Appendix E

Preliminary Geotechnical Evaluation Smith Basin Scour Assessment
Orange Counter Water District, Villa Park, California, Ninyo & Moore
Geotechnical and Environmental Sciences Consultants, November 2015

PRELIMINARY GEOTECHNICAL EVALUATION
SMITH BASIN SCOUR ASSESSMENT
ORANGE COUNTY WATER DISTRICT
VILLA PARK, CALIFORNIA

PREPARED FOR:

Orange County Water District
18700 Ward Street
Fountain Valley, California 92708

PREPARED BY:

Ninyo & Moore
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Irvine, California 92618

November 20, 2015
Project No. 209509001

November 20, 2015
Project No. 209509001

Mr. Ryan Bouley, PE
Orange County Water District
18700 Ward Street
Fountain Valley, California 92708

Subject: Preliminary Geotechnical Evaluation
Smith Basin Scour Assessment
Orange County Water District
Villa Park, California

Dear Mr. Bouley:

In accordance with your request, we have performed a preliminary geotechnical evaluation of the erosion on the embankment slopes at the Orange County Water District's Smith Basin in Villa Park, California. Our study was performed evaluate the erosion on the basin embankment slopes and develop preliminary repair concepts and cost estimates for planning purposes. This report presents our findings, conclusions, and preliminary recommendations relative to the subject site.

Ninyo & Moore appreciates the opportunity to be of service to you on this project.

Respectfully submitted,
NINYO & MOORE

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Distribution: (1) Addressee (via e-mail)

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1. INTRODUCTION

In accordance with your request, we have performed a preliminary geotechnical evaluation of the erosion that has occurred on the embankment slopes of Orange County Water District's (OCWD) Smith Basin in Villa Park, California (Figure 1). Portions of the embankment slopes have experienced varied amounts of erosion from seasonal water runoff, major flood events, and water impoundment. The purpose of our study was to evaluate the erosion on the slopes and to provide a discussion of repair alternatives. This report presents our findings, conclusions, and recommendations.

2. SCOPE OF SERVICES

The scope of our services included the following:

- Review of readily available background material, including geologic maps, previous geotechnical reports, well logs, and a topographic map provided by OCWD.
- Review of historical aerial photographs.
- Site reconnaissance, photographic documentation, and erosion mapping to observe and document the existing conditions of the embankment slopes.
- Attend a field meeting with OCWD representative and our cost estimator (Stantec) to discuss our preliminary findings and the areas of concern.
- Compilation and analysis of background information and site data collection.
- Preparation of probable cost estimate for erosion repairs.
- Preparation of this report to present our findings, conclusions and recommendations regarding the cause of the erosion and repair alternatives.

3. SITE DESCRIPTION

Smith Basin is part of the Santiago Basins, which also includes the Bond Pit and the Blue Diamond Pit. Smith Basin is located north of Villa Park Road between Lemon Street and North Santiago Boulevard in Villa Park, California. The basin is roughly triangular in shape and bordered on the north and west by single-family residential properties, on the east by Oak Ridge Private School and North Santiago Boulevard, and on the south by Villa Park Road and the Blue

Diamond and Bond pits (Figure 1). Santiago Creek flows into the basin at the northeast corner and out of the basin via a 21-foot-diameter corrugated metal pipe that runs under Villa Park Road into Blue Diamond Basin.

The embankment slopes vary in height from 50 to 80 feet high and vary in slope ratio from approximately 1.4:1 to 2:1 (horizontal to vertical), except near the southwest corner of the basin where the embankment slope is approximately 1:1 (horizontal to vertical). A portion of the north embankment slope has been improved with concrete v-ditch drainage improvements. A maintenance road is present along the top of the eastern embankment slope and the eastern portion of the southern embankment slope. Portions of the basin interior and lower areas of the southern and eastern embankment slopes are covered with dense vegetation. Erosion has resulted in near-vertical scarps in some areas. The basin configuration is shown on Figure 2 and the locations where significant erosion has occurred are shown as Areas 1 through 6.

Based on our communication with OCWD, it is our understanding that the areas of primary concern are Area 1 located on the southern embankment slope adjacent to Villa Park Road and Area 2 on the eastern embankment slope located adjacent to Oak Ridge Private School.

4. BACKGROUND AND GEOLOGY

Regional geologic data indicates that the project site is underlain by Quaternary age older stream terrace deposits that were deposited by Santiago Creek (Yerkes, 1957). These materials are well-exposed in the larger erosion areas with near-vertical erosion scarps and are comprised predominantly of silty sand, gravelly sand and sandy gravel with varying amounts of cobbles and boulders.

Younger deposits at Smith Basin include recent alluvial deposits in the basin bottom, eroded talus below the larger erosion areas, soil slumps, and fills associated with a 21-foot-diameter corrugated metal pipe that crosses beneath Villa Park Road and previous mining activities. Talus is generally composed of loose material from the older stream terrace deposits that has accumulated on and at the base of the embankment slopes. In addition, during our geologic mapping, sandstone and conglomerate bedrock materials of the Tertiary-age Topanga Formation were observed along the flow line of the creek near the northeast corner of the site.

In addition to our review of regional geologic publications, we reviewed our previous reports for the Santiago Pits Pump Station projects (Ninyo & Moore, 2002, 2010a,b), other geotechnical reports provided by OCWD for the Bond and Blue Diamond Pits (Group Delta, 1996; TerraCosta Consulting Group, Inc., 2013; Wildan Geotechnical, 2009; Woodward-Clyde, 1988), and well logs for wells constructed near Smith Basin.

5. HISTORICAL AERIAL PHOTOGRAPH REVIEW

Historical aerial photographs were reviewed to evaluate the history of Smith Basin (Continental Aerial Photo, Inc., 1952, 1959, 1967, 1970, 1973, 1975, 1977, 1978, 1981, 1983, 1987, and 1997; HistoricalAerials.com, 1946, 1952, 1963, 1966, 1972, 1980, 1994, 2002-20005, 2009, 2010, and 2012; and Google Earth, 1994, 2002-2005, 2007, 2009-2011, and 2013-2015). Quarry operations in the area of the Santiago Pits began in the early 1950s and progressed into the 1980s. In 1959, a quarry pit had been excavated in the area of Smith Basin and an active quarry pit can be seen in the area of the school. In the 1967 photographs, the quarry pit in the school area had been filled and the quarry pit in Smith Basin appeared similar to the current configuration, but slightly smaller, with relatively steep quarry slopes.

Significant storms occurred between February 21 and February 25, 1969, when approximately 7 to 9 inches of rain fell in the Santa Ana Mountains and Santiago Creek area (Campbell, 1975). Evidence of this storm event can be seen in the aerial photographs from 1970. In aerial photographs prior to 1970, a bridge existed on North Santiago Boulevard across Santiago Creek near the northeast corner of Smith Basin, Area 2. In the 1970 aerial photographs, the bridge has been destroyed. In addition, Villa Park Road has been constructed and Smith Basin is connected to Blue Diamond Pit through a culvert or pipe beneath the new road (Area 6). The terrace drains on the middle portion of the northern embankment slope have also been constructed. The initial formation of the erosion gulley in Area 5 near the southwest corner of the basin can also be seen.

In the 1973 aerial photographs, the southern and eastern steep quarry slopes have been graded to flatter inclinations to the approximate current basin configuration. The erosion scarp in Area 2 is also beginning to develop near the northeast corner of the basin where the bridge was destroyed. The remainder of the northern embankment slope (Area 4) has also been excavated to the present configuration. In the 1975 aerial photographs, the vertical erosion in the area of the former bridge in Area 2 and the erosion gully in Area 5 are more developed. In the 1977 photographs, mining operations have stopped in Smith Basin and vegetation is growing on the basin bottom.

