Harvesting the Rain
An Overview of the Rainwater Collection Systems at McKinney ISD

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ABSTRACT

The primary goal of sustainable design is to utilize the natural resources offered by the surrounding environment. Considering the drought conditions over the past several years, water is a resource that received significant consideration in the planning and design phases at four elementary schools in McKinney ISD.

By harvesting the rainwater from the roof of the building and channeling this water into six on-campus storage tanks, enough rainwater can be collected to flush the toilets and irrigate the school's lawn areas. The rainwater collection and utilization system includes gutters to direct the water to the cisterns, cisterns to collect the rainwater and pumps to distribute the water. A floor plan of Walker Elementary School is shown in Figure 1. Other features of the system include a piping loop for tank equalization, a circulation system for freeze protection, a booster system for flushing, a tie-in to City water for make-up water and chemical treatment.

Another element of sustainable design is "eco education" which is a concept that incorporates sustainability into the curriculum so that students can understand the design and how it impacts the environment. By making this collection system visible, it is a very powerful teaching tool for students to learn about water conservation.

The purpose of this paper is to present detailed information on the rainwater collection and utilization system at four elementary schools in McKinney ISD. This information will include planning issues and considerations, design features and constraints, construction needs and maintenance and operation requirements.

EVOLUTION

The droughts of the past years combined with our sense of responsibility to preserve our environment for future generations has prompted us to resurrect ancient techniques in use for over 4,000 years. The ancient Romans first collected rainwater in cisterns to augment their City's aqueduct systems.

HOW THE RAINWATER COLLECTION SYSTEM WORKS

There are several components needed to harvest the rainwater at each of the four McKinney ISD sustainable elementary schools. They are as follows.

1. Collection
2. Roof Wash
3. Grey Water
4. Treatment
5. Irrigation
6. Windmill

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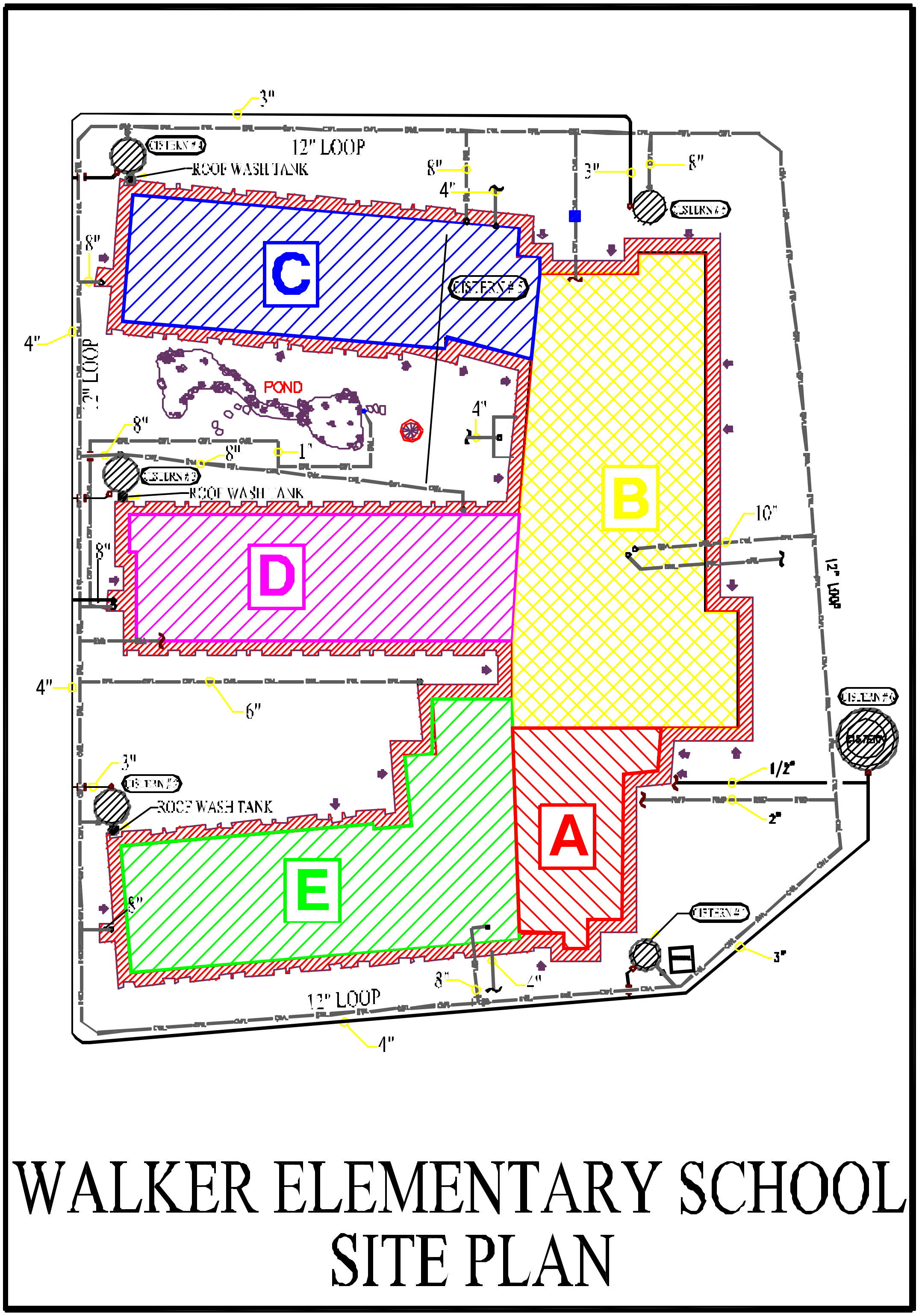

