

Barton Springs Sunken Garden
Austin, Texas

Sunken Garden Improvements Phase I
Preliminary Engineer's Report
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CHAPTER 1: Project Description

1.1 Introduction

The Sunken Garden is an historic site located in Austin, Texas south of Barton Creek and downstream of Barton Springs Pool. Originally constructed in 1938 on the site of a pre-existing mill (ca 1800's), the Sunken Garden consists of terraced circular stone walls enclosing a natural artesian-fed spring, Old Mill Spring (Figure 1.1). The City of Austin (COA) and the Parks & Recreation Department (PARD) is in the process of making improvements to the site. This project encompasses Phase 1 of the improvements, which has the primary objective of improving the habitat for the endangered Barton Springs Salamander and Blind Austin Salamander. A secondary objective for Phase 1 is to preserve the historic stone enclosure. Phase 2 improvements are to be undertaken at a future time and involve making the Sunken Garden a more active amenity.

Figure 1.1: Sunken Garden Site Location

The COA and PARD have tasked the P.E. Structural Consultants, Inc. (PESC) Team with the Phase 1 efforts needed to improve the salamander habitat and create better conditions for increasing the salamander population. Improvements include:

- Modifying the existing wall to create an adequate opening and flow line for unhindered water flow through the stone wall enclosure. Modification of the stone enclosure will include removal of a partially buried concrete pipe and loose concrete that currently impede the flow of water from the spring into the channel, and constructing a new structure to frame the wall opening.
- Developing a means to block backflow from Barton Creek during peak water events from entering the Sunken Garden and potentially causing harm to the salamander population.
- Improving the channel immediately exiting the Sunken Garden enclosure to improve drainage conditions and create an ideal flowing water habitat for the salamanders.
- Remediating the deteriorated cylindrical stone wall surrounding the spring, in order to preserve the historical structure and architecture of the Sunken Garden.

These Phase I Improvement measures are part of the “Barton Springs Master Plan” (Limbacher and Godfrey Architects, 2008, ref. pp. 89-99) and the “Barton Springs Habitat Conservation Plan, Major Amendment and Extension, Final” (City of Austin, July 2013, ref. pp. 7, 20-22, 50, 60-62, 80-81, 112,115 Appendix B pp. 215, 230-231).

1.2 History of the Sunken Garden *(Information from Barton Springs Pool Master Plan)*

Prior to construction of the cylindrical enclosure in 1938, the spring was dammed and used to power a grist mill that was operated by Michael Paggi (Figure 1.2.1). Since that time, the spring has been known as Old Mill Spring. Mill operations became a struggle in the late 1800’s when water levels dropped due to infrequent rainfall. Old Mill Spring and the surrounding property was obtained by Andrew Zilker, who eventually sold the sprawling property to the Austin School Board on the condition that the City purchase the land for use as a public park. Upon his death in 1934, the property was dedicated to the public as Zilker Park.

Figure 1.2.1: Photos of Paggi’s Grist Mill
Overall View of Mill, circa 1876 (Left) and View of Water Exiting the Mill Walls, circa 1870 (Right)

In 1938, the National Youth Administration began a project at Old Mill Spring to construct Austin’s first “municipal sunken garden.” Designed as a series of terraced flagstone platforms stepping up from the spring pool, the Sunken Garden was created as a picnicking place for visitors of Zilker Park.

Outflow from the spring was prevented from exiting the enclosure so that Old Mill Spring could be utilized as a public swimming hole (Figure 1.2.2), and accumulations of silt and debris raised the original substrate level at the spring outsource some 5 to 10 feet. At some point (date unknown, 1950's?), flow from the spring was redirected to Barton Creek through a buried concrete pipe. Degradation of this pipe and lack of maintenance led to its being plugged and abandoned. All of these human manipulations over the years led to a decline in population of endangered salamander species and finally resulted in the site being claimed as a federally protected habitat.

Figure 1.2.2: Visitors Swimming at Old Mill Spring

Since that time, the site has been restricted from the public through the implementation of a locked wrought iron gate (Figure 1.2.3) and attempts have been made to improve the habitat over the years. Beginning around 2003, the substrate within the spring has been incrementally cleaned of debris and lowered approximately 5 feet, and the concrete pipe has been abandoned and partially removed (although a segment still remains lodged under the stone wall) and an overland channel leading to Barton Creek was recreated in 2006. A previous bank stabilization project in 2004 consisted of large limestone blocks stacked to form a boulder drop structure at the junction of this channel with Barton Creek. The top layer of blocks was removed in 2006 to accommodate re-grading of the channel. Trash and miscellaneous debris left inside the fenced site by unauthorized trespassers continues to be a concern.

Figure 1.2.3: Entrance Gate into the Sunken Garden (left) **and New Boulder Drop Structure** (Right)

As the Sunken Garden is a historic site, it is under protection of the National Historic Preservation Act, and improvements to the site are subject to approval of the Texas Historical Commission. Furthermore, Old Mill Spring is a federally protected habitat of endangered salamander species and improvements to the vicinity are governed by the Endangered Species Act, making them subject to the approval of the

United States Fish & Wildlife Service. Proposed Phase I improvements to the Sunken Garden will be located within the boundaries of the Barton Creek watershed and in the COA-defined Barton Springs Zone, and will thus be subject to the "Save Our Springs" requirements of the COA Land Development Code. While these improvements will not be located within the recharge zone or the transition zone of the Edwards Aquifer, they will be located within 100 feet of the spring, which is classified by the COA as a Critical Environmental Feature. In addition, the proposed improvements to the Sunken Garden will be located within the Critical Water Quality Zone and partially within the 100-year floodplain of Barton Creek (Figure 1.2.4).

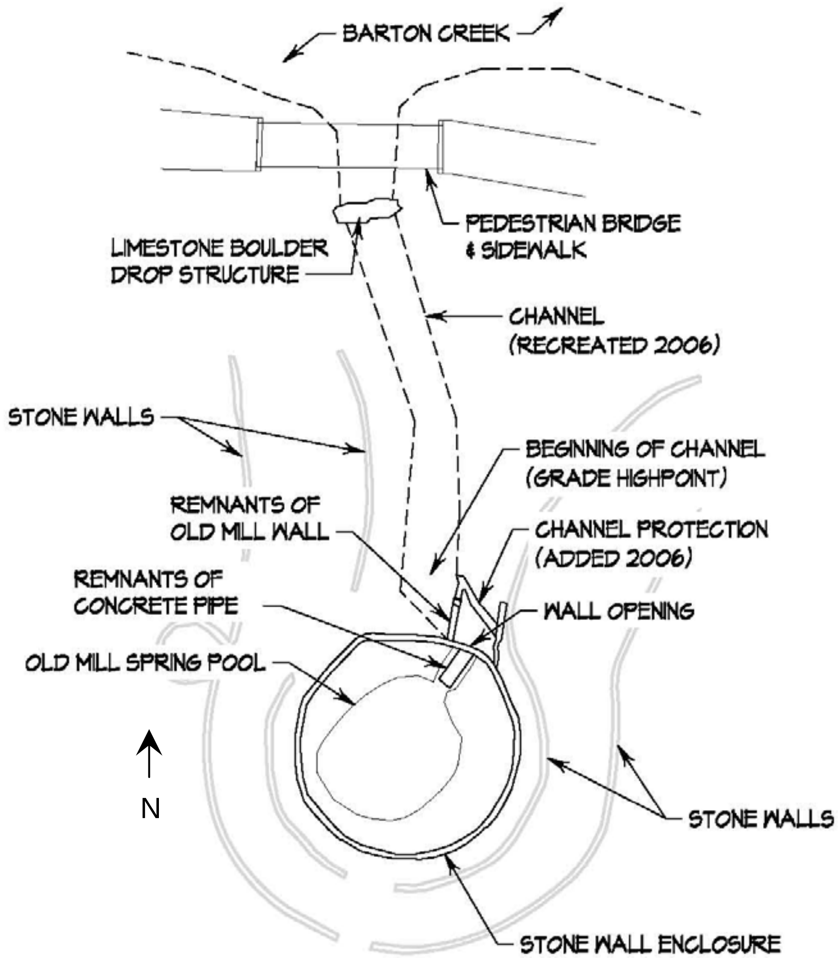


Figure 1.2.4: Schematic Plan View of Site

1.3 Endangered Salamander Species *(Information from TPWD and BSHCP)*

The Barton Springs complex is the only known habitat for the Barton Springs Salamander (Eurycea Sosorum), which has been included on the Endangered Species list since 1997. Barton Springs is also home for the Austin Blind Salamander (Eurycea Waterlooensis), which has recently been proposed for listing as endangered (Figure 1.3). Of the four natural springs within the Barton Springs complex, Old Mill Spring contains the largest population of the Austin Blind Salamander. These small vertebrates have external gills and are entirely aquatic throughout their lives. While they have been found in waters ranging in depth from a few inches to 15 feet, they live at spring outflows and rely on a continuous flow of clear, clean spring water.

Figure 1.3: Endangered Salamander Species
Barton Springs Salamander (Left) and Austin Blind Salamander (Right)

Periodic Surveys have been conducted on the salamanders since the early 1970s, when their population was considered quite abundant. Between 1970 and 1992, it was documented that the salamander population and presence of aquatic plants dropped sharply, sparking several initiatives to improve habitat conditions. Chemicals, hot water, and high-pressure hoses are no longer used in the maintenance procedures at Barton Springs Pool and nearby spring outlets, and aquatic vegetation has been planted in deeper waters to help restore habitat to native conditions. Despite conservation efforts thus far, scientists do not believe the Barton Springs salamander has yet reached a population level comparable to its pre-1970 distribution.

The COA has implemented a team of biologists to oversee improvements to habitat and water quality and to continually survey the salamander population, with the immediate goal of complying with the Endangered Species Act and the long-term goals of conserving and fostering the recovery of both salamander species. Phase 1 improvements directly address the City's goal of protecting the evolutionary potential of both populations by restoring and maintaining natural ecosystem characteristics and natural flow regimes in Old Mill Spring to the maximum extent practical.

CHAPTER 2: Structural Considerations

Please refer to Appendix A for schematic drawings of proposed structural modifications.

2.1 Site Observations of Existing Conditions

PESC visited the Sunken Garden site on August 28, 2013. Standing, stagnant water was observed both within and outside the existing stone wall enclosure at the time of our visit (Figures 2.1.1 and 2.1.2). Water was being re-circulated within the enclosure with a pump and hose, to help aerate the still water and improve habitat conditions. The base of the existing stone wall to the north was penetrated by a plugged concrete pipe and loose concrete debris. Because the plugged concrete pipe has been blocking the natural flow of water exiting the enclosure, the base of the wall on both sides of the plugged pipe has deteriorated, creating self-made openings in the wall to the west and east of the concrete pipe.

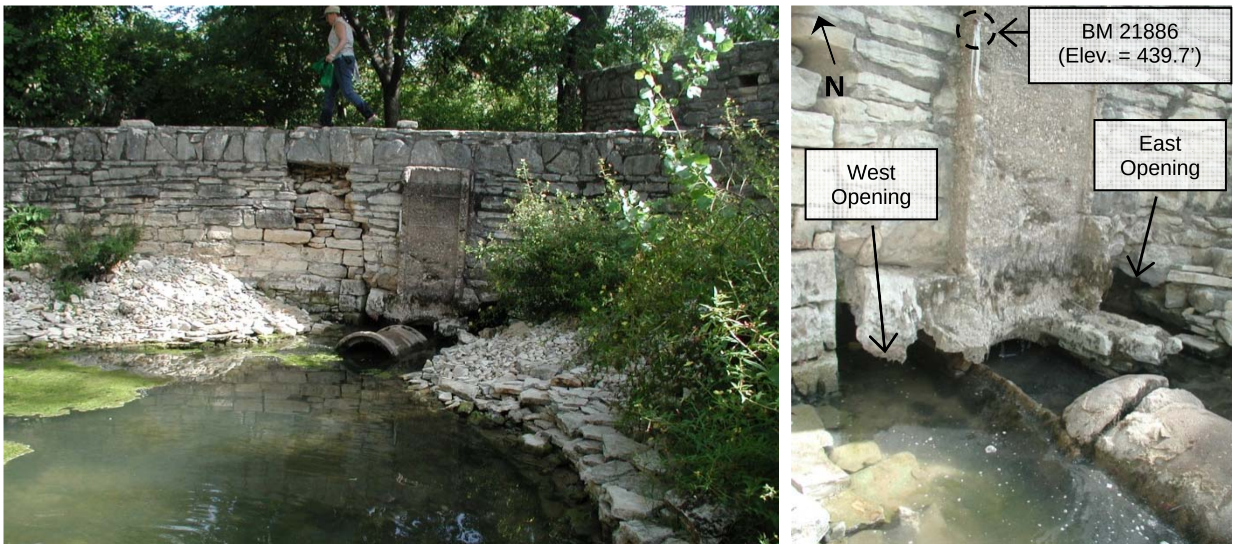


Figure 2.1.1: Outflow Exit Location – Views from within Enclosure
Overall View (Left) and Close-up of Wall Openings (Right)

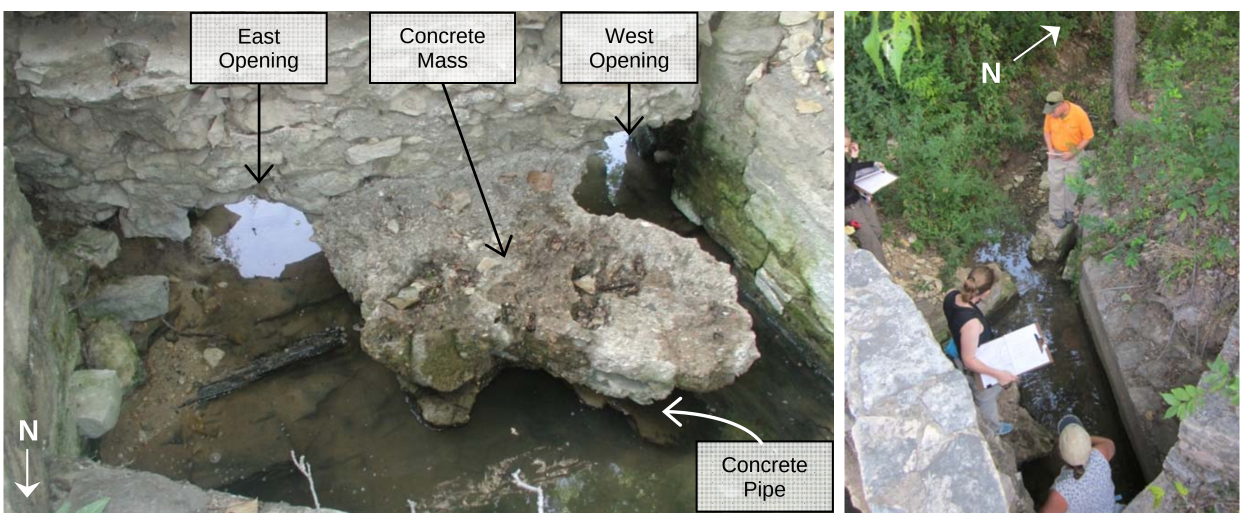


Figure 2.1.2: Outflow Exit Location – Exterior View

At the time of our visit, it was determined that the depth to the bottom of the existing concrete pipe at the enclosure exit (18" ± below the current water level) was the preferred flow line elevation. While this elevation would ideally be the highest flow line elevation between the enclosure and Barton Creek, we observed that the pool of stagnant water continued beyond the enclosure and was blocked by a highpoint in grade near the beginning of the channel (See Figure 1.2.4). The remainder of the channel leading down to Barton Creek was dry (Figure 2.1.4).

It is reported that the spring water within the enclosure backs up against the stone above the rough openings during normal conditions (i.e. not the current severe drought), rather than flowing freely through the opening to the channel. This indicates that the current cumulative size of the openings in the stone wall is too small to accommodate normal spring discharge volumes.

Further impediment of spring outflow appears to be caused by a portion of the historic mill wall that crosses the path of exiting spring water several feet outside of the enclosure (Figure 2.1.3). The old wall is in poor condition and an "opening" has formed for water flow to pass from the enclosure to the channel. At the time of the site visit, the bottom of the wall opening was approximately 2 inches below the top of the standing water.

Figure 2.1.3: Standing Water Outside Enclosure

Figure 2.1.4: View of Channel
Channel Looking Towards Barton Creek (Left) and Boulder Drop Structure at Channel End (Right)

In addition to the wall opening deficiencies observed, we observed a several locations where the stone enclosure wall has experienced significant damage and/or deterioration. Damage nearest to the wall opening location consists of a square-ish-shaped section of wall that had been completed knocked out and is currently filled with dry-stacked pieces of loose stone with no binding mortar (Figures 2.1.5 and 2.1.6).

Figure 2.1.5: Portion of Wall with Dry-Stacked Rubble – Views from within Enclosure
Straight-on View (Left) and Oblique View (Right)

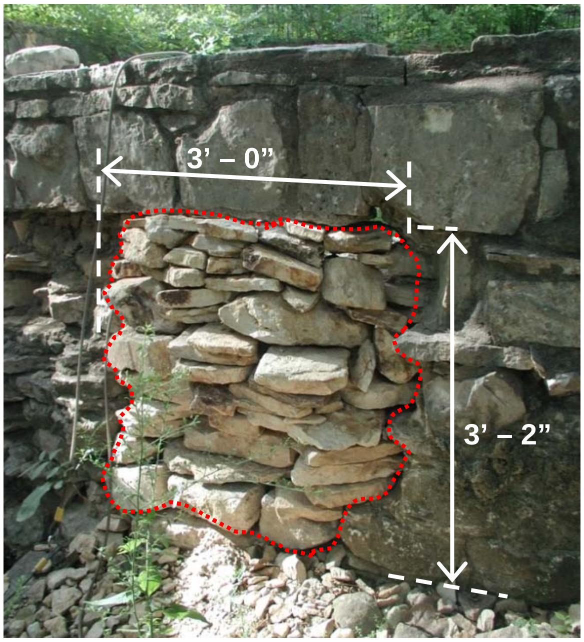


Figure 2.1.6: Portion of Wall with Dry-Stacked Rubble – Exterior View

To the west of the area with dry-stacked stones, there is a large diagonal crack in the wall and a hole at the base of the wall that is known to allow water to pass freely through the enclosure wall when the spring pool water reaches the height of the hole (Figure 2.1.7). Due to overgrown vegetation on the backside of the wall, this area was inaccessible for investigation and photographs are not available for the exterior side of this portion of damaged wall.