In the 1978 through 1981 aerial photographs, the portion of Villa Park Road (Area 6) that spanned the buried pipeline/culvert that connects Smith Basin and Blue Diamond Pit was destroyed by a flood event. A relatively large amount of eroded debris was deposited into Blue Diamond Pit. The vertical erosion scarp in Area 2 beneath the former bridge continues to develop and the erosion scarp in Area 1 is beginning to form in the 1981 photographs. Villa Park Road was reconstructed in the 1983 photographs. In the 1987 photographs, the remainder of the terrace drains on the eastern portion of the northern embankment slope were completed and the basin bottom topography is close to the present day configuration.

From 1978, the flow line of Santiago Creek has migrated to the south over the years. By 1997, the aerial photographs show the flow line near the approximate current location near Area 2 and the stream has been undercutting the toe of the slope. By approximately 2003, the erosion in Area 2 is similar to the current condition and the erosion scarp in Area 1 is increasing due to similar undercutting of the toe of slope. Between 2006 and 2007, a retaining wall was constructed near the top of the erosion gulley at the rear of the adjacent residential property in Area 5. By 2011, the erosion scarp in Area 1 has enlarged to the approximate present day configuration.

6. SITE RECONNAISSANCE AND OBSERVATIONS

Our site reconnaissance was performed on September 2, 2015, and consisted of photographic documentation, geologic mapping of approximate erosion limits, and documentation of potential water sources causing erosion. An undated topographic map of the Santiago Pits provided by

OCWD was utilized as a base map for our geologic mapping. As mentioned above, relatively dense vegetation is present on portions of the basin floor and embankment slopes. The dense vegetation, particularly in the southeastern portion of the basin between Areas 1 and 2, obstructed views of the ground surface and access to the toe of slope areas.

General descriptions of each area of significant erosion are provided in the following sections. Figure 2 presents the locations of the erosion areas, the approximate lateral extent and scarp heights of the erosion features, and the locations of where the photographs were taken. Representative photographs of the erosion areas are included in Appendix A.

6.1. Area 1

Area 1 is located on the southern embankment slope adjacent to Villa Park Road (Appendix A, Photograph 1). The topographic expression of the erosion is not reflected in the topographic map provided by OCWD. The southern embankment slope was constructed at an approximate slope ratio of 1.7:1 (horizontal to vertical) based on the pre-erosion topography. An approximately 450-foot-long area along the toe of the embankment slope has been progressively eroding during high water flow events since approximately 1981. The erosion has created a near-vertical scarp that is estimated to be up to approximately 25 feet high (Appendix A, Photographs 2 through 4). Some eroded talus is present near the base of the scarp, but the majority of the eroded material has presumably been transported downstream. Our interpretations of the subsurface conditions are shown in Cross Section A-A' (Figure 3).

6.2. Area 2

Area 2 is located on the eastern embankment slope which is adjacent to Oak Ridge Private School and the northern end of North Santiago Boulevard (Appendix A, Photograph 5). The topographic expression of the erosion is generally reflected in the topographic map provided by OWCD. The area of erosion is approximately 700 feet in length, however, the northeastern approximately 200 feet of the erosion area is located outside OCWD property. It is our understanding that this portion of the eroded area is within property owned by the County of Orange.

Similar to the southern embankment slope, the eastern embankment slope was constructed at an approximate slope ratio of 1.7:1 (horizontal to vertical) based on the topography in the non-eroded area to the south. The approximately 700-foot-long area along the toe of the embankment slope has been progressively eroding during high water flow events since approximately 1973, or may have begun during the flood event that destroyed the bridge in 1969. The erosion has created a near-vertical scarp that ranges in height from approximately 35 feet at the southwest end (Appendix A, Photographs 6 through 8) up to approximately 65 feet at the northeast end (Appendix A, Photographs 9 and 10). Some eroded talus is present near the base of the scarp, but the majority of the eroded material has also been transported downstream. A relatively large soil slump is present at the OCWD/County of Orange property boundary (Appendix A, Photograph 9). Our interpretations of the subsurface conditions are shown in Cross Sections B-B' and C-C' (Figure 3).

6.3. Area 3

Area 3 is located near the northeast corner of the basin, northwest of Area 2 (Figure 2). The erosion is within the basin interior and begins at the top of a relatively flat area between the creek flow line and the northern embankment slope. The erosion consists of a relatively narrow erosion gulley that has side scarps on the order of 2 to 6 feet deep (Appendix A, Photograph 12).

6.4. Area 4

The western portion of the northern embankment slope that is constructed at approximately 1.4:1 (horizontal to vertical) that does not have drainage improvements has experienced erosion rilling (Appendix A, Photograph 13). The erosion rills vary in depth, but are generally about a foot deep. The western portion of the slope in Area 4 steepens to approximately 1.2:1 (horizontal to vertical) and has more closely-spaced erosion rills and less vegetation as a result of the erosion. The portion of the northern embankment slope that has concrete v-ditch drainage improvements has performed relatively well (Appendix A, Photographs 14 and 15).

6.5. Area 5

Area 5 is located near the top of the embankment slope near the west corner of the basin (Figure 2). The embankment slope in this area is relatively steep, up to approximately 1:1 (horizontal to vertical). The erosion in this area was first observed in the 1970 aerial photographs at about the same time that the grading for the residential property to the west and north was being performed. Over the years, the erosion gulley has widened and retreated to the west toward the adjacent residential property. Based on our aerial photograph review, a retaining wall was constructed near the rear property line of the residential property between 2006 and 2007. The topography in Figure 2 shows the erosion prior to the retaining wall being constructed. The approximate location of the retaining wall was added based on our visual reconnaissance from below the gulley and our aerial photograph review. Access to the slope area is restricted due to the steepness and vegetation. The erosion gully has relatively steep side slope that are estimated to be about 6 to 10 feet in height (Appendix A, Photograph 16).

6.6. Area 6

Area 6 is located on the southern embankment slope near the southwest corner of the basin where the 21-foot-diameter corrugated metal pipe passes beneath Villa Park Road to Blue Diamond Pit (Figure 2). As discussed in the Historical Aerial Photograph Review section of this report, the slope area and the portion of Villa Park Road that spanned the buried pipeline/culvert that connected Smith Basin and Blue Diamond Pit was destroyed by a flood event and was reconstructed by 1983. The slope in this area was constructed at a slope ratio of approximately 1.5:1 (horizontal to vertical). Some near-vertical erosion benches up to approximately 18 inches high are present on the slope (Appendix A, Photograph 17). The slope in this area is generally devoid of vegetation. In addition, there are near-vertical eroded areas near the outlet structure and on the basin interior just upstream of the outlet structure (Appendix A, Photographs 17 and 18).

7. CONCLUSIONS AND RECOMMENDATIONS

The purposes of our study were to evaluate the erosion that is occurring on the Smith Basin embankment slopes, and to provide a discussion of possible repairs to consider in project planning and budgeting. The scope of our study included review of background data, geologic mapping of erosion and soil slump features, data analysis, probable cost estimations, and preparation of this report.

Areas 1 and 2 are the primary areas of concern due to the severity of the erosion and their proximity to Villa Park Road and Oak Ridge Private School, respectively. These areas have tall, near-vertical scarps, which are susceptible to future failures. Future erosion is anticipated during significant rainfall and high water flow events if not mitigated. Constructing a channelized flow path for Santiago Creek near the middle of the basin where it flowed prior to the 1980s is recommended to mitigate high water flows from undercutting the embankment slopes.

