utility grid transients. Shielded VFD cable will be provided between VFDs and pump motors to withstand insulation stresses under VFD use. For VFD-driven motors, shaft grounding rings are proposed for pump motors to prevent bearing damage due to VFD control.

Air scour blowers will be constant speed and controlled by reduced-voltage, solid-state (RVSS) motor starters with input isolation contactors. As with the backwash pump VFDs, the starters will be housed in individual enclosures to facilitate isolation for maintenance replacement if necessary.

Options for materials for electrical conduit, and associated fittings, will be discussed with KAW staff. Options for damp and/or corrosive areas could include PVC-coated rigid galvanized steel, fiberglass, aluminum, or PVC. Underground conduit will be concrete-encased PVC schedule 40. Wiring troughs may be considered for the small but numerous power, control, and instrumentation conductors anticipated in the filter gallery. All underground power conductors are proposed to be XHHW-2. THHN/THWN building wire is proposed for lighting, receptacle, control, and other miscellaneous power wiring within buildings. All analog signaling will utilize twisted, shielded pairs or triads as required by the application. No wire nut-type splices will be allowed for conductors with the exception of lighting and receptacle circuits. Splicing in all other wiring applications shall be at terminal blocks, power blocks, or for motor housing leads, crimp-type connectors.

Lighting will be provided as needed at levels recommended by IES for the filter building. Moist areas will dictate corrosion-resistant material be specified for fixtures. All indoor fixtures will be placed at serviceable heights and locations whenever possible. Outdoor lighting will be aluminum pole-mounted. Hazen and Sawyer will discuss with KAW staff the desired lamp technologies and energy efficiency measures desired such as LED lamps, high-intensity discharge (HID) lamps, occupancy sensing, etc.

Ground grids will be provided around the perimeter of the filter building and chlorine contact basin. Ground rods with inspection wells will be provided at evenly-spaced intervals and exothermically welded to a bare #4/0 buried copper conductor. The need for lightning protection for the structures will be discussed with KAW personnel during design and, if implemented, will be connected to the ground grid.

American Water Company Electrical Standards as well as other applicable codes and standards will be observed during design of the project.

11.1 Plant Control System

The Bristol Babcock ControlWave programmable controller (PLC) is proposed for automatic control of the new filters and backwash pumps, filter flow rates, backwash sequencing, chlorine contact basin, and other appurtenant equipment and instrumentation. Four of 8 recently-installed ControlWave-based PLC enclosures will be removed from the existing filter building and reused in the new filter building to control the 8 new filters, one enclosure per pair of filters. Also, manual controls and displays will be provided at a new console per filter pair located adjacent to the re-used PLC enclosures and will provide manual backup control to the PLC in the event of PLC failure. This configuration duplicates the existing filter building and should provide familiarity to operators. Per KAW staff, panel-mounted operator displays will not be provided. The PLC-based control panels for the backwash pump station, chlorine contact basin, and the filter building would house the PLC and other control equipment such as power supplies, relays, terminal blocks, etc. necessary for each process. Each control panel would be powered via an uninterruptible power supply (UPS) to isolate the PLC control system from power transients and momentary outages ensuring high availability, smooth operation, and limiting the necessity of processor rebooting.

The existing MODBUS TCP/IP protocol via Category-6 and fiber optic cable will be used for communications among the PLCs via industrially-hardened Ethernet switches. A laptop power and network interface port will be available on the outside of the electric room PLC allowing safe programming access to the PLCs via laptop without opening the enclosure doors.

The fiber optic SCADA network will be extended to the filter building from Chemical Building No. 2. The network will be intercepted in an existing fiber termination box inside the building to insert the new filter building in the existing communication loop.

Modifications of the existing Iconics Genesis plant-wide SCADA human machine interface (HMI) will require programming effort to update graphics, trending, alarming, server data bases, historical data archiving, report generation, etc. to allow monitoring and control of the new processes added under this project as well as remove existing filter processes that will be eliminated. It is not uncommon for water and wastewater agencies with established SCADA networks to contract directly or sole-source procure these programming services from system integrators that have previously worked on the SCADA system and therefore are already familiar with it. Hazen and Sawyer will consult with KAW staff on procurement options for this service as well as hardware or software required by the project.

12.1 General

This section provides a functional description of the operation and control features of the proposed facilities at the Richmond Road Water Treatment Plant (WTP). The process covered in this functional description include, filtration, chlorine contact tanks, and backwash pumping.

12.2 Filtration

Eight new conventional dual media filters with sand and granular activated carbon are utilized for filtration. Each filter unit is equipped with a water level sensor, differential pressure transmitter, filter effluent turbidity meter, and a flow meter and control valve in the effluent piping, as well as other filter valves. All filter valves will include new valves with electric actuators. New backwash pumps will also be provided for filter backwash.

