

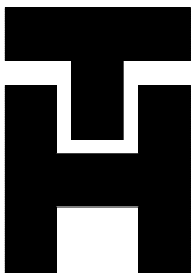
**DRAINAGE STUDY
PHASE 2 REPORT**

FOR:
HIGHWAY 9 & 57
HORRY COUNTY, SC

PREPARED FOR:
**HORRY COUNTY
STORMWATER DEPARTMENT**

APRIL 07, 2016

J-26146.0000



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TABLE OF CONTENTS

Background and Introduction Page 1
Alternative Projects Screening and Evaluation Page 1
Post-Improvement Conditions Model Development Page 3
Study Findings and Summary Page 4
Recommendations Page 7

FIGURES

Alternative 1 1
Alternative 1A 2
Alternative 1B 3
Alternative 2 4
Alternative 2A 5
Alternative 2B 6
Alternative 2C 7
Alternative 3 8

TABLES

Maximum Node Elevation Comparison 1
Flood Risk Analysis 2

APPENDICES

Post-Improvement Conditions ICPR Model Input A
Post-Improvement Conditions ICPR Model Results B
Preliminary Cost Estimates C

EXHIBITS

Post-Improvements ICPR Model Results 1

BACKGROUND AND INTRODUCTION

The Highway 9 & 57 Drainage Study includes two broad phases. Phase 1 was the development of the hydrologic and hydraulic model. Phase 2 consists of an alternatives analysis and recommendations for improvements. This report documents Phase 2 of the study including the screening and evaluation of alternatives and a discussion of the post-improvement model findings. The model developed under Phase 1 was updated to account for build-out conditions of the proposed Baytree development in the upstream (Highway 57) watershed. This build-out model serves as the basis for the analysis of alternatives for Phase 2.

Phase 2 of the Highway 9 & 57 Drainage Study includes the following five tasks:

- Task 1 – Alternative Projects Screening and Evaluation
- Task 2 – Post-Improvement Conditions Model Development
- Task 3 – Opinion of Probable Cost
- Task 4 – Study Findings and Summary

ALTERNATIVE PROJECTS SCREENING AND EVALUATION

Alternative improvement projects were developed to address the flooding issues identified in Phase 1 of the project, consisting of garage and first floor flooding of certain homes during large rainfall events. Figures 1 through 8 illustrate the proposed improvement alternatives.

Alternative 1 – Increase capacity of channel downstream of Highway 9

This alternative consists of improving the channel downstream of Highway 9 to increase capacity. Currently, the dual 6-ft x 6-ft box culvert under Highway 9 outfalls to a narrow channel with steep side slopes.

The improvement would consist of approximately 300 linear feet (LF) of channel improvements with approximately 45 LF being within the existing SCDOT right-of-way and the remainder on private property. This would require the County obtaining drainage easements. The proposed channel improvements would maintain the existing channel alignment and would taper to match the existing channel geometry. Refer to Figure 1.

Alternative 1A – Increase capacity of channel upstream of Highway 9

This alternative consists of improving the channel upstream of Highway 9 to increase capacity. Currently, the channel between the Colonial Charters neighborhood and Highway 9 is narrow with steep side slopes and there is evidence of significant erosion and sediment deposition at the upstream end of the Highway 9 culvert, which blocks a portion of the flow. In addition, portions of the channel and floodplains are overgrown with thick brush.

The improvement would consist of approximately 790 LF of channel improvements with approximately 23 LF being within the existing SCDOT right-of-way and the remainder on private property. This would require the County obtaining a drainage easement. The proposed channel improvements would maintain the existing channel alignment and would taper to match the existing channel geometry. Refer to Figure 2.

Alternative 1B – Increase capacity of channels both upstream and downstream of Highway 9

This alternative consists of improving both channels upstream and downstream of Highway 9 to increase capacity. Currently, the channel downstream of Highway 9 is a narrow channel with steep side slopes. The upstream channel is narrow with steep side slopes and has evidence of significant bank erosion and sediment deposition at the culvert.

The improvement would consist of approximately 300 LF of channel improvements downstream of Highway 9 and 790 LF of channel improvements upstream of Highway 9. Approximately 68 LF of the improvements will be in SCDOT right-of-way, with the remainder on private property. This would require the County obtaining drainage easements. The proposed channel improvements would maintain the existing channel alignment and would taper to match the existing channel geometry. Refer to Figure 3.