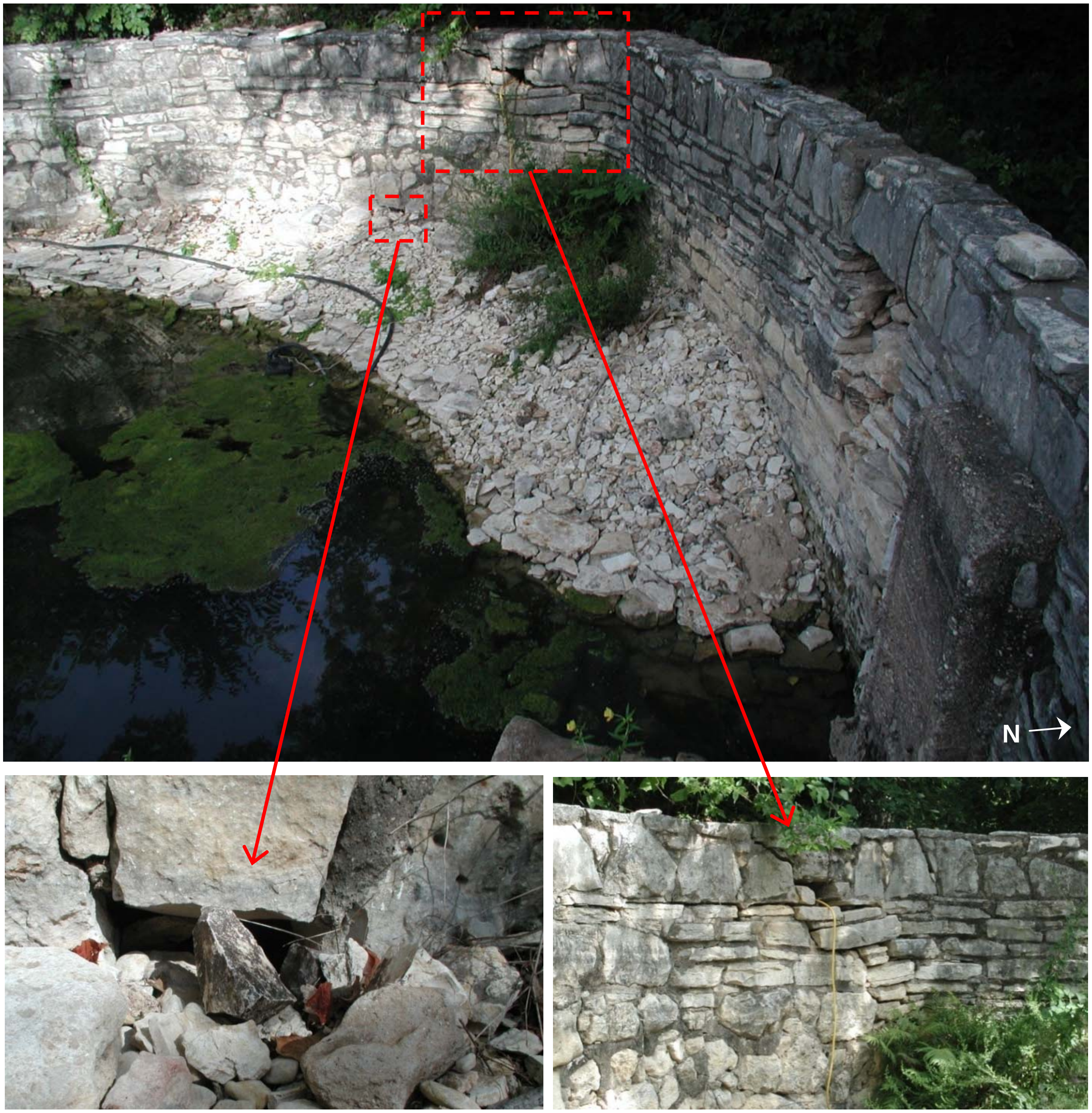


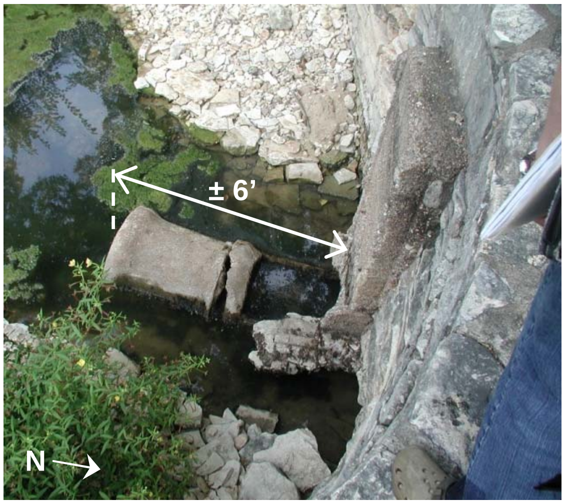
Figure 2.1.7: Damaged Areas of Stone Wall
Overall View (Top) and Close-ups of Hole at Base (Bottom Left) and Diagonal Cracking (Bottom Right)

2.2 Wall Opening Retrofit for Improved Drainage

In order to create an improved salamander environment with freely flowing spring water, the stone wall must be remediated around the opening where spring water exits the enclosure. The following sections describe work required at or around the wall opening. Prior to working in the channel around the opening, the existing stone wall will be deconstructed and stored locally; once work has been completed at the wall opening, the existing stones will be used to rebuild the wall. The stone wall will be reconstructed to match the existing enclosure wall, to the same top of wall elevation.

Removal of Existing Concrete Pipe and Miscellaneous Debris Around Wall

The plugged concrete pipe remnants and the loose concrete debris beneath and around the wall opening need to be removed. The concrete pipe extends approximately 6 feet inside the enclosure and penetrates through the existing wall opening (Figure 2.2). Remnants of the pipe are also present on the exterior side of the wall under a mass of old concrete (Figure 2.1.2, in previous section).



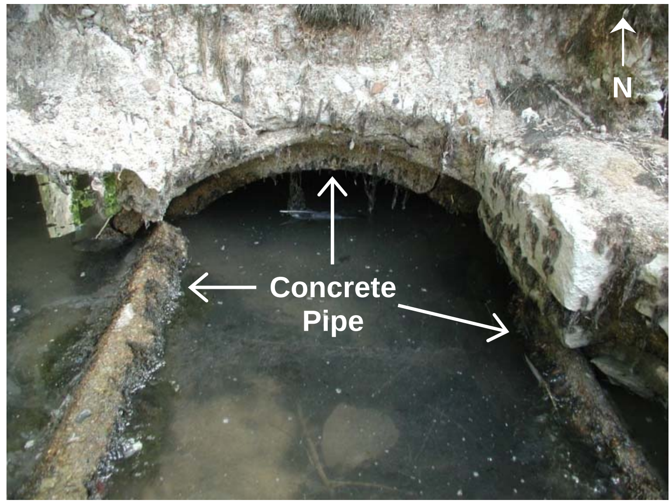


Figure 2.2: Concrete Pipe Blocking Water Flow Below Wall
View of Pipe within Enclosure – from Top of Wall (Left) and Close-up of Pipe Under Wall Opening (Right)

In order to remove the pipe and concrete debris and construct an enlarged wall opening, a temporary dam will need to be installed within the enclosure and any flowing water from the spring diverted so that construction operations can occur on dry soil. Due to the protected nature of the site and accessibility limitations, the pipe and concrete debris will need to be broken up with hand tools and hauled away in buckets. We estimate approximately 11,600 pounds of existing concrete debris will be removed. See civil sections for further information concerning these measures.

Excavate Bottom of Opening to Proposed Flow line Depth

Once the existing pipe and concrete debris have been removed, the substrate below the wall opening needs to be excavated and re-graded to lower the water flow line elevation. Existing silt, pebbles, and other miscellaneous debris in and around the opening have accumulated over time and need to be removed in order to improve drainage from the enclosure. See civil sections for further grading and flow line discussion.

Protect Channel Bed Around Opening

After excavation at the wall opening has been completed, the channel bed around the opening needs to be protected in order to maintain the desired flow line elevation, prevent erosion, encourage proper drainage from Old Mill Spring to Barton Creek, and provide optimal salamander habitat. Protection of the channel bed will likely involve a lining membrane and course cobble stones. See civil discussions for recommended means of protecting the channel bed. Regular maintenance of the opening should include removal of accumulated debris in the channel bed so that the desired flow elevation through the opening can be maintained.

New Concrete Structure to Frame Opening

In addition to lowering the water flow line elevation for improved drainage, a new opening in the existing stone wall should be installed. The opening should be of adequate size to allow spring discharge to exit the enclosure unimpeded and is dependent on the results of water-flow analysis. (See civil discussions for more information on water-flow analysis.) We anticipate that the opening be approximately 3 feet tall and 3 feet wide and will be framed with a cast-in-place reinforced concrete structure. The concrete frame will be roughly one foot thick on each side and above the opening, and will likely have a concrete spread footing foundation below the cobble stone channel. Once the concrete frame is installed, then the original stone wall can be reconstructed around it.

2.3 Drainage Improvements Outside of Enclosure

<u>Retrofit Old Mill Wall</u>

To maintain the proposed drainage flow from the enclosure to the channel, the existing "opening" in the Old Mill wall (Figure 2.1.3) should to be retrofitted to allow the same volume of water flow as the new opening in the enclosure wall. The area of mill wall to be removed will depend on the results of water-flow analysis (see civil discussions).

Beyond the Old Mill wall, the current channel requires re-grading to promote drainage. Presently, the stagnant water inside and outside the stone enclosure is due to the high grade at the beginning of the channel, which is prohibiting water flow down the channel. We have provided three options for improvement to the drainage channel. All options require excavation and removal of in-situ soils, lining of the streambed to prevent soil erosion and allow for improved drainage, and retrofit of the limestone boulder drop structure that is situated at the end of the channel and creates a waterfall as spring outflow cascades into Barton Creek when spring discharge is high. See civil discussions for further information on proposed improvements to the channel.

<u>Option A: Minimum Improvement Outside of Enclosure, No Improvement to Channel</u>

Option A does not include any improvement to the channel that leads down to Barton Creek, but rather includes improvements only from the outside face of the enclosure wall to the "hump" that defines the beginning of the channel (just beyond the Old Mill wall remnants). For this option, from the enclosure to the beginning of channel the flow line will be lowered to match the new flow line at the enclosure wall opening and the bed will be improved with a granular filter layer topped with large cobble stones. The purpose of the granular filter layer and cobble stones is to promote good drainage and simulate an ideal "riverbed" environment for the salamanders. (Please note that we feel improving the channel is important to address the goals of this project, as it would contribute significantly to habitat improvement. However, channel improvement was not considered in the original project scope so we have provided the option here for consideration and comparison.)

<u>Option B: Improve Channel but Maintain Current Channel Slope</u>

Rather than only improving the small area immediately outside the enclosure wall, improving water flow conditions along the entire length of the channel would provide a considerably larger and better playground for the salamander population. Option B represents a low-impact solution to improving the channel drainage. The existing negative drainage condition caused by the highpoint in grade near the beginning of the channel would be removed by lowering the grade elevation at the highpoint so that it matches the proposed flow line elevation. A trench, roughly 18 inches deep to lower the beginning of channel down to the new flow line elevation, would be excavated along the full length of the channel. A protective filter layer would be placed in the excavation and then cobble stone would replace the excavated material. Again, the purpose of the granular filter layer and stones is to promote drainage and create a "riverbed" environment for the salamanders. When spring water flows through the "riverbed", it will provide an ideal habitat for salamanders. The stone boulder drop structure at the end of the channel (also referred to as a dam and waterfall) near Barton Creek will need to be minimally retrofitted to accommodate the trenched-out "riverbed". Note that this improvement option lowers the flow line and creates a "riverbed" but does not improve the channel slope.

Option C: Improve Channel and Increase Channel Slope

Option C incorporates channel slope improvement to the measures described in Option B above. The current channel slope is approximately 0.5%, which does not promote good water flow. The slope could easily be improved by increasing the depth of the excavated "riverbed" proposed in Option B along the length of channel. Increasing the new trench excavation depth by 4" to 8" at the end of channel would double-to-triple the existing channel slope and provide an optimal salamander habitat. Retrofit measures for the existing boulder drop structure will be slightly more extensive (to lower the structure more to accommodate the increased trench depth).

2.4 Preventing Backflow into Enclosure

Interest has been expressed in the incorporation of a method to restrict water infiltration through the Sunken Garden wall opening. It is our understanding that the City is concerned that flood waters from Barton Creek may flow into the Sunken Garden enclosure and potentially cause harm to the salamander population. Predators or perhaps toxic water allowed into the enclosure could potentially decimate the salamanders. We understand that the wall opening would be closed only in the rare occurrence that Barton Creek floods and its water elevation reaches the enclosure. Blocking the opening is not intended to contain spring water within the enclosure, because such actions would be counteractive to the project objective and the City's mission to save its rare salamanders. Salamanders need flowing water to thrive, so great care should be taken in determining when closure of the wall opening is appropriate. Frequent monitoring should occur if it is ever deemed appropriate to close the wall opening, and it should be allowed to flow freely again at the earliest opportunity.

It should also be noted that the 100-year floodplain elevation for Barton Creek is 458 feet above sea level, according to the COA Geographic Information System data. Other high-water elevations for significant flood events such 10-year, 25-year, 50-year or 75 year floods are not available. The top of the existing stone wall elevation is approximately 443 feet, which places the top of wall roughly 15 feet below the 100-yr flood elevation. This likely means that the 50-yr and 75-yr flood elevations are also above the top of wall. If a serious flood were to occur, restricting flow through the enclosure wall would likely be a pointless effort, because the Barton Creek flood water would flood over the top of the enclosure wall. Should flood water flow over the wall into the enclosure, closing the wall opening could actually be detrimental because then predators and/or toxins would be held inside the enclosure and not allowed to return to Barton Creek when the flood elevation lowers.

If a means is implemented to prevent backflow from entering the enclosure, the existing stone wall would be subjected to large lateral forces that it cannot support in its current condition. Closing the wall opening will result in a buildup of large lateral hydrostatic forces as the water level rises outside the enclosure wall. Efforts to strengthen the stone wall so that it is capable of holding water would be extensive. Strengthening of the wall would likely include a new cast-in-place reinforced concrete wall and footing constructed against the outside of the north face of the stone enclosure wall.

To prevent backflow from entering the enclosure, we have evaluated several options for consideration:

Option A: Implement a Manually-Operated Gate

Attaching an operable gate to the outside of the stone wall is one potential solution to prevent creek flood waters from flowing into the Sunken Garden enclosure. Closing the opening will require significant strengthening of the existing stone wall so that it can withstand lateral loads induced by standing water on the outside of the enclosure during a flood condition.

Several options are available for the gate, as described below:

1) Sluice Gates (also known as Slide Gates)

   Many options are available for sluice gates, in terms of size, materials, control method, and installation. The desired depth of water being restrained (called "seating head", see Figure

2.4.1) determines if the sluice gate should be heavy-duty, medium-duty, or light-duty. For the purposes of this project, a light-duty sluice gate is sufficient.

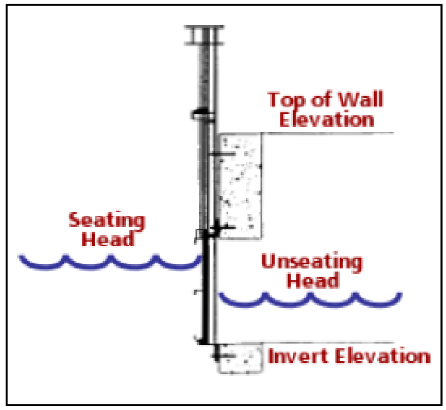
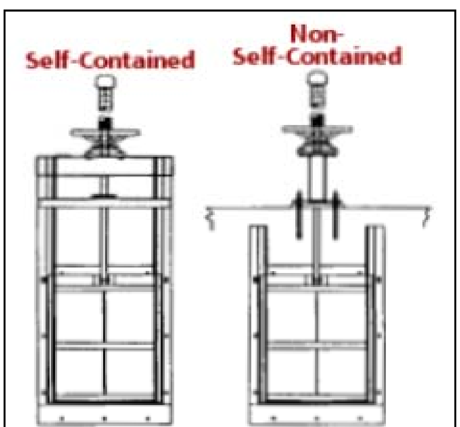


Figure 2.4.1: Example of Sluice Gate (Left) **and Diagram of Seating Head within Enclosure** (Right)

Sluice gates can be built to specified dimensions, ranging from 6in x 6in to 12ft x 12ft and can be square or rectangular in shape. They are typically furnished with rubber seals to improve water-tightness, although most manufacturers offer a more economical version without rubber seals. Gates can be produced using various materials to accommodate the type of environment the gate will be utilized in. Basic sluice gates are made from carbon steel that can be grit blast cleaned and painted to specification, or galvanized carbon steel when painting does not provide adequate protection. The carbon steel options use hot-rolled angles and flats in construction of the gate. Stainless steel (type 304, 304L, or 316) is the recommended material when more corrosion resistance is required. Alternatively, extruded aluminum or plastic materials are also available and can be more economical (although plastic gates are not recommended for outdoor applications subject to UV light).

Once the desired seating head, size, shape and material are determined, methods of installation and operation must be decided. How the gate is connected to the wall will determine if it is self-contained and if it is connected to the wall on either side by a surface-, in-channel, or embedded mount (Figure 2.4.2). Additional options are available for how the bottom of the gate (or invert) will be installed, including wall-mounted, embedded, and thimble-mounted options (Figure 2.4.3). To operate the sluice gate, a hand wheel or hand crank is installed, and several different methods of installation are available (Figure 2.4.4).



Images courtesy of D.J. Gongol & Assoc., Inc.