Conclusions regarding the cause of the erosion and preliminary recommendations for mitigation are provided in the following sections for each erosion area.

7.1. Areas 1 and 2

The primary cause of erosion in Areas 1 and 2 is undercutting of the toe of the embankment slopes from the southerly migration of Santiago Creek. Since approximately 1978, the flow line of Santiago Creek has been progressively migrating to the south resulting in erosive waters flowing along the base on the easterly and southerly embankment slopes during high flow events.

We recommend that restoration of the slopes be extended beyond Smith Basin into the County of Orange property. Preliminary recommendations to mitigate the erosion are provided below.

- Re-establishing and channelizing the flow line of Santiago Creek northward, away from the southern and eastern embankment slopes, toward the center of Smith Basin, is recommended to divert water flow away from the toe of slope areas and reduce the potential for additional erosion and undermining. Placement of rip rap to enhance the surficial stability of the new channelized creek is recommended.

- If diverting and channelizing Santiago Creek is not allowed, placement of rip rap on the lower portions of the southern and eastern embankment slopes is recommended after the erosion scarps are repaired. The rip rap should extend along the entire eastern and southern embankment slopes to the discharge pipeline to Blue Diamond Pit beneath Villa Park Road.

- Rip rap should be placed on the north side of the creek where the creek is narrow as it enters Smith Basin.

  Restoring the slopes to the previous configuration of approximately 1.7:1 (horizontal to vertical) is recommended to stabilize the near-vertical erosion scarps. If the slope is restored to approximately 1.7:1 (horizontal to vertical), the toe of the slope will bury the current flow line of Santiago Creek and the creek will need to be diverted to the north. Remedial grading to remove eroded talus material to expose competent material suitable for support of compacted fill and construction of a fill key should be performed. The anticipated remedial grading and fill key construction for the slope repair in Area 1 and the southwestern portion of Area 2 are shown on Cross Sections A-A' and B-B', respectively (Figure 3). This repair alternative is shown on Cross Section C-C' as Alternative 1.

- If the flow line of Santiago Creek cannot be diverted, utilization of gabions may be considered to provide erosion protection along the creek flow line. Remedial grading to remove loose soil below and behind the gabions is anticipated. Filling behind the gabions may involve placement of Geogrid to increase the stability of the gabions and slope repair. A fill slope may be constructed behind the gabions up to the existing scarp. From this point, a cut slope may be constructed up to the existing street elevation. However, construction of the cut slope will result in losing some of the maintenance road at the northeast end and removing some of the old asphalt concrete from the old bridge approach area. The adjacent area on the North side of the road that is being used by a landscape supply company may also be lost. Approximately 500 lineal feet of gabions for the south side of the creek is estimated (Figure 2). This repair alternative is shown on Cross Section C-C' as Alternative 2.

7.2. Area 3

The primary cause of erosion in Area 3 is uncontrolled surface water flow from the relatively level area between the creek and the northern embankment slope. Water flowing over the top of the slope is resulting in incising, or down-cutting, of the soil material comprising the slope. The erosion gully may continue to widen and retreat toward the northern embankment slope if not mitigated. Eroded debris may also contribute to the ponding condition that has occurred between Areas 2 and 3.

- Repair of the erosion gully may be accomplished by removing the loose debris from the bottom and filling the void with compacted fill.

7.3. Area 4

The primary cause of erosion in Area 4 is uncontrolled surface water flow on the embankment slope and the steepness of the slope. The absence of concrete v-ditch terrace drains and downdrains allow water flowing downslope to reach velocities that result in erosion of the granular soils that comprise the slope. The erosion rills in Area 4 may continue to deepen and widen during heavy and/or prolonged rainfall. The northern embankment slope areas that have drainage improvements were performing relatively well at the time of our site reconnaissance; however, the existing v-ditches on the eastern portion of the northern embankment slope should be cleared of obstructions, including maintaining rip rap energy dissipaters at the base of the downdrains.

- Periodic maintenance to repair erosion rills in Area 4 is anticipated. To reduce the rate of erosion in the portions of the slope that are approximately 1.4:1 (horizontal to vertical) or flatter, the slope surface could be smoothed with a small dozer to fill-in the shallow erosion rills and the surface of the slope recompacted. Following recompaction, re-vegetating the slope face is recommended and straw wattles may be placed on the slope face at approximately 15-foot vertical intervals to reduce water flow velocities down the slope face.
- The western portion of the slope in Area 4, adjacent to Area 5, has a slope ratio of approximately 1.2:1 (horizontal to vertical). Smoothing and recompacting this portion of the slope would be difficult due to the steepness. However, in this area, there are some relatively level areas between the top of the slope and the adjacent residential properties. This portion of the slope could be utilized to lay-back the steep part of the slope to a flatter inclination to provide a more stable slope.

7.4. Area 5

The primary cause of erosion in Area 5 is uncontrolled surface water flow on the relatively steep, approximately 1:1 (horizontal to vertical) embankment slope. The primary concern in Area 5 is continued widening of the erosion gulley and the possible continued westward retreat of the gulley.

- To reduce the potential for further erosion of the gulley and the adjacent portions of the approximately 1:1 slope, placement of fill against the slope to reduce the slope ratio to approximately 2:1 (horizontal to vertical) may be considered. This would involve remedial grading to remove loose soil below the toe of the new fill slope to construct a fill key and to remove loose soil accumulated in the gulley. Typical benching into the existing slope as fill placement progressed should be performed.

7.5. Area 6

The primary cause of erosion in Area 6 below Villa Park Road is wave action during windy conditions when the basin is impounding water. A lack of vegetation on the slope is causing more erosion in Area 6 in comparison to the other slopes that are also impacted by wave action. The erosion on the slope above the outlet structure may continue to expand and new wave-cut benches may form if not mitigated.

The near-vertical exposures upstream of the outlet structures are the result of high water flow velocities where drainage "bottle-necks" just before entering the outlet structure. The erosion on the interior basin slope may generate eroded debris that will be transported downstream.

- Similar repair methods that are recommended for Area 4 may be used in this area. The slope surface could be smoothed with a small dozer to fill-in the shallow erosion rills, the surface of the slope recompacted, and the slope re-vegetated with placement of straw wattles, as described in our recommendations for Area 4.
- Establishing a new channelized flow line of Santiago Creek and re-grading to widen the "bottle-neck" area just upstream of the outlet structure could be performed to mitigate the near-vertical erosion scarps in this area. Placement of rip rap in front of the outlet structure and along the sides will also help to reduce erosion.

8. PROBABLE COST ESTIMATES

Preliminary cost estimates were prepared by our consultant, Stantec, and are included in Appendix B. The topography in some of the erosion areas are not reflected in the topographic base map that was available for our erosion mapping and there is a degree of uncertainty with respect to the earthwork quantities. However, it is our understanding that OCWD is interested in getting rough order-of-magnitude costs for the various repairs for their project planning.

9. ADDITIONAL STUDIES

Additional civil engineering and geotechnical evaluation is anticipated during the design phase of the project. If the flow line of Santiago Creek is re-established in the middle of the basin, a civil engineer should be consulted to design an appropriately-sized channel and slope protection. Future geotechnical evaluation may include subsurface exploration and laboratory testing to develop appropriate design parameters. Consultation with a civil engineer to develop grading and construction drawings is also anticipated to repair the erosion areas.

10. LIMITATIONS

The purpose of this study was to evaluate geologic and geotechnical conditions at the site using readily available data, site reconnaissance, and existing regional geologic publications, and to provide a preliminary geotechnical report which may be utilized in the planning of additional geotechnical evaluation and engineering design for the project.