Alternative 2 – Replace culvert under Highway 9

This alternative would consist of increasing the capacity of the culvert under Highway 9 to reduce the head loss across the culvert. The existing culvert under Highway 9 consists of a dual 6-ft x 6-ft concrete box culvert.

The improvement would consist of dual 10-ft x 6-ft concrete box culverts. Highway 9 is an SCDOT roadway and the entire length of culvert lies within SCDOT right-of-way. This improvement would require localized grading and riprap installation on both the upstream and downstream ends of the proposed culvert. Refer to Figure 4.

Alternative 2A – Add relief culverts adjacent to existing culvert under Highway 9

This alternative would consist of adding culverts on either side of the existing Highway 9 culvert, to provide relief during larger storm events.

The improvement would consist of two 54" RCPs, approximately 130 LF each, to be constructed within existing SCDOT right-of-way. The pipes would outfall to the existing ditch on the downstream side of Highway 9. The channel on both the upstream and downstream sides would require localized grading and riprap installation. The culverts would be installed using the jack and bore method, so as not to disrupt traffic on Highway 9, which is a heavily trafficked principal arterial roadway. Refer to Figure 5.

Alternative 2B – Increase capacity of channel downstream of Highway 9 and add relief culverts

This alternative would consist of adding relief culverts on either side of the existing Highway 9 culvert and improving the channel downstream of Highway 9 to increase capacity. Currently, the dual 6-ft x 6-ft box culvert under Highway 9 outfalls to a narrow channel with steep side slopes.

The improvement would consist of two 54" RCPs, approximately 130 LF each, to be constructed within existing SCDOT right-of-way. The pipes would outfall to the existing ditch on the downstream side of Highway 9. The channel on both the upstream and downstream sides would require localized grading and riprap installation. The culverts would be installed using the jack and bore method, so as not to disrupt traffic on Highway 9, which is a heavily trafficked principal arterial roadway. The downstream channel improvement would consist of approximately 300 LF of channel improvements with approximately 45 LF being within the existing SCDOT right-of-way and the remainder on private property. This would require the County obtaining drainage

easements. The proposed channel improvements would maintain the existing channel alignment and would taper to match the existing channel geometry. Refer to Figure 6.

Alternative 2C – Increase capacity of channels upstream and downstream of Highway 9 and add relief culverts

This alternative would consist of adding relief culverts on either side of the existing Highway 9 culvert and improving the channel downstream of Highway 9 to increase capacity. Currently, the dual 6-ft x 6-ft box culvert under Highway 9 outfalls to a narrow channel with steep side slopes.

The improvement would consist of two 54" RCPs, approximately 130 LF each, to be constructed within existing SCDOT right-of-way. The pipes would outfall to the existing ditch on the downstream side of Highway 9. The channel on both the upstream and downstream sides would require localized grading and riprap installation. The culverts would be installed using the jack and bore method, so as not to disrupt traffic on Highway 9, which is a heavily trafficked principal arterial roadway. The channel improvements would consist of approximately 300 LF of channel improvements downstream of Highway 9 and 790 LF of channel improvements upstream of Highway 9. Approximately 68 LF of the improvements will be in SCDOT right-of-way, with the remainder on private property. This would require the County obtaining drainage easements. The proposed channel improvements would maintain the existing channel alignment and would taper to match the existing channel geometry. Refer to Figure 7.

Alternative 3 – Construct regional stormwater pond

This alternative consists of constructing a regional stormwater pond upstream of the Colonial Charters neighborhood. This will allow for the diversion of the significant offsite flows from the upstream Highway 57 watershed into the pond. The pond will provide detention for the offsite flow to reduce the burden on the downstream channel as it passes adjacent to the Colonial Charters neighborhood, ultimately reducing/eliminating structural flooding during the smaller storm events.

This improvement would consist of a pond to be constructed on private property. Therefore, this alternative would require the County to acquire some property. Flow would pass under Highway 57 then spill over a long broad weir into the stormwater pond. The pond would serve as additional storage. As the peak flow passes, water will slowly release back into the existing channel. Refer to Figure 8.