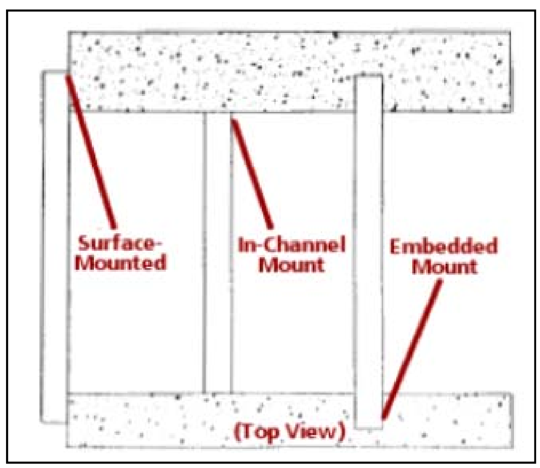


Figure 2.4.2: Methods of Mounting Sluice Gate to Wall
Elevation View (Left) and Plan View (Right)

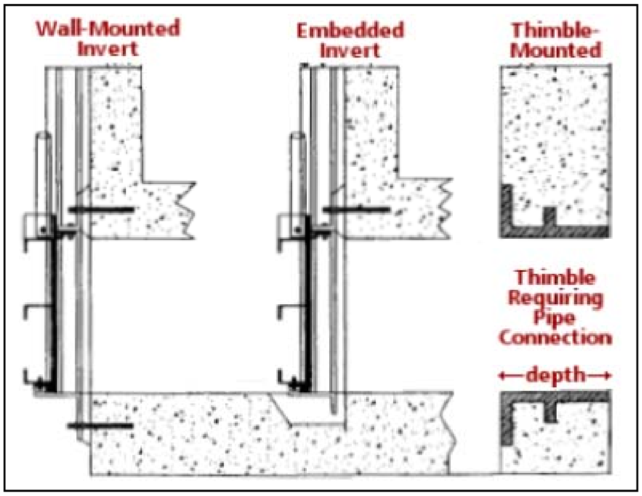
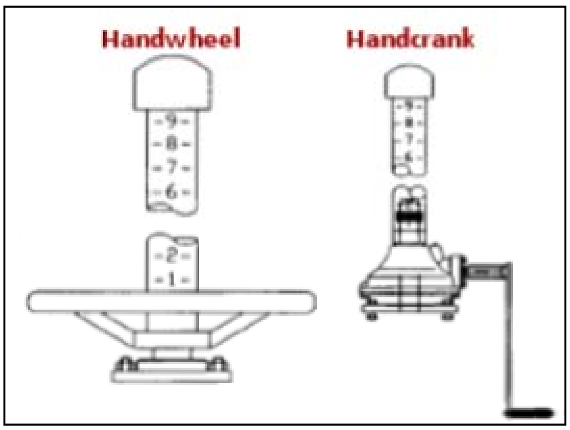


Figure 2.4.3: Methods of Mounting Bottom of Sluice Gate to Wall



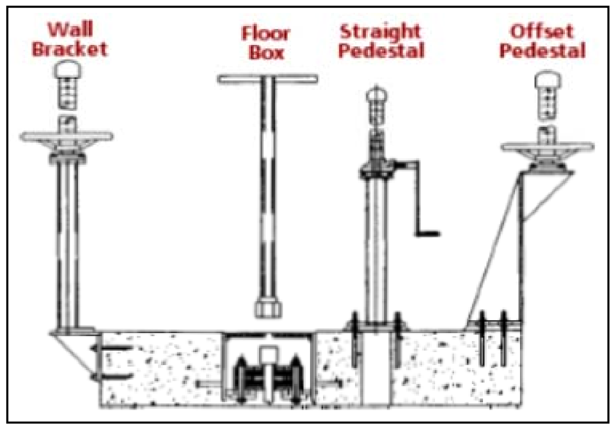


Figure 2.4.4: Manual Hoist Options for Sluice Gate
Hoist Type (Left) and Method of Installation (Right)

2) Flap Gates

If it is desired that operating maintenance be minimized, a flap gate may be a more suitable option, as it would automatically allow drainage in one direction (i.e. out of the enclosure) and prevent backflow from entering from the outside of the enclosure (Figure 2.4.5). When a small differential water pressure develops on the back of the gate (inside the enclosure), the flap automatically opens to allow discharge, and when the water level outside the enclosure rises above the height of water within the enclosure, the gate automatically closes to prevent backflow.

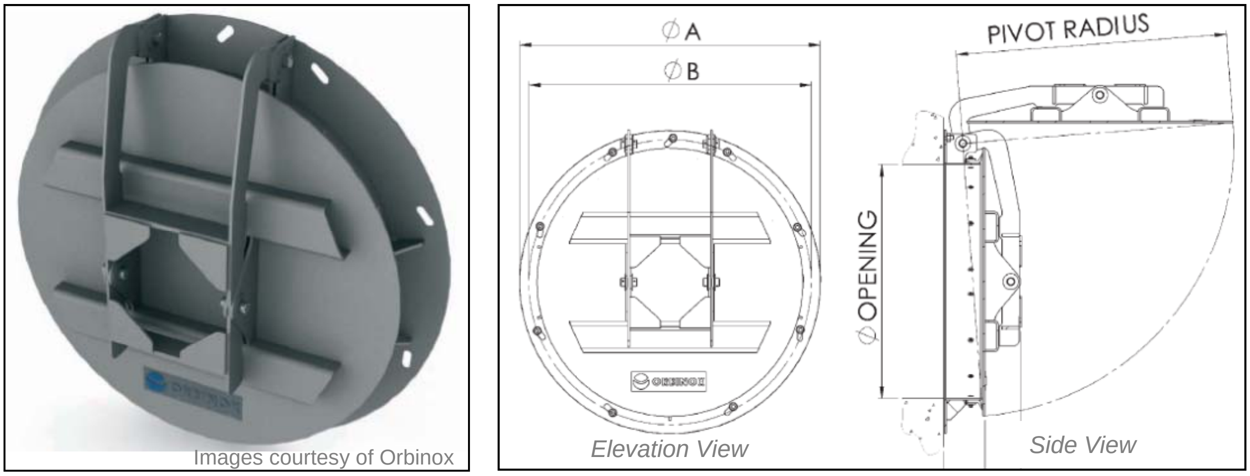


Figure 2.4.5: Example of Round Flap Gate
Oblique View (Left) and Diagram of Flap Gate when Closed and Open (Right)

Flap gates can be constructed to specification, in sizes ranging from 6in x 6in to 12ft x 12ft, can be round, square, or rectangular in shape, and can be hinged on the side or top (Figure 2.4.6). Flap gates can be constructed of cast iron, stainless steel, aluminum or spun aluminum, and are typically supplied with neoprene seals.

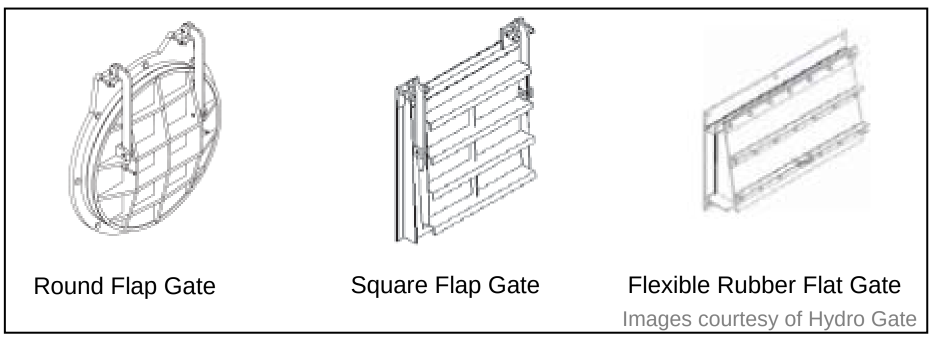


Figure 2.4.6: Examples of Flap Gates of Various Shapes

Note that if any type of operable gate is installed, regular inspection of the gate and regular cleaning of debris around the gate will be required to ensure that the gate will continue to operate properly.

Option B: Implement a Mesh Screen

As an alternative to a gate completely closing the stone wall opening, a mesh screen could be implemented to reduce the amount of undesired objects entering the enclosure during a flood event. The mesh size could be selected so that most predators and any other undesirable objects would be blocked from entering the enclosure but large enough so that salamander could come and go. The use of a mesh screen would greatly reduce the strengthening requirements for the wall, since the existing wall would not be required to retain high flood waters from entering the enclosure. Another advantage of a screen is that no action is required during a flood event (to close a gate) or after a flood event (to open a gate). A mesh screen, however, would require regular inspection and maintenance to keep any debris from accumulating and preventing the free flow of water through the opening. The use of a mesh screen would be less expensive to install than a gate, although pricing information for a screen has not been included in this report (this alternative was developed too late to include detailed information). If it is decided that a mesh screen is desired, further information and cost estimates can be provided.

Option C: Implement a Temporary Sandbag Procedure

Another option considered to temporarily prohibit water backflow into the enclosure is a sandbag wall. In the rare instance where Barton Creek's water reaches the Old Mill Spring enclosure, sandbags would be stacked to block the framed opening in the enclosure wall and form a temporary barrier to prevent backflow. A sand bag wall, however, could be somewhat difficult to build by hand during pre-flood storms and would have to be removed (also by hand) as soon as flood water elevations subside.

Option D: Do not Implement a Backflow Control Measure

A final option to consider is to do nothing. The stone wall opening could remain as a simple opening that freely allows the passage of water and debris in and out of the enclosure. In a flood event where Barton Creek waters raise high enough to enter the enclosure, predators and any other contaminants can enter the enclosure. As soon as flood waters subside they will flow out of the enclosure and back down to Barton Creek (via the improved drainage measures recommended in this report). If Barton Creek does not flood into the Sunken Garden often and/or it is acceptable that salamanders occasionally face natural predators as they might in the natural world, then this option is worth consideration.

2.5 Restoration of Stone Enclosure

The portions of the enclosure wall that are damaged or in a state of disrepair (see Section 2.1) require restoration, including the repair or reconstruction of deteriorated portions of the stone wall and replacement of degraded mortar to ensure that the wall will continue to support itself and so that further deterioration is prevented. It may also be necessary to repair portions of the wall beyond the extents of obvious damage.

If it is decided that a gate will be installed on the enclosure wall, the wall will be required to hold water and repair efforts will be more substantial. Closing the gate will result in unbalanced lateral hydrostatic forces as the water level rises inside or outside the enclosure. Efforts to repair the stone wall so that it is capable of resisting these forces would be extensive.

CHAPTER 3: Civil Considerations

3.1 Site Observations of Existing Conditions

Chapter 2 provides the structural engineers' site observations and evaluation of existing conditions at the time of the site visit on August 28, 2013. This section provides Chan & Partners Engineering, LLC (CPE) civil engineering site observations of existing site civil conditions at the time of the site visit.

Layout of Old Mill Spring Outflow Structures & Discharge Channel

At the time of the site visit, there was 0.0 cfs spring flow (per COA staff). The pool level within the springs and immediately downstream of the enclosure wall was at approximately elevation 434.9 ft-MSL, measured by PESC staff to be 4' – 9½" below the existing benchmark set in the wall (see Figures 2.1.1 through 2.1.3 in Chapter 2). The pool elevation was controlled by the flow line of the discharge channel downstream of the Old Mill Wall opening, i.e. approximately elevation 434.9 ft-MSL (see Figure 2.1.3 in Chapter 2). The flow line of the east opening in the enclosure wall (see Figure 2.1.2 in Chapter 2) was measured to be about 1" below the pool level, the flow line of the west opening of the enclosure wall (see Figure 2.1.2 in Chapter 2) was measured to be about 10" below the pool level, the upstream flow line of the 24" pipe (see Figure 2.1.1 of Chapter 2) was measured to be about 18" below the pool level, and the flow line of the opening in the Old Mill Wall (see Figure 2.1.3 of Chapter 2) was measured to be about 2" below the pool level.

The discharge channel is approximately 80 feet in length at about a 0.005 ft/ft slope (per the topographic survey). The discharge channel width varies between 2 feet to 5 feet. The discharge channel terminates at the boulder drop structure at Barton Creek. The channel bottom is comprised mostly of sand and cobbles with some larger rocks scattered about the channel bottom; however, gradations were not performed to confirm existing channel bottom materials characteristics. The channel grade was lowered in 2006, resulting in steep side slopes along sections of the channel. There are no surveyed sections of the channel.

Hike & Bike Trails

The site is sandwiched between two hike & bike trails (see Figure 1.1 in Chapter 1 and Detail 1/B.1 in Appendix B). The upper trail is a concrete sidewalk that loops around the site and connects to the lower trail via a bridge spanning across the concrete flume on the east side of the site. The lower trail is partially concrete sidewalk and partially crushed granite gravel. There is an existing bridge over the discharge channel at the boulder drop structure.

Site Security

There is currently a metal fence surrounding the site. It contains an access gate at the upper stairway (see Figure 1.2.3 in Chapter 1) and access gate next to the bridge over the discharge channel (see Detail 1/B.1 in Appendix B).

Access to the Old Mill Spring Enclosure and Discharge Channel

Detail 1/B.2 (Appendix B) shows the existing Old Mill Spring enclosure and discharge channel with respect to access into the site for construction purposes. Workmen foot traffic can access the site via the existing gate and stairs on the south (upper) side of the site and via the existing gate next to the bridge over the discharge channel on the northeast side of the site.

Vegetation & Trees

Detail 1/B.1 (Appendix B) maps the existing trees at the site. The site contains at least 6 to 10 large trees that are within or are immediately adjacent to the work area. The groundcover downstream of the enclosure wall and along the channel has naturally re-vegetated itself after the 2004 and 2006 channel improvements.

Spring Flow Records

The Old Mill Spring flow records provided by the City are for the dates of 1/19/2002 through 12/12/2007. The flow rates range from 0.00cfs to 13.6cfs. For preliminary design hydraulic calculations an additional 1cfs was added to the peak record flow to account for direct rainfall on the enclosure wall and discharge channel and for runoff into the channel immediately downstream of the enclosure wall.

3.2 Preliminary Design Hydraulic Analyses

The following preliminary design hydraulic analyses were performed of existing conditions and of alternative proposed conditions.

Hydraulic Analyses of Existing Conditions

Preliminary design hydraulic analyses were performed of the existing two openings in the enclosure wall (i.e. east and west openings), of the opening in the Old Mill wall, and of the discharge channel. It was determined that the discharge channel creates higher backwater levels within the pool than created by the two openings in the enclosure wall or opening in the Old Mill wall, primarily because (1) the flow line of the discharge channel has the highest flow line and (2) the worst –case channel width of 2 feet was used in the hydraulic analyses. Table 3.2.1 summarizes the backwater levels within the enclosure created by the existing discharge channel and openings in the enclosure wall.

Discharge (cfs)	Water Surface Elevation (ft-MSL) Existing Channel & Openings	Water Surface Elevation (ft-MSL) Existing Channel & 3' x 3' Opening
0	434.90	434.90
1	435.35	435.35
2	435.57	435.57
3	435.74	435.74
4	435.88	435.88
5	436.01	436.01
6	436.12	436.12
7	436.22	436.22
8	436.32	436.32
9	436.41	436.41
10	436.49	436.54
11	436.57	436.63
12	436.65	436.73
13	436.72	436.80
14	436.79	436.89
15	436.86	436.98

Table 3.2.1: Summary of Backwater (Pool) Levels Created by the Existing Discharge Channel

Hydraulic shear calculations were performed for the discharge channel under its current configuration. It was determined that cobble stones (D50 = 4" to 6") provide adequate shear resistance against movement. Particle size analysis of the existing channel bottom material is needed to determine the degree to which the in-situ material complies with a cobble stone material.

Hydraulic Analyses of Proposed Opening in Enclosure Wall

Preliminary design hydraulic analyses were performed of the proposed opening in the enclosure wall under two conditions:

1) Condition A:

   At the request of PESC, we assessed the adequacy of a 3' x 3' opening with sill at elevation 433.41 (i.e. the same flow line as the existing 24" abandoned pipe) with the discharge channel at its current grade. The 3' x 3' opening flows (under open flow conditions) up to about 9 cfs, but above 9 cfs the backwater from the discharge channel forces the opening into orifice flow conditions (which has lower discharge capacity than open flow conditions.) Between 10 cfs to 15 cfs, the 3' x 3' opening, with the discharge channel at its current grade, will create pool levels within the enclosure wall between 0.64" to 1.44" higher than existing conditions (see Table 3.2.1).

   As an alternative to a 3' x 3' opening, we assessed a 2' W x 3.5' H rectangular opening. Such an opening configuration will not go into orifice flow conditions and will not create pool levels within the enclosure higher than existing conditions if the discharge channel remains at its current grade.

2) Condition B/C:

   We assessed the adequacy of a 3' x 3' opening with the flow line of the discharge channel lowered 18 inches and determined that the discharge channel (not the 3' x 3' opening) will control pool levels within the enclosure.

   Hydraulic Analyses of Reconstructed Discharge Channel

   The hydraulic conditions of two alternative discharge channel improvements were assessed. The typical channel section for both discharge channel configurations is shown on Detail 1/B.3 (Appendix B).

   1) Discharge Channel Reconstruction Configuration Alternative B:

      For Alternative B, it was assumed that the flow line grade of the discharge channel is lowered by about 18 inches at the upstream end of the channel at the enclosure wall to elevation 433.40 and the slope of the channel remains at its current slope of 0.005 ft/ft. Table 3.2.2 summarizes the backwater levels within the enclosure created by the Alternative B discharge channel configuration:

Discharge (cfs)	Water Surface Elevation (ft-MSL)
0	433.40
1	433.85
2	434.07
3	434.24
4	434.38
5	434.51
6	434.62
7	434.72
8	434.82

Discharge (cfs)	Water Surface Elevation (ft-MSL)
9	434.91
10	434.99
11	435.07
12	435.15
13	435.22
14	435.29
15	435.36

Table 3.2.2: Summary of Backwater (Pool) Levels Created by the Alternative B Discharge Channel Configuration

2) Discharge Channel Reconstruction Configuration Alternative C:

For Alternative C, it was assumed that the flow line grade of the discharge channel is lowered by about 18 inches at the upstream end of the channel at the enclosure wall to elevation 433.40 and the slope of the channel is steepened to 0.01 ft/ft. Table 3.2.3 summarizes the backwater levels within the enclosure created by the Alternative C discharge channel configuration:

Discharge (cfs)	Water Surface Elevation (ft-MSL)
0	433.40
1	433.70
2	433.95
3	434.09
4	434.21
5	434.32
6	434.41
7	434.50
8	434.58
9	434.66
10	434.73
11	434.80
12	434.86
13	434.92
14	434.98
15	435.04

Table 3.2.3: Summary of Backwater (Pool) Levels Created by the Alternative C Discharge Channel Configuration

Hydraulic Analyses of Discharge Channel Bottom Material

Hydraulic shear calculations were performed for the Alternative 1 and Alternative 2 discharge channel reconstruction configurations. It was determined that cobble stones (D50 = 4" to 6") provide adequate shear resistance against movement for both alternative channel configurations. The typical discharge channel reconstruction section on Detail 1/B.3 (Appendix B) shows the proposed cobble stone layer.