Figure 1

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7. Condensate Collection
8. Domestic Water Auto-fill

All of the above components must be integrated together to achieve a complete rainwater harvesting system. A schematic of all of the components is shown in Figure 2. Each of the individual components are addressed below.

Collection

The rainwater is collected into the system as shown on Figure 2. The rainwater is directed from the roof via roof drains and laterals into six above-ground cisterns which are connected together by an underground loop. A conventional roof drain system is used to collect rainwater off of the roof. There is a roof drain relief piped to exterior nozzles on the building to eliminate any back-up of rainwater on the roof during high intensity rainfalls. Cisterns no. 1 through 5 are closed top tanks whereas cistern no. 6 is an open top tank. Cisterns no. 1 through 5 are 11 feet in diameter by 8 feet tall. Cistern no. 6 is 18 feet in diameter by 10 feet tall. The total volume of all six cisterns is approximately 48,000 gallons. Additional system volume is attributed to the rainwater retained in the underground piping loop.

The collected rainwater seeks a uniform level in the overall system. Cistern No. 5 is equipped with both a low level sensor and a high level sensor to protect operation of the circulation pump and the control of the automatic fill of domestic water. The automatic fill is designed to fill the system for no more than one irrigation cycle. This allows the remaining volume in the system to collect rainwater for that day if a rain event occurs. Depending on recent rainfall events the automatic fill amount will vary. The low level sensor insures that there is adequate water available for pump suction so that the circulating pump is protected.

Cisterns no. 1 through 5 are equipped with an overflow port located at the top of each tank. Cistern no. 6 is equipped with an overflow spillway which is visible for the students to observe. The overflow spillway on Cistern no. 6 is approximately 4 inches lower than the overflow for cisterns no. 1 through 5. This will allow the majority of the overflow to discharge at cistern no. 6 for visual effects. All of the cisterns are looped together with a 12 inch PVC loop. There is also a circulating loop consisting of 4 inch PVC pipe and a circulating pump which is located in the equipment room inside the building. The circulating pump provides the following functions.