The filtration system will include the following:

- New Open/Close valves provided for each filter for Filter Influent, Filtered Water, Filter-to-Waste, Backwash Isolation, Backwash Drain, and Air Scour service as shown on the Drawings. Each valve will be provided with an actuator that includes the following:
  - Remote-Off-Local selector switch
  - Open-Stop-Close pushbuttons
  - Digital position status indicator (full open/full closed) to PLC
  - Selector switch in remote status to PLC
  - Actuators to accept Open and Close commands from PLC.
- A new modulating flow control valve provided for each filter for filter effluent flow control as shown on the Drawings. Each valve will be provided with the following:
  - Remote-Off-Local control capability
  - Open-Stop-Close control capability
  - Analog position status feedback to PLC
  - Remote status to PLC
  - Actuators to accept analog positioning command from PLC.
- Two filter backwash pumps with flow monitoring installed at the Backwash Tank attached to the CT basin.

Monitoring and control for the filters will be as follows:

- When filter valves are in the Local control mode, the valve will be opened and closed with the Open-Stop-Close pushbuttons. When valves are the in Remote mode, valve control will be through either the new PLC control system or via manual controls at the appropriate filter console. Valve position (% open) for all modulating valves, and full open/full closed status for open/close valves, will be indicated at theconsole.

- Under PLC control, flow through each filter shall be controlled via a proportional-derivative-integral (PID) control loop in the PLC comparing filter flow with an operator entered setpoint at the HMI and positioning the modulating valve to eliminate the difference between the two. Provisions for automatic and manual manipulation the valve position via a console-mounted backup loop controller will also be provided per staff request.

- Filter backwash will be initiated based on conditions monitored through sensors and analytical instrumentation. Parameters operating outside set tolerances initiate a filter backwash, which will include:
    - Filter Headloss continuously monitored
    - Turbidity levels
    - Filter run time

- The control system will allow only one filter to be backwashed at a time. When a backwash is initiated, the control system will check the volume available in the CT Basin to determine if the level is high enough for a backwash. If required volume is less than available volume, filter backwash will proceed. If required volume is more than available volume, an alarm will be displayed at theHMI. The operator will interact with the control strategy by entering the following parameters:

    - Air scour duration
    - Low wash rate/duration (up)
    - High wash rate/duration
    - Low wash rate/duration (down)

- Filter backwash water will be provided from one of two redundant backwash supply pumps at the Backwash Tank. The operator will select the backwash pump. The backwash isolation valve will open, the filtered water valve will close, and the backwash supply pump will start a low wash cycle and air scour. After the adjustable preset duration, the air scour valve will close and the low wash cycle will continue. After an adjustable preset duration for low water wash, the backwash pump will provide high wash rate for an adjustable duration. After the high water wash, the backwash pump will deliver the low wash rate for an adjustable duration. At the end of the second low wash cycle, the backwash supply isolation valve at the filter will close, the backwash supply pump will stop, and the backwash drain valve will close. Prior to bringing the filter back into service the filter influent valve and filter to waste valve will open, and filter to waste until an adjustable present turbidity level is reached. The filter to waste valve will close and the filter effluent will open to return to constant flowrate control. Once the filter effluent valve opens, the filter run clock will reset and begin recording filter run time. The control system will calculate and record the volume of washwater used.

- The following conditions will initiate a “Backwash Fail” alarm condition and will be reason for removing the filter from service:
  - Neither backwash pump starts
  - Any valve fails to open or close, or fails to reach its position in the allotted time
  - Power fails during backwash

12.3 Chlorine Contact Basin (CT Basin)

One 275,000 gallon contact basin will be provided as described in Section 5. The layout will allow the CT Basin to operate in series or with half out of service (for limited duration) by the opening and closing of valves.

The CT Basin will include the following:

- The basin will be provided with vents, overflows, and adequate access hatches.
- Temperature, chlorine residual and pH monitoring will be provided.
- Either half will be able to be taken out of service with the other half remaining in service. This sequence is for limited duration.

Monitoring and control of the CT Basin will be as follows:

- Clearwell temperature, chlorine residual, and pH will be indicated at theHMI.
- The control system will determine C*T based on flow rate through the basin, basin volume, disinfectant concentration, water temperature, and pH.

12.4 Backwash Tank

One new 150,000 gallon backwash tank will be constructed adjacent to the CT basin. Two vertical turbine backwash pumps will be installed to pump finished water to the filter backwash system. A check valve will be provided on the discharge of each pump. Pumps will be controlled by variable frequency drives (VFDs), as discussed in Section 5.