Hydraulic Analyses of Bypass/Dewatering System for Enclosure Wall and Discharge Channel Improvements

Two alternative bypass/dewatering systems were assessed to divert and bypass up to 15cfs of spring flow to allow construction of the enclosure wall, Old Mill wall, and discharge channel improvements in the dry:

1) Bypass/Dewatering System Alternative 1:

   This configuration provides for a temporary 24" corrugated HDPE pipe to be installed with its intake within the spring enclosure (with flow line at same elevation of the existing abandoned 24" pipe = 433.41) and routed through one of the existing openings in the enclosure wall and down the discharge channel at about a 0.005ft/ft slope. Spring flows enter the 24" pipe by gravity flow. Two flow rates were assessed:

   a) 5 cfs flow rate creates a headwater level (pool within the enclosure) of elevation 435.09. This pool level is almost one foot lower than existing conditions.
   b) 15 cfs flow rate creates a headwater level (pool within the enclosure) of elevation 436.52. This pool level is about 4 inches lower than existing conditions.

2) Bypass/Dewatering System Alternative 2:

   This configuration provides for 6" pumps to discharge spring flows around the work site. Each 6" pump can discharge at a rate of about 1900gpm. Two flow rates were assessed:

   a) 5 cfs (2,244 gpm) flow rate requires two 6" pumps plus one backup pump.
   b) 15 cfs (6,733 gpm) flow rate requires four 6" pumps plus one backup pump.

3.3 Site Civil Preliminary Design Layout Considerations

Demolition of Enclosure Wall and Old Mill Wall

Chapter 2 discusses the requirements for removal of existing concrete pipe and miscellaneous debris around the enclosure wall in order to form and strengthen the opening through the wall. It is anticipated that the flow line (sill) of the opening will be at approximate elevation 433.41 in order to restore spring discharges to free-flow conditions (i.e. minimize ponding within the spring enclosure). Lowering of the discharge channel will require demolition and removal of a portion of the Old Mill wall in order to allow free-flow conditions. The flow-line (sill) of the opening in the wall will be lowered about 16 inches and the gap widened in order to improve the hydraulics of the channel flow downstream of the enclosure wall.

Discharge Channel Improvements

The preliminary design hydraulic analysis indicates a 12" thick cobble stone (D50 = 4" to 6") layer will provide adequate channel bottom protection. A 6" thick granular filter system between the cobble stone layer and natural soils will be required to prevent movement of natural soils into the cobble stone layer. It is assumed that excavation of the discharge channel will be confined within the channel's existing "footprint" in order to minimize impact to adjacent trees and vegetation. Short gabion walls are assumed to be constructed along both banks of the channel, if the channel grade is lowered, in order to retain the natural soils from sliding into the channel. If desired, larger rocks (e.g. 12" rocks) can be interspersed within the cobble stones to enhance the habitat characteristics of the channel bottom. The 12" rock will also be used immediately downstream of the new opening in the enclosure wall to withstand the higher discharge velocities coming through the opening than will be experienced along the discharge channel regardless of the final configuration of the discharge channel. The 12" rock will connect the downstream side of the enclosure wall opening with the discharge channel.

Reconstruction of the boulder drop structure at the downstream end of the discharge channel will be required if the discharge channel grade is lowered. Reconstruction of the boulder drop structure is discussed in the Structural Section of this report.

Plan view and typical section of the proposed discharge channel improvements are shown on Detail 1/B.3 (Appendix B).

Temporary Blocking of the Enclosure Wall Opening

The City of Austin desires some type of method to block off the new opening through the enclosure wall against inflow by flood waters from Barton Creek. The installation of a sluice gate or flap gate is discussed in Chapter 2. Another method to temporarily block off the opening is for the City staff to temporarily install sandbags across the downstream side of the opening in anticipation of the flood event. The sandbags can rest directly on the proposed 12" rock channel lining at the enclosure wall. The sandbags would be removed when the flood waters recede.

Construction Access & Staging

The mostly likely construction staging area is on the existing asphalt parking lot (see Detail 1/B.1, Appendix B). The parking lot has curb & gutters which provides for more efficient containment of runoff and sediments from the staging area. It is probable that excess excavation materials and construction debris will be required to be removed from the work area by the end of each work day, because the work area is within the 100-year floodplain. Space and containment for temporary storage of the materials and debris will be needed within the staging area until the materials are hauled off for permanent disposal.

There are several potential routes for workmen and construction equipment from the staging area to the work site. The most direct route for workmen foot traffic is along the existing upper concrete trail to the upper gate and fence at the enclosure (see Detail 1/B.2, Appendix B). Construction equipment has two potential routes to the work area: (1) along the upper concrete trail and down the concrete drainage flume to the lower level, or (2) along the upper concrete trail and down the pedestrian bridge to the lower level. Detail 1/B.2 (Appendix B) shows both potential construction access routes. Access via the concrete drainage flume will be restricted by the available clearance under pedestrian bridge. Access via the pedestrian bridge will be restricted by maximum allowable construction loading (created by construction equipment transporting materials from and to the work area).

Delivering concrete (and metal gate if installed) for the enclosure wall opening improvements will pose access complications. Concrete can be delivered to the work area via a pump truck situated on the upper level or carried by front-end loader buckets. The use of a pumper truck might require trimming of existing trees between the pumper truck and the enclosure wall opening. The metal gate can be lifted into position by either a crane situated on the upper level or by a small mobile crane that accesses the work area via the lower level. The use of a crane might require trimming of existing trees where the crane must boom out to set the gate in place.

Site Security

The staging area and the work area must be secured at all times. A temporary security fence is proposed around the staging area with two swinging gates. The security fence will be opaque to help contain blowing dust coming off the materials stored in the staging area and to screen the unsightly staging area from the public. Construction equipment will access the work area on the lower level next to the pedestrian bridge over the discharge channel. A 30ft section of the existing metal fence will be temporarily removed to install a construction access gate. Detail 1/B.1 (Appendix B) shows the proposed construction security fencing.

Pedestrian Traffic Controls

Construction traffic will conflict with pedestrian traffic (including bicycle traffic) along the existing hike & bike trails that surround the work site. A combination of closing a section of the existing trail, re-routing pedestrian traffic around the work area and using flagmen is proposed. Detail 1/B.2 (Appendix B) shows the proposed temporary relocation of pedestrian traffic around the staging area and the sections of the trails where flagmen will be used where pedestrian traffic will continue to use the trails.

A section of the trail is proposed to be temporarily re-located on the southwest side of the staging area where the existing trail will be closed during construction. The temporary trail is proposed to be crushed granite (see Detail 1/B.1, Appendix B).

Erosion/Sedimentation Controls & Tree Protection Measures

The proposed construction operations have the potential to create temporary erosion and sedimentation conditions. City of Austin standard temporary erosion/sedimentation controls are proposed within the work area (primarily along the discharge channel to prevent discharge of sediments into Barton Creek) and around the staging area where materials will be storage, in the form of mulch logs, rock berms and triangular filter dikes (see Detail 1/B.1, Appendix B). The proposed construction operations will disturb and damage the existing vegetative ground cover. After construction is completed, all areas disturbed by construction will be re-vegetated with native grass seeding. Steep areas (i.e. slopes steeper than 1V:4H) will be additionally stabilized with a soil retention blanket.

One tree (tree #6369, 9" Cedar Elm) will probably have to be removed in order to construct the channel improvements and to perform demolition of a section of the Old Mill wall. Some of the remaining trees surrounding the work site and along the construction equipment access route may have to be trimmed in order to not damage limbs. Tree trimming will be performed by registered arborists and will be performed only to the extent to reasonably accommodate construction operations. Construction operations will be performed close to and within the critical root zones of the trees immediately surrounding the work site. Tree protective fencing is proposed around all surrounding trees. A 6" layer of mulch (native hardwood) is proposed over the critical root zones that extend outside the protection of the tree protection fencing. Pre-construction and post-construction root treatment might be required for several of the larger trees that are very close to the work site. Detail 1/B.1 (Appendix B) maps the locations of the existing trees and shows the proposed tree protection measures.

CHAPTER 4: Environmental Considerations

4.1 Site Observations of Existing Conditions

Vegetation & Trees

Detail 1/B.1 (Appendix B) maps the existing trees at the site. The site is indicative of its riverine setting, comprising old-growth riparian forest with dense canopy cover formed by large tree species commonly found in the floodplains and lowlands associated with Central Texas waterways, such as Pecan, American Elm, Cottonwood, Sycamore, and Hackberry. Many of these large trees meet the COA Land Development Code criteria for Protected and Heritage Trees. Within the walls that confine the spring, vegetation is limited to tree saplings (Cottonwood and Sycamore), small emergent plants (Seedbox and River Fern), and a few floating species (Water Primrose and Coinwort). Downstream of the enclosure wall and along the channel, the understory includes a diverse array of native and non-native trees, shrubs, vines, and herbaceous plants. Invasive species, such as Ligustrum, Chinaberry, and Chinese Tallow, are well established in previously disturbed areas resulting from prior improvements at the site.

4.2 City of Austin Requirements

The project site is located within COA full purpose jurisdiction, the Barton Creek watershed, and the COA-defined Barton Springs Zone. As such, the project is subject to the COA Land Development Code (LDC), including the Save our Springs Ordinance.

COA Site Development Permit

COA LDC, Chapter 25-5, requires site plan review and approval prior to development of property within the City's jurisdiction. The site plan approval may be obtained through either the Site Development Permit Process or the General Permit Program. This project is eligible to participate in the General Permit Program. The design plans will need to be reviewed by the General Permit Program Coordinator.

Environmental Assessment

COA LDC, Section 25-8-121 (A) states that an applicant shall file an environmental assessment with the Site Development Permit Application for proposed development located:

1) Over a karst aquifer;
2) Within an area draining to a karst aquifer or reservoir;
3) In a water quality transition zone;
4) In a critical water quality zone;
5) In a flood plain; or
6) On a tract with a gradient of more than 15 percent.

The proposed project site meets criteria 3-5 above.

The COA LDC, Section 25-8-121 (B) and (C) states the following:

An environmental assessment must:

1) Identify critical environmental features (CEFs) and propose protection measures for the features;
2) Provide environmental justification for spoil disposal or roadway alignments;
3) Propose methods to achieve overland flow and justify enclosed storm sewers; and
4) Describe proposed industrial uses and the pollution abatement program.

An environmental assessment must include:

1) Hydrogeologic report in accordance with LDC, Section 25-8-122;
2) Vegetation report in accordance with LDC, Section 25-8-123; and
3) Wastewater report in accordance with LDC, Section 25-8-124.

The proposed project must satisfy the above requirements before the COA will approve a Site Development Permit or General Permit. It is expected that the COA will waive the requirement for an Environmental Assessment, given that the project is intended to improve environmental conditions at the site and enhance endangered species habitat.

Critical Environmental Features (CEFs)

The COA LDC, Section 25-8-281 defines CEFs as features that are of vital importance to the protection of natural resources. CEFs include bluffs, canyon rimrock, caves, sinkholes, springs, and wetlands.

The LDC defines these features as follows:

- Bluff CEF – Bluff with a vertical change in elevation of more than 40 feet and an average gradient greater than 400 percent.
- Canyon rimrock CEF – Rimrock with a rock substrate that has a gradient that exceeds 60 percent for a vertical distance of at least four feet and is exposed for at least 50 feet horizontally along the rim of the canyon.
- Cave and sinkhole CEFs – Caverns or fissures that lie over the Edwards Aquifer Recharge Zone and may transmit a significant amount of surface water into the subsurface strata.
- Spring CEF – Point over an aquifer system where water flows from the aquifer to the ground surface.
- Wetland CEF – Transitional area between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water, and conforms to the Army Corps of Engineers' definition.

LDC Chapter 25-8, Article 7, Division 2, Protection of Special Features, establishes a protective buffer around CEFs. This protective buffer is provided for each CEF and includes the following requirements and prohibitions:

- Natural vegetative cover must be retained to the maximum extent practicable;
- Construction is prohibited; and
- Wastewater disposal or irrigation is prohibited.

The project is focused around an existing spring and documented CEF. It is expected that the COA will waive the CEF setback requirement for this project, given that the improvements are intended to assist with achieving sustainable spring flows.

Tree Removal

The COA LDC, Section 25-8-602, defines a protected tree as "*a tree with a diameter of 19 inches or more, measured four and one-half feet above natural grade.*" According to a recent tree survey, there are several protected trees in the project area.

The COA LDC, Section 25-8-621, states that "*except as otherwise provided in this section, a person may not remove a protected tree unless the Planning and Development Review Department has issued a permit for the removal under this division.*" The COA has an approval process that may involve a site visit by a COA arborist as well as certain approval criteria noted below from LDC, Section 25-8-624, Sub-sections A and D:

(A) The Planning and Development Review Department may approve an application to remove a protected tree only after determining that the tree:

1) prevents reasonable access to the property;
2) prevents a reasonable use of the property;
3) is an imminent hazard to life or property, and the hazard cannot reasonably be mitigated without removing the tree;
4) is dead;
5) is diseased, and:
   (a) restoration to sound condition is not practicable; or
   (b) the disease may be transmitted to other trees and endanger their health; or

6) for a tree located on public property or a public street or easement:
   (c) prevents the opening of necessary vehicular traffic lanes in a street or alley; or
   (d) prevents construction of utility or drainage facilities that may not feasibly be rerouted.

(D) The Planning and Development Review Department shall require mitigation as a condition of application approval. A removal permit may not be issued until the applicant satisfies the condition or posts fiscal security to ensure performance of the condition within one year.

The COA LDC, Section 25-8-641, addresses the removal of a heritage tree:

(A) Removal of a heritage tree is prohibited unless the Planning and Development Review Department has issued a permit for the removal under this division.

(B) A permit to remove a heritage tree may be issued only if a variance is approved under Section 25-8-642 (Administrative Variance) or 25-8-643 (Land Use Commission Variance).

A heritage tree is defined as a tree that has a diameter of 24 inches or more, measured four and one-half feet above natural grade, and is one of the following species:

(a) Ash, Texas
(b) Cypress, Bald
(c) Elm, American
(d) Elm, Cedar
(e) Madrone, Texas
(f) Maple, Bigtooth
(g) All Oaks
(h) Pecan
(i) Walnut, Arizona
(j) Walnut, Eastern Black

According to a recent tree survey, there are several heritage trees in the project area. Removal of heritage trees will require a variance from the LDC, and approval from the COA Environmental Board and City Council. The project is not expected to require the removal of protected or heritage trees.

4.3 State and Federal Requirements

Texas Commission on Environmental Quality

The project site is within the Texas Commission on Environmental Quality (TCEQ) defined Edwards Aquifer transition zone, but outside of the recharge zone. A TCEQ water pollution abatement plan is not required for the proposed project. The project should employ erosion and sedimentation control Best Management Practices during storm events to comply with the Texas Pollution Discharge Elimination System General Permit.

U.S. Army Corps of Engineers

The project could impact waters of the U.S., as defined by Section 404 of the Clean Water Act and regulated by the U.S. Army Corps of Engineers (USACE). Coordination with USACE, Fort Worth District, Regulatory Branch, could be required if channel modifications surpass thresholds for impacts to waters of the U.S. set forth by the Clean Water Act and the USACE Nationwide Permit program. If necessary, the COA Watershed Protection Department (WPD) will handle coordination with USACE to obtain Section 404 permitting for this project.

U.S. Fish and Wildlife Service

Although the intent of the project is to enhance endangered species habitat, there is a potential for temporary impacts during construction to the Barton Springs Salamander, a state and federally listed endangered species, which is known to inhabit the enclosed pool of water surrounding Sunken Garden spring. The COA WPD will handle coordination with U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department to facilitate the protection of the Barton Springs Salamander and other biological resources, and to maintain compliance with the current habitat conservation plan for this species.

CHAPTER 5: Engineer's Opinion of Probable Cost of Construction

The following sections present PESC's and CPE's preliminary design opinions of probable construction costs. The unit prices used for preparing probable construction costs were derived from recent COA construction bid tabulations and from local contractor's experienced with this type of work.

5.1 General Construction Costs

Structural Costs

No structural scope in this section.

Civil Costs

The site civil costs associated with general construction include the temporary spring flow diversion/bypass system; tree protection, trimming, root zone treatment, and removal; permanent re-vegetation and soil stabilization; temporary erosion/sedimentation controls; mobilization/demobilization; security fencing; project signs; pedestrian traffic (including bicycle traffic) controls and safety fencing; and crushed granite gravel trail relocation (Table 5.1). The total engineer's preliminary design opinion of probable construction costs for these general site civil improvements is **$96,790** (without contingencies).