1. Mixing of the chlorine (Details of the treatment component are presented below.)
2. Aeration of the water
3. Freeze Protection

The pump was sized for 300 gallons per minute which allows for 50 gallons per minute per cistern. This pump is operated at owner specified intervals by the energy management control system.

Roof Wash

The initial rainwater is bypassed through roof wash tanks interconnected into the rainwater collection system (See Figure 2).

The purpose of the roof wash component is to clean the roof of any debris which might have accumulated on the roof between rainfall events, thereby, providing a better quality of rainwater for irrigation and grey water use. This will also provide protection for the pumps. The roof wash system is designed based on the gravity concept.

The roof wash tanks are sized based on 1 gallon per 100 square foot of roof area. There are five 200 gallon roof wash tanks as shown on Figure 1. There is an air relief vent off of each of the five tanks to displace the air as the tanks are being filled. A detail of this tank is shown in Figure 3.

There are also four exterior roof wash tanks constructed of 12 inch diameter PVC pipe encapsulated in corrugated metal pipe. The 12 inch PVC roof wash tank size is also calculated based on 1 gallon per 100 square feet of roof area. These tanks serve the smaller roof areas. A detail of this roof wash is shown in Figure 4. When a rain event is over, the full roof wash tank drain down valves are opened and the water in the roof wash tank drains off through the subsurface storm drain system. The automatic drain down valve is controlled by an exterior moisture sensor.

The roof wash tanks must be cleaned periodically. As another means of cleaning the system, a strainer is included on the circulating pump and must be cleaned at least once per month to remove any suspended particles in the rainwater.

Grey Water System

The grey water system was designed to supply rainwater to the toilets and the urinals for flushing. A

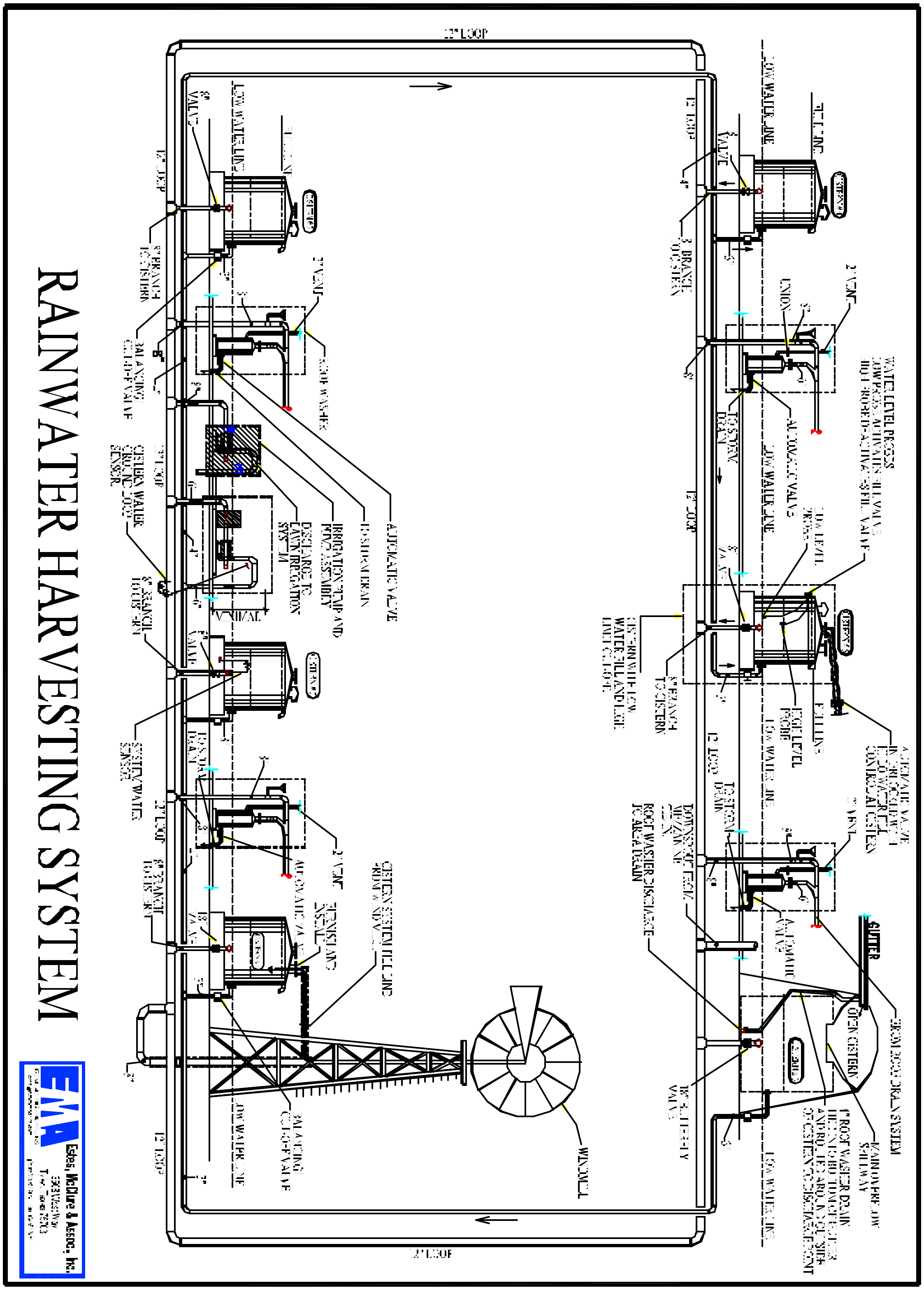
RAINWATER HARVESTING SYSTEM
WINDMILL
GUTTER
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Figure 2

