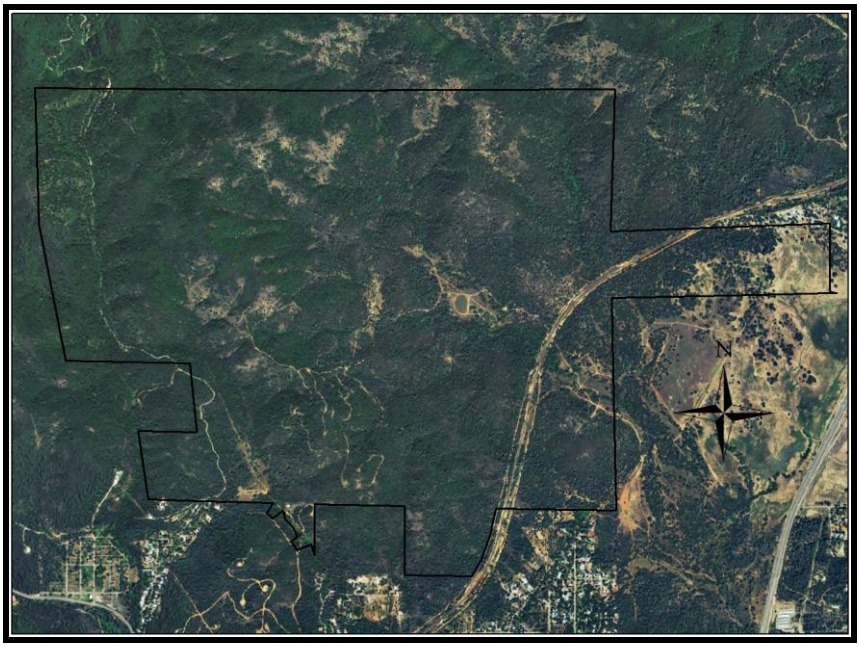
Appendix R:

Greenhouse Gas Analysis

ESTIMATED NET CEQA-BASED GREENHOUSE GAS IMPACT ANALYSIS FOR THE MOODY FLATS QUARRY DEIR

May 25, 2012



Prepared for:
De Novo Planning Group
Sacramento, California

Prepared by:
TSS Consultants
Rancho Cordova, California

INTRODUCTION

De Novo Planning Group (De Novo) is preparing a California Environmental Quality Act (CEQA) compliant environmental impact assessment for a proposed quarry and mining project located in Shasta County. De Novo retained TSS Consultants (TSS) to perform field data collection and compilation, and develop a technical letter report quantifying Greenhouse Gas (GHG) and climate change impacts associated with the removal of trees during project development. The area subject to evaluation is identified as the "Limits of Surface Disturbance."[1] This report provides an estimate of carbon emissions associated with the removal of forest vegetation through analysis of project development as compared to no project development.

SCOPE OF WORK

TSS completed the following tasks in support of this report.

Task 1. Data Collection

Conduct physical inspection of property and perform field data collection for each forest vegetation type identified as shown in the table below.

VEGETATION TYPE	ACRES
Blue oak – grey pine	124
Blue oak woodland	3
Montane hardwood-conifer	304
Montane hardwood	213
Ponderosa pine	7
Valley oak woodland	15
TOTAL	**666**

Pertinent data to be collected was developed to comply with forest inventory protocols and applicable techniques, and provide carbon accounting employing biomass equations provided by the Climate Action Reserve. Field sampling included variable plot sampling for large trees and 1/100th acre fixed area plot. 90 plots were installed on a 528' by 528' grid.

Task 2. Data Compilation

The data generated as a result of completion of Task 1 was processed using biomass equations provided by the Climate Action Reserve to develop carbon outputs. TSS generated estimates of

[1] *"MOODY FLATS QUARRY PROJECT BIOLOGICAL RESOURCES",* Benchmark Resources, revised February 2011.

the CO_2 equivalent[2] (CO_2-e) associated with the existing forest vegetation to estimate CO_2-e released into the atmosphere as a result of the project.

Task 3. Prepare Report

TSS developed a technical report discussing methodology, results and prospective impact of CO_2-e emissions from tree removal in the subject area.

SUBJECT PROPERTY

The subject property is identified as Moody Flats, consisting of a total of approximately 1,900 acres. The portion of the property delineated as the Limits of Surface Disturbance consists of an estimated 666 acres. This portion of the property is where the quarry and mining activity is proposed and is the area under evaluation for this report. The property is located in southwest Shasta County, just west of Interstate 5 and north of the City of Shasta Lake. Figure 1 below highlights the location of the subject property.

Figure 1. Moody Flats Property Location

[2]A measure used to compare the emissions from various greenhouse gases based upon their global warming potential.

Vegetation Cover

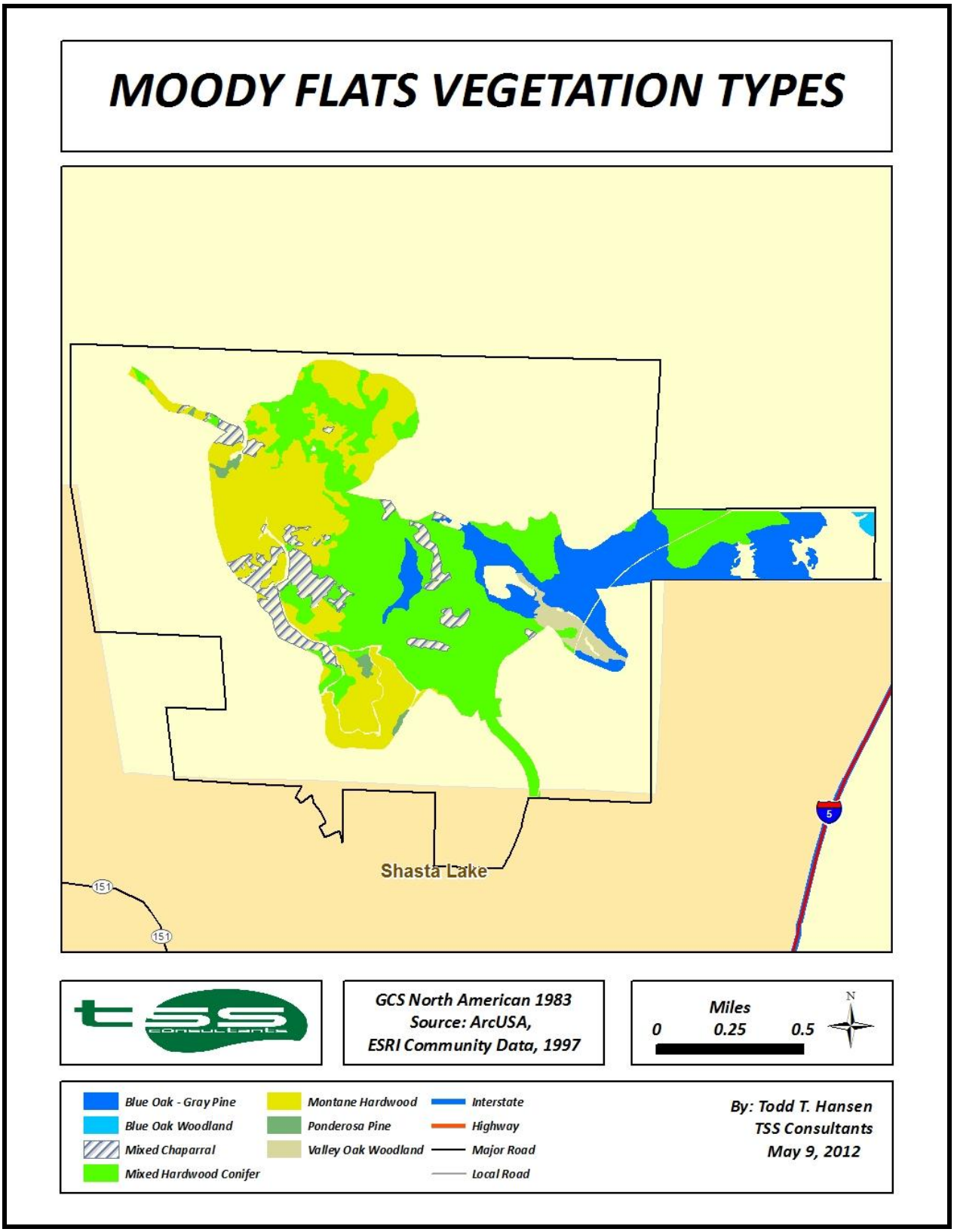
The vegetation types subject to assessment in this report were derived from those identified in the *"MOODY FLATS QUARRY PROJECT BIOLOGICAL RESOURCES"*. Table 1 below shows the various types and associated acreage.

Table 1. Vegetation Types and Acres

VEGETATION TYPE	ACRES
Blue oak – grey pine	124
Blue oak woodland	3
Montane hardwood-conifer	304
Montane hardwood	213
Ponderosa pine	7
Valley oak woodland	15
TOTAL	**666**

Table 1 clearly shows the predominant vegetation types are Montane hardwood with conifer, Montane hardwood and blue oak with gray pine. A map showing the distribution and location of the various vegetation types is shown below in Figure 2.

Figure 2. Vegetation Types



METHODOLOGY

The methodology employed determined estimates of carbon dioxide emissions associated with the removal of all trees during project development within the Limits of Surface Disturbance (LSD), as compared to a scenario where no project is developed. The analysis did not include any carbon assessment from dead/down material, organic material on the forest floor, soil carbon or emissions associated with the operation of machinery to remove trees. Nor was an assessment conducted for that portion of the ownership outside of the LSD. A conservative approach was employed regarding emission analysis where any uncertainty existed to ensure no underestimation of emissions associated with the development of the project.

Sample Plot Determination

A sample plot grid was developed to generate 100 sample plots over the entire LSD. This resulted in a plot grid with sample plots distributed on a 528' by 528' grid oriented in cardinal bearings. Global Positioning System (GPS) coordinates were provided for the majority of the plots. Sample plots close to LSD or vegetation type boundaries were eliminated to avoid ambiguity in determining appropriate vegetation type by field data collection personnel. Employing the grid described above did not always populate the smaller vegetation types with sufficient plots to provide an adequate sample, and additional plots were added within these types to ensure data quality. GPS coordinates for these plots were not provided, and field data collection personnel were instructed to measure bearing distance from grid associated plots to determine plot location. This resulted in a total of 90 sample plots installed and monumented within the LSD and associated vegetation types.

Each plot was monumented to easily facilitate re-establishment of the plot and to facilitate verification of data quality. Plot monumenting consisted of installation of a wooden stake to identify plot center with GPS coordinates from an on-site reading. Two trees, or the main stem of a shrub if no tree is available, at least 20 degrees apart in a measurement from plot center and no greater than 70 degrees were painted and the bearing and distance from plot center was recorded to assist in relocating plot center, if necessary. The plot number and vegetation type were recorded on the data card for each individual plot.

Table 2 below shows the number of plots installed and sampled by vegetative type and acres.

Table 2. Sample Plots and Acres By Vegetation Type

VEGETATION TYPE	ACRES	PLOTS
Blue Oak -Grey Pine	124	19
Blue Oak Woodland	3	3
Montane Hardwood	304	45
Montane Hardwood	213	17
Ponderosa Pine	7	3
Valley Oak Woodland	15	3
TOTALS	**666**	**90**

Tree Sampling

The tree sample included both standing live and dead trees. The trees within the LSD were delineated into two categories: overstory or large trees and understory or saplings and seedlings.

The large trees were categorized as those trees, standing live or dead, with a diameter of the stem at breast height (dbh) greater than or equal to 4.5 inches. If live, the tree must have the capacity to attain a height of at least 15 feet; dead trees must be at least 8 feet tall for inclusion in the sample. The large trees were sampled using variable plot sampling. Variable plot sampling requires use of an angle gauge or prism (or suitable substitute) to determine sample trees. The probability of any given tree being included in the sample is directly proportional to its diameter measured at breast height (4.5 feet above ground). Field data collection personnel were to select a basal area factor that would yield an estimated 5 to 8 trees per plot, but were instructed to use no smaller than a 10 basal area factor to determine sample trees. The data to be collected included tree species, dbh, total tree height, deductions for rot/decay, and the ratio of the tree crown to total tree height (crown ratio). Dead trees do not have live crown foliage.

Understory trees were categorized as those trees, standing live or dead, with a dbh of less than 4.5 inches. All trees meeting this criteria within a 1/100th acre circular plot (11.77 foot radius) were sampled. The sample was further delineated into 1 inch diameter classes. Recorded data included tree species, the total count of each species by the diameter class, the average height and crown ratio.

The tree species found within the LSD included blue oak, brewer oak, California bay laurel, California black oak, canyon live oak, gray pine, interior live oak, ponderosa pine, oracle oak, and valley oak. All measurements were recorded on the plot data cards. The tree data sampling specifications are included as Appendix A.

Data Compilation

The analysis for this report considered sources of carbon dioxide emissions from standing live and dead trees, in both the forest overstory and understory, associated with the development of the quarry and mining project. The calculation of volume, biomass and conversion to CO_2-e for

sample data of standing live and dead trees, for tree bole, bark, branches, foliage and roots, was conducted using guidance and equations from the Climate Action Reserve's Forest Project Protocol Resources guidelines.[3]

The initial step required conversion of raw data into cubic foot volume of wood fiber. The data collected was converted into cubic foot volume using equations from *"FIA Volume Equation Documentation (Updated March 22, 2010)."* This document provides equations for use with various hardwood and conifer species for eastern Washington, western Washington, eastern Oregon, western Oregon and California. A spreadsheet identifies the appropriate equation for conversion by region and species. The output is tree bole and stump volume in cubic feet, which is subsequently converted to biomass by multiplying volume in cubic feet by the particular species wood density.

The biomass for bark and branches/foliage (tree crown material) was determined using equations from *"Regional Biomass Equations Used by FIA to Estimate Bole, Bark, and Branches (Updated January 13, 2010)."* This document provides specific gravity and wood density by species to facilitate tree bole conversion from cubic foot volume to biomass. In addition, the document provides specific equations by region (as described above) and various hardwood and conifer species, for biomass volumes of bark and live branches or crown foliage. Some hardwood volumes do not have separate calculations for bark and foliage, such as California black oak and interior live oak. For some hardwood species, the determination of cubic foot volume as described in the previous paragraph includes output for bark and foliage, but is not available as a separate biomass component.

The biomass volumes were converted to metric tons (2,205 lbs.) and divided by the number of hectares in the LSD (270 hectares) to generate biomass volume in metric tons per hectare. This value was then applied to an allometric regression equation to calculate tree associated biomass below ground[4] (root material). The below ground biomass estimates in metric tons per hectare were then converted to per acre values. These values were added to above ground biomass volumes and subsequently converted from wood fiber biomass to carbon by applying a factor of 0.5.[5] The volume of carbon from the biomass was then converted to CO_2-e by applying a factor of 3.67[6] yielding metric tons per acre of CO_2-e for both above ground and below ground woody biomass. The factor of 3.67 represents the conversion of carbon to CO_2-e predicated upon their molecular weights.

[3]http://www.climateactionreserve.org/how/protocols/forest/resources/#biomass-equations
[4]Cairns, et al. 1997. Root biomass allocation in the world's upland forests. Oecologia 111:1-11.
[5] *"A reassessment of carbon content in wood: variation within and between 41 North American species"*, S. H. Lamlom and R. A. Savidge, Biomass and Bioenergy (2003) Volume: 25, Issue: 4, Pages: 381-388
[6]U.S. Department of Energy's Energy Policy Act, Section 1605(B), Voluntary Reporting Guidelines of Greenhouse Gases, Forestry Appendix.

RESULTS

The statistics for the overall sampling conducted within the LSD are +/- 13% standard error at a 90% confidence interval. The results for CO_2 equivalent in metric tonnes[7] per acre and totals for each vegetation type are shown in Table 3 below.

Table 3. CO_2 Equivalent (Metric Tonnes) by Vegetation Type

VEGETATION TYPE	ACRES	CO_2 EQUIVALENT (METRIC TONNES/ACRE)	CO_2 EQUIVALENT TOTALS (METRIC TONNES)
Blue Oak -Grey Pine	124	84.1	10,424
Blue Oak Woodland	3	126.5	379
Montane Hardwood	304	87.8	26,687
Montane Hardwood	213	79.1	16,838
Ponderosa Pine	7	102.1	715
Valley Oak Woodland	15	176.5	2,647
TOTALS	**666**		**57,690**

Table 3 demonstrates that removal of the vegetation as defined by the scope of work (standing live and dead trees) would result in the loss of 57,690 metric tonnes of CO_2-e. There are a number of options to consider for mitigating this loss, including off-site reforestation or afforestation efforts, on-site but outside the LSD efforts to increase CO_2 sequestration, and procurement of carbon offsets. The current market for carbon offsets through the Climate Action Reserve is estimated at between $8 and $10 per metric tonne.[8]

It is important to note that the data and results from this analysis represent an inventory of CO_2-e as of May 2012. Forests are dynamic, and as such change over time. Significant delay of implementation of forest vegetation removal could result in substantive departure from the results presented here, due to growth of the existing vegetation.

[7]A metric tonne consists of 2205 lbs.
[8]John Nickerson, Director of Forestry, Climate Action Reserve.