Estimated Combined costs

See Table below for combined costs:

COA Spec. Item No. *If Applicable*	Task:	Unit	Unit Cost	Estimated Quantity	Cost per Item	Cost Per Task
	General:					
SP401S-I	Furnish, Install, Operate, Maintain & Remove Temporary Spring Flow Diversion, Cofferdam & Dewatering System	LS	$32,000.00	1.0	$32,000.00	
SP604S-E	Mulch, 6-Inch Thickness, Native Hardwood	SY	$30.00	180.0	$5,400.00	
SP605S-A2H	Soil Retention Blanket Class 2, Type H	SY	$12.00	160.0	$1,920.00	
SP608S-1	Planting Type_,Size_Inches (Wetland Mitigation)	EA			$0.00	
SP609S-C	Native Grassland Seeding and Planting	SY	$26.00	570.0	$14,820.00	
SP610S-A	Protective Fencing Type A Chain Link Fence	LF	$5.00	330.0	$1,650.00	
SP610S-E	Tree Trunk Protection, Wood Planking	EA	$200.00	2.0	$400.00	
SP610S-R	Removal of Existing Trees	EA	$1,400.00	1.0	$1,400.00	
SP610S-F	Trimming and P-6 Root Treatment of Existing Trees of Greater Than 8-In. Caliper	EA	$330.00	5.0	$1,650.00	
SP628S-B	Sediment Containment Dikes with Filter Fabric	LF	$10.00	130.0	$1,300.00	
SP639S	Rock Berm	LF	$44.00	40.0	$1,760.00	
SP641S	Stabilized Construction Entrance	EA	$1,800.00	1.0	$1,800.00	
SP648S	Mulch Sock, 18-Inch Dia.	LF	$12.00	240.0	$2,880.00	
SP700S-TM	Total Mobilization Payment	LS	$10,000.00	1.0	$10,000.00	
SP701S-CD	Chain Link Vehicular Double Swing Gate, 8 Ft x 12 Ft, Temporary Security, Opaque	EA	$800.00	3.0	$2,400.00	
SP701S-T	Temporary Fence, 8 Ft High, Chain Link, Opaque	LF	$16.00	300.0	$4,800.00	
SP702S-H	Removing & Relocating Existing 6 Ft x _Ft Metal Gate	EA	$600.00	1.0	$600.00	
SP702S-1	Removing & Relocating Existing 6 Ft. Metal Fence	LF	$16.00	30.0	$480.00	
SP802S-C.I.P.	C.I.P. Project Signs	EA	$700.00	1.0	$700.00	
SP803S-CD	Barricades, Signs, and Traffic Handling	CD	$80.00	90.0	$7,200.00	
SP803S-SF	Safety Fence	LF	$5.00	150.0	$750.00	
SP1301S-B	Granite Gravel Hike & Bike Trail	SY	$18.00	160.0	$2,880.00	
				Subtotal =	$96,790.00	
				25% Contingency =	$24,197.50	
					Total =	$120,988

Table 5.1: Opinion of Probable General Construction Costs

5.2 Wall Opening Retrofit

Structural Costs

The structural cost associated with the retrofit of the wall opening includes the partial demolition and storage of the enclosure wall, construction of a reinforced concrete structure to frame the wall opening, and reconstruction of the stone wall around the framed opening (Table 5.2). The engineer's opinion of probable construction cost for the frame is **$9,250** (without contingencies).

Civil Costs

The site civil costs associated with the retrofit wall opening include demolition and debris removal for the enclosure wall opening improvements, demolition of the Old Mill wall to widen and deepen the opening, and structural excavations between the enclosure wall and Old Mill wall (Table 5.2). The total engineer's preliminary design opinion of probable construction costs for these wall opening retrofit site civil costs is **$12,850** (without contingencies).

Estimated Combined costs

See Table below for combined costs:

COA Spec. Item No. *If Applicable*	Task:	Unit	Unit Cost	Estimated Quantity	Cost per Item	Cost Per Task
	Retrofit Wall Opening for Improved Drainage:					
SP104S-G	Remove Miscellaneous P.C. Concrete, Pipe	LS	$600.00	1.0	$600.00	
SP104S-J	Remove P.C. Concrete Backfill (Debris Under Wall)	CY	$1,850.00	2.5	$4,625.00	
SP401S-A	Unclassified Structural Excavation, Plan Quantity	CY	$1,850.00	2.5	$4,625.00	
SP403S-CY	New Concrete Structure to Frame Opening	CY	$1,500.00	2.0	$3,000.00	
	Deconstruct Stone Wall and Reconstruct after Opening is Framed	SF	$50.00	125.0	$6,250.00	
	Retrofit Old Mill Wall	EA	$3,000.00	1.0	$3,000.00	
				Subtotal =	$22,100.00	
				25% Contingency =	$5,525.00	
					Total =	$27,625

Table 5.2: Opinion of Probable Costs for Wall Opening Retrofit

5.3 Drainage Improvements Outside of Enclosure

Structural Costs

The structural cost associated with the drainage improvements outside the enclosure includes retrofitting the limestone boulder drop structure at the end of the channel (Table 5.3). The extent to which the structure will need to be retrofitted will depend on the civil option chosen below. Accordingly, the engineer's opinion of probable construction cost is **$1,080** for Option B and **$2,440** for Option C (without contingencies); there is no structural cost associated with Option A.

Civil Costs

The site civil costs associated with the drainage improvements include three alternatives for discharge channel improvements (Table 5.3):

1) Option A:

   Improvements to the existing discharge channel with the channel to remain at its current grades with a total engineer's preliminary design opinion of probable construction cost of **$3,405** (without contingencies) with 12-inch rock riprap and bedding material immediately downstream of the opening in the enclosure wall (assuming the remaining existing channel material has adequate shear resistance) and soil retention blanket to stabilize natural ground where disturbed by construction access activities.

2) Option B:

   Improvements to the discharge channel with the channel lowered 18 inches at the Old Mill wall and its slope remain the same as the current 0.005 ft/ft channel slope with a total engineer's preliminary design opinion of probable construction cost of **$42,400** (without contingencies).

3) Option C:

   Improvements to the discharge channel with the channel lowered 18 inches at the Old Mill wall and its slope steepened to 0.01 ft/ft with a total engineer's preliminary design opinion of probable construction cost of **$50,900** (without contingencies).

<u>Estimated Combined costs</u>

See Table below for combined costs:

COA Spec. Item No. *If Applicable*	Task:	Unit	Unit Cost	Estimated Quantity	Cost per Item	Cost Per Task
	Improve Drainage Outside of Enclosure:					
	Option A: Gravel Stream without Improved Channel Grading					
SP120S-B	Channel Excavation, Plan Quantity	CY	$100.00	6.0	$600.00	
SP591S-A12	Dry Riprap, 12-Inch Rock	CY	$170.00	1.5	$255.00	
SP591S-E	Bedding Material for Dry Rock Riprap, 6-In. Thickness	CY	$180.00	4.5	$810.00	
SP605S-A2H	Soil Retention Blanket Class 2, Type H	SY	$12.00	145.0	$1,740.00	
				Subtotal =	**$3,405.00**	
				25% Contingency =	**$851.25**	
					Total =	**$4,256**
	Option B: Gravel Stream with Lowered Grade & Channel Slope at 0.005					
SP120S-B	Channel Excavation, Plan Quantity	CY	$100.00	100.0	$10,000.00	
SP591S-A4	Dry Riprap, 4-Inch D50 Gradation	CY	$170.00	20.0	$3,400.00	
SP591S-A12	Dry Riprap, 12-Inch Rock	CY	$170.00	5.0	$850.00	
SP591S-E	Bedding Material for Dry Rock Riprap, 6-In. Thickness	CY	$180.00	12.0	$2,160.00	
SP594S-G	Gabions, Twisted Woven Wire	CY	$350.00	65.0	$22,750.00	
SP605S-A2H	Soil Retention Blanket Class 2, Type H	SY	$12.00	270.0	$3,240.00	
	Retrofit Limestone Boulder Drop at End of Channel	SF	$20.00	54.0	$1,080.00	
				Subtotal =	**$43,480.00**	
				25% Contingency =	**$10,870.00**	
					Total =	**$54,350**
	Option C: Gravel Stream with Lowered Grade & Channel Slope at 0.01					
SP120S-B	Channel Excavation, Plan Quantity	CY	$100.00	115.0	$11,500.00	
SP591S-A4	Dry Riprap, 4-Inch D50 Gradation	CY	$170.00	20.0	$3,400.00	
SP591S-A12	Dry Riprap, 12-Inch Rock	CY	$170.00	5.0	$850.00	
SP591S-E	Bedding Material for Dry Rock Riprap, 6-In. Thickness	CY	$180.00	12.0	$2,160.00	
SP594S-G	Gabions, Twisted Woven Wire	CY	$350.00	85.0	$29,750.00	
SP605S-A2H	Soil Retention Blanket Class 2, Type H	SY	$12.00	270.0	$3,240.00	
	Retrofit Limestone Boulder Drop at End of Channel	SF	$20.00	122.0	$2,440.00	
				Subtotal =	**$53,340.00**	
				25% Contingency =	**$13,335.00**	
					Total =	**$66,675**

Table 5.3: Opinion of Probable Costs for Channel Improvements

5.4 Preventing Backflow into Enclosure

<u>Structural Costs</u>

The structural costs associated with preventing backflow into the enclosure include three alternatives for water-control measures (Table 5.4):

1) Option A:

   Implementation of a manually-operable gate will require excavation and the construction of a reinforced concrete wall and footing along the north face of the wall and an additional concrete structure at the wall opening to connect the gate to the wall. Options for an aluminum sluice gate and flap gate have been included; the installation of a gate will also require the use of a crane. The total engineer's opinion of probable construction cost is **$92,375** for a sluice gate and **$90,969** for a flap gate (without contingencies).

2) Option B:

   The use of a mesh screen is a possible option to prevent backflow into the enclosure. While the probable cost of this option has not been included in this report, we would be happy to provide additional information about this option if it is a desirable alternative.

3) Option C:

   A temporary blocking procedure using sandbags would require construction of a reinforced concrete wall and footing along the north face of the wall, similar to Option A. The total engineer's opinion of probable construction cost is **$59,500** (without contingencies).

<u>Civil Costs</u>

The site civil costs associated with preventing backflow into the enclosure include the provision of sandbags and sand for the sandbags (Table 5.4). The total engineer's preliminary design opinion of probable material cost to provide the sandbags and sand is **$13,500** (without contingencies).

<u>Estimated Combined costs</u>

See Table below for combined costs:

COA Spec. Item No. *If Applicable*	Task:	Unit	Unit Cost	Estimated Quantity	Cost per Item	Cost Per Task
	Prevent Backflow from Creek into Enclosure					
	Option A: New Gate					
SP401S-A	Unclassified Structural Excavation, Plan Quantity	CY	$1,850.00	20.0	$37,000.00	
SP403S-CY	New Concrete Wall/Footing at Exterior Face of Stone Wall (to Resist Barton Creek Flood Forces)	CY	$1,500.00	15.0	$22,500.00	
SP403S-CY	Additional Concrete Structure to Frame Gate	CY	$1,500.00	2.0	$3,000.00	
	Crane Rental for Gate Installation	Days	$2,500.00	1.0	$2,500.00	
	New Gate					
	Gate Type 1: 36" x 36" Aluminum Sluice gate	EA	$5,900.00	1.0	$5,900.00	
	Gate Type 2: 36" x 36" Aluminum Flap gate	EA	$4,775.00	1.0	$4,775.00	
	Gate Installation	EA	$3,000.00	1.0	$3,000.00	
		Type 1: Sluice Gate		**Subtotal =**	**$73,900.00**	
				25% Contingency =	**$18,475.00**	
					Total =	**$92,375**
		Type 2: Flap Gate		**Subtotal =**	**$72,775.00**	
				25% Contingency =	**$18,193.75**	
					Total =	**$90,969**
	Option B: Mesh Screen	*Option Costs Not Covered in PER*				
	Option C: No Gate, Develop Procedure for Temp Blocking					
SP401S-A	Unclassified Structural Excavation, Plan Quantity	CY	$1,850.00	20.0	$37,000.00	
SP401S-J	Sand for Sandbags	CF	$50.00	150.0	$7,500.00	
SP401S-K	Sandbags	EA	$40.00	150.0	$6,000.00	
SP403S-CY	New Concrete Wall/Footing at Exterior Face of Stone Wall (to Resist Barton Creek Flood Forces)	CY	$1,500.00	15.0	$22,500.00	
				Subtotal =	**$73,000.00**	
				25% Contingency =	**$18,250.00**	
					Total =	**$91,250**

Table 5.4: Opinion of Probable Costs for Preventing Backflow into Enclosure

5.5 Restoration of Stone Enclosure

<u>Structural Costs</u>

The structural costs associated with the restoration of the stone enclosure include reconstruction of any miscellaneous portions of deteriorated stone wall and the replacement of de-graded mortar. The total engineer's opinion of probable construction cost is **$5,500** (without contingencies).

<u>Civil Costs</u>

There are no site civil costs associated with restoration of the stone enclosure.

<u>Estimated Combined costs</u>

See Table below for combined costs:

COA Spec. Item No. *If Applicable*	Task:		Unit	Unit Cost	Estimated Quantity	Cost per Item	Cost Per Task
	Restoration of Existing Stone Enclosure:						
	Rebuild Miscellaneous Deteriorated Portions of Stone Wall		SF	$50.00	50.0	$2,500.00	
	Replace De-graded Mortar		SF	$20.00	150.0	$3,000.00	
					Subtotal =	$5,500.00	
					25% Contingency =	$1,375.00	
						Total =	$6,875

Table 5.5: Opinion of Probable Costs for Restoration of Stone Enclosure

CHAPTER 6: Recommendations

6.1 Structural Recommendations

Wall Opening Retrofit

As the opening in the existing enclosure stone wall is essential to maintaining unimpeded water flow from the spring out to the channel and Barton Creek, we recommend retaining this portion of the scope in this phase of work. The following are structural recommendations for the wall modifications as we deem necessary to achieve the Phase I Improvements goals:

- Remove the existing concrete pipe and concrete debris from under the wall.
- Temporarily remove the stone wall above the new opening, and then reconstruct on top of new opening frame
- Construct a new opening in the wall. New opening shall be sized for worst-case hydraulic conditions. Opening will have a concrete frame and spread footing foundation.

Drainage Improvements Outside of Enclosure

Similar to retrofitting the stone wall, the area immediately outside of the enclosure's stone wall needs to be remediated to continue undisrupted drainage from the enclosure and also to provide a better habitat for salamanders. We recommend the following:

- Retrofit the old mill wall so that opening is wider and deeper, to accommodate same flow volume as new opening in stone wall and not impede water flow to the channel.
- Line the channel with a cobble stone bed to provide new/better habitat for the salamander. This item is discussed further in the civil section.
- Improve the channel by increasing slope and providing cobbled habitat in the bottom of the channel bed, to provide a pebbled running water condition preferred by salamander. This item is discussed further in the civil section.
- Retrofit the stone boulder drop structure at the end of the channel to accommodate a lower channel elevation.

Prevent Backflow into Enclosure

After studying the flood conditions in the area and calculating costs for the different gate options, we have concluded that installing a gate to prevent backflow into the Sunken Garden is not a good use of City resources. The 100-year flood elevation is 15 feet higher than the existing top of wall elevation and it is likely that the 50-year and 25-year flood elevations are also above the top of wall, so a gate would not be effective to prevent backflow for a major flood event. Also, the cost of installing a gate or sandbags is very expensive because either option requires significant work to strengthen the existing stone wall. Also, a gate or sand bags would only offer benefit to the salamander population in brief periods of high water elevations, whereas some of the other work proposed discussed below will offer improved conditions for the salamander on a daily basis.

However, if the City is adamant that a means to prevent backflow be included in this project, there are a few options. Based on the construction costs tabulated for three options (flap gate, sluice gate and sand bags), the operable gate and sand bag options all have very similar construction costs. A flap gate and a sluice gate only differ in price by $1,400, with the flap gate being the more economical option. Surprisingly, providing sand bags sufficient to block the new wall opening is less than $5,000 cheaper than installing an operable gate. If backflow prevention is deemed necessary, then we recommend using a flap gate: it's less expensive than a sluice gate, operates automatically, is more durable than sand bags, and is the gate preferred by civil.

Interestingly, the civil engineer proposed an alternative option that may meet the City's goal without such great expense. If a permanent screen was placed over the stone wall opening, then water could flow freely through the opening but large predators would be kept out. The mesh would have to be large enough to allow salamanders to pass thru, so the City's biologist would have to confirm whether there is a mesh size would work to keep unwanted animals out and still remain open for salamander. A screen would require regular maintenance to keep loose debris from clogging the opening. This alternative was not priced but would be considerably cheaper than the other options considered. Because this option stills presents a maintenance burden and its effectiveness is questionable, we still recommend foregoing a gate and redirecting those funds to channel improvements that will benefit and expand the current salamander habitat.

<u>Restoration of Stone Enclosure</u>

Although not necessarily pertinent to salamander population, a second goal of the Phase 1 Improvements is to restore the existing stone wall surrounding the spring. It is in a state of disrepair and needs to be re-grouted and/or rebuilt in places around the wall. These repairs are not all that costly, and without them the wall will continue to degrade. We recommend the following:

- Rebuild the areas of wall that have fallen or are loose.
- Re-grout areas with deteriorated or missing grout.

6.2 Civil Recommendations

<u>General Construction</u>

Following are recommendations for the general site civil improvements associated with the construction of the improvements:

- The least costly alternative for installing and maintaining the temporary spring flow dewatering/bypass system is to gravity flow the spring flow into a 24-inch pipe. This type of system is a passive system in that it requires very little operation and maintenance. However, the Contractor will have to move the pipe as construction of the improvements progresses from the enclosure wall to the discharge channel. The temporary discharge pipe will penetrate through one of the existing openings in the enclosure wall; therefore, the retrofit construction of the enclosure wall opening must be conducted in stages.
- The estimated quantities of tree protection measures (i.e. mulch, tree protection fencing, tree trunk planking, trimming, and root treatment) are for cost estimating and allowance purposes. Prior to the initiation of construction, the City arborist and Contractor arborist will consult to adjust the tree protection measures for the proposed construction methods and access routes.
- Currently only one tree has been identified as having a high probability of removal (i.e. tree #6369, 9" cedar elm). The final design of the discharge channel improvements will help determine if this tree remains in conflict with the channel improvements.
- The pedestrian traffic controls (i.e. barricades, signs and traffic handling) must be tailored for the final proposed construction access route(s). It is recommended that sections of the existing trail be opened to the public as much as possible; therefore, sections of the existing trail will be shared by the public and by construction traffic. The use of flagmen will be required where the public and construction traffic share the same sections of the trail.
- One potential access route for construction equipment is over the existing pedestrian bridge on the east side of the site. Maximum allowable construction loading must be identified for the Contractor if the bridge is to be an allowable construction access route. Maximum allowable construction loading and minimum separation distances also need to be identified for construction equipment that is proposed to be situated near the tops of existing structures (such as the enclosure wall).

- It is proposed to situate the construction staging area on the existing curbed asphalt parking lot to provide more efficient containment of runoff from the staging area and from stored materials within the staging area.
- PARD needs to decide if a section of the existing trail needs to be temporarily relocated with a crushed granite gravel trail on the southeast side of the proposed staging area.