The geotechnical analyses presented in this report have been conducted in accordance with current engineering practice and the standard of care exercised by reputable geotechnical consultants performing similar tasks in this area. No other warranty, implied or expressed, is made regarding the conclusions, recommendations, and professional opinions expressed in this report. Our preliminary conclusions and recommendations are based on a review of readily available geotechnical literature, review of the referenced engineering standards and topographic maps provided to us, and an analysis of the observed conditions. Variations may exist and conditions not observed or described in this report may be encountered. The final project design should be based on additional geotechnical exploration and geotechnical and civil engineering analysis.

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AERIAL PHOTOGRAPHS		
Date	**Flight and Frame No.**	**Scale**
12-12-52	AXK-2K-77, 78, 79	1”=2000’
3-25-59	261-4-19-125,126	1”=2000’
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2-18-70	61-6-271, 272	1”=2000’
10-30-73	132-8-8, 9	1”=2000’
1-13-75	157-9-9, 10	1”=2000’
1-24-77	181-9-8, 9	1”=2000’
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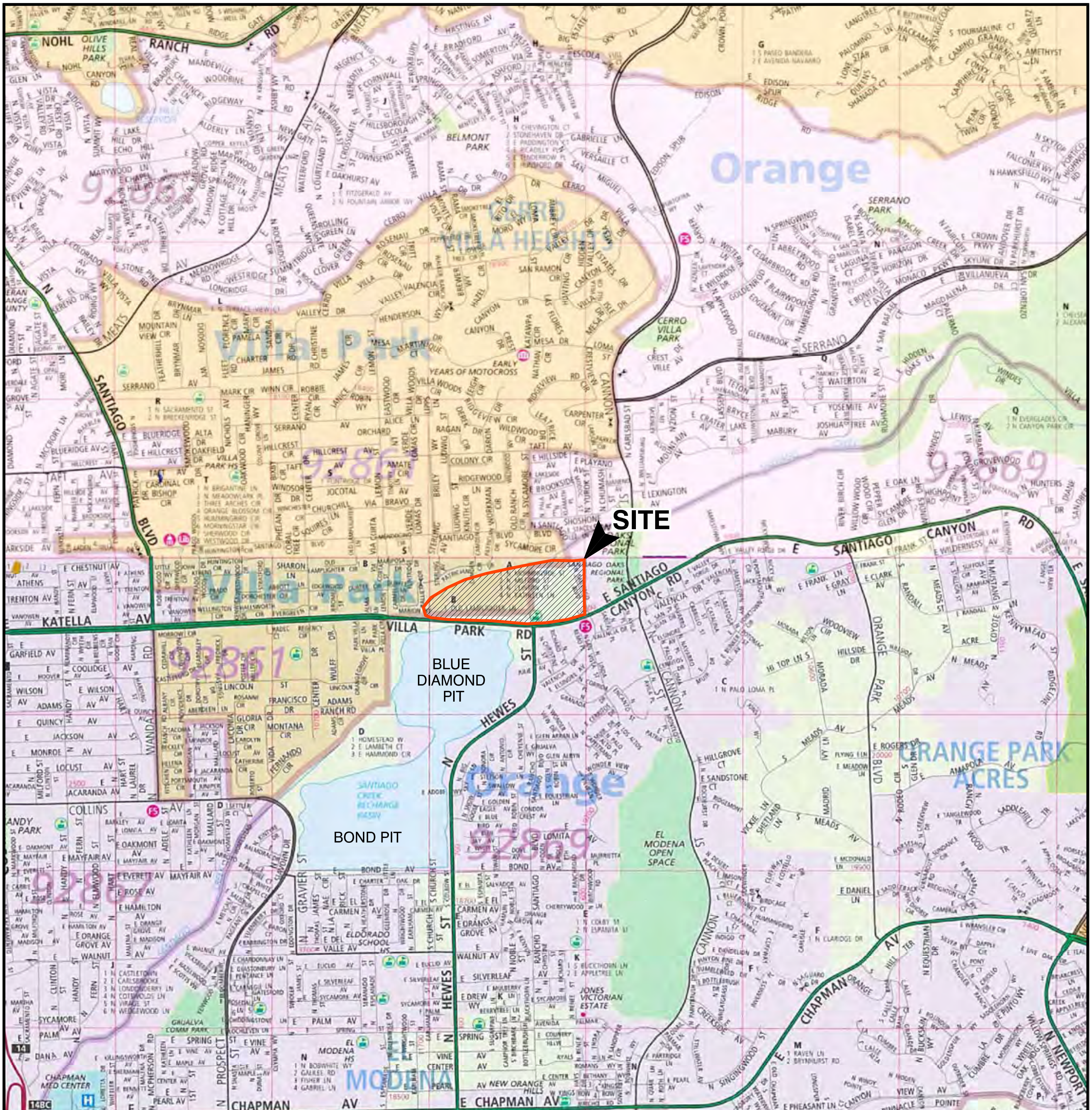
1-31-81	211-9-12, 13	1”=2000’
5-17-83	219-9-15, 16	1”=2000’
1-9-87	F-230, 231	1”=2500’
10-15-97	C117-35-228, 229	1”=2000’



REFERENCE: 52ND EDITION, THOMAS GUIDE FOR LOS ANGELES/ORANGE COUNTIES, STREET GUIDE AND DIRECTORY.

N

SCALE IN FEET

0 2,400 4,800

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

209509001_SL.dwg 14:05:14 10/14/2015 GK

Ninyo & Moore

SITE LOCATION

PROJECT NO.	DATE
209509001	11/15

SMITH BASIN SCOUR ASSESSMENT
ORANGE COUNTY WATER DISTRICT
VILLA PARK, CALIFORNIA

FIGURE

1

N

SCALE IN FEET

0 100 200

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

LEGEND

H=10'	ACTIVE EROSION SCARP; H=VERTICAL HEIGHT
	RECENT SLUMP BLOCKS/ TALLUS
D=6'	EROSION RILLS, EROSION GULLY; D=DEPTH
	AREA OF PONDED WATER
18	LOCATION AND DIRECTION OF PHOTOGRAPH
C C'	CROSS SECTION
	SLOPE FAILURE DIRECTION
Tt	TOPANGA FORMATION

REFERENCE: ORANGE COUNTY WATER DISTRICT, UNTITLTED TOPOGRAPHIC MAP OF SANTIAGO PITS, PROVIDED ON 8/24/15.

