WSDOT Hydraulics Section	Hydraulics Field Report	Project Number: Y12463
	Project Name: Goodnough Creek SR 16 MP 16.59 (WDFW 105 K051618a)	Date: 3/26/2021 7/7/2021
	Project Office: TBD	Time of Arrival: 3/26/2021: 12:00pm 7/7/2021: 11:00am
	Location: Goodnough Creek SR 16 MP 16.59	Time of Departure: 3/26/2021: 3:00pm 7/7/2021: 1:30PM
Purpose of Visit: Site Reconnaissance	Weather: Partly Sunny	Prepared By: Joe Griffin

Meeting Location:
Goodnough Creek, Pierce County, SR 16 MP 16.59

Attendance List:

Name	Organization	Date	Role
Shaun Bevan	HDR	3/26/2021; 7/7/2021	Senior Water Resources Engineer
Ian Welch	HDR	3/26/2021; 7/7/2021	Biologist
Joe Griffin	HDR	3/26/2021; 7/7/2021	Water Resources Engineer
Cade Roler	WSDOT	7/7/2021	WSDOT Tribal Liaison
Inder Atwal	WSDOT	7/7/2021	Project Engineer
Heather Pittman	WSDOT	7/7/2021	HQ Hydraulics
David Molenaar	WSDOT	7/7/2021	Biology Program Manager
Damon Romero	WSDOT	7/7/2021	Fish Passage Coordinator
Gina Piazza	WDFW	7/7/2021	Habitat Biologist
Madeline Smith	WDFW	7/7/2021	Habitat Engineer

Bankfull Width:

Describe measurements, locations, known history, summarize on site discussion

HDR conducted an independent site visit on March 26th, 2021 to measure bankfull width, collect pebble count data, and locate a reference reach. HDR walked the stream approximately 550 feet upstream and approximately 300 feet downstream of the existing 4-foot corrugated metal pipe culvert crossing. HDR took six bankfull width (BFW) measurements upstream of the crossing and two bankfull widths downstream of the crossing. See Figure 1 for measurement locations.

A second site visit with HDR, WSDOT, and WDFW was conducted to gain concurrence on bankfull widths and other design considerations. An additional bankfull width measurement was taken during the second site visit downstream of SR16 as well as some slightly revisions to previously measured bankfull width measurements. Table 1 summarizes bankfull measurements taken during the March 26th and July 7th site visits, which were used to determine the design bankfull width. The measured bankfull widths resulted in a **design average bankfull width of 16.5 feet.**

See last page of this field report for further notes on discussions of concurrence and decisions made that help to inform the design.

Table 1: Bankfull width measurements

BFW #	Location	Width (ft)	Included in Design Average	Concurrence Notes
1	Upstream	11.0	Yes	
2	Upstream	14.0	Yes	
3	Upstream	19.5	Yes	No revisions
4	Upstream	21.0	Yes	No revisions
5	Upstream	26.0	Yes	Increased slightly
6	Upstream	14.7	Yes	Increased slightly
7	Downstream	15.0	Yes	Increased slightly
8	Downstream	14.5	Yes	Increased slightly
9	Downstream	13.0	Yes	New measurement
Design Average	**-**	**16.5**	-	

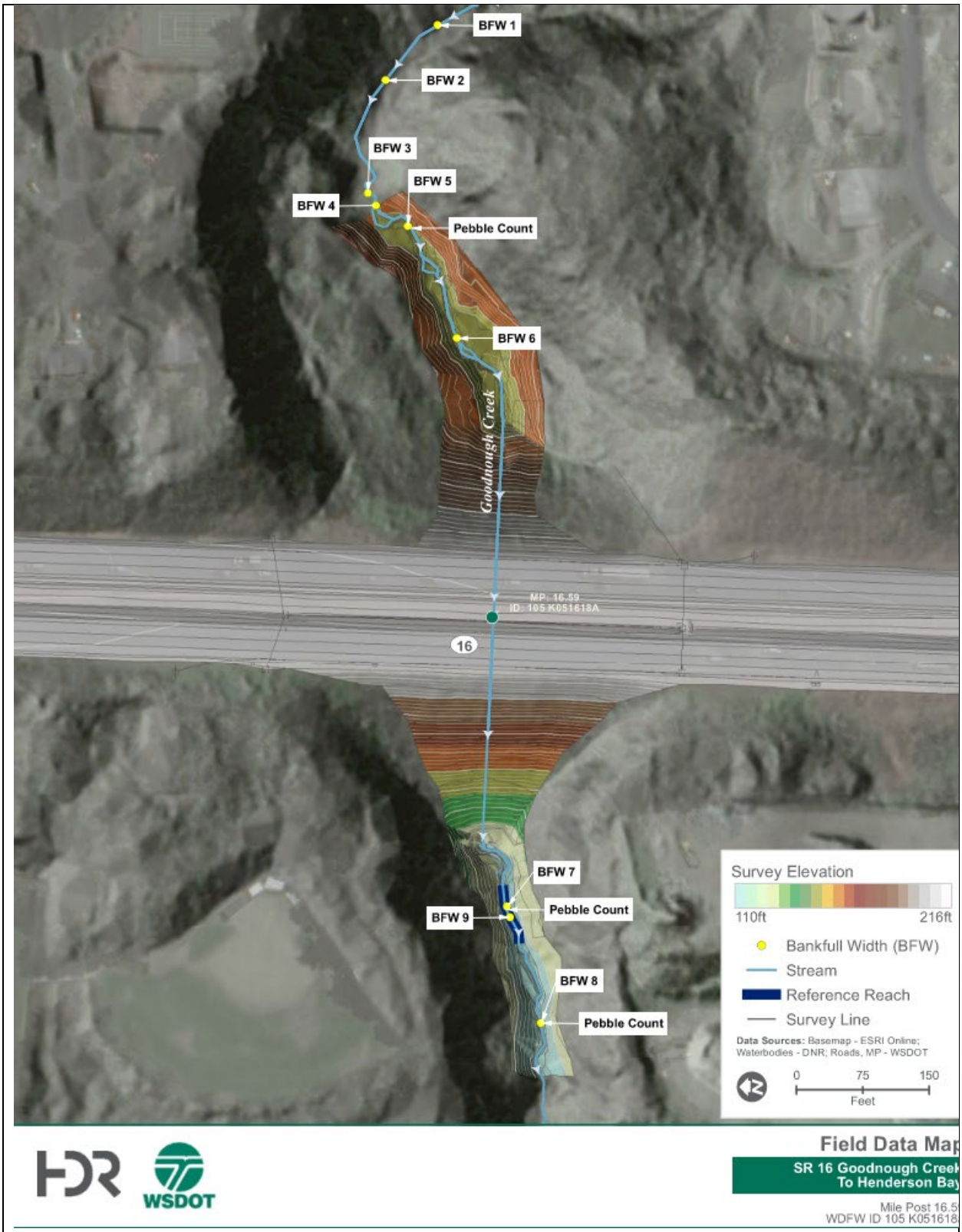

Figure 1: Reference reach, bankfull width, and pebble count locations

Reference Reach:

Describe location, known history, summarize on site discussion, appropriateness, bankfull measurement

The reference reach is located approximately 75 feet downstream of the culvert, shown in Figure 1 above. The reference reach is in a straight section of channel outside of culvert outfall influence and outside of the influence of the downstream LWM accumulation. Cross section geometry in the reference reach will be used for design. BFW 7 was taken within the reference reach and a pebble count was conducted. The slope of the reference reach is analogous to the anticipated design slope for the crossing when looking at the longitudinal profile of Goodnough Creek. The upstream slopes generally appeared shallower than the downstream, which is consistent with the longitudinal profile. During the second site visit with HDR, WSDOT, and WDFW the reference reach and proposed channel cross section was determined to be appropriate.

Data Collection:

Describe who was involved, extents collection occurred within

HDR conducted an independent site visit on March 26th, 2021. HDR walked the stream approximately 550 feet upstream and approximately 300 feet downstream of the existing culvert crossing. HDR took eight BFW measurements, six upstream and two downstream. Three pebble counts were collected during the site visit, one upstream and two downstream. See Figure 1 for locations of bankfull widths and pebble counts.

Observations:

Describe site conditions, channel geomorphology, habitat type and location, flow splits, LWM location and quantity, etc.

Upstream Reach

HDR site observations started 250 feet upstream of the survey limits (approximately 600 feet upstream of the culvert inlet) to collect a wider range of bankfull measurements and evaluate the upstream channel reach. Throughout the upstream reach the channel meanders between the ravine walls, which range from 12 to 25 feet wide from ravine toe to ravine toe. The ravine side slopes are steep with trees and ferns. Within the ravine toe a few small floodplains exists as the bankfull channel meanders between the ravine toes. The channel meandering within the valley is largely driven by large woody material (LWM) recruited through deadfall. The streambed material is primarily sand and gravel with some small cobbles mixed in. The first BFW was taken approximately 200 feet upstream of the survey extents (Figure 3). The valley width was the narrowest at this location and was the smallest bankfull measurement of the eight-total recorded (Figure 4). The observed depth in the channel on the day of the site visit was 4-6 inches with a bankfull depth of approximately 1 foot. The channel slope throughout the upstream reach is approximately 2.5 percent.

Progressing downstream towards the culvert, the valley widens at approximately 450 feet upstream of the existing culvert inlet. The channel morphology in this reach is primarily step pools forced by the LWM that has fallen into Goodnough creek. Active floodplains span the valley and alternate sides as the channel meanders. BFW 2 measurement was 14 feet with a 20" tall depths and a 10-foot-wide floodplain (Figure 5). Shrubs and ferns grow at the top banks and in the floodplains. Some trees of smaller diameter and branches are scattered throughout the channel.

At the upstream survey extents or approximately 350 feet upstream of the culvert entrance, the stream flow depth on the day of the site visit was less than 6-inches and meanders across the entire

ravine width for approximately 100 feet. The ravine side slopes are steep, and the channel is confined. Three bankfull measurements were taken throughout the reach ranging from 19.5 to 25 feet that reached across the whole ravine. See Figure 6 for BFW 3, Figure 8 for BFW 4 and Figure 9 for BFW 5. The channel briefly becomes braided with a mid-channel gravel bar for a short length with a pool under large wood material (Figure 7). The banks are covered in brush and the streambed is a mix of small to medium gravel (Figure 8). Erosion is visible where the channel has incised against the bank toe (Figure 9). A log jam is located approximately 200 feet upstream of the culvert inlet that creates another short segment of braided channel (Figure 12). The sediment around the log jam consists of fines and gravel. Downstream of the log jam (approximately 160 feet upstream of the culvert inlet) the ravine walls widen and there is an approximately 25-foot-wide floodplain on the left bank (Figure 13).

The channel remains relatively uniform from this location up to the entrance of the culvert. The floodplains are covered in small brush and fallen wood (Figure 15). The stream sediment is primarily fines with some gravel mixed in. There are cobbles and small branches in front of the culvert inlet (Figure 16). The culvert has steel wingwalls mitered to the embankment slopes and is a 4-foot CMP pipe that is straight without any drops between the entrance and exit. The entrance to the culvert is clear without sediment present.

Downstream Reach

The culvert exit has scoured the bottom channel and rusted around what was once the steel wingwalls (Figure 17). Ground water was observed seeping through the hill side and a small pipe is visible with little flow coming out of it. The scour pool is approximately 3 feet deep created from high velocity at the culvert outlet. Immediately downstream of the culvert outlet the channel bends left and then immediately right, there is a small water surface drop from a buildup of small branches and cobbles (Figure 18). Like the upstream reach, the creek is at the bottom of a ravine with a small floodplain confined by the steep ravine walls. The channel continues to meander between ravine toes. Meandering is driven by LWM and to a much lesser extent a few boulders observed within the reach. Immediately downstream of the small drop (Figure 19) the channel substrate is mix of moderate to large gravel with a few observed locations of exposed compacted clay banks shown in Figure 20 and Figure 21.

Further downstream of the water surface drop the stream gradient increases and the channel narrows compared to the upstream reach (Figure 22). This location was selected as the reference reach due to the gradient being more closely representative of the prevailing slope of the channel from the survey longitudinal profile. Step pool morphology was observed within the reference reach. The slopes downstream of the culvert and through the reference reach are higher than upstream, approximately 4.0 percent. The stream has low sinuosity through the reference reach. The BFW measurement (BFW 7) within the reference reach was 14.5 feet. Within the reference reach few areas had small floodplains and primarily the top of banks transitioned into the confined ravine walls. The material within the reference reach was larger than the pebble count conducted upstream and consisted primarily of coarse gravel with a few small cobbles (Figure 23).

Continuing downstream from the reference reach the channel remains uniform with a small floodplain on the right bank. Exposed compact clay is visible along the left bank toe (Figure 25). The bankfull depth is roughly 1.5 feet and the floodplains contain small shrubs and downed wood. A few 2-man boulders were observed throughout this reach (Figure 26). Further downstream from

approximately 200 to 280 feet downstream of the culvert outlet, a series of log jams from downed trees with small boulders that have created small water surface drops is shown in Figure 27, Figure 28, and Figure 29. The last BFW measurement (BFW 8) was taken downstream before the end of the survey downstream of the series of water surface drops created by LWM and was 14.0 feet (Figure 30). At the downstream survey limits large wood material spans the width of the channel and another observation of compacted clay along the right bank. After the end of the survey the stream is densely covered by devil's club and small trees (Figure 33). A third pebble count was conducted near BFW 8.

Pebble Counts/Sediment Sampling:

Describe location of sediment sampling and pebble counts if available

Three pebble counts were conducted to provide an accurate assessment of the streambed material distribution throughout the upstream and downstream reach. The upstream pebble count had resulted in a greater amount of fine sediment. The two downstream pebble counts were conducted in the near bankfull widths 7 and 8 (Figure 1) and the upstream pebble count was conducted near BFW 5**.** BFW 5 and BFW 8 pebble counts consisted of approximately 150 particles each. The pebble count in the reference reach near BFW 7 consisted of approximately 250 particles Each individual pebble count and the cumulative distribution is provided in Figure 2 and Table 2**.** The material primarily consists of medium coarse gravels with only a few cobbles observed, most of which were observed within the reference reach at BFW 7. The largest particle observed was 24-inches in diameter found downstream of the reference reach (Figure 26). Boulders up to 46-inches were observed sporadically throughout the downstream reach (Figure 34).

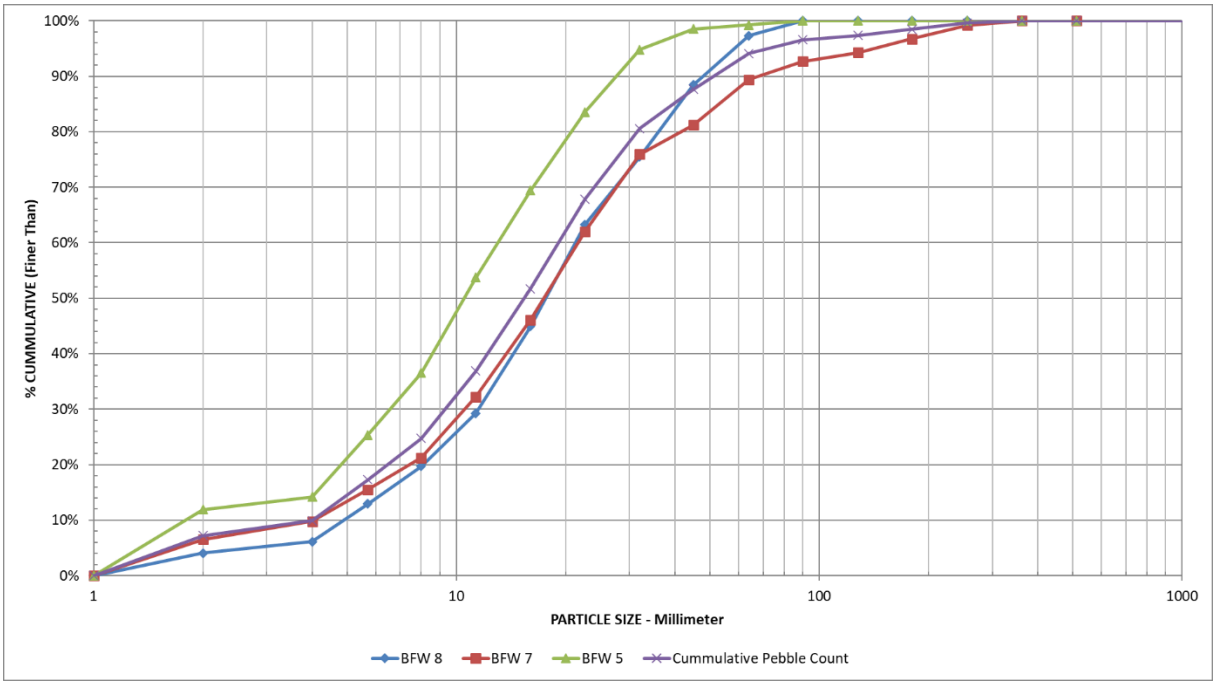

Figure 2: Sediment size distribution

Table 2: Sediment properties upstream and downstream of project crossing

	BFW 5 (US)		BFW 7 (DS)		BFW 8 (DS)		Cumulative	
Particle	Diameter (in)	Diameter (mm)	Diameter (in)	Diameter (mm)	Diameter (in)	Diameter (mm)	Diameter (in)	Diameter (mm)
$\mathbf{D_{16}}$	0.2	4.1	0.2	5.5	0.2	6.3	0.2	5.8
$\mathbf{D_{50}}$	0.4	10.5	0.7	17.4	0.7	17.6	0.7	17.5
$\mathbf{D_{84}}$	0.9	22.3	2.0	50.7	1.6	40.0	1.8	45.1
$\mathbf{D_{95}}$	1.3	32.7	5.6	141.4	2.3	58.4	3.4	86.0
$\mathbf{D_{100}}$	3.5	90.0	14.3	362.0	3.5	90.0	14.3	362.0

Photos:

Any relevant photographs listed above

Figure 3: BFW 1 approximately 250 feet upstream of survey extents

Figure 4: Upstream channel ravine

Figure 5: BFW 2 approximately 100 feet upstream of survey extents

Figure 6: BFW 3 measurement

Figure 7: Braided channel near upstream survey extents

Figure 8: BFW 4 measurement

Figure 9: BFW 5 full ravine toe width measurement

Figure 10: Streambed material at BFW 5

Figure 11: Channel spanning LWM

Figure 12: LWM accumulation

Figure 13: Ravine widens

Figure 14: BFW 6

Figure 15: Upstream channel near culvert entrance

Figure 16: Culvert entrance

Figure 17: Culvert exit

Figure 18: Downstream channel after culvert exit

Figure 19: Channel widens after water surface drop

Figure 20: Typical exposed compacted clay bank

Figure 21: Exposed compacted clay bank

Figure 22: Reference reach

Figure 23: Substrate material in reference reach

Figure 24: Reference reach and BFW 7 measurement

Figure 25: Looking downstream, left bank exposed compact clay at toe

Figure 26: 24-inch boulder in stream

Figure 27: LWM accumulation

Figure 28: Water surface drop from small logs

Figure 29: Water surface drop from boulder and small woody material accumulation

Figure 30: BFW measurement 8

Figure 31: Looking upstream from the end of survey

Figure 32: Channel spanning LWM and clay bank

Figure 33: Downstream survey extents

Figure 34: boulder observed during BFW concurrence

Samples:	
Work within the wetted perimeter may only occur during the time periods authorized in the APP ID 21036 entitled "Allowable Freshwater Work Times May 2018". Work outside of the wetted perimeter may occur year-round. APPS website: https://www.govonlinesaas.com/WA/WDFW/Public/Client/WA_WDFW/Shared/Pages/Main/Login.aspx	
Were any sample(s) collected from below the OHWM?	*No ☒ If no, then stop here.*
	Yes ☐ If yes, then fill out the proceeding section for each sample.

Sample #:	Work Start:	Work End:	Latitude:	Longitude:

Summary/description of location:

Summarize/describe the sample location.

Description of work below the OHWL:

Describe the work below the OHWL, including equipment used and quantity of sediment sampled.

Description of problems encountered:

Describe any problems encountered, such as provision violations, notification, corrective action, and impacts to fish life and water quality from problems that arose.

Bankfull Width Concurrence Meeting:

Describe date and time of BFW concurrence meeting, attendees, any measurements, concurrence or decisions made that help to inform the design. You may have follow up information from this meeting and any follow up may be documented here as well.

A second site visit with HDR, WSDOT, and WDFW was conducted on July 7th, 2021 to gain concurrence on BFWs and other design considerations for Goodnough Creek at SR 16. Squaxin Island Tribe was invited to the site visit but was unable to attend. During the site visit WDFW and WSDOT took spot BFW measurements and concurred with several of the BFWs measurements. BFW measurements 5, 6, 7, and 8 were increased slightly and one additional BFW measurement downstream was collected (BFW 9). The design average is presented in Table 1. The largest BFW observed during the site visit was 26 feet, but this occurred at a location of significant LWM influence and where the channel had recently moved with the active channel encompassing the entire valley width. WDFW was comfortable with the overall average BFW presented in Table 1. WDFW concurred on pebble count classification for all three locations.

HDR clarified that the 4.2% slope in the downstream is likely to be much closer to the design slope through the crossing than the prevailing 2.5% to 3.0% observed upstream. This is driven by the vertical drop that currently exists through the culvert. The difference in slopes between the upstream reach and downstream reach was apparent through the water velocity and step pool configuration downstream. The proposed design is anticipated to use a design slope on the order of 5.2% near the maximum allowable slope ratio to reduce grading impacts. WDFW agreed with the approach and to limit the grading extent and impacts to the existing riparian corridor. WDFW also prefers to end the upstream grading before an existing log jam if possible.

Part of the discussion on site was that the design average from the bankfull width will not be the main factor driving the structure width. The minimum hydraulic opening recommended in the PHD will be based on a meander belt analysis to size the structure to accommodate anticipated plan form variability. During the site visit the proposed channel shape was discussed with the intent to provide a bankfull channel width on the order of 9 feet and floodplain benches beyond that until a total valley bottom width is reached like that observed in the field of 22 feet. WDFW spot checked the valley toe width upstream and agreed with the approach for the cross-section design.

A large cedar tree downstream of the culvert on the left bank ravine wall should be protected during construction. The cedar tree is roughly 13-feet from the existing chain link fence bend as it turns to go up the ravine wall.