Wall Opening Retrofit

Following are recommendations for the site civil improvements associated with the wall opening retrofit:

- If the existing discharge channel remains in its current configuration, it is recommended that the enclosure wall opening be at least a 2' W x 3.5' H size opening with its flow line (sill) at about elevation 433.41 ft-MSL so that the opening does not go into orifice flow and create pool levels within the enclosure higher than current levels. However, leaving the discharge channel at its current grade, even with a wall opening retrofit, the spring flow conditions will not simulate free-flowing stream conditions within the enclosure.
- If the existing discharge channel is lowered to provide for simulation of free-flowing stream, it is recommended that the enclosure wall opening be a 3' x 3' size opening with its flow line (sill) at about elevation 433.41 ft-MSL.
- The enclosure wall opening retrofit will require demolition of the enclosure wall and removal of existing debris, removal of an abandoned 24" pipe, and removal of an existing concrete backfill to obtain the desired opening configuration. The two existing openings in the enclosure wall (i.e. the east opening and the west opening) will be closed where outside the limits of the new opening. Closure of the existing wall openings will be staged in conjunction with the wall opening retrofit to allow temporary routing of the dewatering/bypass pipe through the openings.

Drainage Improvements Outside of Enclosure

Following are recommendations for the site civil improvements associated with the drainage improvements outside of the enclosure wall:

- The primary drainage improvements outside the enclosure wall are the improvements to the discharge channel and widening/deepening of the opening in the existing Old Mill wall.
- Hydraulic analysis of the discharge channel indicates a cobble stone channel bottom will provide adequate shear resistance against movement. Larger rock (e.g. 12" stones) can be interspersed within the cobble stone layer to enhance the channel bottom as a habitat. A granular bedding material is recommended to be placed between the cobble stone layer and the natural soils to prevent movement of the natural soils into the cobble stone layer. The final gradation of the channel bottom material will be adjusted during final design to provide hydraulic shear resistance and to enhance habitat conditions.
- If the discharge channel remains at its current grade, the channel bottom material can be re-constructed with 12" rock placed immediately downstream of the enclosure wall opening to prevent channel scour resulting from discharges through the opening. The natural ground surface will be stabilized with a soil retention blanket where construction access to the channel disturbs the ground. It should be noted that if the discharge channel remains at its current grade, it will not allow the spring to flow under simulated free-flowing stream conditions upstream of the channel and within the enclosure.
- Depending upon the gradation of the existing discharge channel bottom materials, the channel bottom material might need to be replaced with cobble stone and bedding material as recommended above. Gradation test of the existing in-situ material would be needed to confirm shear resistance.
- If it is desired to simulate free-flowing stream conditions, then the discharge channel grade needs to be lowered by about 18 inches. The new channel slope will range from 0.005 ft/ft to 0.01 ft/ft,

with the 0.005 ft/ft slope paralleling the existing channel slope, and the steeper 0.01 ft/ft slope providing higher substrate velocities within the channel bottom rock layer (if desired to enhance the habitat conditions).

- If the discharge channel grade is lowered, the channel bottom material can be reconstructed with cobble stone and bedding material as recommended above and a greater mass of the 12" rock placed immediately downstream of the enclosure wall opening.
- It is recommended that impact to existing trees next to the channel be minimized by maintaining channel improvements within the existing footprint of the channel. Lowering of the discharge channel will result in potential steepening of the bank slopes, so some type of channel bank retaining structure will probably be required (such as gabions or limestone blocks).
- Lowering of the discharge channel will require reconstruction of the boulder drop structure. Discussion of the requirements for reconstruction of the boulder drop structure is provided in the Structural Section of the recommendations.

<u>Preventing Backflow into Enclosure</u>

Following are recommendations for the site civil improvements associated with preventing backflow into the enclosure:

- The City desires to prevent Barton Creek flooding from back-flowing into the enclosure, primarily to prevent predators from entering the enclosure within the floodwaters. Three options have been considered to prevent the entry of predators: sluice gate (or flap gate), bar screen, and stacked sandbags. It should be noted that the City's regulatory 100-year floodplain at the Sunken Garden is approximately elevation 458 ft-MSL, which is about 15 feet over the enclosure wall; therefore, at some flood event more frequently than the 100-year flood, the enclosure walls will be overtopped and the measures to prevent entry of predators will be bypassed.
- The use of a sluice gate requires active operation to close the gate in anticipation of the flood event and opening of the sluice gate after the flood event. City staff will not know in advance if the anticipated Barton Creek flood event will or will not inundate the enclosure wall opening; therefore, the sluice gate will have to be operated in advance of every significant rainfall event in the Barton Creek watershed. During the time the sluice gate is closed, the Old Mill springs will continue to flow and create a hydraulic loading against the wall from inside the enclosure.
- The use of a flap gate, rather than a sluice gate, is a passive operation and is probably a more desirable option than the sluice gate, because it will automatically release impounded water within the enclosure with minimal head pressure above the downstream conditions. However, the normal operation of the flap gate is in a closed position, so modifications would have to be made to allow passive operation of the flap gate during flooding conditions but also allow the release of normal spring flows without buildup of excessive hydraulic head pressure. It should also be noted that the flap gate would be susceptible to jamming by flood debris if inundated by flood waters.
- The use of a bar screen across the opening is a passive operation. The bar screen would not prevent the backflow of floodwaters into the enclosure, but would prevent the entry of predators. The bar screen would be susceptible to clogging by debris if inundated by flood waters.
- The temporary installation of sandbags to block the enclosure wall opening is an active operation in that it requires the City staff to stack about 150 sandbags in front of the opening in anticipation of each Barton Creek flood event. City staff will not know in advance if the anticipated Barton Creek flood event will or will not inundate the enclosure wall opening; therefore, the sandbags will have to be installed in advance of every significant rainfall event in the Barton Creek watershed. During the time the sandbags are in place, the Old Mill springs will continue to flow and create a hydraulic loading against the wall from inside the enclosure. The sandbags will have to be removed once the flood event has passed. The sandbags can be stacked directly on the proposed 12" rock layer along the downstream toe of the enclosure wall.

6.3 Environmental Recommendations

Protective measures should be implemented during construction to maintain safe water chemistry for the sensitive biological community that inhabits the Sunken Garden Spring. Appropriate erosion and sedimentation controls should be installed prior to construction, and they should be inspected and maintained throughout the duration of the project. The construction activities should be monitored by a qualified biologist at all times to reduce impact to rare and endangered species. The monitor should create a barricade that prohibits salamander access to the construction site, while creating a waiting pool sufficient for the salamanders to occupy during construction.

Upon completion of the project, invasive plants should be removed to the extent feasible and disturbed areas should be re-vegetated with native, beneficial plant species that are acclimated to the growing conditions existing at the site. The re-vegetation plan should include species currently existing at the site and beneficial species that would be introduced to the site to bolster local biodiversity.

6.4 Conclusions and Final Recommendations

After careful review of all options available for this project and related construction costs, the Design Team offers the following recommendations.

Preferred Scope for Project:

Based on the project primary objective to improve salamander habitat and increase salamander population, we feel the best use of resources for this project would be to construct a new opening in the wall enclosure, improve the area immediately outside the wall and improve the channel. Because implementation of a gate or sand bags is so costly and at best will only partially achieve its goal of preventing backflow into the enclosure, we recommend delaying this feature and focusing on water flow improvement. Our recommended scope for this project and the combined costs are as follows:

General Costs	$120,988	
Retrofit Wall Openings	$27,625	
Improve Channel, Option C	$66,675	
Restore/Repair Enclosure	$6,875	
TOTAL	**$222,163**	(includes a contingency of 25%)

First Alternative Scope for Project:

If the preferred option listed above exceeds budget constraints, then our alternative recommendation would be the same as above, except reduce the channel improvements to Option B:

General Costs	$120,988	
Retrofit Wall Openings	$27,625	
Improve Channel, Option B	$54,350	
Restore/Repair Enclosure	$6,875	
TOTAL	**$209,838**	(includes a contingency of 25%)

Second Alternative Scope for Project:

If the alternative option listed previously exceeds budget constraints, then our second alternative recommendation would be the same as above, except reduce the channel improvements to Option A:

General Costs	$120,988	
Retrofit Wall Openings	$27,625	
Improve Channel, Option A	$4,256	
Restore/Repair Enclosure	$6,875	
TOTAL	**$159,744**	(includes a contingency of 25%)

CHAPTER 7: Potential Scope Modifications

7.1 Structural

A brief summary of P.E. Structural's original scope for final design services includes the following main components:

- General project management;
- AUCLL coordination;
- Design structural support for new opening in existing stone wall and old mill wall;
- Design structural support for and specify new operable gate;
- Design retrofit for existing stone wall to support increase lateral loads related to gate closure;
- Provide assistance obtaining General Permit;
- Develop plans and specifications for all structural components;
- Participate in Design Review Meeting and address all review comments by COA; and
- Attend pre-bid meeting, provide assistance during bidding as needed, and prepare addenda.

This PER has suggested several modifications to the original project scope elements, which will either increase PESC's work or reduce it. Potential changes to PESC scope are described below:

Wall Opening Retrofit for Improved Drainage

No change to PESC's scope of work.

Drainage Improvements Outside of Enclosure

If channel improvement is included in the project scope, then PESC scope will be expanded to include retrofit of the existing boulder drop structure to accommodate a lower channel. All other new channel work will be included in the civil scope.

Prevent Backflow into Enclosure

If COA decides to eliminate the addition of an operable gate from this project, then a significant portion of PESC's design work will also be eliminated. Strengthening of the existing stone wall and designing/detailing a gate frame will be removed from the scope altogether.

Restoration of Stone Enclosure

No change to PESC's scope of work.

7.2 Civil

Chan & Partners Engineering, LLC (CPE) original scope of final design services included preparing final civil designs for the following elements of the project:

- Hydraulic design of the vertical slide water control gate,
- Removal of the existing abandoned concrete pipe,
- Hydraulic design of a temporary system to bypass spring flows to allow construction of the vertical water control slide gate in the dry,
- Civil site plan of the proposed improvements,
- Temporary erosion/sedimentation controls and tree protection and permanent re-vegetation of areas disturbed by construction (except for permanent re-vegetation for wetlands mitigation),
- Pedestrian control plan.

Based upon the results of the preliminary design assessments, following are potential scope modifications to CPE's final design services:

Hydraulic Design of the Vertical Slide Water Control Gate

If the vertical slide water control gate is eliminated, then CPE's scope of providing the associated hydraulic design will also be eliminated. However, if the enclosure wall opening is improved, CPE will still be providing final hydraulic design of the enclosure wall opening improvements. CPE final hydraulic design will also expand to include hydraulic assessments to widen/deepen the opening in the Old Mill wall to make sure the Old Mill wall opening does not create a backwater pool into the enclosure.

Removal of the Existing Abandoned Concrete Pipe

All proposed enclosure wall improvements include removal of the existing abandoned concrete pipe, so this aspect of CPE final design will remain unchanged. However, CPE final design scope may be expanded to include removal of existing concrete backfill and debris associated with the enclosure wall opening improvements and widening of the existing opening in the Old Mill wall to make sure the opening does not create a backwater pool within the enclosure.

Hydraulic Design of the Temporary System to Bypass Spring Flows

CPE scope of final design will still include hydraulic design of the bypass system to allow construction of the enclosure wall opening improvements (with or without installation of a vertical slide water control gate or flap gate). The final design of the temporary bypass system will be expanded to include a bypass system around or through the discharge channel improvements (if constructed) and will include continued assessment of a gravity flow bypass system versus a pumped bypass system.

Civil Site Plan of the Proposed Improvements

CPE scope of final design will still include preparing the civil site plan for the proposed improvements; however, the site plan will be expanded to include delineation of discharge channel improvements and associated construction access requirements (if discharge channel improvements are constructed).

Temporary Erosion/Sedimentation Controls & Tree Protection Measures

CPE scope of final design will still include preparing the temporary erosion/sedimentation controls and tree protection measures (ES&TP); however, the ES&TP plan will be expanded to include the measures associated with the discharge channel improvements and construction access for the channel improvements (if discharge channel improvements are constructed).

Permanent Re-Vegetation of Areas Disturbed by Construction

CPE scope of final design will still include preparing the permanent re-vegetation plan (excluding wetland mitigation plantings); however, the permanent re-vegetation plan will be expanded to include re-vegetation associated with the discharge channel improvements and construction access for the channel improvements (if discharge channel improvements are constructed).

Pedestrian Control Plan

CPE scope of final design will still include preparing the pedestrian traffic (including bicycle traffic) control plan; however, the pedestrian traffic control plan will be expanded to include pedestrian traffic controls, trail closure, and trail relocations associated with the discharge channel improvements and construction access for the channel improvements (if discharge channel improvements are constructed).

Discharge Channel Improvements

CPE scope of final design will be expanded to include the discharge channel improvements if the City decides to have the discharge channel reconstructed (except PESC will be responsible for the final design of the boulder drop structure at the downstream end of the channel). The scope of final design of the channel improvements will include additional field measurement of the existing channel alignment and configuration, preparing final hydraulic designs of the channel configuration and of the channel bottom materials, and assessments of a gabion soil retention system along the channel banks depending upon the final configuration and depth of the discharge channel improvements.

7.3 Environmental

If the project goes beyond the original scope to include modifications to the channel downstream of the Sunken Garden Spring, the environmental considerations and requirements could change, as described in the following subsections.

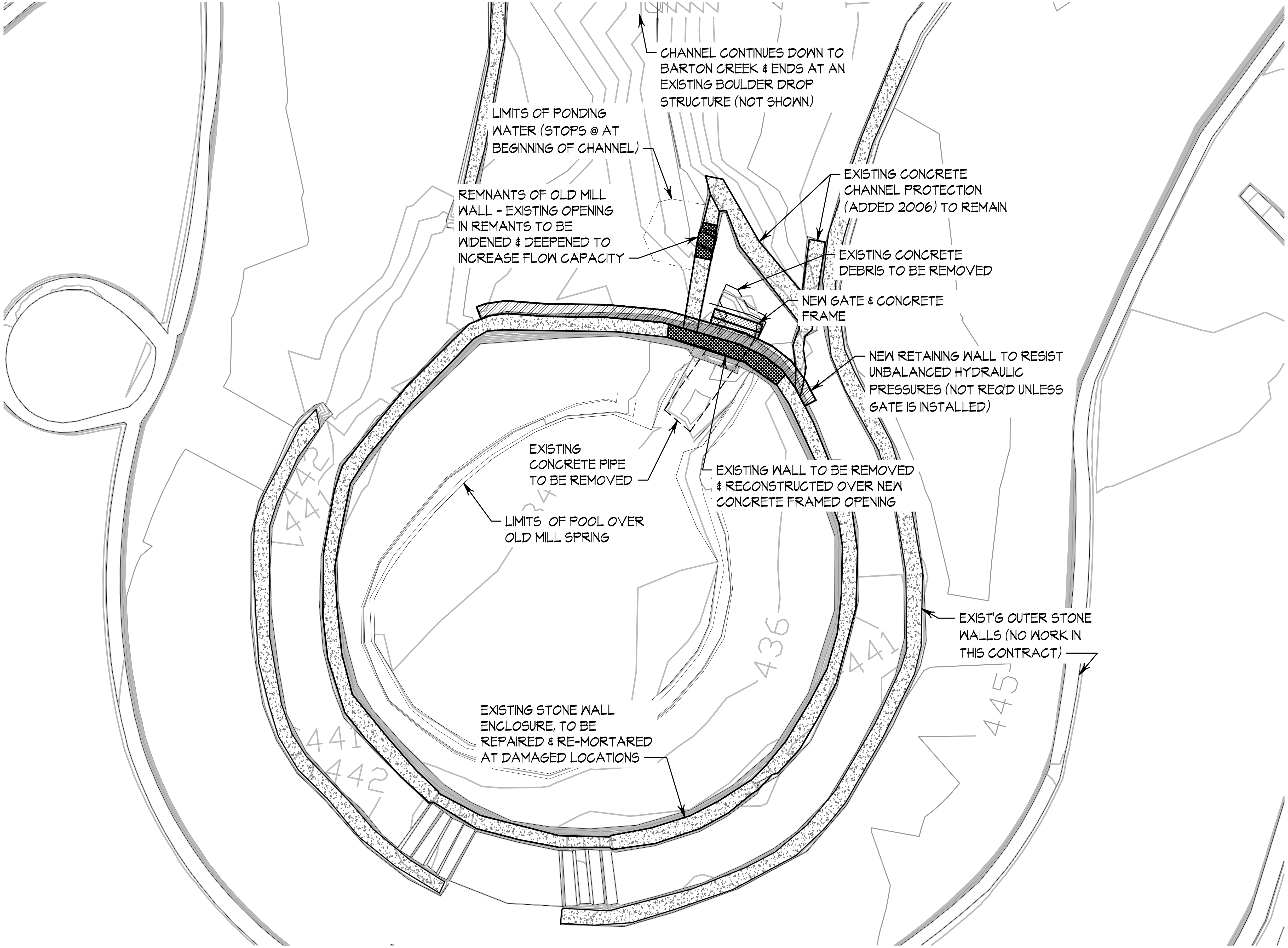
COA Requirements

Currently, it is expected that the project would be eligible to participate in the COA General Permit Program. Depending on the magnitude of the selected channel improvements, it is possible that the City would require the project to go through the full Site Development Permit process. Similarly, the City would be less likely to waive the Environmental Assessment requirement if the project were to include substantial channel modifications. Additionally, substantial channel modifications would likely require the use of heavy machinery in an area where access is limited. Careful planning and review would be required to limit impacts to existing trees and natural vegetation at the site. If required, removal of protected or heritage trees would involve LDC variance acquisition, either through an administrative process, or by way of COA Environmental Board and City Council reviews.

State and Federal Requirements

From a regulatory standpoint, the greatest change to the project scope that would result from including substantial modifications to the channel downstream of the Sunken Garden Spring would be additional USACE Permitting Requirements. It is highly likely that the channel modifications would trigger the requirement for the preparation and submittal of Pre-construction Notification to the USACE in order to obtain coverage under a Nationwide Permit. This level of coordination would require a preliminary jurisdictional determination, which would include an on-site survey for waters of the U.S., including wetlands.

END OF REPORT.