Ninyo & Moore

EROSION MAP

FIGURE 2

PROJECT NO.	DATE
209509001	11/15

SMITH BASIN SCOUR ASSESSMENT
ORANGE COUNTY WATER DISTRICT
VILLA PARK, CALIFORNIA

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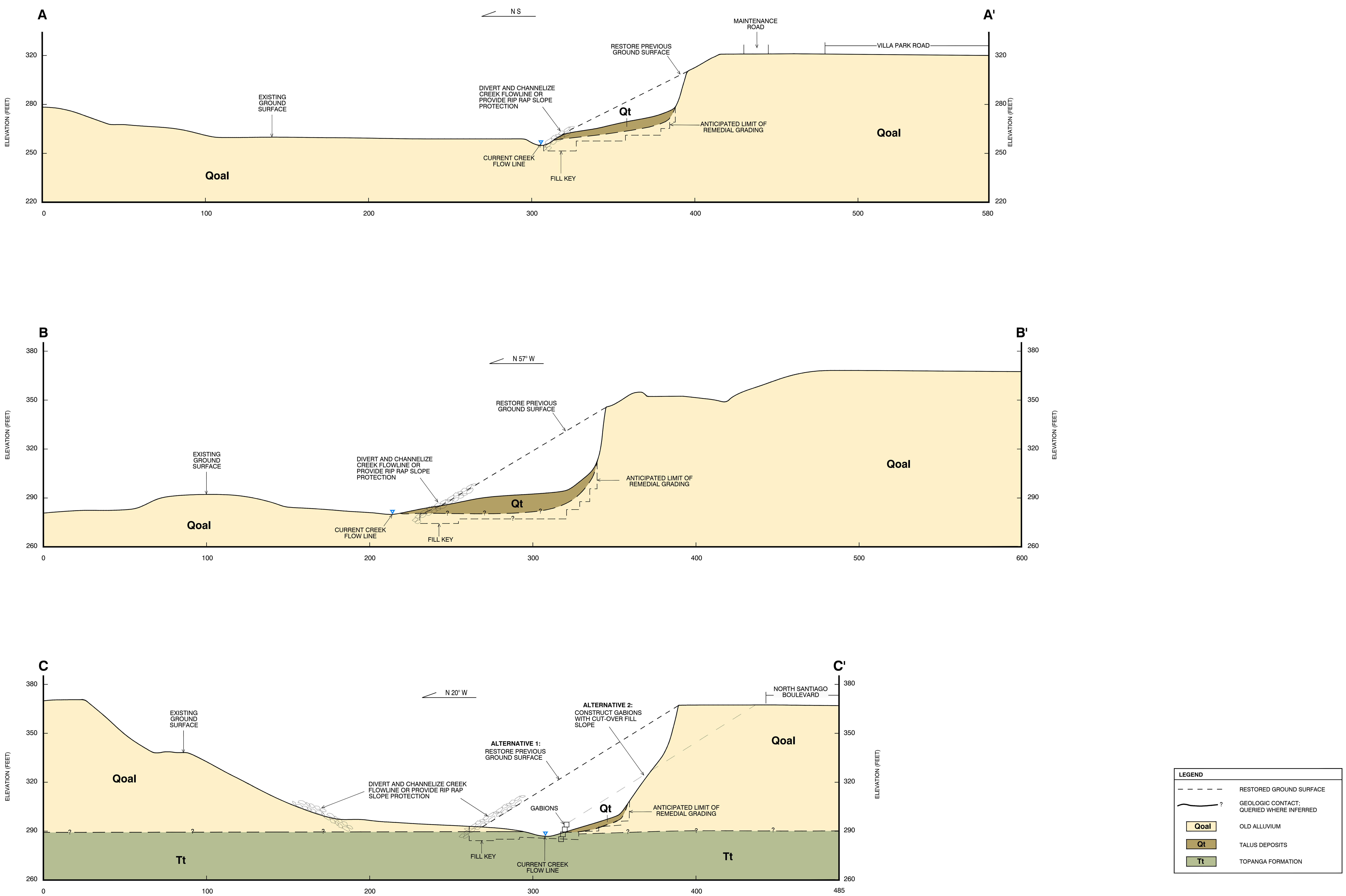

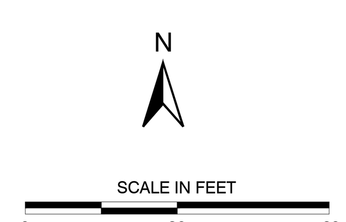

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

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Ninyo & Moore

PROJECT NO.	DATE
209509001	11/15

CROSS SECTIONS

SMITH BASIN SCOUR ASSESSMENT
ORANGE COUNTY WATER DISTRICT
VILLA PARK, CALIFORNIA

FIGURE
3

APPENDIX A

PHOTOGRAPHIC DOCUMENTATION

Photograph 1: **Looking southwest toward Area 1 slope failure. Photograph also shows thick vegetation growth in the basin bottom.**

Photograph 2: **Western portion of slope failure in Area 1 adjacent to Villa Park Road.**

Photograph 3: Central portion of slope failure in Area 1 adjacent to Villa Park Road.

Photograph 4: Easter portion of slope failure in Area 1 adjacent to Villa Park Road.

Photograph 5: **Looking northeast toward Area 2 slope failure. Photograph also shows thick vegetation growth in the basin bottom.**

Photograph 6: **Southwest portion of slope failure in Area 2 adjacent to Oakridge Private School.**

Photograph 7: **Central and southwest portions of slope failure in Area 2 adjacent to Oakridge Private School.**

Photograph 8: **Current flow line of Santiago Creek incising into bedrock and ponding of surface water adjacent to base of Area 2.**

Photograph 9: **Relatively large soil slump near north end of Area 2.**

Photograph 10: **Northeast end of Area 2 below North Santiago Boulevard cul-de-sac where a bridge was destroyed in the 1969 flood event.**

Photograph 11: **Looking northwest across basin, photograph shows thick vegetation growth on the lower portions of the slope and basin bottom.**

Photograph 12: **Approximately 2- to 6-feet-deep erosion in slope area within the basin, Area 3.**

Typical Erosion Rills

Photograph 13: **Area 4 - Erosion rills on south-facing slope that does not have concrete v-ditch drainage improvements.**

Line of dead brush stockpiled on the north basin slope

Near-vertical flood bank in the interior of the basin

Photograph 14: **South-facing slope constructed with concrete v-ditches do not show signs of significant erosion. Dead brush has been stockpiled adjacent to the lower v-ditch. Photograph also shows a near-vertical interior flood bank.**

Obstructed Down drain

Photograph 15: **Concrete v-ditch downdrain obstructed by vegetation.**

Retaining Wall constructed at top of slope

Steeply-eroded side slopes

Photograph 16: **Area 5 - Erosion from beneath residential property extending down basin slope with approximately 6 to 10-foot-high near-vertical side slopes. A retaining wall has been constructed at the top of the slope that is not depicted on Figure 2.**

Photograph 17: **Area 6 - Fill slope above culvert with wave-cut erosion benches up to approximately 18 inches high and near-vertical erosion near basin outlet structure.**

Photograph 18: **Area 6 – Near-vertical erosion scarp upstream of outlet structure.**

APPENDIX B

PROBABLE COST ESTIMATES

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OPINION OF PROBABLE COST
SMITH BASIN
ONSITE FILL FOR SLOPE RECONSTRUCTION

Item No.	Description	Quantity	Unit	Unit Price	Total
I.	**BASE CONTRACT**				
A.	GENERAL				
1	MOBILIZATION	1	LS	$25,000.00	$25,000.00
2	DEVELOP CONSTRUCTION WATER	1	LS	$25,000.00	$25,000.00
3	CLEAR AND GRUB	50	AC	$1,488.00	$74,400.00
B.	AREA 1				
4	FILL KEY	2,315	CY	$7.53	$17,431.95
5	REMEDIAL	2,176	CY	$7.53	$16,385.28
6	Ot REMOVALS	5,831	CY	$7.53	$43,907.43
7	FILL REPLACEMENT FROM ONSITE	4,712	CY	$7.53	$35,481.36
C.	AREA 2				
8	FILL KEY	2,766	CY	$7.53	$20,827.98
9	REMEDIAL	11,279	CY	$7.53	$84,930.87
10	Ot REMOVALS	17,224	CY	$7.53	$129,696.72
11	FILL REPLACEMENT FROM ONSITE	32,598	CY	$7.53	$245,462.94
	AREA 2 - ALTERNATE 1				
12	FILL KEY	1,379	CY	$7.53	$10,383.87
13	REMEDIAL	4,383	CY	$7.53	$33,003.99
14	Qt REMOVALS	1,089	CY	$7.53	$8,200.17
15	FILL REPLACEMENT FROM ONSITE	25,063	CY	$7.53	$188,724.39
	AREA 2 - ALTERNATE 2				
16	GABIONS	3,360	SF	$50.00	$168,000.00
17	REMEDIAL	1,378	CY	$7.53	$10,376.34
18	Qt REMOVALS	1,089	CY	$7.53	$8,200.17
19	CUT	6,431	CY	$7.53	$48,425.43
20	FILL REPLACEMENT FROM ONSITE	3,517	CY	$7.53	$26,483.01
D.	AREA 3				
	REMEDIAL FILL	289	CY	$50.00	$14,450.00
E.	AREA 4				
21	SMOOTH AND RECOMPACT SLOPE	54,215	SF	$1.00	$54,215.00
22	TRIM SLOPE	4,073	CY	$7.53	$30,669.69
F.	AREA 5				
23	REMEDIAL FILL	1,169	CY	$30.00	$35,070.00
G.	AREA 6				
24	SMOOTH AND RECOMPACT SLOPE	25,250	SF	$1.50	$37,875.00

