Appendix H:

Fish Use and Channel Adjustments Technical Memo

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TECHNICAL MEMORANDUM

Date: 8 June 2012

To: Ben Richie, De Novo Planning Group

From: Dennis Halligan and Jay Stallman

Subject: Potential for Fish use and Channel Adjustments Associated with the Proposed Moody Flats Quarry

1 INTRODUCTION

Moody Flats Quarry, LLC, a wholly-owned subsidiary of 3M Company (Applicant), proposes to develop the Moody Flats Quarry (Project). The proposed Project is a hardrock quarry that is expected to supply aggregate construction material to markets in and around Shasta County and for export by rail to points south. The proposed Project includes development of the quarry, an aggregate processing facility, stockpiles, loading facilities, and a rail siding/spur.

The proposed Project is located primarily within three watersheds: Moody Creek, Rancheria Creek, and Salt Creek. Moody Creek and Rancheria Creek are intermittent tributaries to the West Fork of Stillwater Creek, which flows into Stillwater Creek and then joins the Sacramento River near Anderson. Salt Creek, within the Moody Flats property, is an ephemeral tributary to Churn Creek. Elevations within the proposed project area range from 900–2,000 feet (ft), annual rainfall is approximately 64 inches (in), and vegetation cover is predominantly Montane Hardwood-Conifer and Montane Hardwood. For more detailed information, refer to the *Moody Flats Quarry Project Description* (Benchmark Resources 2011).

The County of Shasta is the lead California Environmental Quality Act permitting agency for the Project. The County has determined that the Project review process will require the development of an Environmental Impact Report (EIR). As part of the EIR process, the County solicited comments from regulatory agencies and the general public on issues relating to the proposed Project. The California Department of Fish and Game (DFG) responded with comments in a letter dated 1 April 2011 (DFG 2011). In their comment letter, DFG stated that "Surveys must be conducted throughout the year to determine use of creeks and drainages by native fish. Particular attention should be given to Moody Creek and the reach proposed for re-alignment."

No information or reports were found regarding fish use within the proposed Project area; however, Leidy (1998 as cited in NSR 2007) sampled fish in portions of West Fork Stillwater Creek from near Mountain Gate to its confluence with the East Fork. Leidy (1998) found that juvenile rainbow trout (*Oncorhynchus mykiss*), adult and juvenile suckers (*Catostomus* spp.), and California roach (*Hesperoleucus symmetricus*) were relatively common throughout this reach.

Stillwater Creek is within the Central Valley steelhead Distinct Population Segment (NMFS 2006). Critical habitat for steelhead is not designated in West Fork Stillwater Creek (NMFS 2005). Stillwater Creek is known to be utilized by fall-run Chinook salmon (*Oncorhynchus tshawytscha*) (City of Redding 2008). A small amount of spawning gravel exists in West Fork Stillwater Creek and Moody Creek (City of Redding 2008). Churn Creek flows into the Sacramento River and its lower reaches are known to be occupied by fall-, winter- , and spring-run Chinook salmon (NSR 2007). No barrier falls are known to exist in Stillwater and Churn creeks, however these watercourses contain numerous road culvert crossings that may or may not be barriers to anadromous salmonid migration (NSR 2007).

In their comment letter dated 1 April 2011, DFG also stated that the Project would "likely change the percolation and infiltration patterns of rainfall and their entrance times" in Moody Creek and Salt Creek, and that the Project would likely cause stream flows to "rise faster, with higher peak flows and possibly more rapid decline in low flows." A Stormwater, Erosion Control, and Drainage Plan (Crawford and Kopania 2010) was prepared for the proposed Project that included conceptual designs for stormwater system features (drainage channels, diversions, detention features, and culverts) and analysis of stormwater routing (Crawford and Kopania 2010). The plan also included permanent facilities for erosion and sediment control (surge ponds, rate control basins, ditches, settling ponds, and a vegetated sheet drain); typical grading and drainage specifications for slopes, terraces, ditches, and downdrains; and typical best management practices that will be used to control erosion in actively disturbed areas. The analysis of stormwater routing indicated that the stormwater control system at Project build-out would attenuate flood flows, reducing the 25-year 24-hour storm on the site from 633 to 358 cfs.