1 PLAN OF PROPOSED WORK TO THE SUNKEN GARDEN

1/8" = 1'-0"

TRUE NORTH

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IT IS NOT TO BE USED FOR BIDDING OR CONSTRUCTION PURPOSES

PE STRUCTURAL CONSULTANTS
INCORPORATED
8436 SPICEWOOD SPRINGS ROAD • AUSTIN, TEXAS • 78759
512.250.5200 • FAX 512.250.5222 • WWW.PESTRUCTURAL.COM
PESC PROJECT No. 1016-C TBPE FIRM No. F-1475

Project Name: BARTON SPRINGS SUNKEN GARDEN IMPROVEMENTS PHASE I

Project Location: BARTON SPRINGS

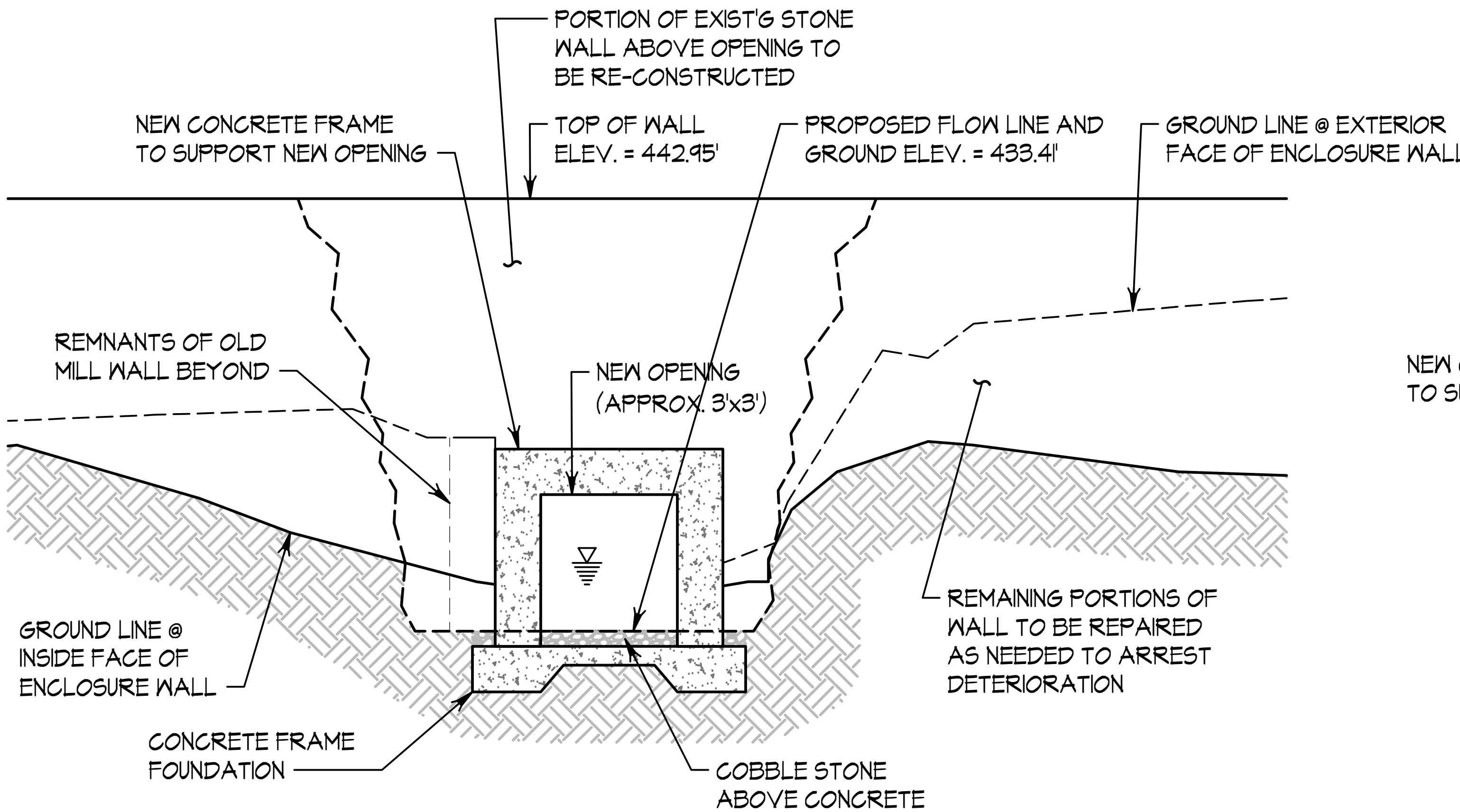
Client: COA PARD

Sheet Name: PLAN VIEW

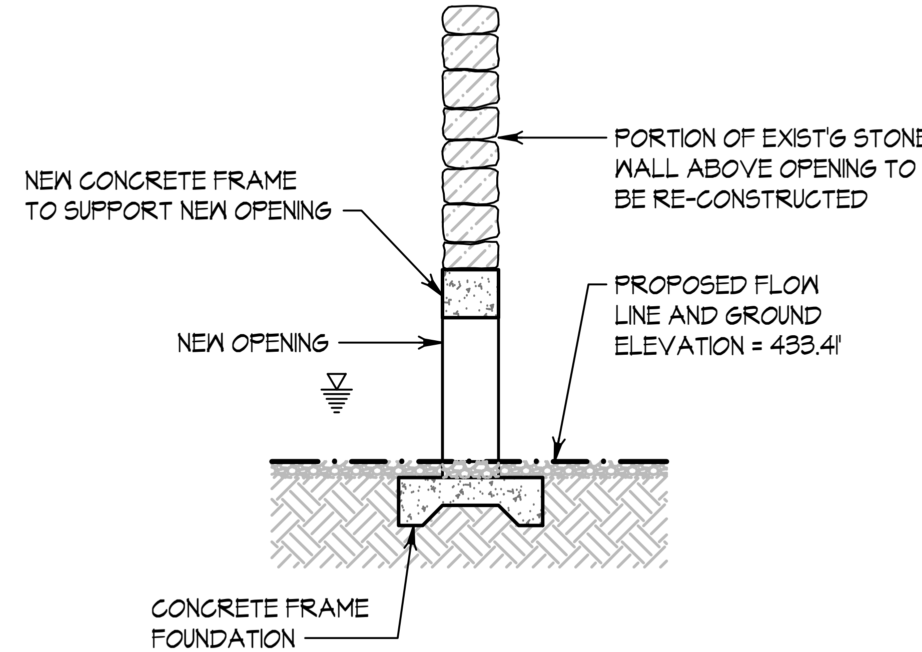
Date: 10-22-2013

Revision: 0

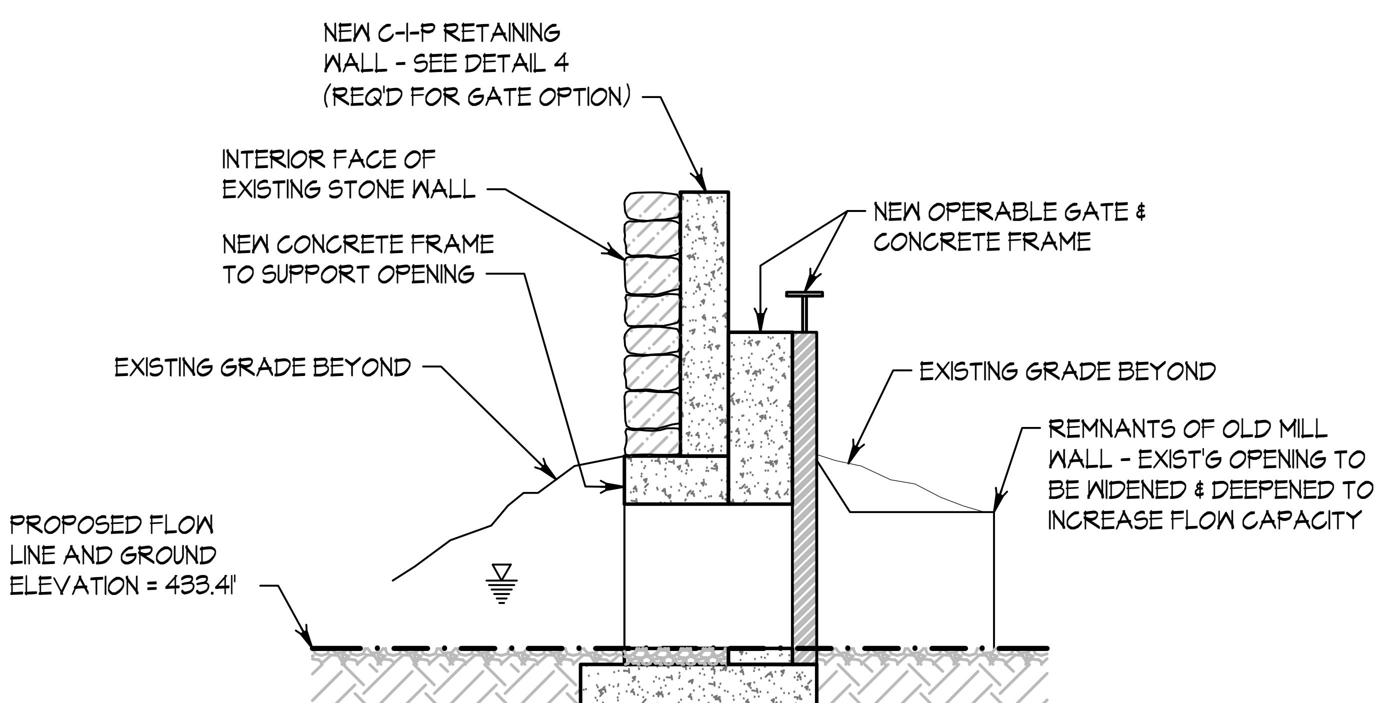
Sheet Number: A.1



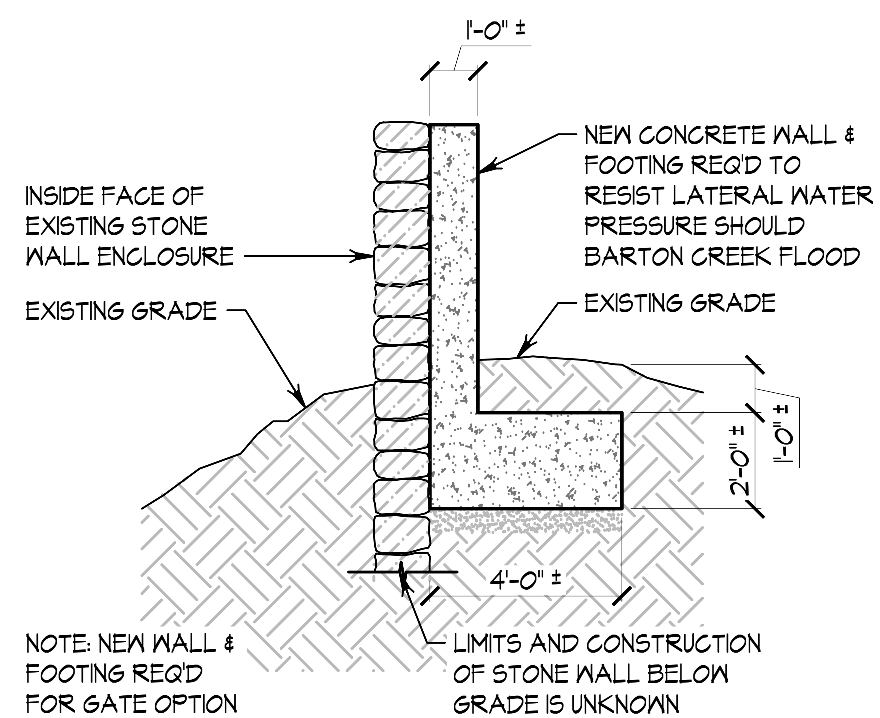
1 **WALL ELEVATION @ PROPOSED OPENING**
LOOKING NORTH FROM INSIDE ENCLOSURE 1/4" = 1'-0"



2 **WALL SECTION @ PROPOSED OPENING**
1/4" = 1'-0"



3 **WALL SECTION @ PROPOSED GATE**
1/4" = 1'-0"



4 **SECTION @ PROPOSED WALL STRENGTHENING**
1/4" = 1'-0"

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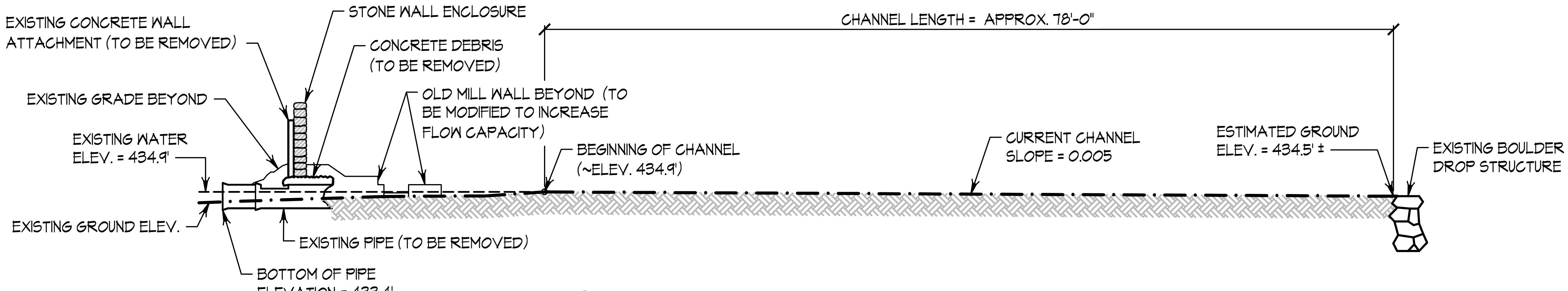
PESC PROJECT No. 1016-C TBPE FIRM No. F-1475

Project Name: BARTON SPRINGS SUNKEN GARDEN IMPROVEMENTS PHASE I
Project Location: BARTON SPRINGS
Client: COA PARD

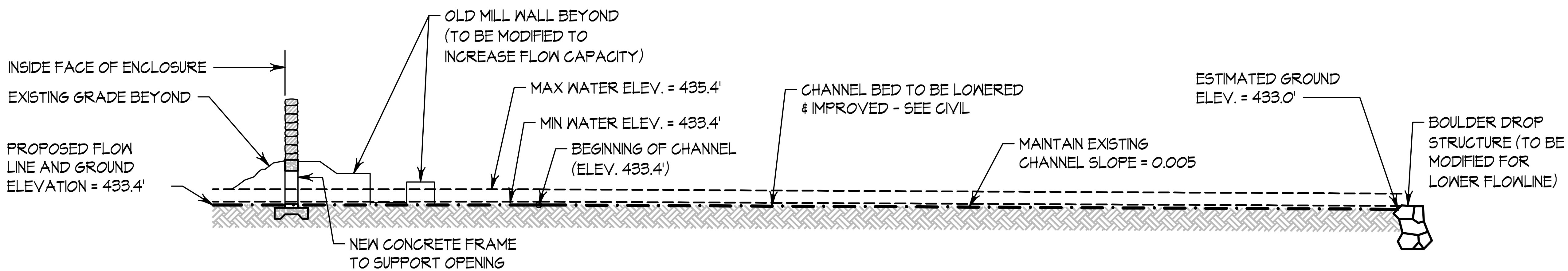
Sheet Name: WALL ELEVATION AND SECTION VIEWS

Date: 10-22-2013
Revision: 0
Sheet Number: A.2



1 **EXISTING FLOWLINE CROSS-SECTION**

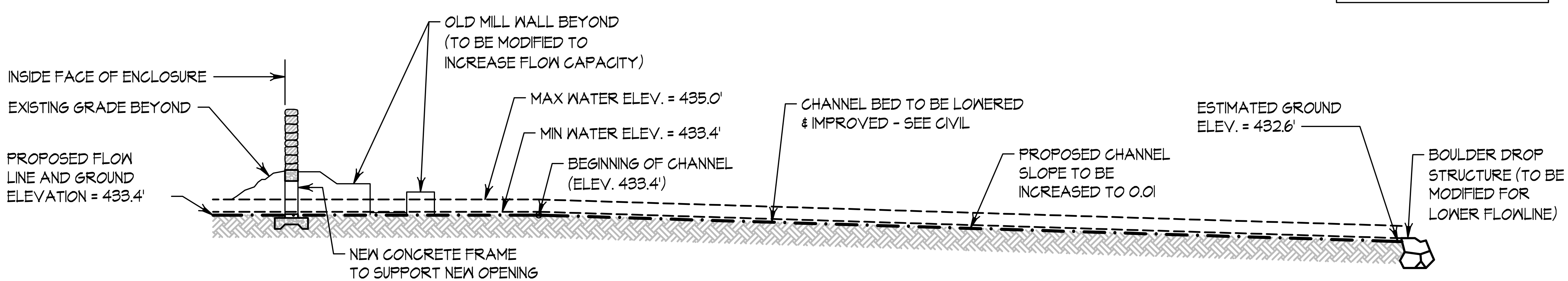
3/32" = 1'-0"



2 **PROPOSED FLOWLINE CROSS-SECTION - OPTION B**

3/32" = 1'-0"

NOTE: NEW GATE & WALL STRENGTHENING RETAINING WALL NOT SHOWN IN THESE DETAILS.