skid-mounted package pump system with a pneumatic tank would have been used to pressurize the system to meet the minimum flushing pressure requirements. The air chamber created by the bladder allows the air inside to compress, thereby pressurizing the system. The pump and tank were to be located in the main mechanical room by cistern no. 5.

Due to budget constraints, the system was deleted as part of a cost cutting measure before construction began. As a back-up measure, the domestic water system was sized to adequately provide for flushing of the toilets and urinals. Consequently, the domestic cold water system was designed originally so that design adjustments were not necessary when the grey water system was deleted.

As a safeguard, the grey water would have been protected by chemical treatment with chlorine. Signs were to have been posted on the toilets and urinals notifying the user that this water was non-potable.

Water Treatment

Chlorine is injected for disinfection purposes into the 4 inch circulating loop. The water treatment system is located in the pump room in Area "D" as shown on Figure 2.

The chlorine injection system monitors the ph (2 to 12), chlorine (0 to 6 ppm) and the temperature (0 to 160 degrees Farenheit). A detail of this system is shown in Figure 5.

Irrigation

The landscape architect specified the pump for the lawn irrigation system. This pump is located in Area "D" pump room. For example at Malvern Elementary School, the lawn irrigation system is separated into approximately 40 zones. The maximum gpm required for any one zone is 65 gpm.

There is a moisture meter on the irrigation system to detect the moisture content of the soil. Water is conserved since the lawn is only watered when needed.

Windmill

The windmill was originally designed to replenish the water in the cisterns at a rate of 385 gallons per hour based on a 15 mile per hour wind. At Roy Lee Walker Elementary School, a test bore drilled before construction yielded no groundwater above the 300 foot mark. There was groundwater available at Malvern Elementary School and at McNeil Elementary School. However, the City of McKinney would not allow the school district to pump water from a well within the City limits. The windmill would have provided approximately 10% of irrigation needs.

As it was constructed, the windmill assists in circulating the water in the loop.

Condensate Collection

The condensate extracted by the HVAC units during the cooling cycle is being collected into the rainwater collection system. The average condensate collected is 0.3 gallon per hour per ton of cooling. This will supplement the rainwater collected.