- Each pump will be provided with the following monitoring and control features:

- Remote-Off-Local selector switch at pump. Local providing manual on/off control at pump via momentary start/stop pushbuttons, Remote passing control to VFD, Off prevent operation from any location.
    - Hand-Off-Auto selector switch at VFD. With Remote-Off-Local switch above in Remote, Hand providing for manual on/off control at the VFD via momentary start/stop pushbuttons, Auto passing control to the PLC, Off shall prevent operation from the VFD or PLC.
    - In Remote + Hand, manual speed control via VFD keypad.
    - In Remote + Auto, VFD to accept analog speed control from PLC.
    - Analog speed feedback from VFD to PLC.
    - VFD fault alarm to PLC.
    - Motor temperature fault to PLC.
    - High discharge pressure to PLC.

- A flow meter will be provided on the backwash supply header.

Monitoring of the Backwash Pump Station will be as follows:

- Backwash supply water will be metered at the common discharge header. Backwash supply flow will be displayed at theHMI.
- The following will be monitored at the HMI for each backwash pump:
    - Run and auto status of each pump
    - Pump motor run time
    - Pump discharge high pressure alarm
    - Pump motor overtemperature alarm

13.1 General

The intent of this section is to outline the minimum requirements necessary to provide continuous pumping and treatment throughout the construction period.

Existing plant operation will be continuously maintained by Kentucky American Water during the entire construction period. Construction work will be scheduled so as not to impede any treatment process, reduce the quality of the finished water, or cause other nuisances.

H&S will work closely with the Construction Manager (CM) to coordinate the design and general construction as well as the mechanical, electrical and instrumentation construction schedules. The Contractor will provide permanent or temporary power for all existing, proposed, and temporary facilities that are required to be on-line at any given time. The Contractor will also provide additional temporary facilities, if needed, to eliminate a constraint and maintain continuous and dependable plant operation at the flow rate required to satisfy system demands.

All treatment processes will be maintained in continuous operation during the construction period except during approved process interruptions. All system or partial system shutdowns and diversions will be approved, coordinated, and scheduled at times suitable to Kentucky American Water. Contingency planning is required for all shutdowns, and standby equipment may be necessary, depending on the situation. Shutdowns will be fully coordinated with Kentucky American Water at least 7 days, and in some cases 14 days, before the scheduled shutdown. Shutdowns will typically be scheduled for weekend or midnight low flow periods and will be limited depending on distribution system rate demands and finished water storage volume at the plant and in the distribution system. The duration of shutdowns will be at the discretion of Kentucky American Water. Further, Kentucky American Water will have the authority to order work stopped or prohibited that would, in their opinion, unreasonably result in interrupting the necessary functions of the plant operations.

Shutdowns will not begin until all required materials are on hand and ready for installation. The Contractor shall proceed with the work continuously, start to finish, until the work is completed and normal plant operation is restored. Appropriate diversion facilities will be furnished when the plant cannot be shut down for a sufficient period of time to accomplish the work. If the Contractor completes all required work before the specified shutdown period has ended, Kentucky American Water may immediately place the existing system back into service. In the event that plant operation is impaired, the Contractor will immediately make all repairs or replacements and do all work necessary to restore the plant to operation to the satisfaction of Kentucky American Water. Such work shall progress continuously to completion on a 24-hours-per-day, seven-work-days-per-week basis.

Listed in this section are specific construction restraints and shutdowns required for the different project components. Work not specifically covered in the following paragraphs may, in general, be done at any time during the contract period; subject to the operating requirements and constraints, and construction requirements. See Section 1 of this document to review the construction schedule proposed considering continuous plant operation and the construction restraints and shutdowns identified in this section.

13.2 Specific Operational Constraints

Specific operational constraints will be provided after layout of the filter building, chlorine contact basin and backwash pump station have been finalized.

In general, the new facilities will be constructed prior to taking any of the existing facilities out of service. This will significantly reduce the impacts to the operation of the Richmond Road Station WTP during construction. The only plant shutdowns that may be required during construction of the new filter building, chlorine contact basin and backwash pump station would be related to relocation of buried utilities. Additional shutdowns will be required to connect the existing settled water piping to the new filter building and to connect the effluent from the chlorine contact basin to the existing influent to Clearwell No. 1.

These shutdowns will be defined when the location of the new facilities are finalized and the existing utilities have been located.

14.1 Equipment Manufacturers

The following is a list of manufacturers proposed for the major equipment required for the Richmond Road Station Treatment Plant Addition. The list is based on the Preliminary List of Manufacturers discussed at the kick-off meeting, but also reflects recommendations from Hazen and Sawyer based on past AWC projects. The manufacturers listed in red are KAW's acceptable manufacturers, with preferred manufacturers noted in bold. Those listed in blue are manufacturers that Hazen and Sawyer considers comparable and recommends including to promote competition.

