DRAINAGE STUDY

FOR

LAKEVILLE QUARRY

Sonoma County, California

Prepared By

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Prepared:
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A. INTRODUCTION

The intent of this report is to address the pre- and post- peak discharge rates, detention, and sediment yield associated with the quarry activities at the Ghilotti Brothers, Inc. property. This plan outlines practices that will be implemented to prevent increases in peak storm water discharges and sediment management throughout each phase of the project. The Ghilotti Brothers, Inc. property is located at 4955 Lakeville Highway, Petaluma, California.

B. EXISTING CONDITIONS

The Ghilotti Brothers, Inc. property was previously quarried out creating a lower, generally flat, area. The low flat area is currently used as a corporation and storage yard for equipment and materials utilized for construction projects.

The existing project site and surrounding tributary generally slope from north to south. Site storm water runoff flows through the site through a series of natural drainage channels and storm drain pipes. There are three sediment ponds on-site. Ponds 2 and 3, see H0-Pre-Development Hydrology Map for pond locations, capture all surrounding storm water runoff within the industrial operational area. Anecdotally, the Ponds 2 and 3 have never spilled over; however, existing corrugated metal pipe overflows connect the ponds to the existing storm drain system which discharges to an existing swale. Pond 1, also known as the Lakeville Reservoir, captures both on-site and off-site runoff. When Pond 1 fills, overflow is directed through a weir into an existing natural drainage channel, Stage Gulch, towards the south side of the site.

Stormwater discharge from the site drains through a series of culverts beneath Highway 116 (Lakeville Highway) thence into natural and manmade channels, ultimately discharging into the Petaluma River. Stormwater discharges from the north side of the site enters Stage Gulch (an intermittent stream) then crosses Highway 116 through a culvert thence into a manmade channel and into the Petaluma River.

C. PROPOSED CONDITIONS

The project proposes to perform quarry operations at the Ghilotti Brothers, Inc. property. The grading operations have been defined and analyzed in four phases: existing conditions, initial grading, intermediate grading, and final grading.

Sediment laden runoff is anticipated as a result of grading activities. As such, a proposed expansion of sediment Pond 2 is included as a part of the initial quarry activities. The expanded sediment pond would also act as a detention pond to prevent an increase in peak storm water discharge. In the final grading condition, the new quarry floor would act as a sediment and detention pond. Ponds 2 and 3 will be filled in during the close out of the final grading phase.

D. ANALYTICAL APPROACH

Rational Method: The Rational Method was utilized to calculate design peak discharge in accordance with the Sonoma County Water Agency Flood Control Design Criteria Manual for Waterways, Channels and Closed Conduits, dated August 1983 (SCWA Manual). The Rational method is based on the following formula:

$$Q=CiAK$$

Where: Q = design discharge (cubic feet per second, cfs)
C = runoff coefficient
i = intensity of rainfall (inches per hour, in/hr)
A = tributary watershed area (acres, ac)
K = K-factor (from Plat No. B-4, SCWA)

See hydrology maps for tributary watershed areas. The project site has a mean seasonal precipitation of 25 (from Plat No. B-3, SCWA Manual) which produces a resulting K-factor of 0.833.

Runoff Coefficient: The runoff coefficient for pervious areas was determined from the Highway Design Manual Figure 819.2A – Runoff Coefficients for Undeveloped Areas Watershed Types. The runoff coefficient for impervious areas was taken as 0.9. The runoff coefficient for each watershed was determined by the following equation:

$$C_{CUM} = \frac{C_{PERVIOUS}*AREA_{PERVIOUS}+C_{IMPERVIOUS}*AREA_{IMPERVIOUS}}{AREA_{PERVIOUS}+AREA_{IMPERVIOUS}}$$

Time of Concentration: The time of concentration (T_c) was determined in four parts. First, the T_c was calculated assuming an initial time of concentration of 15 minutes (SCWA Manual) representing overland flow for areas up to two (2) acres. Second, flow rates for shallow concentrated flow were determined from the Highway Design Manual Figure 816.6 – Velocities for Upland Method of Estimating Travel Time for Shallow Concentrated Flow. Thirdly, flow rates were estimated to determine velocity through natural channels. And finally, flow rates were estimated to determine velocity through storm drain pipes. The time of concentration for each segment of shallow concentrated flow, channelized flow, and pipe flow is based on the following formula:

$$T_c = \frac{L}{(60/V)}$$

Where: T_C = Travel Time (min)
L = Length of flow (feet)
V = Velocity (feet per second)

The velocity was calculated by estimating the average flow through the reach and utilizing the computer program Hydraflow Express Extension for AutoCAD Civil 3D 2008 to process calculations to solve for variables in Manning's Formula, which is appropriate for open channel flow regimes and pipe flows.