Item No.	Description	Quantity	Unit	Unit Price	Total
H.	RIP-RAP LINED CHANNEL				
25	CLEAR AND GRUB	7	AC	$1,488.00	$10,416.00
26	CHANNEL EARTHWORK (CUT)	42,500	CY	$7.53	$320,025.00
27	RIP-RAP LINED CHANNEL	190,000	SF	$20.00	$3,800,000.00
I.	RIP-RAP LINED BANK				
28	RIP-RAP LINED BANK	56,000	SF	$20.00	$1,120,000.00
	BASE CONTRACT WITH AREA 2 ALT. 1 AND RIP-RAP LINED CHANNEL				$5,261,558.00
	BASE CONTRACT WITH AREA 2 ALT. 1 AND RIP-RAP LINED CHANNEL (25% CONTINGENCY)				$6,577,000.00
	BASE CONTRACT WITH AREA 2 ALT. 1 AND RIP-RAP LINED BANK				$2,251,117.00
	BASE CONTRACT WITH AREA 2 ALT. 1 AND RIP-RAP LINED BANK (25% CONTINGENCY)				$2,813,875.00
	BASE CONTRACT WITH AREA 2 ALT. 2 AND RIP-RAP LINED CHANNEL				$5,282,730.00
	BASE CONTRACT WITH AREA 2 ALT. 2 AND RIP-RAP LINED CHANNEL (25% CONTINGENCY)				$6,603,375.00
	BASE CONTRACT WITH AREA 2 ALT. 2 AND RIP RAP LINED BANK				$2,272,289.00
	BASE CONTRACT WITH AREA 2 ALT. 2 AND RIP RAP LINED BANK (25% CONTINGENCY)				$2,840,375.00

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OPINION OF PROBABLE COST
SMITH BASIN
IMPORT FILL FOR SLOPE RECONSTRUCTION

Item No.	Description	Quantity Unit	Unit Price	Total
I.	**BASE CONTRACT**			
A.	**GENERAL**			
1	MOBILIZATION	1 LS	$25,000.00	$25,000.00
2	DEVELOP CONSTRUCTION WATER	1 LS	$25,000.00	$25,000.00
3	CLEAR AND GRUB	50 AC	$1,488.00	$74,400.00
B.	**AREA 1**			
4	FILL KEY	2,315 CY	$7.53	$17,431.95
5	REMEDIAL	2,176 CY	$7.53	$16,385.28
6	Qt REMOVALS	5,831 CY	$7.53	$43,907.43
7	FILL REPLACEMENT FROM OFF SITE	4,712 CY	$18.00	$84,816.00
C.	**AREA 2**			
8	FILL KEY	2,766 CY	$7.53	$20,827.98
9	REMEDIAL	11,279 CY	$7.53	$84,930.87
10	Qt REMOVALS	17,224 CY	$7.53	$129,696.72
11	FILL REPLACEMENT FROM OFF SITE	32,598 CY	$18.00	$586,764.00
	AREA 2 - ALTERNATE 1			
12	FILL KEY	1,379 CY	$7.53	$10,383.87
13	REMEDIAL	4,383 CY	$7.53	$33,003.99
14	Qt REMOVALS	1,089 CY	$7.53	$8,200.17
15	FILL REPLACEMENT FROM OFF SITE	25,063 CY	$18.00	$451,134.00
	AREA 2 - ALTERNATE 2			
16	GABIONS	3,360 SF	$50.00	$168,000.00
17	REMEDIAL	1,378 CY	$7.53	$10,376.34
18	Qt REMOVALS	1,089 CY	$7.53	$8,200.17
19	CUT	6,431 CY	$7.53	$48,425.43
20	FILL REPLACEMENT FROM OFF SITE	3,517 CY	$18.00	$63,306.00
D.	**AREA 3**			
	REMEDIAL FILL	289 CY	$50.00	$14,450.00
E.	**AREA 4**			
21	SMOOTH AND RECOMPACT SLOPE	54,215 SF	$1.00	$54,215.00
22	TRIM SLOPE	4,073 CY	$7.53	$30,669.69
F.	**AREA 5**			
23	REMEDIAL FILL	1,169 CY	$30.00	$35,070.00
G.	**AREA 6**			
24	SMOOTH AND RECOMPACT SLOPE	25,250 SF	$1.50	$37,875.00

Item No.	Description	Quantity	Unit	Unit Price	Total
H.	RIP-RAP LINED CHANNEL				
25	CLEAR AND GRUB	7	AC	$1,488.00	$10,416.00
26	CHANNEL EARTHWORK (CUT)	42,500	CY	$7.53	$320,025.00
27	RIP-RAP LINED CHANNEL	190,000	SF	$20.00	$3,800,000.00
I.	RIP-RAP LINED BANK				
28	RIP-RAP LINED BANK	56,000	SF	$20.00	$1,120,000.00
	BASE CONTRACT WITH AREA 2 ALT. 1 AND RIP-RAP LINED CHANNEL				$5,914,603.00
	BASE CONTRACT WITH AREA 2 ALT. 1 AND RIP-RAP LINED CHANNEL (25% CONTINGENCY)				$7,393,250.00
	BASE CONTRACT WITH AREA 2 ALT. 1 AND RIP-RAP LINED BANK				$2,904,162.00
	BASE CONTRACT WITH AREA 2 ALT. 1 AND RIP-RAP LINED BANK (25% CONTINGENCY)				$3,630,250.00
	BASE CONTRACT WITH AREA 2 ALT. 2 AND RIP-RAP LINED CHANNEL				$5,710,189.00
	BASE CONTRACT WITH AREA 2 ALT. 2 AND RIP-RAP LINED CHANNEL (25% CONTINGENCY)				$7,137,750.00
	BASE CONTRACT WITH AREA 2 ALT. 2 AND RIP RAP LINED BANK				$2,699,748.00
	BASE CONTRACT WITH AREA 2 ALT. 2 AND RIP RAP LINED BANK (25% CONTINGENCY)				$3,374,685.00

Stantec

O.C.W.D. SMITH BASIN
JN 2042 509700

10/29/15

AREA 1

FILL KEY	133sf x 470' / 27cf =	2,315 CY
REMEDIAL	375sf x 470' / 27cf / 3 =	2,176 CY
Qt REMOVAL	335sf x 470 / 27cf =	5,831 CY
FILL REPLACEMENT	812sf x 470 / 27cf / 3 =	4,712 CY
AREA 1 TOTAL	=	15,034 CY