Peer review of the *Stormwater, Erosion Control, and Drainage Plan* (Moore and Connell 2012) and *Hydrology and Water Quality Analysis* (Moore and Loy 2012) were conducted by West Yost Associates. The peer reviewers identified the following points relevant to evaluating the potential effects of stormwater runoff on stream channels:

1. A 25-year, 24-hour design storm event is not an appropriate basis for designing detention basins or preventing/mitigating downstream flooding impacts. The 100-year and 200-year storms should be evaluated, and storm events of at least 4 days should be used.
2. The analysis should include runoff from mining pits, and the potential flooding impacts should be evaluated over the whole site for each watershed, with the results presented as hydrographs of flow leaving the property.
3. The plan should be developed in greater detail, including sizing of stormwater conveyance facilities.
4. The plan includes typical best management practices for erosion control, but does not provide enough specific information to determine if streams will be protected. A specific erosion control plan should be prepared for the Project.
5. Reliance on preparation of future documents to address changes in drainage prevented a thorough evaluation of potential impacts.
6. A phasing plan should be developed that allows an evaluation of erosion, drainage, and downstream flooding impacts at interim time periods during the 100-year build-out of the Project.

The Applicant is in the process of revising the *Stormwater, Erosion Control, and Drainage Plan* (Crawford and Kopania 2010) to address the peer review comments (B. Ritchie, De Novo Planning, pers. comm., 5 June 2012).

The purpose of this technical memorandum is to report the results of a reconnaissance-level field investigation to (1) determine native and non-native fish use, and (2) assess the potential for channel adjustment from any Project-related changes in stormwater runoff.

2 METHODS

Stillwater Sciences conducted a reconnaissance-level field investigation of the Project-affected reaches of Moody, Rancheria, and Salt creeks on 5 April 2012 to identify potential fish use and potential for channel adjustment from Project-related changes in runoff. Stillwater Sciences personnel were accompanied by Frank Borden (Shasta Land Management Consultants) and Andrew White (Benchmark Resources). A second survey of potential fish use was conducted on 17 May 2012.

Surveys of potential fish use were conducted using streambank observation to eliminate potential impacts to individual fish that could occur by using more intensive survey methods such as electrofishing, beach seining, or dipnetting. The size and headwater nature of the creeks are potentially more suitable for steelhead and rainbow trout use than Chinook salmon. Spring surveys are therefore more likely to identify potential steelhead and rainbow trout redds, swim-up fry emergence, and fry occupancy should these fish occur within channel reaches on the site. A second survey was conducted to assess fish occurrence in a few pools potentially deep enough to support fish during low to intermittent stream flows. Additional surveys of potential fish use during summer months were limited by lack of perennial streamflow.

The potential for flow-related Project effects to alter channel conditions was assessed during the April field visit, when surface runoff and baseflow allowed for qualitative observation of both channel hydraulics and fluvial geomorphology. The proposed Moody Creek diversion alignment was traversed, and observations were made regarding the potential impacts of realignment and associated changes in surface water hydrology in the affected reaches of Lower Moody Creek and Rancheria Creek. Reaches of Upper Moody Creek, Lower Moody Creek, Rancheria Creek, and Salt Creek within and immediately downstream of the Project site were walked from upstream to downstream, except where dense vegetation prohibited access. Qualitative observations of channel conditions included the following:

- channel morphology (e.g., gradient, planform, bankfull width and depth, sediment storage),
- bed surface texture,
- channel hydraulics (e.g., flow depths and velocities),
- base-level controls influencing potential channel adjustment (e.g., bedrock, boulders, large wood, engineered structures), and
- bank stability (e.g., bank height, bank materials, vegetation reinforcement, existing bank erosion).