Domestic Water Auto-Fill

When the water is below the low level line in the cisterns, domestic water is used to fill the cisterns up to the high level line so that the pumps are protected.

The volume of water from the low level line up to the high level line is approximately equal to one days irrigation cycle. The high level line is below the overflow of the cisterns. This allows collection of rainwater into the cisterns for that day even though the domestic water auto-fill was utilized.

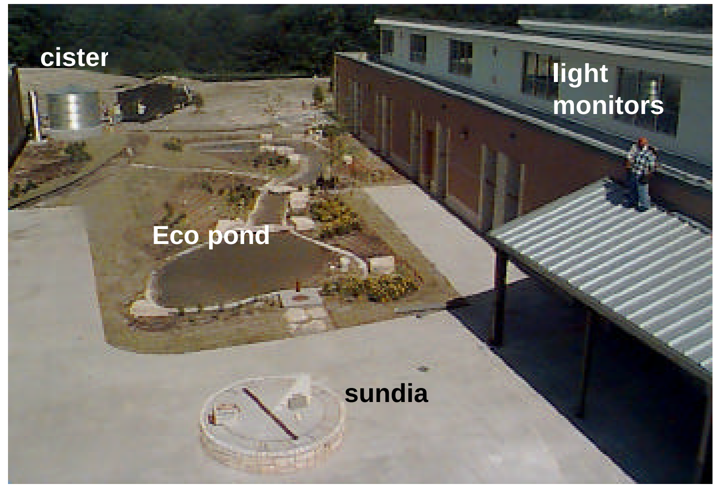
INTEGRATING IT INTO LEARNING

Studies are showing that the various environmental benefits of sustainable design also benefit our children in the classroom. One of the many learning features incorporated into the design of this school is the clear graduated cylinder located in the hall for students to observe the level of the rainwater in the system.

Another feature of the system is the overflow drain on the open cistern no. 6. When the tanks are full, the water overflows for the students to observe as shown in Figure 2. The windmill, which assists in circulating the water in the loop, provides a visual for the students as they can see the water being pumped as the windmill turns.

An "eco-pond" provides hands-on learning about fresh water ecology. There are two ponds connected in tandem. The low pond basin has a level sensor which maintains that level in the pond at all times. When the water level is low, a float valve opens to the collection loop which then fills the pond. There is a manual hand pump which allows the students to pump water from the basin, thereby, learning the mechanics of a pump.

Students will also have the opportunity to water their bean plants which they will keep in the school's greenhouse with harvested rainwater.



