# 3.0 ERRATA TO THE DRAFT EIR

This section shows the revisions that have been made to the July 2007 Draft EIR for the Bonny Doon Limestone Quarry Boundary Expansion Project and Reclamation Plan Amendment Draft EIR. Revisions have been made in response to comments received on the Draft EIR.

The revisions have been presented in the consecutive order they appear in the Draft EIR, except revisions to the summary table (Table S-1), which is included in its entirety in Section 4.0 of this Final EIR. Pages are shown in their entirety from the Draft EIR to provide context. In addition, Chapter 4.0 Geology and Soils, and Chapter 5.0 Hydrology and Water Quality are included in their entirety due to the number of revisions. The chapter and page number from the Draft EIR are indicated in the top margin. Text in standard print is original text from the Draft EIR. Underlined text indicates additions to the original text, and strikeout text indicates deletions from the original text.

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# 1.0 INTRODUCTION

## 1.1 BACKGROUND

The Bonny Doon Limestone and Shale Quarries are owned and operated by CEMEX (RMC Pacific Materials, dba CEMEX). The quarries operate under use permits issued by the County of Santa Cruz (County) in May 1964, April 1967 and December 1968, which establish the operating conditions of the quarries and the mining boundaries. The County approved a Certificate of Compliance for the quarries in July 1997. The State Mining and Geology Board (SMGB) approved the Reclamation Plan for the Bonny Doon Quarries in December 1996 as amended by mitigation measures identified in the Bonny Doon Quarries Certificate of Compliance and Reclamation Plan Final Environmental Impact Report (County of Santa Cruz, 1996).

CEMEX has filed an application with the County to extend the active mining boundary of the Limestone Quarry by 17.1 acres requiring amendments to their current Use Permit (3236-U), Certificate of Compliance and the 1996 Reclamation Plan 89-0492 (COC). The proposed expansion would also require the issuance of a Coastal Development Permit. The proposed Expansion Area is within the Quarry Legal Limit, which is protected under vested rights established by the County. Under vested rights, the quarry operator is entitled to continue mining within the established legal boundary as long as operations conform to the permit conditions and County mining regulations. However, it remains within the legal authority of the County to review the proposed expansion for conformance with relevant County regulations and ordinances, and to modify the project where non-conformance is found. The County determined that the mining plan expansion, while covered under vested rights, is subject to environmental review under the California Environmental Quality Act (CEQA).

The County's authority under vested rights, is described in a letter from County Counsel to the Board dated March 11, 2002.

> *"…as previously acknowledged by the County, and out of respect for the vested rights which RMC does possess, and consistent with the County Code, the County will impose additional conditions or restrictions only in the case that the stricter standards 'are necessary to mitigate a potentially significant environmental impact, and/or to protect public health or safety, and/or to respond to a public nuisance.' Should additional limitations be found to be necessary to prevent significant environmental impacts or threats to public health and safety, the risks associated with these impacts must be weighed against the effects of such restrictions on quarry operations to ensure that they do not unreasonably constrain the permit holder from exercising their vested rights."*

During the review and approval of the 1996 Reclamation Plan by the SMGB, debate occurred between the County, the SMGB, and RMC over the best approach toward re-establishing plant cover on land disturbed by mining. Presently, the revegetation plan specifies planting vegetation communities that were pre-existent to the mining operation. The replacement of lost vegetation types as specified in the 1996 Reclamation Plan mitigated the significant environmental impact upon sensitive plant communities (County of Santa Cruz, 1996). However, the SMGB recognized that soils heavily disturbed from mining would not readily support ~~climax~~ vegetation communities such as redwood forest and ~~maritime chaparral~~ mixed evergreen forest specified in the Bonny Doon Quarry 1996 Reclamation Plan. The SMGB reclamation standards are based on a more modest approach of using early successional vegetation such as grasslands to establish plant cover in areas where well-developed soil structure is lacking. During SMGB review of the Bonny Doon 1996 Reclamation Plan, a third party study of revegetation methods and materials was conducted for the Bonny Doon Quarries (Hart 1999). The study recommended a shift in revegetation strategy from a climactic to an early successional planting scheme. Since this change substantially alters the revegetation plan assessed in the Certificate of Compliance and 1996 Reclamation Plan, the proposed (2001) revisions to the 1996 Revegetation Program are subject to environmental review under CEQA.

## 1.2 INTENDED USE OF EIR

The County is responsible for amending Use Permit 3236-U, amending COC and Reclamation Plan Approval 89-0492, and issuance of a Coastal Development Permit. This Draft Environmental Impact Report (EIR) assesses the environmental effects associated with each of these three discretionary actions. As the Lead Agency, the County will use this EIR to satisfy the requirements of CEQA when taking action on the Use Permit, COC, and Coastal Development Permit.

The Expansion Area covers 17.1 acres within the Legal Mining Limit. The remaining unmined portion of the Legal Mining Limit, roughly 9.4 acres, is not included in the proposed mining plan amendment. Amending the mining plan boundary to include the remaining 9.4-acre area would require separate application to the County and environmental review in compliance with CEQA. The remaining area is not addressed in detail in this EIR. However, the environmental effects of mining the remaining area are considered along with the effects of the proposed project in the discussion of cumulative impacts (See Section 11.4).

The Reclamation Plan Amendment would also be reviewed by the SMGB. Other responsible or trustee agencies may review this EIR to determine regulatory jurisdiction over the project. Such agencies may include the U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), California Department of Forestry (CDF), California Coastal Commission (CCC), Monterey Bay Unified Air Pollution Control District (MBUAPCD), and California Regional Water Quality Control Board (RWQCB).