The total time of concentration is determined by adding the incremental times of concentration.

Rainfall Intensity: Intensities for Rational Method calculations were determined using the intensity-duration-frequency equations contained within the SCWA Manual. The rainfall intensity for the 10- and 100-year recurrence intervals were calculated using the following equations:

$$I_{10} = \frac{7.08}{t^{0.526}}$$

$$I_{100} = \frac{10.15}{t^{0.529}}$$

Where: I = rainfall intensity (inches per hour, in/hr)
t = time of concentration (minutes)

Stormwater Detention: The detention pond was designed to detain the increase in peak storm water discharge for the 100-year recurrence interval storm event due to quarry activities. The storm water volume for the pre- and post-project conditions was determined using the 1 to 2 lead to lag leg hydrograph method. The computer program Hydraflow Hydrograph Extension for AutoCAD C3D 2008 was used to model the hydrographs. Outflow structures were designed as constricting orifices to prevent an increase in pea storm water discharge for the 100-year recurrence interval storm.

The detention pond doubles as a sediment basin. The sediment basin will collect and temporarily detain storm water runoff to proved ample settling time before runoff is discharged. The pond was designed to meet allow sufficient time for sediment settlement for the 10-year recurrence interval using the following equation:

$$A_S = \frac{1.2Q}{V_S}$$

Where: A_S = Surface area of settling basin with 2-foot minimum depth
Q = 10-Year recurrence interval flow (cfs)
V_S = Settling velocity of particle (feet per second, fps)
(medium silt, 0.02mm particle size, VS=0.00096 fps)

Erosion Rate: The erosion rate for the site was determined from the Revised Universal Soil-Loss Equation (RUSLE). The RUSLE method is based on the following equation:

$$A = R * K * L * S * C * P$$

Where: A = computed spatial average soil loss
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = cover-management factor
P = erosion control practice factor

Due to the location of grading activities, all exposed slopes are tributary to Pond 2 and subsequently accounted for. None of the proposed grading activities are tributary to Pond 1 or Pond 3. All calculations were performed in accordance with the "Guide for Erosion & Sediment Control in California," USDA Soil Conservation Services, Davis, California.

E. RESULTS OF ANALYSIS

Table 1: Existing Conditions Peak Discharge Rate

Discharge Point	Time of Concentration (min)	Watershed Area (acres)	Runoff Coefficient	10-Year Peak Discharge (cfs)	100-Year Peak Discharge (cfs)
A	35.0	249.8	0.40	90.94	129.00
B	21.2	22.8	0.40	10.79	15.33
C	20.2	24.8	0.49	14.63	20.79
D	21.3	11.0	0.41	5.26	7.48
E	19.1	9.1	0.40	4.55	6.46
F	18.9	12.4	0.40	6.23	8.86
G	15.8	6.7	0.42	3.88	5.51
H	17.1	9.3	0.41	5.06	7.19

Note: 1. See Appendix 3 – Existing Condition Hydrology Calculations.

Table 2: Initial Grading Peak Discharge Rate

Discharge Point	Time of Concentration (min)	Watershed Area (acres)	Runoff Coefficient	10-Year Peak Discharge (cfs)	100-Year Peak Discharge (cfs)
A	35.0	240.0	0.40	87.39	123.95
B	20.3	15.8	0.40	7.65	10.87
C	35.8	44.1	0.44	17.43[3]	24.72[3]
D	19.4	9.4	0.41	4.74	6.73
E	17.9	8.0	0.40	4.14	5.88
F	18.9	12.4	0.40	6.23	8.86
G	15.8	6.7	0.42	3.88	5.51
H	17.1	9.3	0.41	5.06	7.19

Note: 1. See Appendix 4 – Initial Grading Condition Hydrology Calculations.
2. Watersheds tributary to Discharge Points G & H are same as Pre-Project Conditions.
3. Values for Discharge Point C do not account for detention. See Table 5 for final discharge.

Table 3: Intermediate Grading Peak Discharge Rate

Discharge Point	Time of Concentration (min)	Watershed Area (acres)	Runoff Coefficient	10-Year Peak Discharge (cfs)	100-Year Peak Discharge (cfs)
A	35.0	240.0	0.40	87.39	123.95
B	20.3	13.6	0.40	5.24	9.35
C	36.3	52.9	0.43	20.28[3]	28.77[3]
D	18.2	6.7	0.41	3.49	4.96
E	16.5	5.3	0.40	2.86	4.07
F	20.1	11.5	0.40	5.62	7.98
G	15.8	6.7	0.42	3.88	5.51
H	17.1	9.3	0.41	5.06	7.19

Note: 1. See Appendix 5 – Intermediate Grading Condition Hydrology Calculations.
2. Watersheds tributary to Discharge Points G & H are same as Pre-Project Conditions.
3. Watersheds tributary to Discharge Point A are same as Initial Grading Conditions.
4. Values for Discharge Point C do not account for detention. See Table 5 for final discharge.