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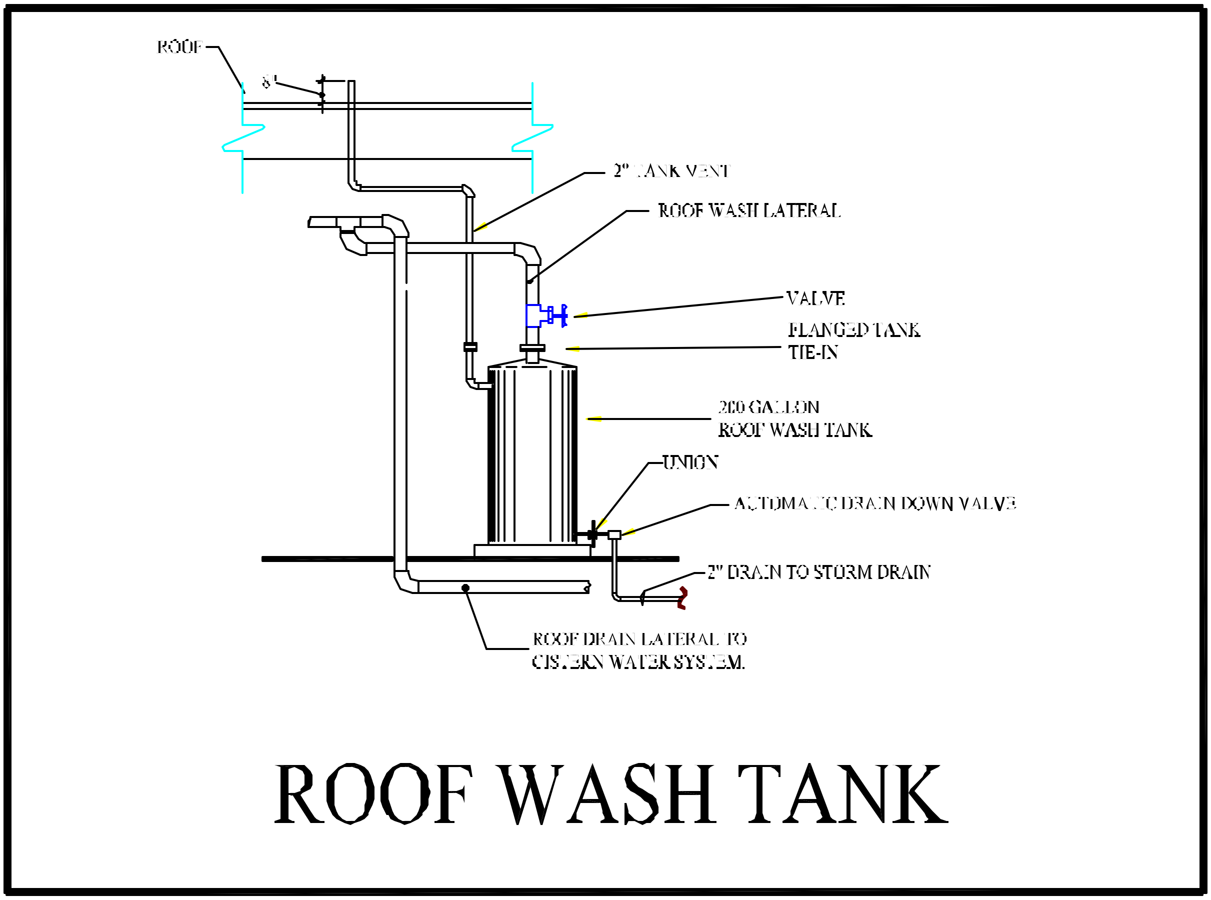
ROOF
8"
2" TANK VENT
ROOF WASH LATERAL
VALVE
FLANGED TANK
TIE-IN
200 GALLON
ROOF WASH TANK
UNION
AUTOMATIC DRAIN DOWN VALVE
2" DRAIN TO STORM DRAIN
ROOF DRAIN LATERAL TO
CISTERN WATER SYSTEM.
ROOF WASH TANK