## PERMIT REQUIREMENTS

The Bonny Doon Quarries operate under various permits by regulatory agencies as shown in Table 1-1 below. The proposed mining expansion would facilitate a continuation of the existing operation; no other changes are proposed to the operation of the quarry that requires permitting by other regulatory agencies. The project does require approval of a Coastal Development Permit that can be appealed to the CCC, and approval of a Reclamation Plan Amendment that can be appealed to the SMGB.

**Table 1-1**
**Summary of Permit Requirements**

| Agency | Existing Permit | Limestone Quarry Boundary Expansion and Reclamation Plan Amendment |
|---|---|---|
| County of Santa Cruz | Use Permit 3262-U and Certificate of Compliance 89-0492 | Amendment required |
| California Coastal Commission | County of Santa Cruz is lead agency for Coastal Development Permit, which is appealable to the CCC. | Application includes Coastal Development Permit |
| California Department of Fish & Game (Bay Delta Region) | Existing Stream Alteration Agreements for Disposal Area C and periodic Settlement Basin cleanout | No change |
| Regional Water Quality Control Board (Central Coast Region) | Existing General Storm Water Permit for Industrial Activities | No change |
| Monterey Bay Unified Air Pollution Control District[1] | Permits to Operate existing emissions-producing equipment | No change |
| U. S. Fish & Wildlife Service (Ventura Office) | Incidental Take Permit for California red-legged frogs due to operation of settlement basins. Expires in 2009. | No change |
| U. S. Army Corps of Engineers (San Francisco District) | Authorization under Nationwide Permit 26 to fill wetlands in Disposal Area C | No change |
| State Mining and Geology Board | County is Lead Agency for Reclamation Plan Amendment approval, which is appealable to the State Mining and Geology Board | Application includes a Reclamation Plan Amendment |
| California Department of Forestry | Timber Harvest Plan and Timberland Conversion permit | Required for proposed project |

[1] Rule 440 was adopted in March of 2008 and is discussed in detail in Section 7.2.3 of the Final EIR.

existing mining area, the extended mining area would be developed upon permit approval and would be mined in conjunction with the existing area.

The currently approved final mining configuration for the Limestone Quarry is shown in Figure 6 (Currently Approved Limestone Quarry Final Development). This would be changed by the proposed expansion and mining plan amendment. Interim configurations are shown in Figures 7 and 8. The final mining configuration of the proposed project is shown in Figure 9 (Limestone Quarry Proposed Amendment to Mining Plan -- Final Development).

Quarry floor elevation is approximately at 750 feet, which is the permitted mining limit depth. Under the proposed boundary expansion, the quarry floor would be extended eastward at the 750-foot elevation. Although high grade limestone does extend below the 750-foot level, no change to the mining depth limit is proposed by the proposed expansion. The proposed mining plan amendment would only extend the mining plan boundary and final contours as discussed below.

Under the proposed expansion, the bench configuration and pit development would continue in the same manner as presently occurring under the existing operation. Benches would still be constructed with lift heights of 40 feet and bench widths of 16 feet. No operational changes in mining methods, equipment used, production rates, or hours of operation are proposed. No changes in permit conditions are proposed.

Primary development of the existing quarry pit consists of working the benches back into a steeper configuration. Most of the pit is in the schist and limestone units with high slope stability. There, final contours show slopes averaging 60 degrees (0.58:1 horizontal to vertical), having 40-foot, 80-degree bench heights, with bench widths of 16 to 20 feet sloped inboard 1.5 to 2 percent. In the upper portions of the northern end of the quarry in the Lompico Sandstone, the final slopes would be less steep at 1.5:1 horizontal to vertical for greater long-term stability.

### 2.4.1 Vegetation, Topsoil and Overburden Removal

Land preparation of the 17.1 acre Boundary Expansion Area would occur in two stages. It is currently anticipated that land clearing would be conducted during the late ~~spring~~ summer and ~~summer~~ fall months in each of the first two years of operation. Approximately one-half of the acreage would be cleared each year. The initial removal is planned for the highest elevations that are closest to the existing operation. Newly developed areas would generally be mined from the top down.

For proper utilization of natural resources, the California Department of Forestry (CDF) would require a Timberland Conversion Permit under Public Resources Code Section 4621-4628 and an approved Timber Harvest Plan (Rich Sampson, CDF, pers. Comm.). Marketable timber would then be trucked to a local mill.

Slash and other remaining vegetation would be blended with the topsoil that would be removed to add structure and possible nutrients to the topsoil. This topsoil would be stored at the top of Disposal Area C for use in reclamation/revegetation at the Limestone and Shale Quarries. Redwood stumps may also be stored for future use in riparian restoration projects throughout the

Revegetation Plan modifications that include a planting scheme more suitable to post-mining soil conditions. The proposed 1996 Reclamation Plan Amendment is a component of the project under consideration in this EIR because it significantly departs from the 1996 Reclamation Plan that was subject to environmental review under CEQA in 1996. Whereas, the 1996 plan proposed the re-establishment of ~~climax~~ vegetation communities, the proposed 1996 Reclamation Plan Amendment would establish ~~an early successional~~ native vegetation ~~community~~ communities more suited to post quarried soils and abandon attempts to directly replace the lost acreages of ~~specific climax~~impacted vegetation communities. Under the proposed approach, ~~climax~~ impacted vegetation communities would eventually establish naturally as soil conditions improve over time as a result of the early successional plant community having been established. A comparison of the revegetation components of the approved 1996 Reclamation Plan and the proposed 1996 Reclamation Plan Amendment are presented in Table 2-1. The revegetation plans evaluated in the approved 1996 Reclamation Plan are shown in Figures 11 and 12. The revegetation plans proposed under the 1996 Reclamation Plan Amendment are shown in Figures 13 and 14. Table 2-2 provides an overview to the changes made in the revegetation plans. The proposed 1996 Reclamation Plan Amendment substantially modifies the approved Revegetation Plan and is therefore subject to environmental review under CEQA.