3 RESULTS AND DISCUSSION

3.1 5 April 2012 Survey

The results of the 5 April 2012 field assessment are discussed below by watershed, beginning at the upstream extent of the Project's potential influence on stream channels (i.e., proposed diversion of Upper Moody Creek) and progressing downstream to the approximate location of the vegetated sheet drain (i.e., the downstream extent of Project).

3.1.1 Upper Moody Creek

The first field assessment on 5 April 2012 followed several days of rain. Flow in Upper Moody Creek during the survey was estimated at approximately 2–3 cubic feet per second (cfs).

At the upstream end of Moody Flats, near the proposed diversion point for routing flows in Upper Moody Creek to Lower Moody Creek, the channel is entirely controlled by bedrock with no potential for future adjustment from Project-related changes in stormwater runoff (Figure 1). A bedrock step creates a natural barrier to upstream adult and juvenile salmonid migration approximately 50 ft downstream of the proposed diversion point (Figure 2). The barrier is approximately 5 ft high, with a 4-ft deep jump pool at the base. The bedrock channel at the top of the barrier contains no resting areas and would experience high water velocities during storm runoff events.

Figure 1. Upper Moody Creek at the upstream end of Moody Flats at the approximate location where flow would be diverted to Lower Moody Creek.

Figure 2. Natural bedrock barrier to fish migration.

Downstream of this bedrock controlled reach, Upper Moody Creek flows along the east side of Moody Flats. This reach would be dewatered by the proposed diversion and filled during construction of the processing and loadout area. The channel in this reach is confined within moderately steep side slopes comprised of bedrock with a thin soil mantle (Figure 3). Channel gradient, determined from topography shown in the Applicant's *Hydrology and Water Quality Report* (Benchmark Resources 2011), averages approximately 1.8%. The channel has a gravel bed with a median grain size of 15–20 mm. Plane bed and pool-riffle morphology is intermittently controlled by bedrock outcrops and boulders. Persistence of dense herbaceous vegetation occupying the active channel bed suggests that the flow observed during the assessment was relatively high and typically of short duration. The vegetation also suggests a relatively stable channel bed with infrequent scour.

Figure 3. Confined reach of Upper Moody Creek within Moody Flats construction footprint.

Near the downstream end of Moody Flats, the Upper Moody Creek channel has unconfined riffle-pool morphology, with approximately 8-ft bankfull channel widths and 1.5-ft bankfull depths (Figure 4). Channel gradient, determined from topography shown in the Applicant's *Hydrology and Water Quality Report* (Benchmark Resources 2011), averages less than 1.5%. The channel typically had a bed of gravel and small cobble, with a median grain size of approximately 12–20 millimeters. Localized scour was evident at the outside of bends and associated with instream woody vegetation and woody debris. In many locations, herbaceous cover on the channel substrate suggests a stable channel with infrequent scour. Channel banks were locally 2–3 ft high where stream bank erosion occurred at the outside of bends and where the channel was incised into alluvial and colluvial deposits (Figure 5). A narrow and discontinuous riparian zone provided up to 60% canopy cover. Riffle and run aquatic habitats dominated, with occasional shallow pools. Little instream cover was present.

Figure 4. Upper Moody Creek at the downstream end of Moody Flats.

Figure 5. Bank exposure of unconsolidated alluvium and colluvium in Upper Moody Creek at the downstream end of Moody Flats.

Downstream of Moody Flats, Upper Moody Creek flows through a concrete box culvert beneath the Union Pacific railroad grade. The flat bottom culvert is approximately 50 ft long and 6 ft wide. The outlet of the culvert drains across a 10-ft wide concrete apron before flow discharges back to the natural channel (Figure 6). During the time of the survey, the culvert had a 1.1-ft jump height and 1.4-ft deep jump pool. Water depth over the concrete apron at the outlet was 0.1 ft. This culvert presented a complete barrier to upstream adult and juvenile salmonid migration during the flows observed. It is likely that water velocities over the flat culvert bottom would be high enough during storm runoff events to prohibit upstream adult salmonid migration.

Figure 6. Outlet of the Upper Moody Creek culvert beneath the Union Pacific Railroad grade.