Figure 3

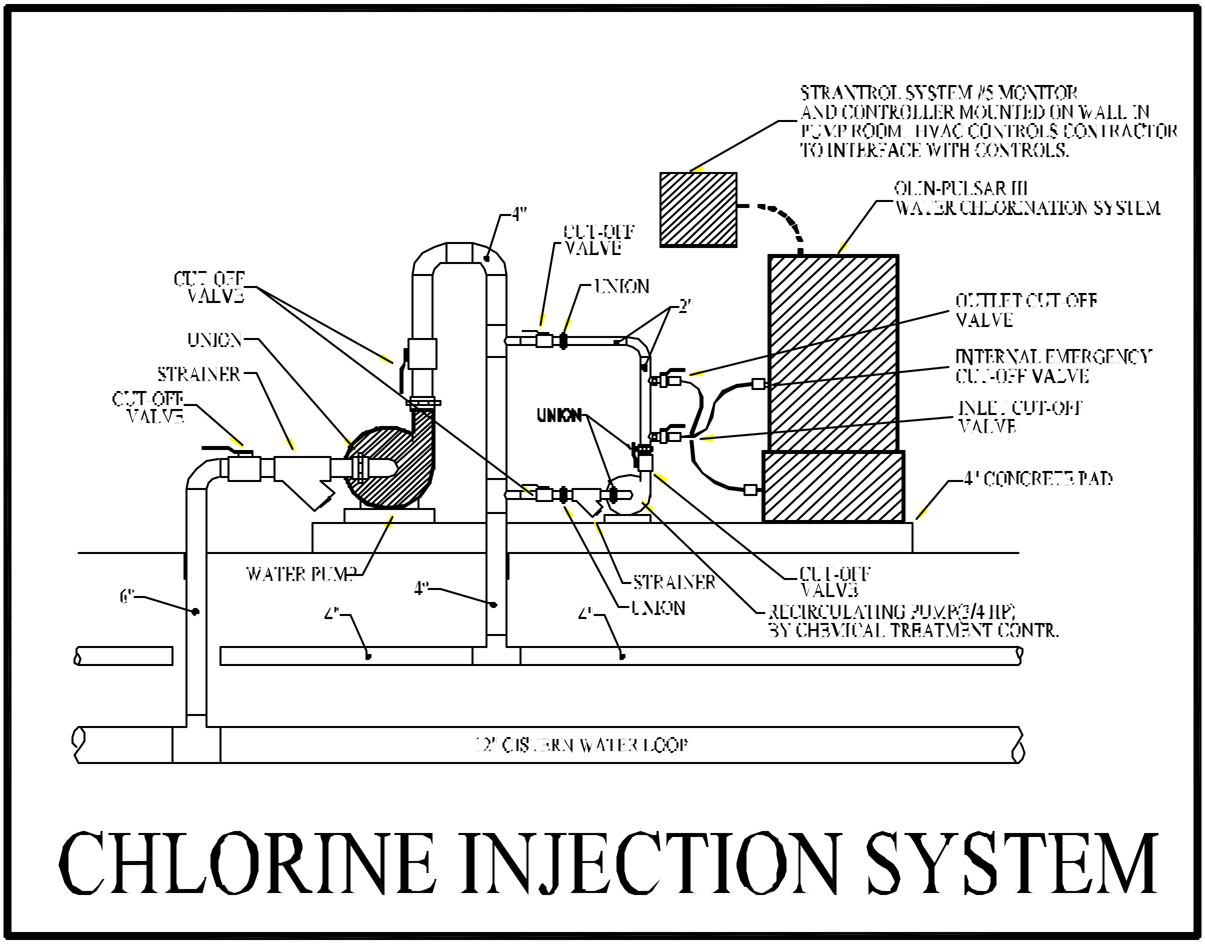
STRANTROL SYSTEM #5 MONITOR
AND CONTROLLER MOUNTED ON WALL IN
PUMP ROOM. HVAC CONTROLS CONTRACTOR
TO INTERFACE WITH CONTROLS.
OLIN-PULSAR III
WATER CHLORINATION SYSTEM
4"
CUT-OFF
VALVE
UNION
2"
CUT-OFF
VALVE
UNION
STRAINER
CUT-OFF
VALVE
OUTLET CUT-OFF
VALVE
INTERNAL EMERGENCY
CUT-OFF VALVE
UNION
INLET CUT-OFF
VALVE
4" CONCRETE PAD
WATER PUMP
STRAINER
UNION
CUT-OFF
VALVE
RECIRCULATING PUMP(3/4 HP)
BY CHEMICAL TREATMENT CONTR.
6"
4"
4"
4"
12" CISTERN WATER LOOP
CHLORINE INJECTION SYSTEM