3 **PROPOSED FLOWLINE CROSS-SECTION - OPTION C**

3/32" = 1'-0"

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PESC PROJECT No. 1016-C TBPE FIRM No. F-1475

Project Name: **BARTON SPRINGS SUNKEN GARDEN IMPROVEMENTS PHASE I**

Project Location: BARTON SPRINGS

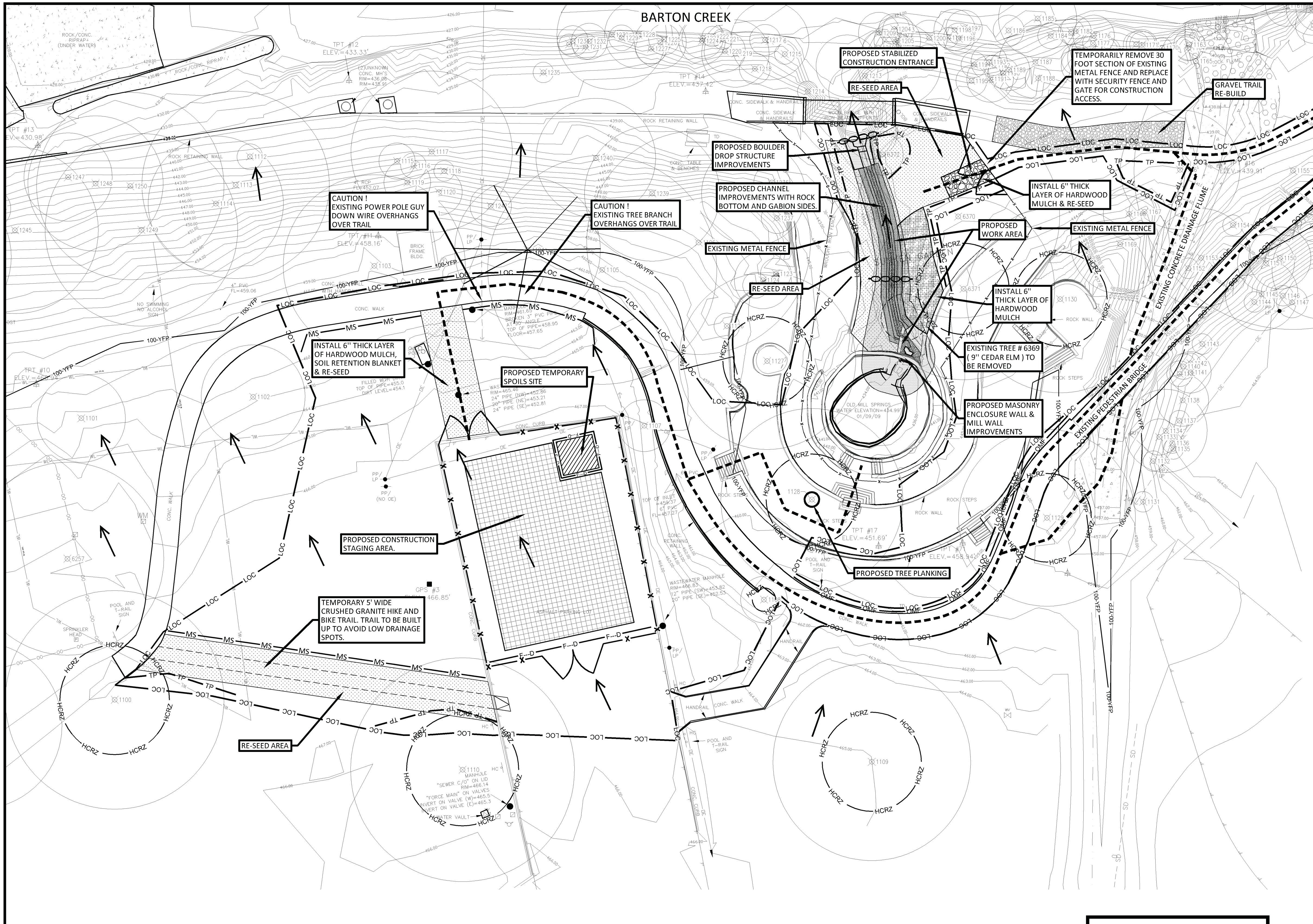
Client: COA PARD

Sheet Name: FLOW LINE CROSS SECTIONS

Date: 10-22-2013

Revision: 0

Sheet Number: A.3



EROSION / SEDIMENTATION AND TREE PROTECTION LEGEND

LOC — LIMITS OF CONSTRUCTION

DRAINAGE FLOW DIRECTION

TP — TREE PROTECTION FENCE (C.O.A. DETAIL 610S-1 & 610S-4)

REINFORCED ROCK BERM (C.O.A. DETAIL 639S-1)

MS — MULCH SOCK

OMF — ORANGE MESH SAFETY FENCE

F—D / F---D — FILTER DIKE CURB INLET PROTECTION (C.O.A. DETAIL 628S-2)

HCRZ — HALF CRITICAL ROOT ZONE

100-YFP — FEMA 100 YEAR FLOODPLAIN

CONSTRUCTION AND EQUIPMENT ACCESS ROUTE

TEMPORARY CONSTRUCTION FENCING

1000 EXISTING TREES (TO REMAIN)

1000 EXISTING TREES (TO BE REMOVED)

STABILIZED CONSTRUCTION ENTRANCE (SCE) (C.O.A. DETAIL 641S-1)

TEMPORARY SPOILS SITE

CONSTRUCTION STAGING AREA

EROSION CONTROL BLANKET

DETAIL NUMBER → X, SHEET NUMBER → XX, DETAIL NAME — DETAIL CALLOUT REFERENCE

NOTES:

1. THE ENVIRONMENTAL INSPECTOR HAS THE AUTHORITY TO ADD AND/OR MODIFY EROSION/ SEDIMENTATION CONTROLS ON SITE TO KEEP PROJECT IN COMPLIANCE WITH THE CITY OF AUSTIN RULES AND REGULATIONS.
2. CONTRACTOR SHALL UTILIZE DUST CONTROL MEASURES DURING SITE CONSTRUCTION SUCH AS IRRIGATION TRUCKS AND MULCHING AS PER ECM 1.4.5(D), OR AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
3. SILT FENCE TYPE AND INSTALLATION SHALL COMPLY WITH ECM 1.4.2(G).
4. ALL DISTURBED AREAS SHALL BE REVEGETATED WITH NATIVE GRASSES (REFER TO NOTE SHEET FOR SPECS). ALL DISTURBED AREAS WITH SLOPES 5:1 OR STEEPER, WHICH ARE NOT ARMORED OTHERWISE, SHALL HAVE A SOIL RETENTION BLANKET (EXCELSIOR II OR APPROVED EQUAL) INSTALLED TO ASSIST WITH REVEGETATION.

NOTES:

1. CONTRACTOR TO PROVIDE TREE TRIMMING AND REMEDIAL TREE CARE AS NEEDED TO FACILITATE CONSTRUCTION ACCESS OF EQUIPMENT AND MATERIALS.

2. REMOVE EXISTING TREE # 6369 (9" CEDAR ELM) DUE TO CONFLICT WITH PROPOSED CHANNEL IMPROVEMENTS.

CONTRACTOR NOTES:

EXISTING UNDERGROUND & OVERHEAD UTILITIES IN VICINITY. CONTRACTOR TO CONTACT UTILITY COMPANIES PRIOR TO CONSTRUCTION. CONTRACTOR TO FIELD VERIFY EXISTING UTILITY LOCATIONS & DEPTH PRIOR TO BEGINNING CONSTRUCTION.

CONTRACTOR SHALL CONSIDER PROPOSED UTILITY IMPROVEMENTS AND PROVIDE ADEQUATE HORIZONTAL AND VERTICAL CLEARANCE DURING INSTALLATION OF ALL UTILITY INFRASTRUCTURE.

CPE CHAN & PARTNERS CONSULTING CIVIL ENGINEERS

CHAN & PARTNERS ENGINEERING, LLC
4319 JAMES CASEY STREET, #300
AUSTIN, TEXAS 78745
512-480-8155 (PH) ◆ 512-480-8811 (FAX)
E-mail: info@chanpartners.com
WWW.CHANPARTNERS.COM
TEXAS REGISTRATION NO. F-13013

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CORRECTION			
NO.	CORRECTION DESCRIPTION	APPROVED BY	DATE

BARTON SPRINGS SUNKEN GARDENS IMPROVEMENTS PHASE 1

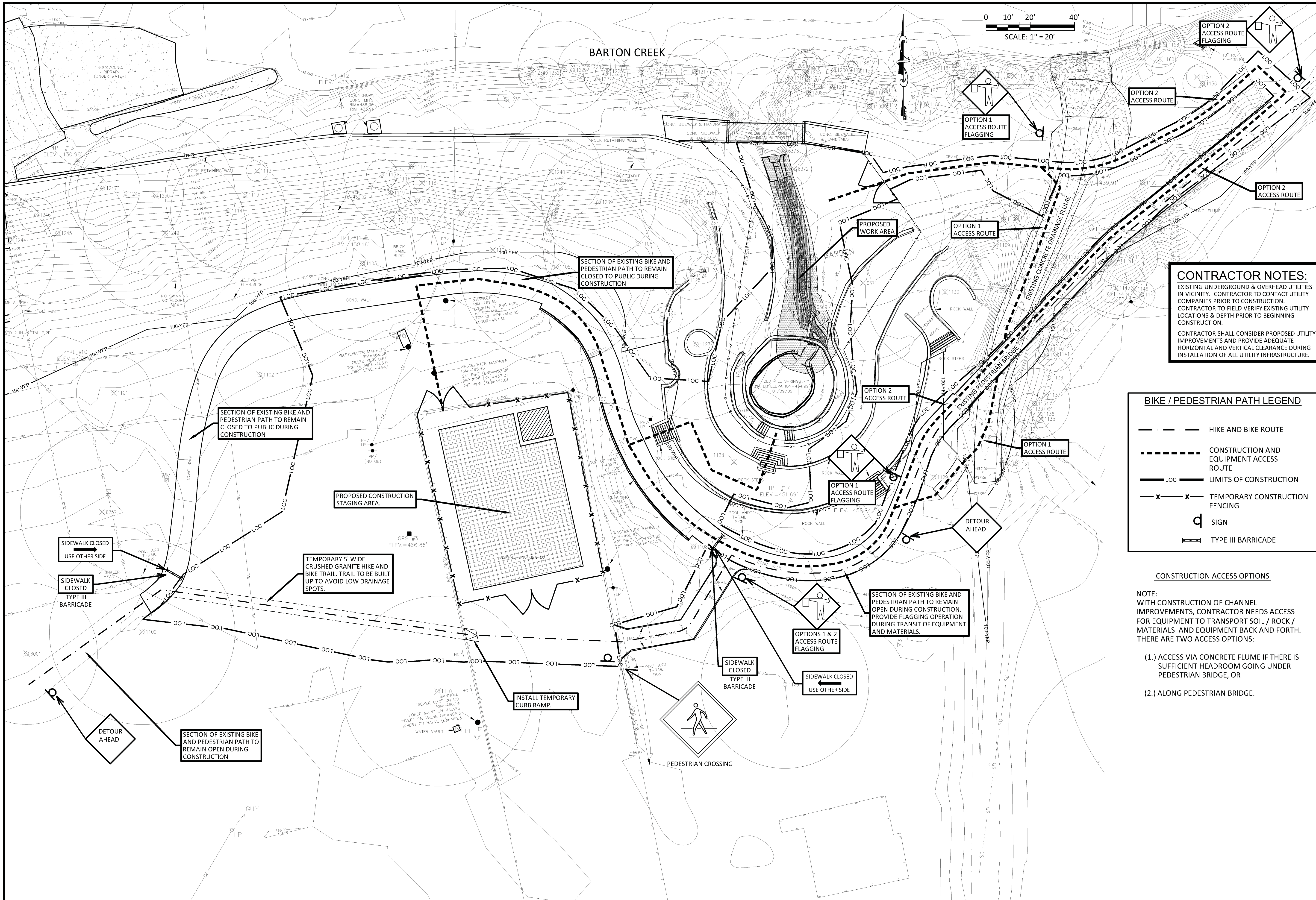
SITE IMPROVEMENTS EROSION SEDIMENTATION AND TREE PROTECTION PLAN

ISSUE DATE: 09/06/13

PROJECT NO: 1038
DESIGNED BY: JRK/AW
DRAWN BY: RT
CHECK BY: JRK
CLIENT: P.E. STRUCTURAL CONSULTANTS, INC.

DETAIL 1 / B.1

IF THIS SHEET IS NOT 22" X 34", IT IS A REDUCED PRINT.
PLOTTED: Oct 22, 2013 - 2:35pm Drawing name: J:\1038-Sunken Garden\00-DRAWINGS\PERMIT\1038-C-SITE PLAN.dwg



CONTRACTOR NOTES:

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CONTRACTOR SHALL CONSIDER PROPOSED UTILITY IMPROVEMENTS AND PROVIDE ADEQUATE HORIZONTAL AND VERTICAL CLEARANCE DURING INSTALLATION OF ALL UTILITY INFRASTRUCTURE.

BIKE / PEDESTRIAN PATH LEGEND

- HIKE AND BIKE ROUTE
- CONSTRUCTION AND EQUIPMENT ACCESS ROUTE
- LOC — LIMITS OF CONSTRUCTION
- x — TEMPORARY CONSTRUCTION FENCING
- SIGN
- TYPE III BARRICADE

CONSTRUCTION ACCESS OPTIONS

NOTE:
WITH CONSTRUCTION OF CHANNEL IMPROVEMENTS, CONTRACTOR NEEDS ACCESS FOR EQUIPMENT TO TRANSPORT SOIL / ROCK / MATERIALS AND EQUIPMENT BACK AND FORTH. THERE ARE TWO ACCESS OPTIONS:

(1.) ACCESS VIA CONCRETE FLUME IF THERE IS SUFFICIENT HEADROOM GOING UNDER PEDESTRIAN BRIDGE, OR

(2.) ALONG PEDESTRIAN BRIDGE.

C P E
CHAN & PARTNERS
CONSULTING CIVIL ENGINEERS

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NO.	CORRECTION DESCRIPTION	CORRECTION	APPROVED BY	DATE

BARTON SPRINGS SUNKEN GARDENS IMPROVEMENTS PHASE 1

SITE IMPROVEMENTS

PEDESTRIAN PLAN

ISSUE DATE: 09/06/13

PROJECT NO:	1038
DESIGNED BY:	JRK/AW
DRAWN BY:	RT
CHECK BY:	JRK
CLIENT:	P.E. STRUCTURAL CONSULTANTS, INC.

DETAIL
1 / B.2

IF THIS SHEET IS NOT 22" X 34", IT IS A REDUCED PRINT.
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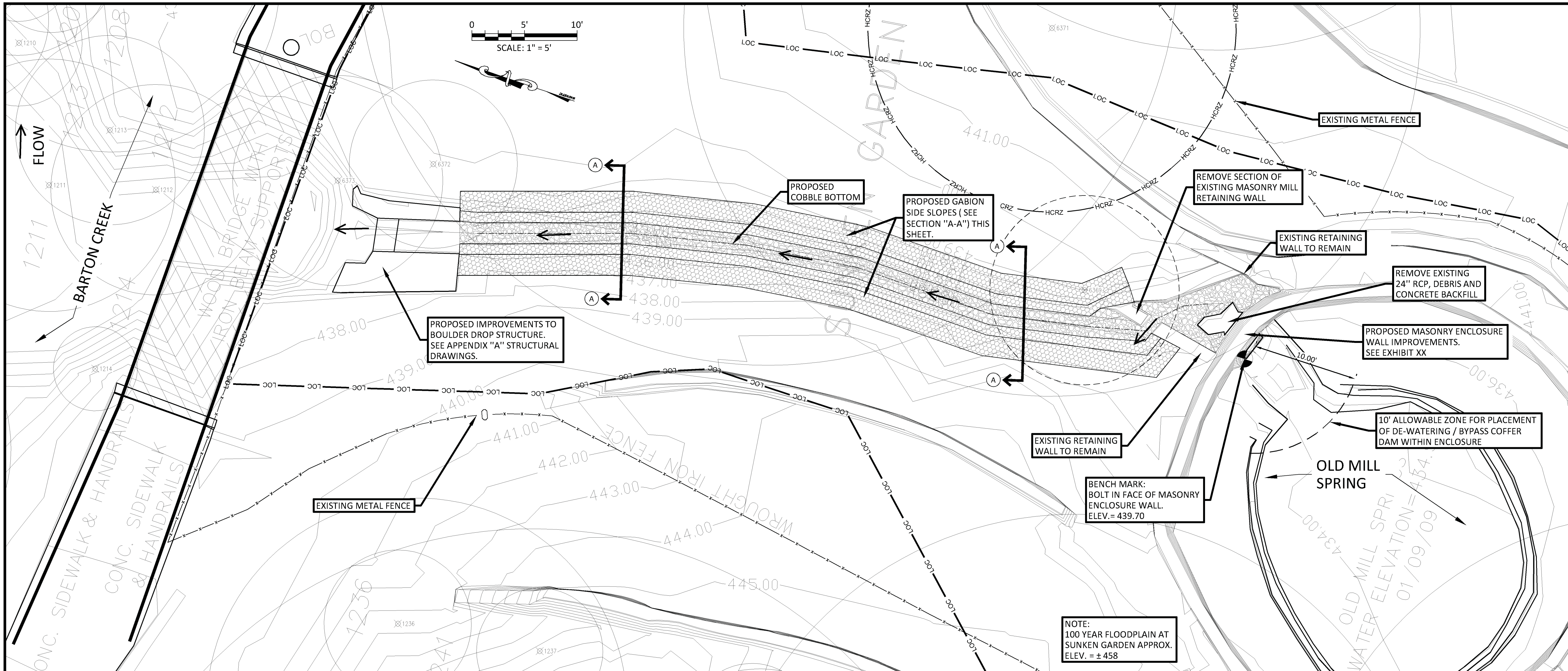
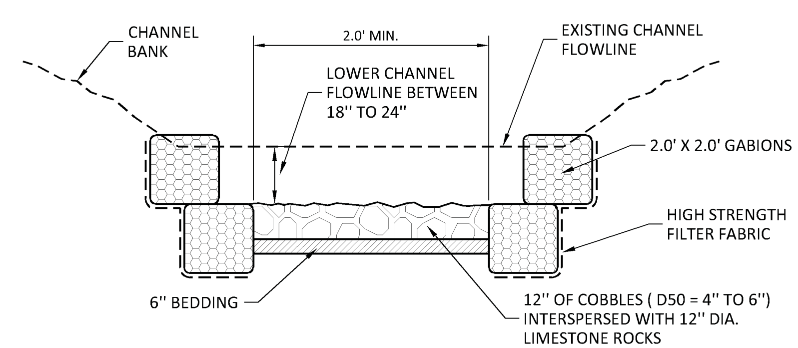


OUTLET CHANNEL IMPROVEMENTS

SCALE: 1" = 5'



SECTION "A-A"

TYPICAL CHANNEL SECTION IMPROVEMENT

SCALE: NONE

IF THIS SHEET IS NOT 22" X 34", IT IS A REDUCED PRINT.

PLOTTED: Oct 22, 2013 - 2:36pm Drawing name: J:\1038-Sunken Garden\00-DRAWINGS\PERMIT\1038-C-SITE PLAN.dwg

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NO.	CORRECTION DESCRIPTION	APPROVED BY	DATE

CORRECTION

BARTON SPRINGS SUNKEN GARDENS IMPROVEMENTS PHASE 1

SITE IMPROVEMENTS

OUTLET CHANNEL IMPROVEMENTS

ISSUE DATE: 09/06/13

PROJECT NO:	1038
DESIGNED BY:	JRK/AW
DRAWN BY:	RT
CHECK BY:	JRK
CLIENT:	P.E. STRUCTURAL CONSULTANTS, INC.

DETAIL
1 / B.3