POST-IMPROVEMENT CONDITIONS MODEL DEVELOPMENT

The proposed projects were assessed further by incorporating the proposed improvements into post-improvement conditions ICPR models. The proposed models were based on the existing conditions model developed in Phase 1, with the addition of the proposed Baytree development in the upstream (Highway 57) watershed. An independent ICPR model was developed for each alternative scenario and examined for effectiveness. Additional models were developed where the cumulative impact of multiple improvement projects, where feasible, were assessed. The proposed improvements were optimized and sizing and configurations for each proposed improvement project are documented in this report. The 100-year storm event was analyzed for each proposed improvement scenario to compare to existing conditions and to determine if structural flooding or nuisance flooding was occurring. Model inputs are included in Appendix A.

STUDY FINDINGS AND SUMMARY

Thomas & Hutton developed several post-improvement conditions models to analyze a selected group of alternative improvement projects. The improvements were designed to address flooding issues in the Colonial Charters neighborhood consisting of garage and first floor flooding of several private residences. The model results for each alternative are described in detail below. In addition, known disadvantages of each proposed alternative including utility conflicts, site constraints, required easements, etc. are discussed for each alternative. For each alternative project, the maximum stages for nodes within the detailed study area are compared to existing conditions (see Table 1 and Exhibit 1). Model outputs are included in Appendix B. Refer to Exhibit 1 for a summary of the results. The following are observations made from examining the post-improvement conditions model results:

Alternative 1 – Increase capacity of channel downstream of Highway 9

Results show that increasing the capacity of the outfall channel on the downstream side of Highway 9 would reduce peak stages within the area of concern, along the Colonial Charters neighborhood, by anywhere from 0.1 feet to 0.4 feet for the 10-year storm event. Structural flooding of at least two private residences is expected to occur during the 25-year storm event and 11 residences in the 50-year storm event.

There is a potential utility conflict with this alternative consisting of overhead powerlines and power poles running parallel to Highway 9 located about 250 feet downstream of the culvert. These utility poles and overhead lines could conflict with the proposed channel improvements. This alternative requires the County obtaining drainage easements for the construction and maintenance of the improved channel downstream of Highway 9.

Alternative 1A – Increase capacity of channel upstream of Highway 9

Results show that increasing the capacity of the channel on the upstream side of Highway 9 between Colonial Charters neighborhood and Highway 9, does not make much of an impact on the peak stages within the area of concern. The peak stages are reduced by anywhere from 0.0 feet to 0.1 feet for the 2-year storm event. The risk of structural flooding is not being reduced from existing conditions. At least 10 homes still experience flooding during the 25-year storm event and 13 homes during the 50-year storm event.

There is a potential utility conflict with this alternative consisting of a gravity sewer line that crosses under and runs alongside the existing channel from Colonial Charters to Highway 9, before turning and flowing south along Highway 9. Any excavation activities may conflict with this utility and could require relocation. In addition, this alternative requires the County obtaining drainage easements for the construction and maintenance of the improved channel. Additionally, there are overhead powerlines and power poles running parallel to Highway 9 located along the northern SCDOT right-of-way line, and extend east towards the Colonial Charters neighborhood. These utility poles and overhead lines could conflict with the proposed channel improvements.

Alternative 1B – Increase capacity of channels both upstream and downstream of Highway 9

Results show that increasing the capacity of both the outfall channel and the channel upstream of Highway 9 would reduce peak stages within the area of concern, along the Colonial Charters neighborhood, by anywhere from 0.1 feet to 0.5 feet for the 10-year storm event. These reductions are only slightly more than Alternative 1 (improving the downstream channel only).

Structural flooding of at least 2 private residences is expected to occur during the 25-year storm event and 11 residences in the 50-year storm event. Therefore, improving the upstream channel in addition to the downstream channel does not reduce the flooding risk when compared to improving the downstream channel only.

This alternative requires the County obtaining drainage easements on both the upstream and downstream sides of Highway 9 for the construction and maintenance of the improved channels. In addition, there is a potential utility conflict with this alternative consisting of a gravity sewer line that crosses under and runs alongside the existing channel from Colonial Charters to Highway 9, before turning and flowing south along Highway 9. Any excavation activities may conflict with this utility and could require relocation. Additionally, there are overhead powerlines and power poles running parallel to Highway 9 located along the northern SCDOT right-of-way line, and extend east towards the Colonial Charters neighborhood. There are also overhead powerlines and power poles running parallel to Highway 9 located about 250 feet downstream of the culvert. These utility poles and overhead lines could conflict with the proposed channel improvements.