AREA 2

SECTION B

FILL KEY	145sf x 515' / 27cf =	2,766 CY
REMEDIAL	728sf x 145' / 27cf / 3 =	1,303 CY
	728sf x 370' / 27cf =	9,976 CY
Qt REMOVAL	903sf x 515' / 27cf =	17,224 CY
REPLACEMENT FILL	2104sf x 145' / 27cf / 3 =	3,766 CY
	2104sf x 370' / 27cf =	28,832 CY

SECTION C

FILL KEY	133sf x 280' / 27cf =	1,379 CY
REMEDIAL	582sf x 165' / 27cf =	3,557 CY
	582sf x 115' / 27cf / 3 =	826 CY
Qt REMOVAL	105sf x 280' / 27cf =	1,089 CY
REPLACEMENT FILL	3328sf x 165' / 27cf =	20,338 CY
	3328sf x 115' / 27cf / 3 =	4,725 CY

AREA 2 TOTAL 95,781 CY

Designed by: Checked by:

Stantec

O.C.W.D. SMITH BASIN
JN 2042 5097.00

AREA 2, ALT. 2

10/29/15

SECTION C

GABION	12' HIGH X 280 LF	= 3,360 sf
REMEDIAL	183sf/3 x 115'/27cf =	260 CY
	183sf x 165'/27cf =	1,118 CY
CUT	854sf/3 x 115'/27cf =	1,212 CY
	854sf x 165'/27cf =	5,219 CY
FILL	467sf/3 x 115'/27cf =	663 CY
	467sf x 165'/27cf =	2,854 CY
G+ REMOVAL	105sf x 280'/27cf =	1,089 CY

AREA 2, ALT 2 TOTAL 15,775 CY

AREA 3

REMEDIAL FILL 3,900 # x 4'/2 /27cf = 289 CY

AREA 4

SMOOTH & RECOMPACT SLOPE 54,215 s.f.

(CUT) TRIM SLOPE 564 sf x 195'/27cf = 4,073 CY.

AREA 5

REMEDIAL FILL 6312 sf x 10'/2 /27cf = 1,169 CY

Designed by: Checked by:

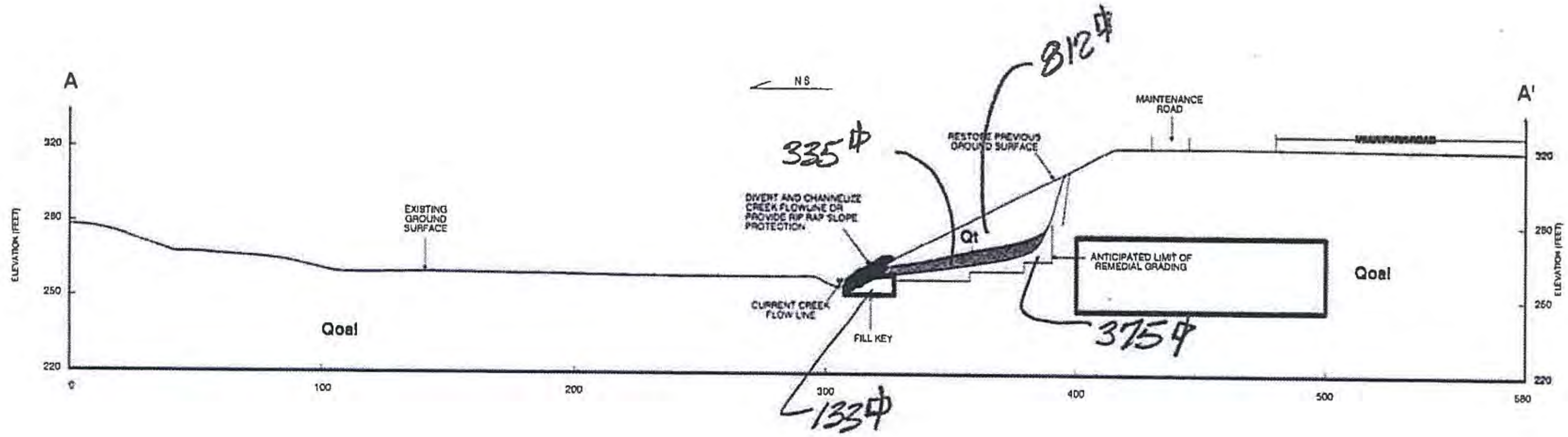
Stantec

AREA 6

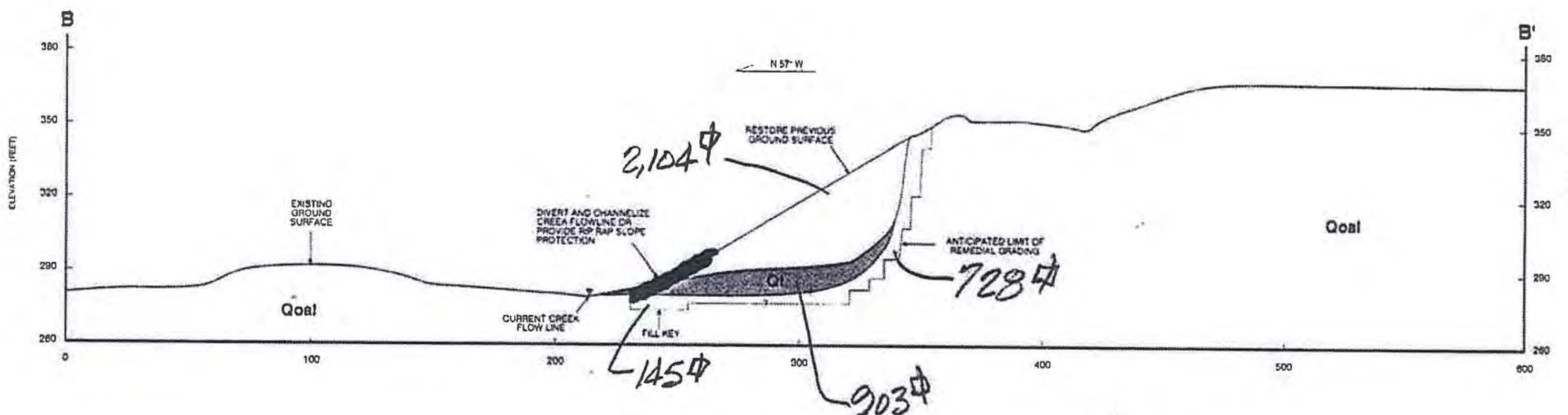
10/29/15

SMOOTH & RECOMPACT 25,250 s.f.