No salmonid redds or fish were observed in Upper Moody Creek during the survey. Benthic macroinvertebrates were absent from the approximately 85 cobbles that were turned over in runs and riffles, indicating very limited food availability for any fish potentially occupying the reach. Two northwestern pond turtles (*Actinemys marmorata*) were observed in the reach of the Upper Moody Creek that would be filled to create the proposed processing and loadout area. In addition, several Pacific tree frogs (*Pseudacris regilla*) were observed in Upper Moody Creek.

Upper Moody Creek would be dewatered downstream of the approximate location of the diversion (near the bedrock step), and the channel would be filled between this point and the railroad grade to construct the processing and loadout area. It is unclear if construction of the processing and loadout area would be phased over the 100-year buildout of the Project, and if so, how Upper Moody Creek might be affected by phased construction. In reaches where the channel is filled for construction, there would be no potential for any additional effects in these areas resulting from Project-related changes in stormwater runoff. Remaining channel segments could receive water and sediment inputs from upslope areas to the east and from the surrounding processing and loadout area. The existing *Moody Flats Quarry Stormwater, Erosion Control, and*

Drainage Plan (Crawford and Kopania 2010) does not provide sufficient detail to evaluate the potential effects of phased construction on these channel segments. At the downstream end of Moody Flats, the unconfined channel is formed in unconsolidated alluvial and colluvial deposits and has a relatively high potential to incise and/or shift laterally if phasing of Project construction were to accelerate peak runoff to the reach.

3.1.2 Lower Moody Creek

The first field assessment on 5 April 2012 followed several days of rain. Flow in Lower Moody Creek during the survey was estimated at approximately 1.5 cfs.

In Moody Flats, where Lower Moody Creek would receive runoff diverted from Upper Moody Creek, the channel has relatively unconfined plane bed and riffle-pool morphology (Figures 7 and Figure 8). Bankfull widths are approximately 8–10 ft, and bankfull depths are approximately 1–1.5 ft. The wetted channel was between 4 and 6 feet wide. Channel gradient, estimated in the field, averages approximately 0.8–1.2%. The channel typically had a bed of gravel and small cobble. Substrate was 20–50 percent embedded with sand. Localized scour was evident at the outside of bends and associated with instream woody vegetation and woody debris. In many locations, herbaceous cover in the active channel suggested a stable channel bed with infrequent scour. Aquatic habitat was predominantly riffle and run, with occasional shallow pools. An extensive and continuous riparian zone provided up to 70% canopy cover. Little instream cover was present.

Figure 7. Lower Moody Creek in Moody Flats.

Figure 8. Lower Moody Creek at the downstream end of Moody Flats.

Downstream of Moody Flats, Lower Moody Creek flows through a concrete box culvert beneath the Union Pacific railroad grade (Figure 9). The flat bottom culvert is approximately 50 ft long and 6 ft wide. The culvert is set to grade and was partially backwatered during the field assessment. The culvert would likely not be a barrier to adult or juvenile salmonids.

Figure 9. Outlet of the Lower Moody Creek culvert through the Union Pacific Railroad grade.

Downstream of the Union Pacific Railroad grade, Lower Moody Creek is extensively controlled by bedrock. A small bedrock step is located in Lower Moody Creek approximately 300 ft downstream of the railroad culvert outlet (Figure 10). This step is approximately 4ft high and is composed of two jumps. The first jump is 1.5 ft high and may be swimmable from the shallow pool at its base. The second jump is at least 2 ft high and 4 ft long with a 1.5-ft deep jump pool. This would be a complete barrier to juvenile and adult salmonids at the flows observed during the survey. However, it may be possible for adult salmonids to swim around the barrier during very high flow events.

Figure 10. Possible fish migration barrier on Lower Moody Creek downstream of the railroad right of way.

No salmonid redds or fish were observed in Lower Moody Creek during the survey. Benthic macroinvertebrates were absent from the approximately 75 cobbles that were turned over in the active channel, indicating very limited food availability for any fish potentially occupying the stream. Several Pacific tree frogs were observed in Lower Moody Creek.