The proposed 1996 Reclamation Plan Amendment specifies shifting revegetation efforts away from ~~late successional~~impacted vegetation communities, which have been difficult to re-establish, towards early successional communities. Native species more tolerant of post-mining soil conditions would be planted to increase the success rate of establishing vegetative cover on the reclaimed areas. An early successional shrub mix is proposed for the Shale Quarry (Figure 14) and both an early successional shrub mix combined with a mid-successional forest mix is proposed for the Limestone Quarry (Figure 13). A list of species proposed for planting in each community is presented in Table 2-3. Table 2-3 is composed of early successional native species that have established through natural recruitment in disturbed areas of the quarry site.

The proposed change to an early successional approach to revegetation eliminates direct replacement of ~~most climax~~several impacted vegetation communities identified in the approved 1996 Reclamation Plan. A comparison of the approved and the proposed reclamation plan revegetation plans by vegetation community in acres is presented in Table 2-2. The proposed 1996 Reclamation Plan Amendment would eliminate the direct replacement of three native vegetation communities to include: maritime chaparral (4.5 acres), needlegrass grassland (4.0 acres), and diverse native grassland (12 acres). These vegetation communities are required by the1996 Certificate of Compliance and Reclamation Plan EIR as mitigation for significant biological impact of the mining operation. Rather than in-kind replacement, the 1996 Reclamation Plan Amendment would establish early and mid-successional vegetation communities that would ultimately climax into mixed evergreen forest. The proposal would preserve two of the native vegetation communities (redwood forest and riparian) and fully replace one community (northern coastal scrub).

**Table 2-1**
**Overview of Proposed Amendment to Bonny Doon Quarries 1996 Reclamation Plan**

| Approved 1996 Reclamation Plan with EIR Mitigation Conditions (Existing Requirement of Use Permit 3236-U) | Proposed under the 1996 Reclamation Plan Amendment (Component of Current Application Under County Review) | Purpose of Proposed Amendment to the 1996 Reclamation Plan |
|---|---|---|
| Revegetation Program to include 1:1 replacement of seven vegetation communities affected by the mining operation (see Table 2-2), and the replacement of one vegetation community (riparian) at a 3:1 replacement ratio as required by CDFG.<br>**(1996 EIR Measure VEG-2)**<br>Requirement to directly replant sensitive vegetation communities to mitigate loss of native vegetation communities from mining operations. In addition, a Mt. Diablo cottonweed re-establishment component is to be specified.<br>**(1996 EIR Measure VEG-5)** | Revegetation Program would preserve two existing communities and establish an early successional shrub and mid-successional mixed evergreen forest community (see Table 2-2).<br>Required planting of climax vegetation communities specified in 1996 EIR Measure VEG-5 would not occur. Reclaimed areas to recruit sustainable vegetation types based on natural succession | A third party study requested by Department of Conservation (Hart, October 2000) concluded that Reclamation Plan species are poorly adapted to the highly altered soils and recommended species adapted to early successional environments. Department of Conservation concurred with the revegetation recommendations (December 22, 2000). |
| Establish a test plot program to determine best methods and materials for establishing permanent native vegetation communities on the quarry benches and disposal areas.<br>**(1996 EIR Measure VEG-6)** | Proposed program does not identify a test plot program. Plant selection would be based on early successional species, which have shown natural recruitment to the reclaimed areas and success in initial plantings. No further testing proposed. | Test plots were established under the draft 1999 program. Test plot results were that vegetation types of ~~three~~two of the targeted communities (maritime chaparral, needlegrass grassland ~~and mixed grassland~~) could not be established given existing soil conditions (Table 2-2). |

*The 1996 Reclamation Plan Amendment incorporates all remaining revegetation requirements of 1996 EIR including Measures VEG-3, VEG-4, VEG-7, VEG-8, VEG-9 and VEG-10.
Source: TRA Environmental Sciences, Inc., 2007

## 2.6 MEASURES INCORPORATED THROUGH PROJECT DESIGN

CEMEX has incorporated the following measures into the project design:

- Continued monitoring of Liddell Spring by the City of Santa Cruz and CEMEX.
- For each complete blasting round, two additional holes would be drilled 20 feet deeper than the bench elevation. These holes would be drilled to intercept any potential ground water in the new areas to be mined. If water is encountered in these holes, a pump test would be conducted according to the protocols outlined in Section 15e of the revised mining plan application to determine the significance of the encountered water. If pumping of the boring suggests that the water encountered in the boring may be connected to the marble aquifer, then mining would be limited in that area to the elevation 20 vertical feet above the peak ground water level.
- Compliance with existing mining conditions of approval set forth by Use Permit 3236-U, and COC, and Reclamation Plan Approval 89-0492.

## 2.7 ISSUES OF PUBLIC CONCERN

An Initial Study was prepared for the Bonny Doon Limestone Quarry Boundary Expansion Project by Santa Cruz County planning staff in November 2001 and is attached as Appendix A. In response to the Notice of Preparation for the EIR, several issues of concern were raised by the public or public agencies concerning the potential environmental impacts of the quarry expansion project. The letters received in response to the Notice of Preparation are also attached in Appendix A.

<u>Water Quality and Quantity</u>. The City of Santa Cruz Water Department expressed concern that there is inadequate understanding of the hydrogeologic conditions that exist beneath the quarry and the proposed Boundary Expansion Area which supply Liddell Spring – an important water source for the City of Santa Cruz. The concerns are that expansion of the mining pit could adversely affect the quantity and/or quality of Liddell Spring water thus impacting this municipal water source, and that the expansion project could trigger landslides that would impact Liddell Spring.