Table 4: Final Grading Peak Discharge Rate

Discharge Point	Time of Concentration (min)	Watershed Area (acres)	Runoff Coefficient	10-Year Peak Discharge (cfs)	100-Year Peak Discharge (cfs)
A	35.0	240.0	0.40	87.39	123.95
B	20.3	13.6	0.40	5.24	9.35
C	36.3	52.9	0.43	20.28[3]	28.77[3]
D	18.2	6.7	0.41	3.49	4.96
E	16.5	5.3	0.40	2.86	4.07
F	20.1	11.5	0.40	5.62	7.98
G	15.8	6.7	0.42	3.88	5.51
H	17.1	9.3	0.41	5.06	7.19

Note: 1. See Appendix 6 – Final Grading Condition Hydrology Calculations.
2. Watersheds tributary to Discharge Points G & H are same as Pre-Project Conditions.
3. Watersheds tributary to Discharge Point A are same as Initial Grading Conditions.
4. Watersheds tributary to Discharge Point B, C, E, & F are same as Intermediate Grading Conditions.
5. Values for Discharge Point C do not account for detention. See Table 5 for final discharge.

Table 5: Post-Detention Discharge Rate at Discharge Point C

Grading Phase	10-Year Peak Discharge (cfs)	Percent Reduction	100-Year Peak Discharge (cfs)	Percent Reduction
Existing	14.59	n/a	20.54	n/a
Initial	5.75	60.6	8.55	58.4
Intermediate	6.12	58.0	8.73	57.5
Final	5.47	62.5	7.76	62.2

Note: 1. See Appendix 7 – Detention & Sediment Basin Calculations.

Table 6: Sediment Yield at Pond 2

Grading Phase	Average Soil Loss (tons/acre/year)	Total Area (acres)	Sediment Yield (tons/year)
Initial	0.8	7.91	3.1
Intermediate	0.6	11.15	3.3
Final	0.9	17.96	7.9

Note: 1. See Appendix 8 – Sediment Yield Calculations.

F. CONCLUSIONS

The existing peak discharge rates for the 10-, 25-, and 100- year recurrence interval at each discharge point from the site are depicted in Table 1. The initial, intermediate, and final grading peak discharge rates for the 10-, 25-, and 100- year recurrence interval at each discharge point from the site are depicted in Tables 2, 3, and 4, respectively. However, Tables 2, 3, and 4 do not account for detention in Pond 2. It is not anticipated that the proposed phased grading will increase peak discharge from the site except at Discharge Point C.

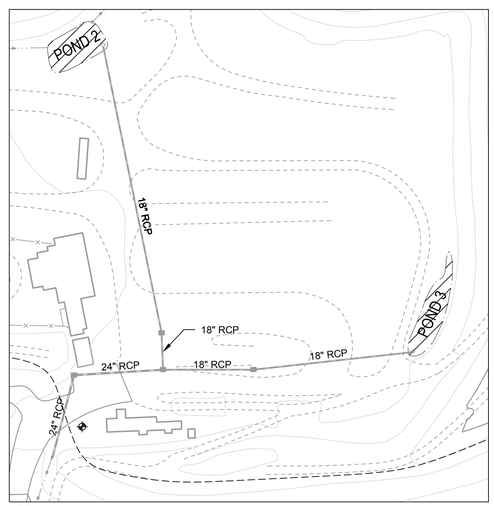
The use of a detention pond is necessary to prevent an increase in peak runoff at Discharge Point C. Utilizing the expanded sediment pond, Pond 2, for detention, there is a net reduction in the peak runoff rate for the 10- and 100-year recurrence interval storm events at Discharge Point C, as seen in Table 5. As a result the proposed phased grading will not increase peak discharge from the site.

The maximum sediment yield from quarry operations is 7.9 tons/year during the final grading phase, see Table 6. The sediment pond will be dredged annually, in summer, to remove sediment deposited throughout the year. The collected sediment will be stockpiled on site and used as a base material for the re-vegetation of the quarry slopes at the end of the final grading phase.

This analysis conforms to the documents "Lakeville Quarry Grading Plans," prepared by CSW|ST2, and dated June 10, 2011.