TABLE 14.1
GENERAL EQUIPMENT

Equipment Description	Manufacturers
Ductile Iron Pipe	American Ductile Iron Pipe Griffin Pipe Products United States Pipe and Foundry
Butterfly Valves w/Electric Operators	DeZurik Valve Company Henry Pratt Company
Butterfly Valves w/Manual Operators	DeZurik Valve Company Henry Pratt Company Clow Valve Company Val-Matic
Resilient Seat Gate Valves	Mueller Company Clow Valve Company United States Pipe and Foundry American Flow Control
Check and Air Valves	Golden Anderson Cla-Val APCO Val-Matic
Electric Valve Operators	**Auma Actuators, Inc.** **EIM**
Rate of Flow Control Valve Operators	**Beck** **REXA Electraulic Actuation**
Bronze Ball Valves	Conbraco Industries Nibco Watts Regulator Company
Backflow Preventers	Ames Company, Inc. Watts Regulator Company
Paint	Carboline Paint Company M.A. Bruder and Sons (MAB) Sherwin Williams Company Tnemac Company, Inc.

TABLE 14.2 WATER TREATMENT PROCESSES	
Equipment Description	**Manufacturers**
Filtering Equipment	**Roberts**
Blowers	**Kaeser Compressors**
Vertical Turbine Pumps	**Flowserve** **Floway** Goulds Peerless Fairbanks Morse

TABLE 14.3 PROCESS INSTRUMENTATION	
Equipment Description	**Manufacturers**
Venturi Meters	Primary Flow Signal Leeds and Northrup Henry Pratt Company
Magnetic Flow Meters	Sparling Instruments, Inc. ABB Rosemont Endress Hauser
Displacement and Turbine Meters	Sensus Technologies, Inc. Schlumberger Industries
Ultrasonic Level Probes	Endress Hauser Inventron Miltronics Drexelbrook
Turbidimeters	Rosemount Analytical Hach Company Sigma **Great Lakes Instrument**
Temperature Transmitters	Rosemount Endress Hauser
pH Analyzers	Rosemount Analytical Endress Hauser Leeds & Northrup Great Lakes Instruments Hach Company
Chlorine Residual Analyzers	Rosemount Analytical Wallace & Tiernan Hach Company ProMinent
Pressure Gauges	Trerice Ashcroft

TABLE 14.4 ELECTRICAL EQUIPMENT	
Equipment Description	**Manufacturers**
Motor Control Centers	General Electric Allen Bradley Eaton Cutler Hammer Square D
Panel Boards	General Electric Eaton Cutler Hammer Square D
Outdoor Transformers	General Electric Eaton Cutler Hammer Square D
Dry Type Transformers	General Electric Eaton Cutler Hammer Square D
Variable Frequency Drives	**Allen Bradley PowerFlex** **Eaton Cutler Hammer SVX** **Toshiba** **Danfoss**
Reduced Voltage Solid State (Soft) Starters	**Allen Bradley SMC Flex** **Eaton Cutler Hammer S811** **Square D Altistart**
Power Generation Equipment	Caterpillar, Inc. Engine Division Onan Corporation Penn Detroit Diesel
Automatic Transfer Switch	Automatic Switch Company Onan Corporation Russelectric
Push Button Selector Switches/Pilot Light	General Electric Allen Bradley Eaton Cutler Hammer **Square D**
Relays	General Electric Eaton Cutler Hammer Potter Brumfield **Square D**
Control Relays, Timing Relays	IDEC Diversified Electronics Agastat General Electric
Power Panels	General Electric Square D Eaton Cutler Hammer
Lighting	Holophane Day-Brite Benjamin

TABLE 14.5 SCADA EQUIPMENT	
Equipment Description	**Manufacturers**
Fiber Optic Modems	Phoenix Microwave
Uninterruptable Power Supply	Best Falcon **Sola Hevi-Duty**
PLCs	Allen Bradley ControLogix or CompactLogix
Operator Interface Terminals	**Allen Bradley Panelview Plus**
Laptop Access Port	**Graceport**
PLC Cabinets	**Hoffman** Rittal **Hammond**
Ethernet Switches	**N-Tron** **Hirschmann** **Phoenix Contact**
Power Supplies	**Phoenix Contact** **Allen Bradley** **Sola Hevi-Duty**
Systems Integrators	**TBD**

TABLE 14.6 HVAC EQUIPMENT	
Equipment Description	**Manufacturers**
Electric Unit Heaters	Indeeco Chromalox Qmark
Exhaust Fans	**Big Ass Fans** Greenheck Loren Cook Twin City Aerovent
Dehumidifiers	**HI-E Dry** Desert Aire Dectron, Inc.
Louvers and Dampers	Construction Specialties (C/S), Inc. Ruskin Airolite Company