<u>Fisheries</u>. Steelhead trout and coho salmon are listed as threatened species under the federal Endangered Species Act. The National Oceanic and Atmospheric Administration (NOAA) Fisheries expressed concern that lack of adequate flows in Liddell Creek and San Vicente Creek are likely impairing listed anadromous salmonid species, and that the current level of water use at the quarry may be adversely affecting these species.

<u>Air Quality</u>. The Monterey Bay Unified Air Pollution Control District noted that mining operations in the Boundary Expansion Area would generate emissions of fine particulate matter (PM10). The impact of these emissions upon nearby sensitive receptors and project consistency with the 200~~0~~<u>8</u> Air Quality Management plan for the Monterey Bay Region must be assessed. <u>In addition District Rule 440 adopted in March 2008 applies to mineral processing facilities.</u>

### 3.2.1 General Plan/Local Coastal Program

The County of Santa Cruz GP/LCP Land Use Plan designates the Limestone and Shale mining areas as Mineral Resource Areas with a Quarry ("Q") designation. The continuation and expansion of mining activities is encouraged within these designations pursuant to a valid Mining Permit and Reclamation Plan. The Boundary Expansion Area is designated Quarry by the GP/LCP and is zoned Heavy Industrial (M-3). The use of the Boundary Expansion Area for mining purposes is consistent with the GP/LCP Land Use and Zoning designations. The zoning districts for the quarry property and surrounding parcels are shown in Figure 15, Zoning Map.

Policies of the GP/LCP Land Use Plan (Section 16.54.010) relevant to the mining operations at the Bonny Doon Quarries are implemented through the Mining Regulations. GP/LCP policies relevant to the project are listed in Table 3-1. Project conformance to the General Plan policies is described below in Section 3.3.2. Project compliance with the Mining Regulations would result in project compliance with the GP/LCP policies. Project conformance with the Mining Regulations requirements are described in Sections 3.3.3 and 3.3.4 below.

**Table 3-1**
**Relevant County General Plan Policies for the**
**Bonny Doon Limestone Quarry Boundary Expansion Project and Reclamation Plan Amendment**

| | |
|---|---|
| **Policies — Land Use** | |
| 2.19.1 | **Siting of Heavy Industries and Quarries.** Any change in use or major expansion shall be subject to full environmental and economic analysis and review by the County for the adequacy and appropriateness of the site for the proposed use. |
| 2.19.2 | **Operation of Existing Quarries.** Allow continued operation of existing quarries and allow expansion within areas designated as Mineral Resources, including those located in the Coastal Zone, where impacts of environmental and scenic resources and surrounding residential uses can be mitigated. Require that all existing quarries meet the requirements of the County's Mining Ordinance. Require that all mining operations maintain and implement a County approved reclamation plan as required under the California Surface Mining and Reclamation Act (SMARA) and ensure that the rehabilitation and future uses of depleted quarry sites are in accordance with conservation and open space values. |
| **Policies — Biotic Resources** | |
| 5.1.3 | **Environmentally Sensitive Habitats.** Allow only uses dependent on such resources in Environmentally Sensitive Habitats in the Coastal Zone unless other uses meet certain criteria. |
| 5.1.6 | **Development Within Sensitive Habitats.** Sensitive habitats shall be protected against any significant disruption of habitat values. |
| 5.1.7 | **Site Design and Use Regulations.** Protect sensitive habitats against any significant disruption or degradation of habitat values in accordance with the Sensitive Habitat Protection ordinance. |
| 5.1.9 | **Biotic Assessments.** Require a biotic assessment as part of project review in areas of biotic concern and sensitive habitats. |

| **Table 3-1<br>Relevant County General Plan Policies for the<br>Bonny Doon Limestone Quarry Boundary Expansion Project and Reclamation Plan Amendment** | |
|---|---|
| 6.3.8 | **On-site Sediment Containment.** Require containment of all sediment on-site during construction and require drainage improvements for the completed development that will provide runoff control, including onsite retention or detention where downstream drainage facilities have limited capacity. Runoff control systems or Best Management Practices shall be adequate to prevent any significant increase in site runoff over pre-existing volumes and velocities and to maximize on-site collection of non-point source pollutants. |
| **Policies – Noise** | |
| 6.9.4 | **Commercial and Industrial Development.** For all new commercial and industrial developments which would increase noise levels above the maximum allowable standards of the Land Use Compatibility Guidelines in Figure 6-1, or Figure 6-2, the best available control technologies will be used to minimize noise levels. In no case shall the noise levels exceed the standards of Figure 6-2. |

Source: County of Santa Cruz 1994.

### 3.2.2 Mining Regulations 16.54.050, Required Conditions and Standards for Mining Approval, Certificate of Compliance, Reclamation Plan Approval

The proposed project amends the COC and is subject to the required conditions and standards of the Mining Regulations 16.54.050. The conditions and standards of the Mining Regulations 16.54.050 relevant to the project are listed below in Table 3-2. A complete listing of all standards of the Mining Regulations is presented in Appendix B. Project conformance to the Required Conditions and Standards is described below in Section 3.3.3.

| **Table 3-2<br>County Mining Regulations 16.54.050<br>Required Conditions and Standards for Mining Approval,<br>Certificate of Compliance, Reclamation Plan Approval** |
|---|
| **1. Noise and Vibration** |
| All facilities and equipment shall be constructed, maintained and operated in compliance with the Industrial Performance Standards of Section ~~13.10.445~~16.54.050(c)(1) and County General Plan Section ~~3.6.1~~6.9.4. Maximum noise level measured at property boundaries shall be no greater than 60 dBA for a cumulative period of 15 minutes in any hour of operation. A lower noise level may be required by the Planning Commission if a health or safety effect or nuisance related noise level is demonstrated. A higher noise level may be authorized by the Planning Commission if the increase in noise level is from construction related activity, the noise is generated only on a specified temporary basis and all neighbors within 1000 feet of the property have been notified in writing of the increase in noise level by the operator. |
| (i) Each mining operation and reclamation activity shall be conducted in compliance with the requirements of the Monterey Bay Unified Air Pollution Control District |
| (ii) Removal of vegetation shall only be permitted in accordance with the approved phasing plan. |
| (iii) Each mining operation shall be conducted so as to minimize dust, particulate matter (PM10), crystalline silica, and any other potentially significant effect of wind erosion. |