Peak flows through the Moody Flats reach of Lower Moody Creek will increase over existing conditions due to diversion of surface runoff from the Upper Moody Creek and Salt Creek basins. The Lower Moody Creek channel through Moody Flats is formed in unconsolidated alluvium and colluvium with long continuous lengths of channel bank lacking reinforcement by roots of woody riparian vegetation. This reach therefore has a relatively high potential of incising or adjusting laterally through bank erosion in response to increased peak flows during storm runoff. The figure titled "Stormwater Feasibility Moody Flats" included in the *Moods Flats Quarry Stormwater, Erosion Control, and Drainage Plan* (Crawford and Kopania 2010) suggests that the existing Lower Moody Creek channel will be relocated to the south margin of the Plant Area, from the point at which it receives inflow from the Upper Moody Creek basin to the point at which flow enters the concrete box culvert at the Union Pacific Railroad grade. This plan does not, however, provide any information describing proposed changes to the existing channel over this reach, and it is unclear if and how the Lower Moody Creek channel through Moody Flats would be modified (e.g., by rip rap armoring, structural grade control, and/or engineered surface or subsurface channelization) to limit channel adjustment. The concrete box culvert through the Union Pacific Railroad would serve as grade control prohibiting downstream propagation of any channel adjustments initiated upstream. Accelerated runoff is unlikely to result in channel adjustment in the bedrock-controlled reach downstream of the Union Pacific Railroad.

3.1.3 Rancheria Creek

Rancheria Creek is located in the northeastern portion of the Moody Flats Project area. Channel gradient within the Moody Flats property, determined from topography shown in the Applicant's

Hydrology and Water Quality Report (Benchmark Resources 2011), averages approximately 4.5%. The bed is comprised predominantly of gravel and small cobble.

Assessment of native and non-native fish use in Rancheria Creek focused on the channel approximately 50 ft upstream and downstream of the Union Pacific Railroad grade. Rancheria Creek flows under the railroad though an approximately 50-ft-long, 6-ft-wide concrete box culvert with a flat-bottom. The outlet of the culvert drains across a 20-ft concrete apron before discharging back into the natural channel (Figure 11). During the time of the survey, the culvert had a 1.0-ft jump height with no jump pool and no rest area upstream of the culvert inlet. Water depth was 0.1 ft over the concrete apron and about 0.2 ft deep in the body of the culvert. The culvert formed a complete barrier to upstream adult and juvenile salmonid migration at the flows observed during the survey. It is likely that water velocities over the flat culvert bottom would be high enough during storm events to prohibit upstream migration of adult salmonids. No fish were observed upstream or downstream of the railroad crossing.

The *Moody Flats Quarry Stormwater, Erosion Control, and Drainage Plan* (Crawford and Kopania 2010) indicates that runoff in several small channels currently draining to Moody Flats would be diverted along the northern margin of the Plant Area and conveyed to Rancheria Creek. These three channels have small drainage areas and are not likely to generate substantial runoff. This plan indicates that the surface water diversion would route through the railroad grade and into a tributary to Rancheria Creek. The consultant to 3M (Andrew White) who escorted Stillwater Sciences personnel in the field indicated that the intent of the plan was to route the diversion to the mainstem of Rancheria Creek upstream of the railroad grade, and that the figure from the *Moody Flats Quarry Stormwater, Erosion Control, and Drainage Plan* (Crawford and Kopania 2010) showing the drainage alignment is likely in error (A. White, Benchmark Resources, pers. comm., 5 April 2012). This uncertainty in the receiving waters, combined with the lack of information in the plan describing the diversion, prohibited an assessment of the potential effects of Project-related changes in stormwater runoff on adjustment of the Rancheria Creek channel.

Figure 11. Rancheria Creek railroad box culvert.