Alternative 2 – Replace culvert under Highway 9

Increasing the capacity of the Highway 9 culvert reduces peak stages in the area of concern by anywhere from 0.1 feet to 0.7 feet for the 25-year storm event. Structural flooding is not expected to occur in the 25-year storm event. 11 homes are expected to flood in the 50-year storm event. The size of the box culvert under Highway 9 serves as a downstream control. In existing conditions, the dual box culvert experiences as much as 1.8 feet of head loss across the culvert in the 25-year storm event. For this alternative, only widening the existing dual culvert was considered, to maintain sufficient cover over the culvert. The resulting head loss is reduced to about 1 foot for the 25-year storm event.

There are several disadvantages to this alternative. Highway 9 is a SCDOT roadway and would require approval/coordination from the SCDOT to proceed with any improvements to the existing structure. Highway 9 is a principal arterial roadway with high traffic volumes and phased traffic control would be required during the installation of the culverts. The cost of excavating, filling, and repaving sections of Highway 9 would also be a factor. There are also potential utility conflicts for this alternative. There is a 10-inch PVC water line crossing the downstream end of the culvert. Excavation activities and the proposed culvert widening could create a conflict and require relocation of the utility. Additionally, there are overhead powerlines and power poles running parallel to Highway 9 located along the northern SCDOT right-of-way line, and extend east towards the Colonial Charters neighborhood. These utility poles and overhead lines could conflict with the installation of the proposed box culvert.

Alternative 2A – Add relief culverts adjacent to existing culvert under Highway 9

Adding relief culverts parallel to the existing box culvert will increase the capacity of the system conveying water under Highway 9. This alternative reduces peak stages in the area of concern by 0.1 feet to 0.6 feet for the 25-year storm event. Structural flooding of at least 1 home during the 25-year storm event and 11 homes during the 50-year storm event is expected to occur. The size of the box culvert under Highway 9 serves as a downstream control. In existing conditions, the dual box culvert experiences as much as 1.8 feet of head loss across the culvert in the 25-year storm event. The addition of the relief culverts reduces this head loss to about 1.1 feet.

There are several disadvantages to this alternative. The proposed method of installation for the two relief culverts is the jack-and-bore method. This is a very expensive method of installation;

however, this would eliminate the need for phased traffic control and the replacement of sections of Highway 9. There are also potential utility conflicts for this alternative. There is a 10-inch PVC water line crossing the downstream end of the proposed culverts. The culvert installation could create a conflict and require relocation of the utility. Additionally, there are overhead powerlines and power poles running parallel to Highway 9 located along the northern SCDOT right-of-way line, and extend east towards the Colonial Charters neighborhood. These utility poles and overhead lines could conflict with the installation of the proposed culverts.

Alternative 2B – Increase capacity of channel downstream of Highway 9 and add relief culverts

Adding relief culverts parallel to the existing box culvert and increasing the capacity of the downstream receiving channel will reduce peak stages in the area of concern by 0.3 feet to 1.3 feet for the 25-year storm event. No structural flooding is expected to occur in the 25-year storm event. Structural flooding of at least 2 homes is expected to occur during the 50-year storm. The size of the box culvert under Highway 9 serves as a downstream control. In existing conditions, the dual box culvert experiences as much as 1.8 feet of head loss across the culvert in the 25-year storm event. The addition of the relief culverts and downstream channel improvements reduces this head loss to about 1.1 feet.

There are several disadvantages to this alternative. The proposed method of installation for the two relief culverts is the jack-and-bore method. This is a very expensive method of installation; however, this would eliminate the need for phased traffic control and the replacement of sections of Highway 9. There are also potential utility conflicts for this alternative. There is a 10-inch PVC water line crossing the downstream end of the proposed culverts. The culvert installation could create a conflict and require relocation of the utility. In addition, there are overhead powerlines and power poles running parallel to Highway 9 located along the northern SCDOT right-of-way line, and extend east towards the Colonial Charters neighborhood. These utility poles and overhead lines could conflict with the installation of the proposed culverts. Additionally, the downstream channel improvements will require the County to obtain drainage easements for the construction and maintenance of the channel.

Alternative 2C – Increase capacity of channels upstream and downstream of Highway 9 and add relief culverts

Adding relief culverts parallel to the existing box culvert and increasing the capacity of both the upstream and downstream channels will reduce peak stages in the area of concern by 0.3 feet to 1.5 feet for the 25-year storm event. No structural flooding is expected to occur in the 25-year storm event and only 1 home is expected to flood during the 50-year storm event. The size of the box culvert under Highway 9 serves as a downstream control. In existing conditions, the dual box culvert experiences as much as 1.8 feet of head loss across the culvert in the 25-year storm event. The addition of the relief culverts and channel improvements reduces this head loss to about 1.1 feet.