Project mining of the Boundary Expansion Area would remove 2.5 acres of northern coastal scrub and 0.9 acre of coast live oak forest (see Table 6-2, Biology and Figure 29), which are identified by the Sensitive Habitat Protection Ordinance as sensitive habitat. Avoidance of impacts to the habitat areas cannot be achieved due to the site-specific nature of the mining operation. Replacement of the northern coastal scrub and coast live oak forest habitats would occur through implementation of the Mitigated 1996 Reclamation Plan Amendment; the revegetation plan proposed in the 1996 Reclamation Plan Amendment.

The proposed 1996 Reclamation Plan Amendment specifies plant species more suitable to post-mining soil conditions, and would eliminate the planting of three sensitive habitats (needlegrass grassland, maritime chaparral, and diverse native grassland) required by the 1997 COC Conditions of Approval. The removal of these habitats from the 1996 Reclamation Plan was proposed in the 1996 Reclamation Plan Amendment based on test plot trials showing poor success of plant species that require better developed soil conditions. However, the recent discovery of previously stockpiled topsoil at the quarry has led to plantings of these communities that are showing signs of success (see Biology discussion for further analysis). Therefore, the successful creation of these sensitive vegetation communities as required by the COC Conditions of Approval should be achievable. The re-instatement of needlegrass grassland, maritime chaparral, needlegrass grassland, and mixed grassland into the revegetation plan (Measure BIO-3) is provided as project mitigation.

The Boundary Expansion Area contains habitat for the San Francisco dusky-footed woodrat (*Neotoma fuscipes annectens*; "SFDW"), a California Species of Special Concern (CSC). Impacts to this special status species is described in Chapter 6.0 Biological Resources. A Woodrat Mitigation Plan has been prepared and is incorporated into Biological Resources chapter of this EIR. A mitigation program has been identified (Measures BIO-1 and BIO-2) to offset the impacts to the SFDW.

Implementation of Measures BIO-1, BIO-3, and BIO-4 brings the project into conformance with the GP/LCP Biotic Resource Policies 5.1.7 and 5.1.10.

**Water Resources.** In Compliance, with Mitigation. Liddell Spring is a Water Supply for the City of Santa Cruz. The Quarry operations must meet erosion control and water quality protection standards. Mining in the proposed Boundary Expansion Area would be subject to the Drainage and Erosion Control Plan approved for the existing Quarry operation. Mining expansions could result in erosion and sedimentation affecting the water quality of Liddell Spring. Mitigation Measure HYD-1 would improve erosion control during removal of the overburden and to protect the spring from sedimentation. Measure HYD-2 provides for additional monitoring of water quality and Measure HYD-3 requires that CEMEX ~~enter into an~~ comply with their existing 1964 ~~agreement~~Agreement with the City of Santa Cruz for ~~additional treatment~~ outlining thresholds of significance and mitigation measures for impacts to ~~of~~ Liddell Spring water~~s~~ quality and quantity. Implementation of these measures brings the project into conformance with the GP/LCP Water Resource Policy 5.5.9.

**Maintaining Adequate Streamflows.** In Compliance. Liddell Creek is a Critical Water Supply Stream. The Limestone Quarry is situated in the headwaters of Liddell Creek. CEMEX diverts up to 21 gallons per minute (927,000 gallons per month) from Plant Spring for its existing operation. This diversion represents approximately 2 percent of the combined baseflow of Plant Spring and Liddell Spring, which feed Liddell Creek. The proposed mining expansion

Mining the Expansion Area would result in increased runoff volumes and sediment loads entering Settlement Basin 3. A liquefaction assessment of the quarry settlement basin levees has not been performed. A displacement analysis for seismic shaking shows basin levees would move under seismic shaking. Sedimentation of downstream areas could occur if settlement basin levees receiving runoff from the quarry Boundary Expansion Area fail during a major seismic event. Updated analysis and modification of the levees as recommended is identified in Measure GEO-1. Implementation of this measure would bring the project into compliance with Use Permit Condition III.26 and III.27.

**RWQCB and CDFG Requirements.** In Compliance. The continuation of mining into the proposed Boundary Expansion Area would remain subject to the General Storm Water Permit for Industrial Activities. New drainage features implemented in accordance with Measure HYD-1 would be subject to review and permit approval by RWQCB. The continued mining operation would also remain subject to requirements of CDFG for periodic cleanout of settlement basins through provisions of a Streambed Alteration Agreement. CDFG has review authority over project impacts to the SFDW and the CRLF, which are both CSC. Project impacts to SFDW are mitigated through Measures BIO-1, and BIO-2 that include habitat conservation, habitat enhancement, dismantling nests to avoid direct loss of individuals, and data collection. Mitigation for the SFDW has been developed in consultation with CDFG and is subject to CDFG review.

**Non-compliance Cause for Permit Revocation.** In Compliance, with Mitigation. The project requires mitigation to comply with Use Permit Conditions III.7 and III.25 regarding water quality impacts at Liddell Spring, Condition III.8 regarding final cut slopes of the quarry, and Condition III.23 regarding dust impacts on adjacent property. With implementation of Measures HYD-1, HYD-2, HYD-3, GEO-2 and AQ-1, the project complies with Use Permit 3236-U Conditions.