3.1.4 Salt Creek

Salt Creek is an ephemeral channel located in the southern portion of the Moody Flats Project area. Channel gradient within the Moody Flats property, determined from topography shown on the Applicant's *Hydrology and Water Quality Report* (Benchmark Resources 2011), averages approximately 3.5%. The bed is comprised predominantly of gravel and sand. The channel bottom was completely vegetated within the area surveyed and lacked fish habitat.

Assessment of native and non-native fish use in Salt Creek focused on the channel approximately 50 ft upstream and downstream of the Union Pacific Railroad grade. Flow during the time of the survey was approximately 0.5 cfs. Salt Creek flows under the railroad though a flat-bottomed concrete box culvert that is approximately 100 ft long and 6 ft wide. The outlet of the culvert drains across a 12-ft concrete apron before discharging into the natural channel (Figure 12). The culvert is set at a grade of approximately 4%. Water depth over the outlet apron was less than 0.1 ft. There is no rest area upstream of the culvert inlet. The culvert is a complete barrier to upstream adult and juvenile salmonid migration at all flows due to its length, gradient, and flat bottom. No fish were observed.

Downstream of the box culvert crossing, the creek flows through a 20-ft-long, 24-in diameter corrugated metal pipe that runs under the railroad access road. The culvert pipe is severely deteriorated by rust. The culvert discharges to a channel constricted with blackberries (*Rubus spp.*).

The headwater reaches of Salt Creek would be disturbed by excavation of the south pit and construction of the primary processing plant. Excavation of the South Pit would reduce the area

draining to Salt Creek. The figure titled "Stormwater Feasibility Moody Flats" included in the *Moods Flats Quarry Stormwater, Erosion Control, and Drainage Plan* (Crawford and Kopania 2010) indicates that surface runoff from the proposed primary processing plant would drain to the South Sump Pit, further reducing surface runoff to Salt Creek compared with existing conditions. The Stormwater, Erosion Control, and Drainage Plan indicates that the South Sump Pit would be pumped, as needed, to the O.B. Surge Basin and then to Rate Control Basin 1 or 2. Both rate control basins route to the water quality ponds and eventually to the vegetated sheet drain, which would supply surface and/or subsurface flow to the bedrock-controlled reach of Lower Moody Creek downstream of the proposed Project area.

Figure 12. Salt Creek railroad box culvert.

3.2 17 May 2012 Survey

3.2.1 Upper Moody Creek

The Upper Moody Creek survey consisted of four reaches that varied in length from 100–350 ft and totaled 900 ft. Water depth within the railroad crossing box culvert was less than 0.1 ft (Figure 13). During the time of the survey, Upper Moody Creek exhibited intermittent flow in the lower gradient valley floor (Figure 14). Isolated pools were common. Surface flow of approximately 0.25–0.5 cfs was present in the higher gradient reach upstream of the valley (Figure 15). Water temperatures ranged from 64 to 68°F between 10 a.m. and 12 noon.

Several of the isolated pools and deep pools in flowing reaches were baited with bread, but with no response. No fish were observed in any habitat unit with the reaches.

Several of the pools contained what appeared to be Pacific tree frog larvae openly swimming on the surface away from cover. This was another indication that predatory fish such as steelhead/rainbow trout were not present.

Figure 13. Upper Moody Creek railroad box culvert flow on 17 May 2012.

Figure 14. Isolated pool in Upper Moody Creek along the valley floor.

Figure 15. Upper Moody Creek flow over a bedrock sill.

3.2.2 Lower Moody Creek

The Lower Moody Creek survey consisted of three reaches that were between 200 and 300 feet in length and totaled 700 ft. During the time of the survey, Lower Moody Creek was experiencing intermittent flow of, at most, 0.25 cfs in the flowing reaches (Figure 16).

Figure 16. Isolated pool in Lower Moody Creek. Note the dry channel in the upper center of the photograph.

The flat-bottomed concrete box culvert under the railroad was still backwatered, but no fish were observed in the pool. The backwatered pool tail crest was filled with sediment and leaves, forming a barrier to upstream and downstream migration.

The reaches were surveyed for fish presence and several of the pools were baited with bread. No fish were observed. Similar to Upper Moody Creek, frog larvae were observed swimming in the open water of the pools.