HYDROLOGY LEGEND

- # / XXX AC / C — DRAINAGE SUB-AREA DESIGNATION
- SUB-AREA IN ACRES
- RUNOFF COEFFICIENT
- OVERLAND FLOW DIRECTION
- DRAINAGE AREA BOUNDARY
- DRAINAGE SUB-AREA BOUNDRY
- DRAINAGE SWALE



1 **EXISTING STORM DRAIN SYSTEM**
SCALE: 1"=11'

CSW | ST2

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Civil & Structural Engineers
Surveying & Mapping
Environmental Planning
Land Planning
Construction Management

http://www.cswst2.com

Rev	Date	Description	Designed	Drawn	Checked

LAKEVILLE QUARRY
EXISTING HYDROLOGY
GHILOTTI BROTHERS, INC.

City Of
Novato

County Of
Marin

State Of
California

Prepared Under the Direction of:

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Scale:	1" = 200'
Date:	XX/XX/XX
Project Number:	5.1318.00
Plan File:	D-XXXX-XX

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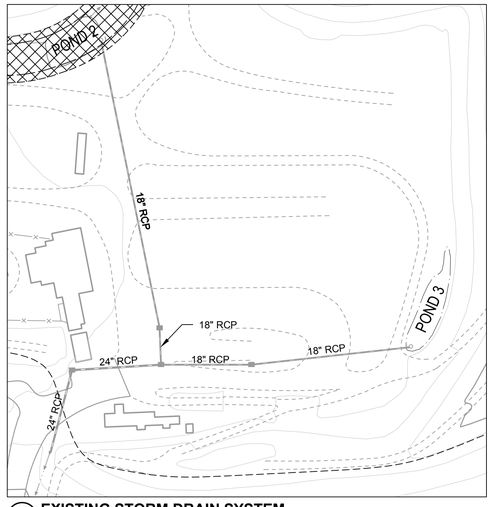
HYDROLOGY LEGEND

- # / XXX AC / C — DRAINAGE SUB-AREA DESIGNATION
- SUB-AREA IN ACRES
- RUNOFF COEFFICIENT
- OVERLAND FLOW DIRECTION
- DRAINAGE AREA BOUNDARY
- DRAINAGE SUB-AREA BOUNDRY
- DRAINAGE SWALE



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Rev	Date	Description	Designed	Drawn	Checked

LAKEVILLE QUARRY

INITIAL GRADING HYDROLOGY MAP

GHILOTTI BROTHERS, INC.

City Of
PETALUMA

County Of
SONOMA

State Of
California

Prepared Under the Direction of:

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Scale:	1" = 200'
Date:	XX/XX/XX
Project Number:	5.1318.00
Plan File:	D-XXXX-XX

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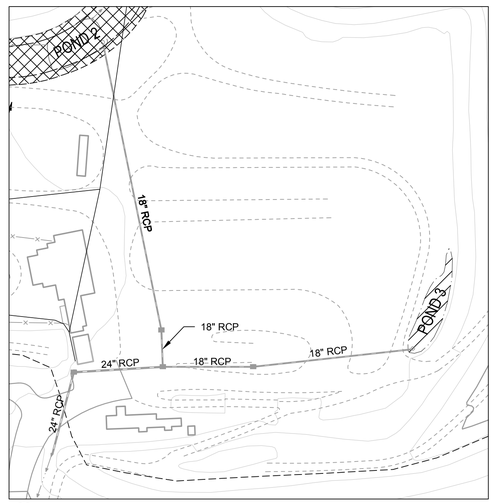
HYDROLOGY LEGEND

- # / XXX AC / C — DRAINAGE SUB-AREA DESIGNATION; SUB-AREA IN ACRES; RUNOFF COEFFICIENT
- OVERLAND FLOW DIRECTION
- DRAINAGE AREA BOUNDARY
- DRAINAGE SUB-AREA BOUNDRY
- DRAINAGE SWALE



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LAKEVILLE QUARRY

INTERMEDIATE GRADING HYDROLOGY MAP

GHILOTTI BROTHERS, INC.

City Of
PETALUMA

County Of
SONOMA

State Of
California

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Project Number:	5.1318.00
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HYDROLOGY LEGEND

- # / XXX AC / C — DRAINAGE SUB-AREA DESIGNATION
- SUB-AREA IN ACRES
- RUNOFF COEFFICIENT
- OVERLAND FLOW DIRECTION
- DRAINAGE AREA BOUNDARY
- DRAINAGE SUB-AREA BOUNDRY
- DRAINAGE SWALE

1 **EXISTING STORM DRAIN SYSTEM**
SCALE: 1"=11'

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LAKEVILLE QUARRY

FINAL GRADING HYDROLOGY MAP

GHILOTTI BROTHERS, INC.

City Of
PETALUMA

County Of
SONOMA

State Of
California

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