### 3.3.6 Conformance with Certificate of Compliance and Reclamation Plan Approval 89-0492

**Vegetation.** In Compliance, with Mitigation. The Revegetation Plan component of the 1996 Reclamation Plan Amendment does not include the replacement of lost native vegetation communities and a test plot program as required in COC Condition III.D.6. See discussion of General Plan Biotic Resources Policies above in Section 3.3.2 and Table 3-1. Implementation of Measure BIO-3 would re-instate these communities into the Revegetation Program and bring the project into compliance with COC Condition III.D.6.

**Wildlife.** In Compliance, with Mitigation. The proposed project could increase runoff volumes and sediment loads discharged to Settlement Basin 3, which is known breeding habitat for CRLF. Maintenance of the settlement basins and possible impacts to CRLF are addressed in the Bonny Doon Quarries Settlement Ponds Habitat Conservation Plan (HCP). The mining expansion project is subject to the conditions of the HCP. The proposed project would not impact Coho salmon or steelhead habitat in the lower reaches of Liddell Creek. Construction of a filter base on the quarry floor as required in Measure HYD-1 would reduce sediment loads in storm water runoff recharging to Liddell Spring or discharging to Settlement Basin 3 thereby reducing the potential for sediment to be discharged downstream to ~~Coho salmon or~~ steelhead habitat in the lower reaches of Liddell Creek. With Measure HYD-1 and existing drainage controls at the quarry, the project would not impact steelhead ~~or Coho salmon~~. Implementation of Measure HYD-1 bring the project into compliance with COC Condition III.E.1

# 4.0 GEOLOGY AND SOILS

The following sections describe the geologic setting, impacts, and mitigation recommendations. They are abstracted from the *Geologic, Hydrologic, and Hydrogeologic Technical Appendix for Draft EIR, Bonny Doon Quarry Proposed Expansion* (Nolan Associates, 2007), referred to hereafter as the Geology and Hydrology Technical Appendix (Appendix F).

The geologic environmental setting also provides necessary background information for the analysis of hydrologic and hydrogeologic conditions at the project site that are discussed in Hydrology, Section 5.0.

## 4.1 ENVIRONMENTAL SETTING

Because of its importance in understanding the hydrology and hydrogeology of the project in a regional context, the area evaluated for the geologic portion of the environmental impact analysis extended well beyond the boundaries of the quarry and proposed Boundary Expansion Area. The following discussion will therefore refer to the geologic/hydrologic study area, bounded on the north by Ice Cream Grade, on the west by Bonny Doon and Pine Flat Roads, on the east by Laguna Creek, and on the south by an east-west line drawn approximately through Liddell Spring (Figure 16, Geologic/Hydrologic Study Area Topographic Index Map).

The above description of the "geologic/hydrologic study area" (G/HAS) is intended only to orient non-technical readers with easily recognized landmarks. The expression "geologic/hydrologic study area" is not used in Appendix F. Boundaries used to define the quarry area hydrology in Appendix F are based entirely on drainage divides, lithologic units and their corresponding properties, geologic structure, hydrology, and hydrogeology. The technical basis for the study area is provided in detail in Chapter 4 of Appendix F.

The Environmental Setting for Soils and Geology is based on:

- a review of available geologic literature describing the geologic/hydrologic study area and previous geologic and geotechnical consulting reports, maps, and other documents prepared for the quarry;
- inspection of stereographic aerial photos ranging in age from the 1930's to the present;
- field collection of geologic information in the quarry and throughout the geologic/hydrologic study area; and
- review of geologic information from drilling records in the area.

The information obtained from these sources was used to develop an updated geologic map of the geologic/hydrologic study area to serve as a basis for the geologic, geotechnical, and hydrological evaluation of the project impacts. Regional and local scale sources of geologic information included Brabb (1997), Clark (1981), Leo (1967), and Wisser and Cox (1958).

Portions of the following discussion of the geologic setting refer to the geologic time scale. A summary of the geologic time scale is included as Table 4-1 for reference.

**Table 4-1**
**Geologic Time Scale**

| Eon | Era | Period | Epoch | Time Span (Ma*) | Duration (My**) |
|---|---|---|---|---|---|
| Phanerozoic | Cenozoic | Quaternary | Holocene | –0.01 | 0.01 |
| | | | Pleistocene | 0.01–1.6 | 1.59 |
| | | Tertiary | Pliocene | 1.6–5.3 | 3.7 |
| | | | Miocene | 5.3–23.7 | 18.4 |
| | | | Oligocene | 23.7–36.6 | 12.9 |
| | | | Eocene | 36.6–57.8 | 21.2 |
| | | | Paleocene | 57.8–65 | 7.2 |
| | Mesozoic | Cretaceous | | 65–140 | 75 |
| | | Jurassic | | 140–205 | 65 |
| | | Triassic | | 205–250 | 45 |
| | Paleozoic | Permian | | 250–290 | 40 |
| | | Carboniferous | | 290–355 | 65 |
| | | Devonian | | 355–410 | 55 |
| | | Silurian | | 410–438 | 28 |
| | | Ordovician | | 438–510 | 72 |
| | | Cambrian | | 510–540 | 30 |

* millions of years before present
** millions of years
Source: Nolan Associates, 2007.

### 4.1.1 Physiographic Setting

The Bonny Doon Limestone Quarry site is situated on the southwestern flank of Ben Lomond Mountain, a large, eroded mass of granitic rock that has been uplifted by vertical movement on the Ben Lomond fault, located along its steep northeast flank (Figure 17, Regional Topographic Index Map and Figure 18, Regional Geologic Map). The quarry presently occupies about 80 acres between native (pre-quarry) elevations of about 752 and 1,100 feet above mean sea level (msl) (Figure 16). Due to quarrying, the original topography has been modified into a large open pit with a floor between 750 and 760 feet msl. The proposed 17.1 acre Boundary Expansion Area would extend easterly from the present quarry into an area with native elevations between 1,100 and 1,250 feet msl (Figure 18).