3.2.3 Rancheria Creek

The Rancheria Creek survey consisted of two reaches totaling approximately 500 ft of stream length. Flow during the time of the survey was between 0.25 and 0.5 cfs.

The railroad box culvert formed a complete barrier to any upstream migrating fish (Figure 17). No fish were observed in a 400 foot long reach downstream of the crossing. No fish responded to the baiting efforts. No fish were observed in Rancheria Creek.

Figure 17. Rancheria Creek railroad box culvert flow during 17 May 2012.

3.2.4 Salt Creek

Given the very low flows in Salt Creek during the 4 April 2012 survey, no survey was conducted during this effort due to the expectation that the reach would be dry.

4 CONCLUSION

Stillwater Sciences conducted a reconnaissance-level field investigation of the Project-affected reaches of Moody, Rancheria, and Salt creeks on 5 April 2012 to assess potential for channel adjustment from Project-related changes in runoff and on 5 April 2012 and 17 May 2012 to identify potential fish use. Conditions were excellent for observing hydraulics, channel condition, aquatic habitat, and fish presence during the field assessments. Assessment of the potential for channel adjustment included identification of channel morphology, bed surface texture, channel hydraulics, base level, and bank stability. Assessment of fish use included streambank observations during early spring and early summer baseflows, baiting of numerous isolated pools, and identification of potential migration barriers along the railroad right of way and elsewhere on the property.

Based on observation made during the field investigation, the stream channels within the Project area do not support native or non-native fish. The channels are inhabited, however, by amphibians and reptiles, as evidenced by observations of Pacific tree frogs and northwestern pond turtles in Upper Moody Creek.

The Upper Moody Creek channel is bedrock-controlled near the proposed diversion point and has little potential for channel adjustment. Downstream of the diversion point, where the Upper Moody Creek channel would be filled by construction of the processing and load-out area, there would be no potential for additional effects resulting from Project-related changes in stormwater runoff. The existing *Moody Flats Quarry Stormwater, Erosion Control, and Drainage Plan* (Crawford and Kopania 2010) does not provide sufficient detail to evaluate the potential effects of phased construction on this channel reach. At the downstream end of Moody Flats, Upper Moody Creek has a relatively high potential to incise and/or shift laterally if phasing of Project construction were to accelerate peak runoff to the reach.

Peak flows through the Moody Flats reach of Lower Moody Creek will increase over existing conditions due to diversion of surface runoff from Upper Moody Creek and Salt Creek. The Lower Moody Creek channel through Moody Flats is formed in unconsolidated alluvium and colluvium with long continuous lengths of channel bank lacking reinforcement by roots of woody riparian vegetation. This reach has a relatively high potential of incising or adjusting laterally by bank erosion in response to increased peak flows during storm runoff. The *Stormwater, Erosion Control, and Drainage Plan* (Crawford and Kopania 2010) does not provide information describing proposed changes to the existing channel over this reach, and it's unclear if and how the Lower Moody Creek channel through Moody Flats would be modified (e.g., by rip rap armoring, structural grade control, and/or engineered surface or subsurface channelization) to limit channel adjustment. The concrete box culvert through the Union Pacific Railroad would prohibit downstream propagation of any channel adjustments initiated in upstream reaches of Lower Moody Creek, and increased runoff is unlikely to result in channel adjustment in the bedrock-controlled reach downstream of the Union Pacific Railroad.

The *Stormwater, Erosion Control, and Drainage Plan* (Crawford and Kopania 2010) indicates that runoff in several small channels currently draining to Moody Flats would be diverted along the northern margin of the Plant Area to Rancheria Creek, but uncertainty in the receiving waters and the lack of information in the plan describing the diversion prohibited an assessment of the potential effects of Project-related changes in stormwater runoff on the Rancheria Creek channel. The headwater reaches of Salt Creek would be disturbed by excavation of the south pit and

construction of the primary processing plant, reducing the drainage area contributing to Salt Creek.

5 REFERENCES

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