There are several disadvantages to this alternative. The proposed method of installation for the two relief culverts is the jack-and-bore method. This is a very expensive method of installation; however, this would eliminate the need for phased traffic control and the replacement of sections of Highway 9. There are also potential utility conflicts for this alternative. There is a 10-inch PVC water line crossing the downstream end of the proposed culverts. The culvert installation could create a conflict and require relocation of the utility. In addition, there is a potential utility conflict with this alternative consisting of a gravity sewer line that crosses under and runs alongside the existing channel from Colonial Charters to Highway 9, before turning and flowing south along Highway 9. Any excavation activities may conflict with this utility and could

require relocation. Additionally, there are overhead powerlines and power poles running parallel to Highway 9 located along the northern SCDOT right-of-way line, and extend east towards the Colonial Charters neighborhood. There are also overhead powerlines and power poles running parallel to Highway 9 located about 250 feet downstream of the culvert. These utility poles and overhead lines could conflict with the proposed channel improvements. This alternative requires the County obtaining drainage easements on both the upstream and downstream sides of Highway 9 for the construction and maintenance of the improved channels.

Alternative 3 – Construct regional stormwater pond

Constructing a regional stormwater pond to provide additional storage for the upstream offsite flow has a minimal effect on the peak stages in the area of concern, adjacent to the Colonial Charters neighborhood. The ponds were modeled as in-line structures that essentially created additional storage for the flow passing from the upstream (Highway 57) watershed to the Highway 9 watershed. Alternative 3A analyzed a smaller 5-acre pond, which resulted in a reduction of peak stages ranging from 0 to 0.3 for the 25-year storm event. Alternative 3B analyzed a large-scale 25-acre pond which resulted in a reduction in peak stages ranging from 0.1 to 0.8. The structural flooding risk for Alternative 3A is not improved when compared to existing conditions. The structural flooding of 10 homes is expected to occur in the 25-year storm event and 13 homes in the 50-year storm event. For Alternative 3B, no structural flooding is expected to occur in the 25-year storm and only 9 homes are expected to experience flooding.

The disadvantages to this alternative include land acquisition for access, construction, and maintenance, as well as the considerable cost of excavation. In addition, depending on the site-specific details, there could be utility conflicts.

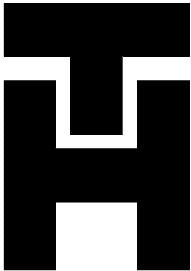
RECOMMENDATIONS

Alternative 2C is the recommended improvement, which consists of the installation of relief culverts and channel improvements upstream and downstream of Highway 9. This recommendation is based on the peak stage and flood risk analyses as described above and a cost comparison of all the alternatives (refer to the preliminary construction cost estimates included in Appendix C). Alternative 2C has the lowest flood risk. The other alternatives are not cost efficient from a flood risk perspective. Based on this information, Alternative 2C will provide desired results at the most effective cost.

**HIGHWAY 9 & 57
DRAINAGE STUDY**

TABLES

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**Table 1
Maximum Node Elevation Comparison**