The southwestern flank of Ben Lomond Mountain, overlooking the Pacific Ocean, is a relatively broad, gently sloping surface displaying a series of ascending, stairstep-like topographic benches that were cut by marine wave erosion at a time when the land was lower relative to sea level than at present. These benches, referred to as marine terraces, were preserved by gradual uplift of the mountain. Visible marine terraces are identified up to about 800 feet in elevation, and the effects of marine erosion probably extend much farther up the mountain (Figure 19, Local Geologic Map).

The broad surface that forms this side of Ben Lomond Mountain is cut by a series of southwest flowing streams occupying narrow, V-shaped stream valleys separated by flat-topped ridges (Figure 17). This drainage pattern is locally interrupted where large bodies of marble bedrock crop out. Marble is unique among the rock types in the geologic/hydrologic study area because it can dissolve in water. Therefore, in areas underlain by marble, dissolution of the marble by percolating water leads to the formation of underground caverns. This type of setting can inhibit the formation of interconnected surface streams, because surface water may disappear underground rather than flowing off in streams.

The topography of Ben Lomond Mountain can be highly irregular where it is underlain by marble, appearing as knobs or short ridges separated by short, intersecting valleys (Figure 20, Quarry Area Fracture Map). This topographic pattern is due to dissolution of the marble by water flowing through fractures in the rock and is readily apparent in the geologic/hydrologic study area on aerial photographs taken prior to development of the quarry. This type of landscape is common in areas underlain by marble or limestone and ~~it~~is referred to as *karst*. The dissolution-widened fractures can act as conduits for the flow of groundwater.

### 4.1.2 Regional Geologic Setting

The quarry property is situated on the western slope of the central Santa Cruz Mountains, part of the Coast Ranges physiographic province (Figure 17). The northwest-southeast structural grain of the Coast Ranges is controlled by a complex of active faults within the San Andreas fault system (Figure 18). Southwest of the San Andreas fault, the Coast Ranges, including the Santa Cruz Mountains, are underlain by a large, northwest-trending, fault-bounded, elongate prism of granitic and metamorphic basement rocks (Figure 18). The marble being mined in the quarry is part of the metamorphic rock unit that also includes schist and quartzite (Figure 19). The granitic and metamorphic rock basement is overlain by a sequence of dominantly marine sedimentary rocks of Paleocene to Pliocene age and non-marine sediments of late Pliocene to Pleistocene age (Figure 19).

The region around the quarry is tectonically active, that is, it is subject to forces causing the earth's crust to deform. The deformation can occur as movement on active faults, folding of layered rocks, or down warping or uplifting of portions of the crust. The Santa Cruz Mountains are cut by several active faults, of which the San Andreas is the most important (Figure 21, Regional Seismicity Map). Along the coast, the ongoing tectonic activity is most evident in the uplift of the southwest slope of Ben Lomond Mountain, as indicated by the series of uplifted marine terraces that sculpt the surface. The Loma Prieta earthquake of 1989 and its aftershocks are recent reminders of the geologic unrest in the region.

### 4.1.3 Regional Seismic Setting

California's broad system of strike-slip faulting has a long and complex history. Locally, the San Andreas, Zayante-Vergeles and San Gregorio faults and the Monterey Bay-Tularcitos fault zone present a seismic hazard to the subject project (Figure 21). These faults are associated with Holocene activity (movement in the last 11,000 years) and are therefore considered to be active. The most severe historical earthquakes to affect the project site are the 1906 San Francisco earthquake and the 1989 Loma Prieta earthquake, with Richter magnitudes of about 8.3 and 7.1, respectively.

For the purpose of evaluating seismic shaking at the site, this study focuses on the San Andreas, Zayante-Vergeles, San Gregorio, and Monterey Bay-Tularcitos fault systems (Figure 21). These faults are considered active seismic sources by the State of California (Petersen et al., 1996; Cao et al., 2003). While other faults in this region may be active, their potential contribution to seismic hazards at the site is overshadowed by these four faults. The distances between these faults and the proposed Boundary Expansion Area are listed in Table 4-2.

**Table 4-2**
**Distances and Directions to Local Faults**

| Fault | Distance from site (km) | Distance from site (miles) | Direction from site |
|---|---|---|---|
| San Gregorio | 7.5 | 4.7 | Southwest |
| Zayante-Vergeles | 11.5 | 7.1 | Northeast |
| Monterey Bay-Tularcitos | 12 | 7.5 | Southeast |
| San Andreas | 21 | 13.1 | Northeast |

Source: Nolan Associates, 2007.

#### 4.1.3.1 San Andreas Fault

The San Andreas fault is active and represents the major seismic hazard in northern California (Jennings, 1994). The main trace of the San Andreas fault trends northwest-southeast and extends over 700 miles from the Gulf of California through the Coast Ranges to Point Arena, where the fault passes offshore and merges with the Cascadia fault zone.

Geologic evidence suggests that the San Andreas fault has experienced right-lateral, strike-slip movement throughout the latter portion of Cenozoic time, with cumulative offset of hundreds of miles. Surface rupture during historical earthquakes, fault creep, and historical seismicity confirm that the San Andreas fault and its branches, the Hayward, Calaveras, and San Gregorio faults, are all active today.