Figure 5

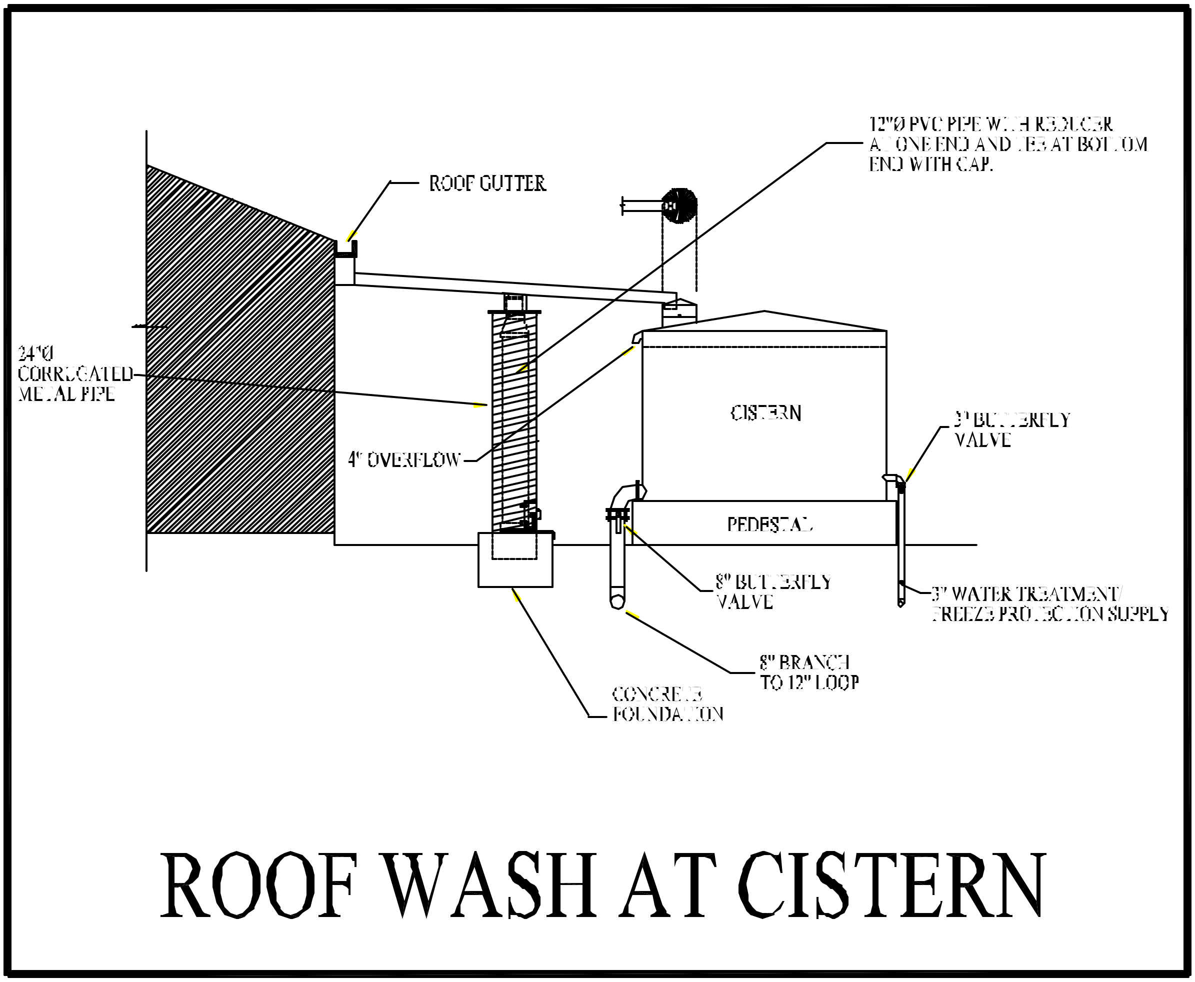
12"Ø PVC PIPE WITH REDUCER AT ONE END AND TEE AT BOTTOM END WITH CAP.
ROOF GUTTER
24"Ø CORRUGATED METAL PIPE
CISTERN
3" BUTTERFLY VALVE
4" OVERFLOW
PEDESTAL
8" BUTTERFLY VALVE
3" WATER TREATMENT/ FREEZE PROTECTION SUPPLY
8" BRANCH TO 12" LOOP
CONCRETE FOUNDATION
ROOF WASH AT CISTERN

Figure 4