Storm	WSEL at Node A_up (Upstream of HWY 9)																		
	EX	Alt 1	Δ	Alt 1A	Δ	Alt 1B	Δ	Alt 2	Δ	Alt 2A	Δ	Alt 2B	Δ	Alt 2C	Δ	Alt 3A	Δ	Alt 3B	Δ
2-year	25.58	25.39	-0.19	25.58	0.00	25.39	-0.19	25.27	-0.31	25.32	-0.26	25.02	-0.56	25.03	-0.55	25.37	-0.21	25.34	-0.24
10-year	27.48	26.99	-0.49	27.48	0.00	27.00	-0.48	26.72	-0.76	26.81	-0.67	26.20	-1.28	26.05	-1.43	27.22	-0.26	26.69	-0.79
25-year	28.17	27.82	-0.35	28.16	-0.01	27.81	-0.36	27.38	-0.79	27.51	-0.66	26.47	-1.70	26.53	-1.64	28.08	-0.09	27.36	-0.81
50-year	28.41	28.25	-0.16	28.41	0.00	28.26	-0.15	28.27	-0.14	28.29	-0.12	27.50	-0.91	27.45	-0.96	28.38	-0.03	28.03	-0.38
100-year	28.52	28.40	-0.12	28.52	0.00	28.41	-0.11	28.42	-0.10	28.43	-0.09	28.16	-0.36	28.16	-0.36	28.49	-0.03	28.36	-0.16
Oct-15	28.58	28.48	-0.10	28.58	0.00	28.48	-0.10	28.50	-0.08	28.51	-0.07	28.28	-0.30	28.27	-0.31	28.57	-0.01	28.49	-0.09
Oct-16	28.47	28.34	-0.13	28.47	0.00	28.33	-0.14	28.35	-0.12	28.37	-0.10	27.94	-0.53	27.91	-0.56	28.47	0.00	28.43	-0.04
Storm	WSEL at Node A2 (Adjacent to Colonial Charters)																		
	EX	Alt 1	Δ	Alt 1A	Δ	Alt 1B	Δ	Alt 2	Δ	Alt 2A	Δ	Alt 2B	Δ	Alt 2C	Δ	Alt 3A	Δ	Alt 3B	Δ
2-year	25.85	25.76	-0.09	25.76	-0.09	25.66	-0.19	25.72	-0.13	25.74	-0.11	25.68	-0.17	25.50	-0.35	25.68	-0.17	25.66	-0.19
10-year	27.56	27.15	-0.41	27.52	-0.04	27.09	-0.47	26.98	-0.58	27.04	-0.52	26.58	-0.98	26.38	-1.18	27.31	-0.25	26.84	-0.72
25-year	28.23	27.91	-0.32	28.21	-0.02	27.87	-0.36	27.54	-0.69	27.64	-0.59	26.98	-1.25	26.78	-1.45	28.14	-0.09	27.44	-0.79
50-year	28.50	28.36	-0.14	28.48	-0.02	28.34	-0.16	28.37	-0.13	28.39	-0.11	27.74	-0.76	27.60	-0.90	28.47	-0.03	28.08	-0.42
100-year	28.65	28.55	-0.10	28.62	-0.03	28.52	-0.13	28.56	-0.09	28.57	-0.08	28.34	-0.31	28.29	-0.36	28.61	-0.04	28.44	-0.21
Oct-15	28.74	28.66	-0.08	28.71	-0.03	28.62	-0.12	28.67	-0.07	28.68	-0.06	28.49	-0.25	28.43	-0.31	28.73	-0.01	28.61	-0.13
Oct-16	28.58	28.46	-0.12	28.56	-0.02	28.43	-0.15	28.47	-0.11	28.49	-0.09	28.12	-0.46	28.03	-0.55	28.58	0.00	28.53	-0.05

- Alt 1 Widen downstream channel (15' bottom width and 2:1 side slopes)
- Alt 1A Widen channel upstream of Highway 9 (12' bottom width and 2:1 side slopes)
- Alt 1B Widen upstream and downstream channels (12' bottom width and 2:1 side slopes)
- Alt 2 Upsize HWY 9 Box Culvert to Dual 10' x 6'
- Alt 2A Provide 2 - 54" RCP relief pipes parallel to Existing Highway 9 Culvert
- Alt 2B Provide 2 - 54" RCP relief pipes and widen downstream channel
- Alt 2C Provide 2 - 54" RCP relief pipes and widen both upstream and downstream channels
- Alt 3A Regional stormwater pond (5 acres)
- Alt 3B Regional stormwater pond (25 acres)

**Table 2
Flood Risk Analysis**

Alternative	Flood Houses				
	2-year	10-year	25-year	50-year	100-year
Existing	0	0	10	13	15
1	0	0	2	11	14
1A	0	0	10	13	15
1B	0	0	2	11	14
2	0	0	0	11	14
2A	0	0	1	11	14
2B	0	0	0	2	11
2C	0	0	0	1	11
3A	0	0	10	13	15
3B	0	0	0	9	13

- Alt 1 Downstream Channel Improvements
- Alt 1A Upstream Channel Improvements
- Alt 1B Channel Improvements
- Alt 2 Upsize HWY 9 Box Culvert
- Alt 2A Relief Culverts
- Alt 2B Relief Culverts and Downstream Channel Improvements
- Alt 2C Relief Culverts and Channel Improvements
- Alt 3A Regional stormwater pond (5 acres)
- Alt 3B Regional stormwater pond (25 acres)