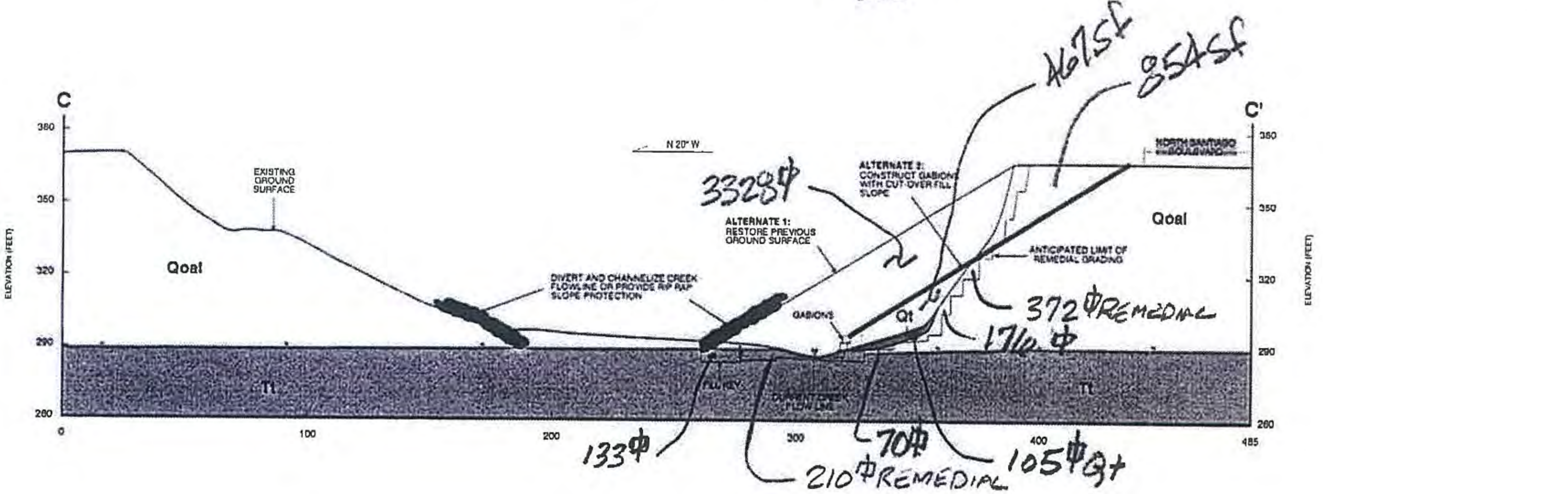
Designed by: Checked by:



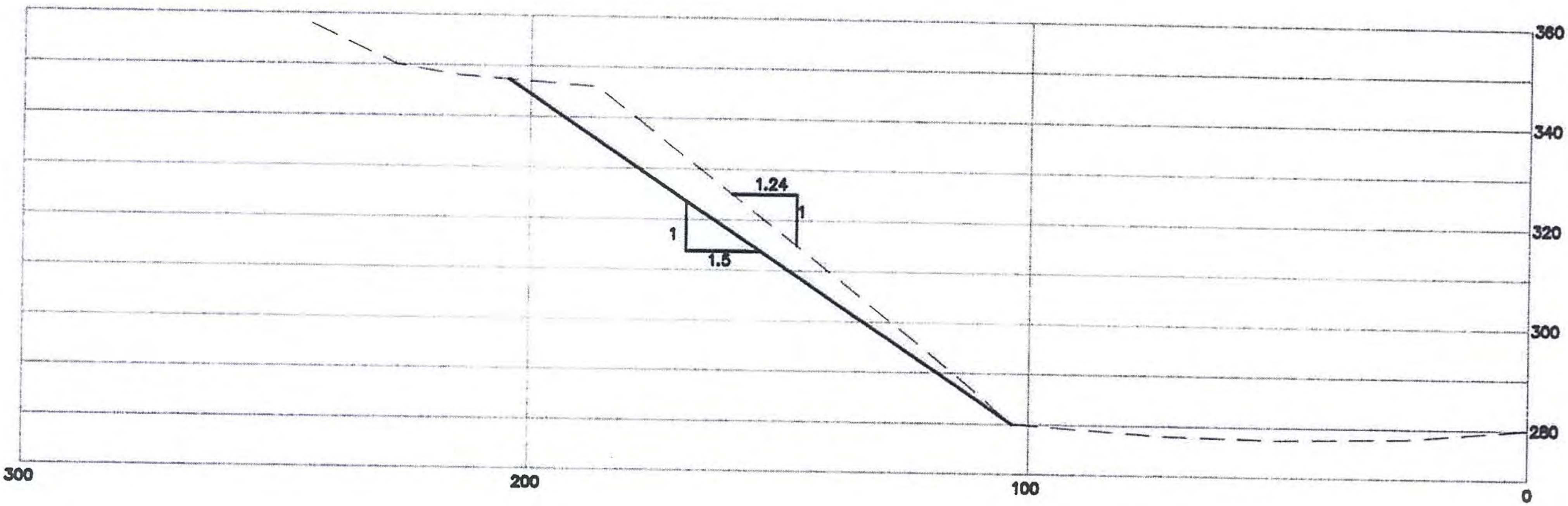
A
A'
N S
MAINTENANCE ROAD
RESTORE PREVIOUS GROUND SURFACE
EXISTING GROUND SURFACE
DIVERT AND CHANNELIZE CREEK FLOWLINE OR PROVIDE RIP RAP SLOPE PROTECTION
Qt
ANTICIPATED LIMIT OF REMEDIAL GRADING
Qoal
CURRENT CREEK FLOW LINE
FILL KEY
ELEVATION (FEET)
812Φ
335Φ
375Φ
133Φ



B
B'
N 57° W
RESTORE PREVIOUS GROUND SURFACE
EXISTING GROUND SURFACE
DIVERT AND CHANNELIZE CREEA FLOWLINE OR PROVIDE RIP RAP SLOPE PROTECTION
Qt
ANTICIPATED LIMIT OF REMEDIAL GRADING
Qoal
CURRENT CREEK FLOW LINE
FILL KEY
ELEVATION (FEET)
2,104Φ
728Φ
145Φ
903Φ



C
C'
N 20° W
NORTH SANTIAGO BOULEVARD
EXISTING GROUND SURFACE
ALTERNATE 2: CONSTRUCT GABIONS WITH CUT-OVER FILL SLOPE
ALTERNATE 1: RESTORE PREVIOUS GROUND SURFACE
DIVERT AND CHANNELIZE CREEK FLOWLINE OR PROVIDE RIP RAP SLOPE PROTECTION
GABIONS
Qt
Qoal
Tt
ANTICIPATED LIMIT OF REMEDIAL GRADING
FILL KEY
CURRENT CREEK FLOW LINE
ELEVATION (FEET)
467sf
854sf
3328Φ
372Φ REMEDIAL
176Φ
133Φ
70Φ
210Φ REMEDIAL
105Φ Qt



AREA 4
SECTION

LAYBACK SLOPE

SCALES
1" = 30'

Stantec

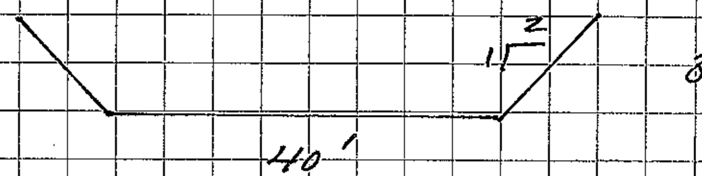
11-18-15

SMITH BASIN

- RIP-RAP LINED CHANNEL – CHANNEL DESIGNED TO CONVEY MAX FLOW OF ABOUT 6,000 CFS

  - EARTHWORK

① 1/2 (40+72) x 8
  ≈ 17 CY/LF



TRAPEZOIDAL CHANNEL TYP. SECTION

② 17 CY/LF x 2,500 LF
  = 42,500 CY

  - RIP-RAP

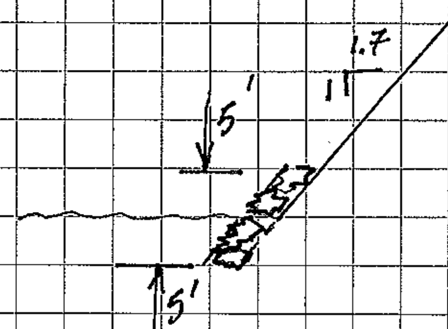
① 18' x 2 + 40'
  = 76 SF/LF

② 76 SF/LF x 2,500 LF
  = 190,000 SF

- RIP-RAP LINED BANK – RIP-RAP REVETMENT ALONG TOE OF SOUTHERLY SLOPE FROM CULVERT TO SCHOOL SITE

  - RIP-RAP

① 2,800 LF x 20 SF/LF
  = 56,000 SF



Designed by: Checked by: