GREEN DIAMOND RESOURCE COMPANY
California Timberlands Division
PO Box 1089
Arcata, California 95518
T (707) 668-4400
F (707) 668-3710
greendiamond.com

February 15, 2016

Mr. John Corbett, Chairman

Mr. Matt St John, Executive Officer

North Coast Water Quality Control Board

5550 Skylane Blvd. Suite A
Santa Rosa, CA 95403

VIA EMAIL; NORTHCOAST@WATERBOARDS.CA.GOV

RE: Comments on the Tetra Tech, Inc. report (Oct. 21, 2015): "Upper Elk River: Technical Analysis for Sediment" and the "Draft Action Plan for the Upper Elk River Sediment TMDL"

Dear Chairman Corbett and Matt:

Thank you for the opportunity to provide comments on the Upper Elk River: Technical Analysis for Sediment (Tetra Tech Report) and the Draft Action Plan for the Upper Elk River Sediment TMDL (Draft Action Plan). Green Diamond owns 2059 acres of timberland in the Elk River drainage with all but 154 acres in the South Fork Elk River drainage. This land was acquired by Simpson Timber Company in 1978, and this property experienced limited harvesting activing during this period until 2006.

Recognizing that Elk River is a very sensitive watershed, we have worked closely with your staff for over 20 years to develop workable management solutions for our ownership in this basin. This started in 1993 with the development of the Salmon Creek Management Plan which was also implemented in Elk River. This plan recognized the sensitivity of these two drainages and included unique and "ahead of their time" mitigations that included: straw mulching of new roads, no winter road use, and no broadcast burning. In 2006 we worked closely with your staff to develop the "South Fork Elk River Management Plan" that was the foundation for the SF Elk River Watershed Wide-WDR (SF Elk WDR) approved in 2006. In 2010 we again worked with staff to develop the Property-Wide Roads WDR (Roads WDR), that directs the reconstruction and maintenance of forest roads. This was followed by the property-wide Forest Management WDR in 2012 that covers silviculture, road construction and other management activities and is the only such permit in the state.

Even though we purchased the property in 1978, our first harvest occurred in 1993 under the Salmon Creek Management Plan with a second harvest in 1998. Our next harvest entry was not until 2006 , after the approval of the 2006 SF Elk WDR. From 1978 to 2006 we harvested a total of 280 acres, which included long periods of no harvest. In 2006 we conducted a complete sediment-source survey of our road system in the SF Elk River drainage and implemented a sediment removal and road upgrading program. This sediment reduction program is now 98% complete with final completion planned for 2016. Based on Tetra Tech Report the total management-related sediment from our lands from 2006-

2011 was 3290 yd^3/mi^2. During this same time period we have removed or prevented 9353 yd^3/mi^2 of sediment from delivering from our road system to a watercourse.

Based on GDRCo's long history of proactive and prudent management in the watershed, we believe the management related sediment estimates provided in the Tetra Tech Report are inaccurate and the natural sediment estimates are underestimated. We also believe there are many other technical issues and concerns in the Tetra Tech Report. As such GDRCo, in coordination with HRC, requested Dr. Lee MacDonald to conduct a thorough technical review of the Tetra Tech Report. Dr. MacDonald has provided his technical comments in a separate correspondence to the Water Board. However, GDRCo would like the Water Board to recognize Dr. MacDonald's technical comments on the Tetra Tech Report as an extension of GDRCo's comments. Additionally, GDRCo conducted a thorough evaluation of an underlying and foundational assumption made in the Tetra Tech Report which has been perpetuated from previous Water Board Staff reports (e.g. Peer Review Draft Staff Report to Support the Technical TMDL for the Upper Elk River). This key issue is related to the inappropriate estimation of the drainage density for both managed and unmanaged basins. This issue results in a significant overestimation of management related sediment sources (e.g. bank erosion, streamside landslides, low order channel incision, and deep-seated landslides) and a significant underestimation of natural sediment sources (e.g. bank erosion, streamside landslides, and deep-seated landslides). As you can see this error impacts nearly all the sediment source categories; both natural and management. The write-up of this evaluation of the drainage density assumptions in the Tetra Tech Report and other related Water Board staff documents is included as Attachment 1 to this comment letter and should be utilized in adjusting the sediment source estimates that were derived and extrapolated based on drainage density estimates.

For reference, included as Attachment 2 is a summary of the unique management practices that GDRCo implements on our South Fork of Elk River property.

<u>Response to Sediment Source Analysis</u>

A review of Table 1 from the Draft Action Plan and Table 9 from the Tetra Tech Report provides a timeline of sediment estimates for the period 1955- 2011 by anthropogenic and natural loading. The peak sediment anthropogenic loading occurred during the period 1988- 1997 at 966 $yd^3/mi^2/yr$. During this 10 year period Green Diamond only harvested 140 acres in the Elk River drainage. During the period 1998-2000 the anthropogenic loading was 531 $yd^3/mi^2/yr$, when we harvested an additional 140 acres. Given that GDRCo only harvested 280 acres for the period 1978-2000 (23 years for an average of 12.2 acres per year), it is hard to imagine that GDRCo's harvest contributed significantly to the sediment loading during this period. It is also of interest to note that Table 1 from the Draft Action Plan and Table 9 and Figure 15 from the Tetra Tech Report show improving sediment conditions for Elk River. Attachment 3 shows the gross harvest acres per year since GDRCo has owned property in Elk River through 2015 with the corresponding watershed-wide annual management related sediment delivery estimated from the Tetra Tech Report from 1978 through 2011 (the latest year estimated in the report). The estimates in the Tetra Tech Report do not correlate with our harvesting activities in the watershed. Furthermore, as mentioned above, when GDRCo did conduct operations in the watershed we did so recognizing the basin's sensitivity by incorporating additional mitigation measures in our practices.

Response to Hillslope Water Quality Indicators and Numeric Targets

The following is an item-by-item response to Table 2 of the Draft Action Plan and Table 5 of the Tetra Tech Report that outlines the Hillslope Water Quality Indicators and Numeric Targets for the Upper Elk River Sediment TMDL:

Hydrologic connectivity of roads to Watercourses: Since 2006 GDRCo has upgraded nearly all of the road systems and treated 98% of the sediment sites. This included hydologically disconnecting the roads from watercourses and installing "critical dips" at every watercourse crossing. It must be noted that it is not possible to achieve 100% disconnection. With critical dips properly installed there are short distances (potentially on either side of the crossing depending on the road grade) that slopes towards the watercourse. These segments of road can never be truly hydrologically disconnected as the numeric target indicates (e.g. 100% of road segments hydrologically disconnected from watercourse). GDRCo has specific feasible mitigation measures to address to address surface erosion from roads such as by straw mulching all newly-constructed roads prior to the winter period, excluding winter operations and limiting winter road use. The only management use of the roads during the winter is for quad runners, and we even close some roads to quad runners.

Sediment delivery due to road-related landslides: Our road construction, reconstruction and maintenance efforts are designed to minimize road width and soil movement and to address unstable fill slopes. GDRCo's road treatment efforts have been very extensive and effective over time as evidenced by the road effectiveness monitoring GDRCo has conducted under the Road WDR for Elk River.

Sediment delivery due to surface erosion from harvest areas: Our harvesting systems are designed to minimize soil disturbance. We use skyline cable yarding on slopes averaging >35% and shovel yarding on the more gentle slopes. This means that we not construct skid roads. We also do not conduct broadcast burning. Post- harvest conditions often include undisturbed duff layers and small to medium sized slash distributed across the area. We are concerned that "100% of harvest areas have ground cover sufficient to prevent surface erosion" is an unobtainable goal. There will always be small areas of bare soil. Where these areas are adjacent to watercourses they are treated to prevent sediment from entering the watercourse. A better way to word with numeric target is: "Harvest areas have ground cover sufficient to prevent sediment from surface erosion from delivering to watercourses."

Sediment delivery from open slope landslides due to harvest-related activities: We have not witnessed non-road related "open slope landslides" as a sediment source on our Elk River timberlands. Our road management and harvest planning are designed to avoid and mitigate identified unstable features. By not constructing skid trails and by hydrologically disconnecting the road systems we maintain the natural surface and subsurface drainage system thereby preventing concentration of water or disrupting soil tubes. Since 2001 (beginning 5 years prior to the implementation our SF Elk WDR) we have observed only 5 landslides on our Elk River timberlands through aerial photo review. Of these five landslides none would be considered an open slope landslide and only two resulted in delivered sediment to a watercourse for a total of 243 cubic yards of delivered sediment. Both of the landslides that delivered to a watercourse would be considered streamside landslides and represent an annual loading of about 6 $yd^3/mi^2/yr$ over this period using aerial photographs.

Sediment delivery from deep-seated landslides due to harvest- related activities: We believe GDRCo's harvesting mitigations are effective in preventing accelerated movement of deep-seated landslide. See above response.

New management discharge sites: Our entire management regime (SF Elk Management Plan, Roads WDR, shovel yarding, sediment site treatments/road upgrades, no winter operations, seasonal road use restrictions, no broadcast burning) is designed to avoid sediment discharge into watercourses. Looking forward, the potential for generating new sediment sources will occur following treatment of the sediment sites and road upgrades due to minor site adjustments. Small amounts of mobilized sediment from post-treatment adjustments is fully expected and justified as these actions are preventing potential larger volumes of sediment from entering the system. GDRCo's road treatment process is nearly completed and was delayed in 2015 due to the presence of a spotted owl.

Headward incision in low order channels: This has been a key discussion with staff and an issue we have investigated. We have not seen examples of this on harvested areas in Elk River. Our management measures that include RMZs and EEZs adjacent to all watercourses and our cable and shovel yarding minimizes soil compaction and prevents the need to construct skid trails thereby not interrupting the soil tubes and maintaining natural water drainage patterns.

Peak flows: Our ownership in nearly entirely in the SF Elk drainage. The confluence of the NF and SF are downstream of the area with chronic flooding (Dead Woman's Curve). In our 2006 SF Elk WDR we were not regulated for peak flow issues. Regardless, we do not believe GDRCo's limited harvesting is significantly contributing to peak flows. Our ownership represents 15.3% of SF Elk River and 5.5% of the entire Elk River drainage. Our SF Elk River Management Plan provides for 75 acres/year (three year average) of harvest. Since 2006 , in actuality GDRCo has harvested an average of 63 acres/year, of which 55.4 acres/year were harvested using evenaged management.

Channels with actively eroding Banks: Actively eroding stream banks are a natural process within the watershed that can be exacerbated by harvest activities. Our observations indicate that the observed bank erosion adjacent to watercourses on our ownership is primarily related to stored sediment from historical logging. These areas are protected by RMZs and EEZs that prevent disturbance during operations. We have observed occasional inter-channel soil movement and stream bank erosion. However these processes are not the result of contemporary practices, but are the result of a combination of natural processes and historical logging events (pre 1900 and 1950-1960s). This stored sediment appears to move when in-stream LWD decays and during high flow events. The degree of movement and adjustment is dependent upon the channel flows.

Characteristics of riparian zones (i.e., 300 feet on either side of the channel) associated with Class I and II watercourses: The use of a 300' zone is based on the North West Forest Plan that was applicable to federal lands with the habitat of the northern spotted owl. We do not believe this should be used in the TMDL/WDR process. The following is an excerpt from RECORD OF DECISION for Amendments to Forest

Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl, April 1994: "Riparian reserves are areas along all streams, wetlands, ponds, lakes, and unstable or potentially unstable areas where the conservation of aquatic and riparian-dependent terrestrial resources receives primary emphasis. **The main purpose of the reserves is to protect the health of the aquatic system and its dependent species; the reserves also provide incidental benefits to upland species. These reserves will help maintain and restore riparian structures and functions, benefit fish and riparian-dependent non-fish species, enhance habitat conservation for organisms dependent on the transition zone between upslope and riparian areas, improve travel and dispersal corridors for terrestrial animals and plants, and provide for greater connectivity of late-successional forest habitat." (emphasis added)** Clearly this is out of the scope of the TMDL and beyond the authority of the Board. Further, we believe that our current RMZ measures that are part of the approved SF Elk Management Plan and our approved federal Aquatic HCP is adequate to protect the beneficial uses of water and the goals of the TMDL. Under our evenaged management regime it may be difficult to demonstrate "Improvement in the quality/health of the riparian stand so as to promote 1) delivery of wood to channels, 2) slope stability, and 3) ground cover" within the proposed 300' riparian zone. We have found that our 150' zones on Class I and 75-100' zones on Class II watercourses are providing the key riparian function of: sediment filtering, large wood recruitment, and temperature control. We do believe there is a need for 300' zones. Also, we have a limitation of one entry per rotation within our riparian zones. This means that once we have harvested any trees within a riparian zone, we will not reenter that zone for 50+ years in the future. Given the average harvest age is around 60 years of age, upon reentry the riparian zones will be over 100 years of age before any future harvesting occurs.

<u>Characteristics of riparian zones (150' on either side of the channel) associated with Class III watercourses:</u> The primary purpose for Class III protection is to maintain channel and bank stability, and maintain in-channel structures that store and meter sediment. We have EEZs that prevent any equipment disturbance within the protection zone (30' for slopes <60% and 50' for slopes >60%). The protection measures within these zones include retention of hardwood and sub-merchantable conifers (<12" DBH) and all trees that provide channel and bank stability.

<u>Bankfull Channel Capacity:</u> See Dr. Lee MacDonald's comments on the Tetra Tech Report for additional information on this subject.

<u>Chronic turbidity:</u> Based on the responses provided above, we do not believe that our current management practices are significantly contributing to chronic turbidity. GDRCo believes that Elk River has always had exceptionally high natural sediment loads and associated turbidity levels due to the poorly consolidated underlying bedrock and rapid uplift rates in the watershed. We further believe the principle source of management turbidity is from the adjustment of in-channel stored sediment that is a function of historical logging practices. See Dr. Lee MacDonald's comments on the Tetra Tech Report for additional information on this subject.

Again, we appreciate the opportunity to comment on the Tetra Tech Report and Draft Action Plan and look forward to the completion of this TMDL process and plan to continue to support and participate in the Elk River Watershed Stewardship Program. In addition we recognize the need to reconsider the South Fork Elk River Management Plan to ensure consistency with the TMDL and look forward to working with your staff in this process.

Sincerely,

Gary C. Rynearson

Gary C. Rynearson, Manager

Forest Policy and Communications

CC: NCRWQCB Members

ATTACHMENT 1

Analysis of the Drainage Density Assumption in the Elk River TMDL Documents

Analysis of the Drainage Density Assumptions in the Elk River TMDL Documents

By

Matthew House and David Lamphear

The following three documents make the assumption that management activities have expanded the drainage network in Elk River due to a combination of tractor and road crossings and hydrologic modifications: 1) Peer Review Draft Staff Report to Support the Technical TMDL for the Upper Elk River (Regional Water Board 2013), 2) Upper Elk River Sediment Analysis and Implementation Plan (Regional Water Board 2015), and 3) Upper Elk River: Technical Analysis for Sediment (Tetra Tech 2015). In the following text, these three documents are collectively referred to as the "Elk River Sediment Source Analysis", unless otherwise specifically identified.

The management effects identified in the Elk River Sediment Source Analysis on the natural drainage network is purported to have caused headward incision of low order channels. GDRCo believes the methodology utilized in the Elk River Sediment Source Analysis to estimate this potential management effect and determine the drainage density for both the unmanaged and managed basins is fundamentally flawed and grossly overestimates management related sediment where ever the analysis utilizes a natural or management derived drainage density.

The Elk River Sediment Source Analysis relies on the PhD dissertation of Matthew Buffleben (Buffleben 2009) to establish unmanaged and managed drainage densities. The assumed differences in drainage densities are the basis for which the sediment delivery estimates are extrapolated from an unmanaged condition to a managed condition. Buffleben (2009) surveyed six channels heads in Little South Fork Elk River (representing an unmanaged area) and derived a median contributing area value (4.22 ha) that defined the stream inception to then develop a representative natural drainage density for all of Elk River (5.5 mi/mi^2). Buffleben (2009) similarly surveyed a total of 39 channel heads in two managed basins (Corrigan Creek and South Branch North Fork Elk River). The median contributing area value for these managed basins was 0.52 ha that defined the stream inception and resulted in a purported management drainage density 16.5 mi/mi^2 for Elk River.

It has long been recognized that drainage densities are a function of more than simply drainage area (e.g. Montgomery and Dietrich, 1988). Pelletier (2013) describes two fundamental problems with the contributing area methodology: 1) a drainage density derived from the analysis of average (or median) contributing area depends on the threshold, which is circular reasoning; and 2) the contributing area methodology doesn't account for the fact that channels typically form in areas of localized, concentrated flow; not just because there is a large contributing area. We believe Pelletier's second point is the principal reason the drainage density is so grossly overestimated. The process creates so many fictitious channels in areas where there are no valley constrictions in which to confine flow. The literature is rich with many more sophisticated methodologies to derive a drainage network (e.g. Montgomery and Dietrich, 1988; Montgomery and Dietrich, 1989; Tarboton and Ames 2001; Orlandini et al. 2011; Pelletier 2013; Clubb et al. 2014) than the contributing area process alone; but, it is has been demonstrated that these methodologies overestimate the true drainage density (Clubb et al. 2014). The methodology used by Buffleben was a contributing area process whereby the median contributing area calculated from a sample of field mapped channel heads was used as the threshold to derive a GIS-based stream network for managed and unmanaged conditions.

GDRCo further evaluated the validity of the contributing area approach presented in Buffleben (2009) to derive managed versus unmanaged drainage densities by utilizing field based channel mapping that was conducted for timber harvest plan layout within the McCloud Creek basin. McCloud Creek is a 2.37 mi^2 watershed and GDRCo owns approximately 85% of the basin. In 2006, GDRCo was issued WDRs for its operations in S.F. Elk River including McCloud Creek. Since 2006, GDRCo laid out 17 THP units within the McCloud Creek catchment that included 46 channel heads that terminated either within or adjacent to the THP boundary (Figure 1). Since these channel heads were within a THP boundary they were guaranteed to be field verified by an RPF and a high proportion received confirmation by state agency representatives during the Pre-Harvest Inspection process for THP approval to ensure no watercourses were missed and to verify the terminus of the channel head (e.g. top of the Class III channel). A GIS analysis was conducted to calculate the contributing area for each channel head location. The summary results for the two managed basins from Buffleben (2009) were included with the McCloud Creek data for comparison (Table 1). The drainage areas for the channel heads in McCloud Creek is highly positively skewed (Figure 2). Based on the range, median and average presented for the data in Buffleben (2009) we assume the data for all three study basins were also highly positively skewed (Table 1). GDRCo's actual field mapped drainage density is 9.41 mi/mi^2. If GDRCo was to derive the stream layer using the contributing area methodology with the median drainage area (0.258 ha), the resulting drainage density would be 26.28 mi/mi^2, 2.8 times higher than reality (Figure 3). For illustration purposes GDRCo also developed the hypothetical drainage network for McCloud Creek using the 0.52 ha as was applied in the Elk River Sediment Source Analysis and compared it to GDRCo's field mapped drainage network (Figure 4). The resulting stream density was 18.86 mi/mi^2 which overestimates the actual field mapped stream density by 100%. All the watercourses shown in yellow in Figure 4 are fictitious streams that amount to an extra 22.4 miles of channels that do not exist on the landscape. The implications of this is that Elk River Sediment Source Analysis attributes management related sediment from deep seated landslides, low order channel incision, bank erosion, and streamside landslides to these nonexistent channels.

As mentioned above, the Elk River Sediment Source Analysis assumes that the managed drainage density is 16.5 mi/mi^2. With such highly skewed data and with drainage areas of channel heads that span multiple orders of magnitude, it is inappropriate to use simple descriptive statistics such as average, median, or mode and expect to derive a realistic watercourse network that represents field conditions. Utilizing the median and average, for example, creates fictitious watercourse channels that do not exist on the landscape which the Elk River Sediment Source Analysis assumes are present and asserts are causing and delivering sediment to the Lower Elk River.

It is equally inappropriate to use simple descriptive statistics of a few drainage areas of channel heads to derive the natural stream network and drainage density (especially from a sample size of six) in Little South Fork Elk River and assume a uniform natural drainage density. An appropriate methodology would be to field map the drainage network in the manner in which THPs are laid out; all the channel heads are delineated. The actual drainage density of the field mapped watercourses from an unmanaged watershed would determine the natural drainage density. However it is important to note that even extrapolating an average drainage density from a complete field derived drainage network such as what we recommend be done in Little South Fork Elk River can still result in great uncertainties in the actual natural drainage densities and spatial arrangement of the watercourses across the entire Elk River watershed. To illustrate this point we evaluated the drainage density of various watersheds where the drainage network was derived from a standardized contributing area (e.g PWA 2008).

PWA (2008) conducted bank erosion surveys in three watersheds within Elk River (Corrigan Creek, South Branch North Fork Elk River, and Little South Fork Elk River). The basins were selected to represent managed (Corrigan Creek and South Branch North Fork Elk River) and unmanaged areas (Little South Fork Elk River) for purposes of comparing banks erosion estimates. PWA developed a GIS-based stream layer by assuming a 0.8 ha contributing area to define the location of the stream inception and create a sampling frame to randomly select reaches to survey for bank erosion. This stream layer development process is management independent and heavily influenced by basin shape (long and skinny vs round) and drainage pattern (trellis vs dendritic). Utilizing the standardized contributing area of 0.8 ha resulted in varying stream densities for these three basins within Elk River (11.09 mi/mi^2, 11.88 mi/mi^2, and 10.57 mi/mi^2 for Corrigan Creek, South Branch North Fork Elk River, and Little South Fork Elk River, respectively). Even though these three basins have similar shape (long and skinny) and drainage patterns (trellised), this contributing area methodology resulted in a greater than 12% difference in drainage densities. If you compare a drainage pattern that is more dendritic, you would expect to have even a higher drainage density using the contributing area methodology. For example McCloud Creek has a combination of a dendritic and trellised drainage pattern. The drainage density of McCloud Creek when a 0.8 ha contributing area is used to define the location of the stream inception is 15.19 mi/mi^2 (a 43.7% increase above Little South Fork Elk River simply due to basin shape and drainage pattern). This illustrates the flawed methodology of utilizing a standardized contributing area approach to create a drainage network. Interestingly the GDRCo field mapped drainage density of 9.41 mi/mi^2 compares very closely to the HRC field mapped drainage density of 9.96 mi/mi^2 that was reported in the Peer Review Draft Staff Report to Support the Technical TMDL for the Upper Elk River (Regional Water Board 2013). However the Board staff dismisses this best available data and chooses to utilize the flawed methodology presented in Buffleben (2009). The Water Board staff gave the following reasons for disregarding this information (Regional Water Board 2013):

1) Incomplete mapping of low order channels in the watershed assessment area as they were done associated with THP lay-out over time and standards of practice for identification of low order watercourses have evolved.

2) Most watercourses were initially mapped on the coarser-scale USGS topographic maps. The use of LiDAR for channel mapping would likely improve the channel mapping, however was not available until 2005.

3) Watercourses have likely extended following first, second, and third cycle logging. Watercourses identified as part of THP layout in the period spanning the1980s through the 2000s, likely have incised headward following THP operation.

It is interesting that GDRCo's and HRC's independent drainage density estimates that were derived from LiDAR and field mapping differed by only 6%. Even if we were to assume that all the watercourses in GDRCo's McCloud Creek had extended due to headward incision from early logging practices by 100 feet, the drainage density would have been 8.51 mi/mi^2(potentially a realistic unmanaged drainage density). This illustrates how the attempt by Water Board staff to account for the potential effect of early logging practice impacts on the watercourse network has resulted in a gross overestimate of the management related sediment inputs to Elk River.

To illustrate the magnitude of error this created in the Elk River Sediment Source Analysis let's assume a theoretical management related rate 3 $yds^3/mi/yr$ for bank erosion and streamside landslides. The sediment yield on a per unit area basis utilizing GDRCo's actual field mapped drainage density value of 9.41 mi/mi^2 for McCloud Creek would result in 28 $yds^3/mi^2/yr$; however, using the inappropriately modeled drainage network derived from Buffleben (2009) with the median contributing area value of 0.52 ha and resulting drainage density of 16.5 mi/mi^2 would result in 48 $yds^3/mi^2/yr$ (a 70% overestimate in management related bank erosion and streamside landslides. There would be similar gross overestimations for each sediment source category in the Elk River Sediment Source Analysis that utilized the fictitious management drainage density estimate. A corresponding underestimation error will also be present for all nature sediment source categories in the Elk River Sediment Source Analysis that relied on the fictitious natural drainage density estimate.

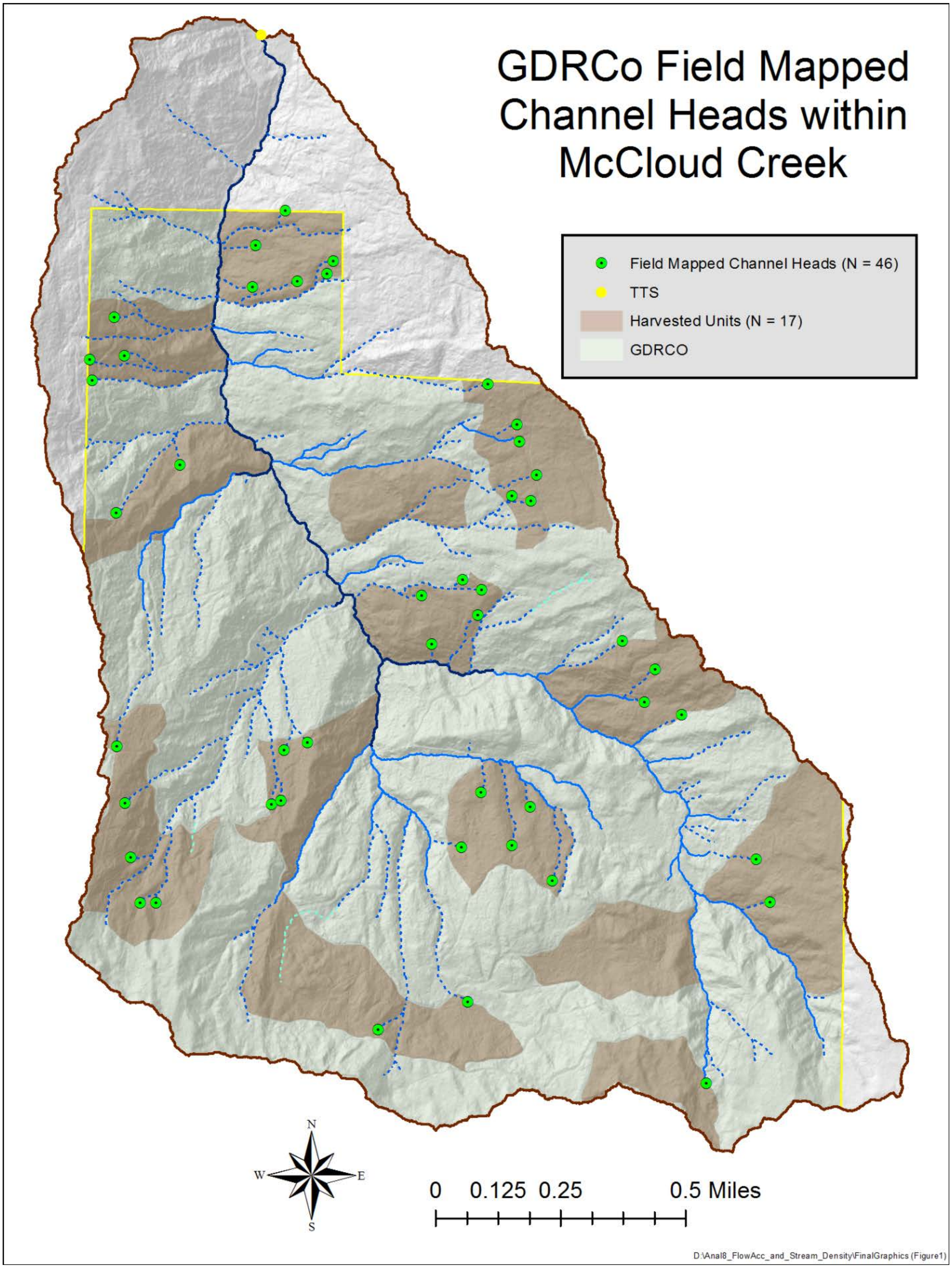

Figure 1. GDRCo's field mapped channel heads from 14 THP units in McCloud Creek.

Table 1. Contributing drainage area above field mapped channel heads. South Branch North Fork Elk and Corrigan Creek data from Buffleben (2009).

		Drainage Area (ha)			
Watershed	Number of channel heads	Minimum	Maximum	Median	Average
South Branch North Fork Elk River	22	0.07	2.69	0.42	0.69
Corrigan Creek	17	0.12	3.3	0.72	0.98
McCloud Creek	46	0.0015	4.098	0.258	0.746

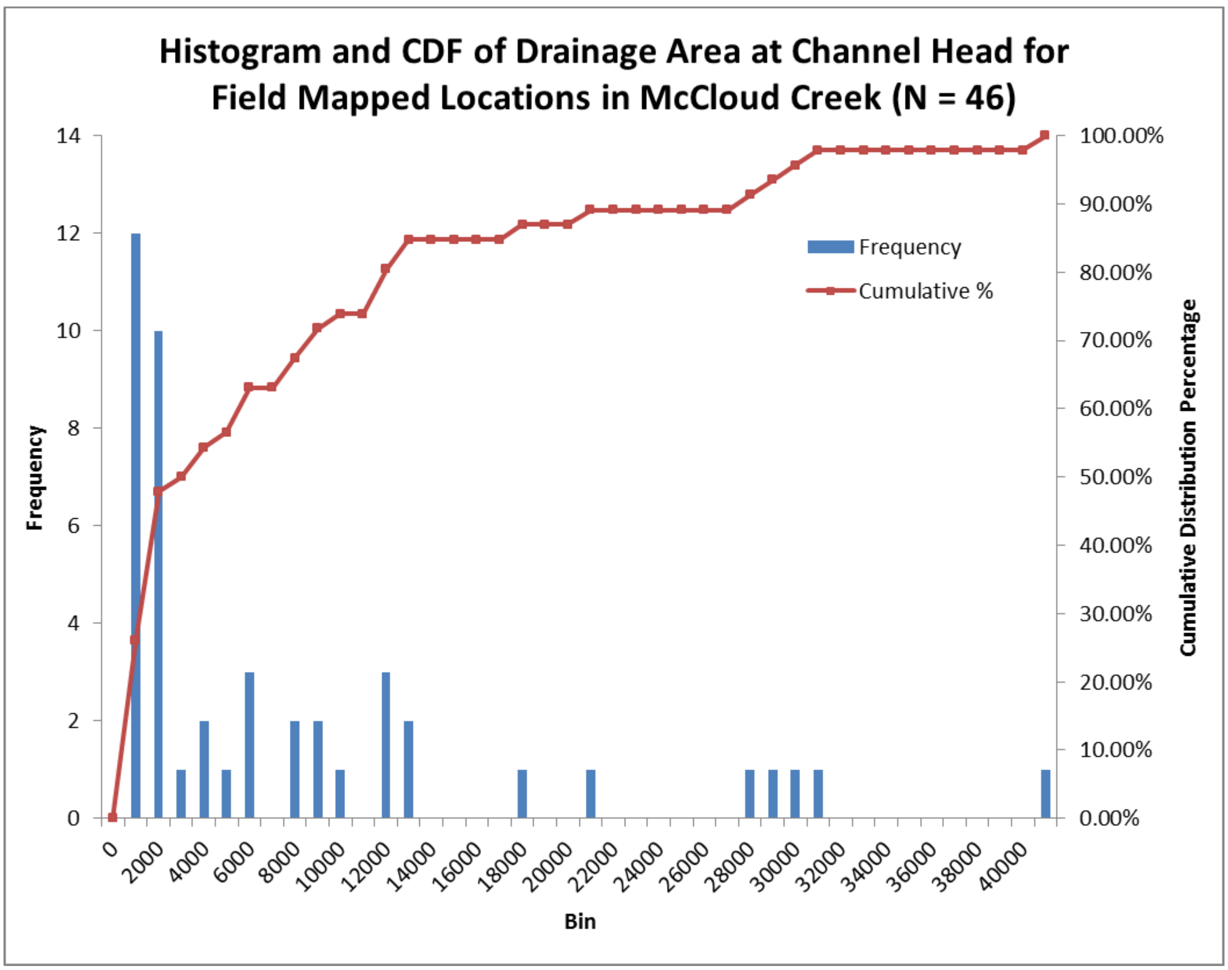

Figure 2. Histogram and cumulative distribution of drainage area above the 46 field mapped channel heads from 17 THP units in McCloud Creek. Bins are in units of m^2.

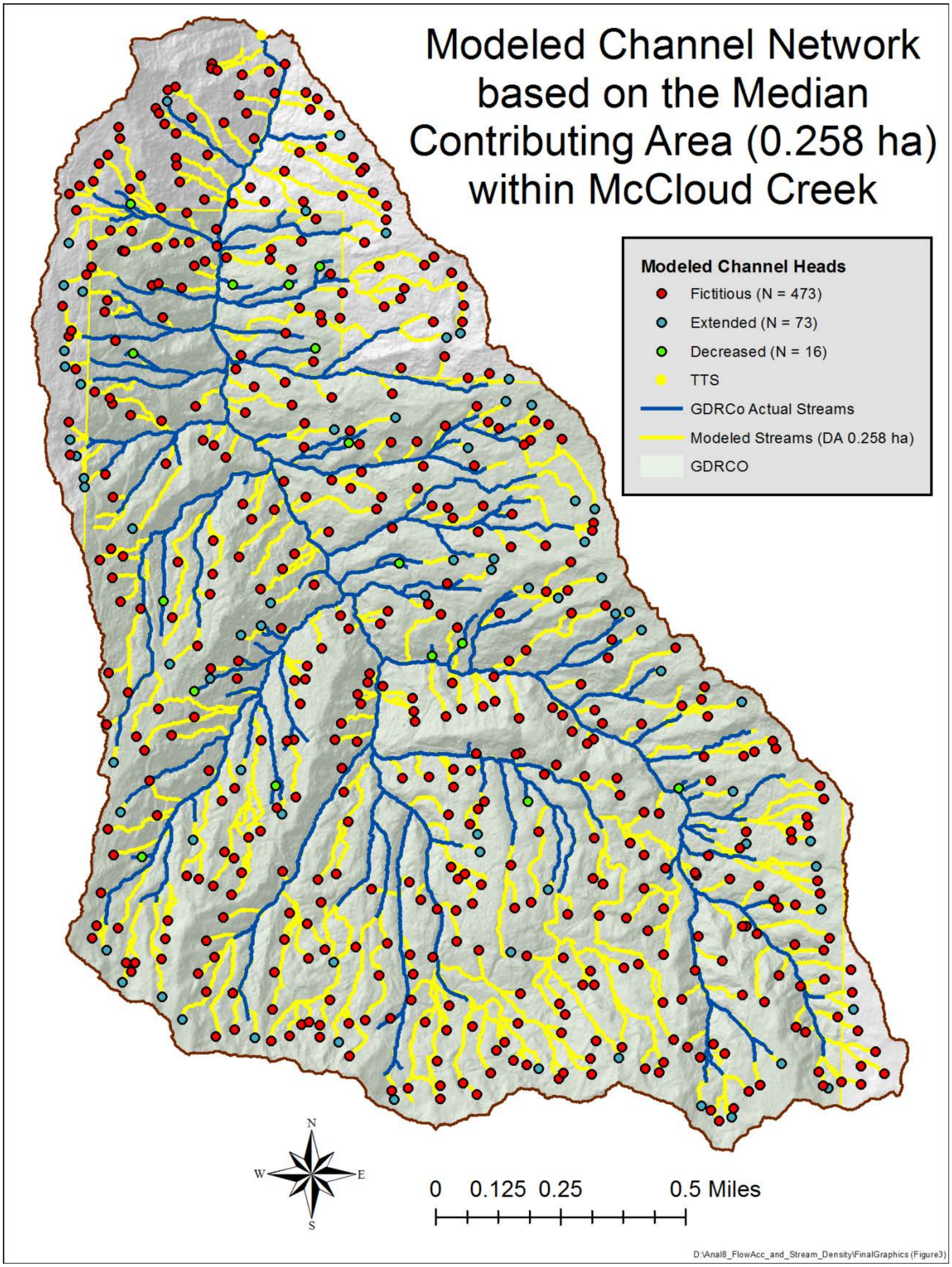

Figure 3. McCloud Creek field mapped channel network (blue lines) compared to the fictitious channel network (26.28 mi/mi^2) derived from the median contributing drainage area (0.258 ha) from field mapped channel heads within 14 THP units in McCloud Creek. Note: an additional 40 miles of hypothetical stream are shown in yellow due to this contributing area calculation.

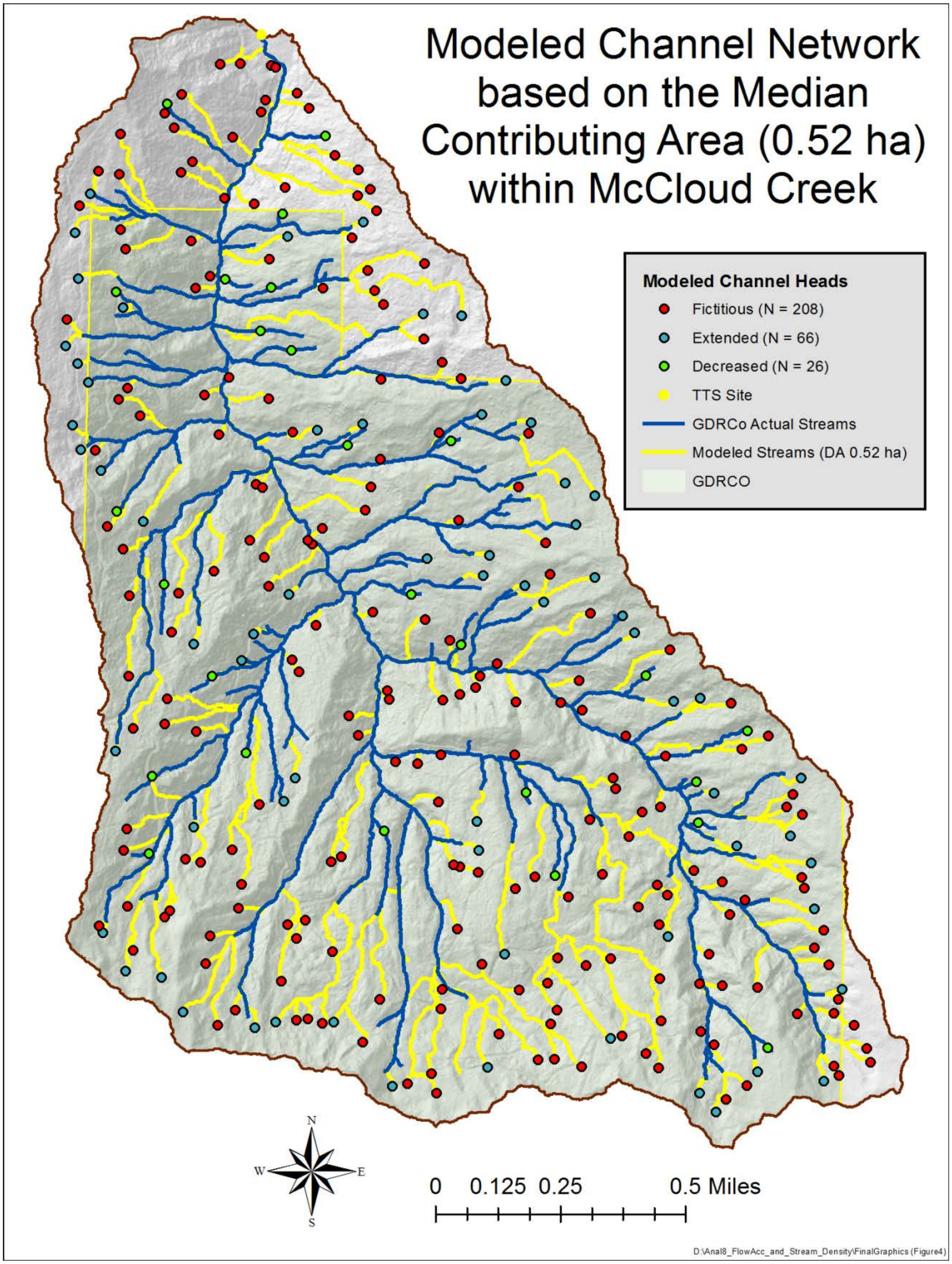

Figure 4. McCloud Creek field mapped channel network (blue lines) compared to the fictitious channel network (18.86 mi/mi^2) derived from the median contributing drainage area (0.52 ha) used in the Elk River Sediment Source Analysis (yellow lines). Note: an additional 22.4 miles of hypothetical stream are shown in yellow due to this contributing area calcuation.

References

Buffleben M. 2009. Assessment of soil creep sediment generation for total maximum daily load development in a Northern Coastal California Watershed. PhD Dissertation, University of California, Los Angeles.

Clubb, F. J., S. M. Mudd, D. T. Milodowski, M. D. Hurst, and L. J. Slater (2014), Objective extraction of channel heads from high-resolution topographic data, Water Resour. Res., 50, 4283–4304, doi:10.1002/2013WR015167.

Montgomery, D.R. and Dietrich, W.E., 1988. Where do channels begin? Nature 336, 232-234.

Montgomery, D.R. and Dietrich, W.E., 1989. Source areas, drainage density, and channel initiation. Water Resources Research 25, 1907–1918.

North Coast Regional Water Quality Control Board (Regional Water Board). 2013. Peer Review Draft Staff Report to Support the Technical Sediment Total Maximum Daily Load for the Upper Elk River. March 4, 2013.

North Coast Regional Water Quality Control Board (Regional Water Board). 2015. Upper Elk River Sediment Source Analysis and Implementation Plan. March 18, 2015.

Orlandini, S., P. Tarolli, G. Moretti, and G. Dalla Fontana (2011), On the prediction of channel heads in a complex alpine terrain using gridded elevation data, Water Resour. Res., 47, W02538, doi:10.1029/2010WR009648.

Pacific Watershed Associates (PWA). 2008. Elk River bank erosion void assessment and bank erosion-related wood inventory Humboldt County, California, report prepared for North Coast Regional Water Quality Control Board, Arcata, CA. June 2008.

Pelletier J. D. (2013): A robust, two-parameter method for the extraction of drainage networks from high-resolution Digital Elevation Models (DEMs): Evaluation using synthetic and real-world DEMs. *Water Resources Research 49(1): 75–89*. DOI: 10.1029/2012WR012452

Tarboton, D. G., and D. P. Ames (2001), Advances in the Mapping of Flow Networks from Digital Elevation Data, World Water and Environmental Resources Congress, ASCE, Orlando, Fla.

Tetra Tech. 2015. Upper Elk River: Technical Analysis for Sediment. Report to the Environmental Protection Agency, Region 9 and North Coast Regional Water Quality Control Board. October 21, 2015.

ATTACHMENT 2

Summary of GDRCo's Key South Fork Elk River Management Measures

- Shovel logging of all evenaged ground based yarding (no tractor trails or tractor skidding)
- No winter operations (except tree falling)
- Winter access limited to quads only
- No broadcast burning
- Single entry into RMZs for the life of the AHCP/WDRs
- High basal area retention in RMZs
- Enhanced Class III EEZs
- Completed treatment of all road-related sediment sites
- Surface treatment of all new roads prior to first winter period
- 4-year adjacency; 75-acre harvest limit (3-yr rolling avg.)
- Extended no harvest periods: 1978-1992; 2002-2005 (18 years total)
- Limited harvest period: 1993-2001 (280 acres)

ATTACHMENT 3

Harvest history on GDRCo's Elk River property through 2015 with the corresponding watershed-wide annual management related sediment delivery from 1978 through 2011 estimated in the Tetra Tech Report.