Historical earthquakes along the San Andreas fault and its branches have caused substantial seismic shaking in Santa Cruz County. The two largest historical earthquakes on the San Andreas to affect the area were the moment magnitude (Mw) 7.9 San Francisco earthquake of 18 April 1906 and the Mw 6.9 Loma Prieta earthquake of 17 October 1989. The San Francisco earthquake caused severe seismic shaking and structural damage to many buildings in the Santa Cruz Mountains. The Loma Prieta earthquake may have caused more intense seismic shaking than the 1906 event in localized areas of the Santa Cruz Mountains, even though its regional effects were not as extensive. There were also major earthquakes in northern California along or near the San Andreas fault in 1838, 1865, and possibly 1890 (Sykes and Nishenko, 1984; WGONCEP, 1996).

Geologists have recognized that the San Andreas fault system can be divided into segments with "characteristic" earthquakes of different magnitudes and recurrence intervals (WGCEP, 1988 and 1990; WGONCEP, 1996). Two overlapping segments of the San Andreas fault system represent the greatest potential hazard to the project site. The first segment is defined by the rupture that occurred from the Mendocino triple junction to San Juan Bautista along the San Andreas fault during the great Mw 7.9 San Francisco earthquake of 1906. The WGONCEP (1996) has hypothesized that this "1906 rupture" segment experiences earthquakes with comparable magnitudes about every 200 years.

The second segment is defined approximately by the rupture zone of the Mw 6.9 Loma Prieta earthquake. The WGONCEP (1996) has posited earthquakes of Mw 7.0 on this segment of the fault, with an independent segment recurrence interval of 138 years.

Modified Mercalli Intensities (see Table 4-3) of up to VII (7) due to an earthquake on the San Andreas fault are possible at the site, based on the intensities reported by Lawson et al. (1908) for the 1906 earthquake and by Stover et al. (1990) for the 1989 Loma Prieta earthquake.

**Table 4-3**
**Modified Mercalli Intensity Scale**

The modified Mercalli scale measures the intensity of ground shaking as determined from observations of an earthquake's effect on people, structures, and the Earth's surface. This scale assigns to an earthquake event a Roman numeral from I to XII as follows:

| | |
|---|---|
| I | Not felt by people, except rarely under especially favorable circumstances. |
| II | Felt indoors only by persons at rest, especially on upper floors. Some hanging objects may swing. |
| III | Felt indoors by several. Hanging objects may swing slightly. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake. |
| IV | Felt indoors by many, outdoors by few. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing automobiles rock. Windows, dishes, doors rattle. Wooden walls and frame may creak. |
| V | Felt indoors and outdoors by nearly everyone; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset; some dishes and glassware broken. Doors swing; shutters, pictures move. Pendulum clocks stop, start, change rate. Swaying of tall trees and poles sometimes noticed. |
| VI | Felt by all. Damage slight. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks and books fall off shelves; pictures off walls. Furniture moved or overturned. Weak plaster and masonry cracked. |
| VII | Difficult to stand. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings; considerable in badly designed or poorly built buildings. Noticed by drivers of automobiles. Hanging objects quiver. Furniture broken. Weak chimneys broken. Damage to masonry; fall of plaster, loose bricks, stones, tiles, and unbraced parapets. Small slides and caving in along sand or gravel banks. Large bells ring. |
| VIII | People frightened. Damage slight in specially designed structures; considerable in ordinary substantial buildings, partial collapse; great in poorly built structures. Steering of automobiles affected. Damage or partial collapse to some masonry and stucco. Failure of some chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed pilings broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. |
| IX | General panic. Damage considerable in specially designed structures; great in substantial buildings, with some collapse. General damage to foundations; frame structures, if not bolted, shifted off foundations and thrown out of plumb. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground; liquefaction. |
| X | Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Landslides on river banks and steep slopes considerable. Water splashed onto banks of canals, rivers, lakes. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly. |
| XI | Few, if any masonry structures remain standing. Bridges destroyed. Broad fissures in ground; earth slumps and landslides widespread. Underground pipelines completely out of service. Rails bent greatly. |
| XII | Damage nearly total. Waves seen on ground surfaces. Large rock masses displaced. Lines of sight and level distorted. Objects thrown upward into the air. |

Source: Nolan Associates, 2007.

#### 4.1.3.2 Zayante-Vergeles Fault

The Zayante fault lies west of the San Andreas fault and trends about 50 miles northwest from the Watsonville lowlands into the Santa Cruz Mountains (Figure 21). The postulated southern extension of the Zayante fault, known as the Vergeles fault, merges with the San Andreas fault south of San Juan Bautista.

The Zayante-Vergeles fault has a long, well-documented history of vertical movement (Clark and Reitman, 1973), probably accompanied by some right-lateral, strike-slip movement (Hall et al., 1974; Ross and Brabb, 1973). Stratigraphic and geomorphic evidence indicates that the Zayante-Vergeles fault has undergone late Pleistocene and Holocene movement and is potentially active (Coppersmith, 1979).

Some historical seismicity may be related to the Zayante-Vergeles fault (Griggs, 1973). The Zayante-Vergeles fault may have undergone sympathetic fault movement during the 1906 earthquake centered on the San Andreas fault, although this evidence is equivocal (Coppersmith, 1979). Gallardo et al. (1999) concluded that a magnitude 4.0 earthquake in 1998 in the Santa Cruz Mountains occurred on the Zayante fault.

In summary, the Zayante-Vergeles fault should be considered active for design purposes. Cao et al. (2003) concluded that the Zayante-Vergeles fault is capable of generating an Mw 6.8 earthquake, with a recurrence interval of almost 9,000 years.

#### 4.1.3.3 San Gregorio Fault

The San Gregorio fault skirts the Santa Cruz County coastline seaward of Monterey Bay and intersects the coast at Point Año Nuevo. North of Año Nuevo it passes offshore, intersecting the coast again at Half Moon Bay (Figure 21). North of Half Moon Bay, the San Gregorio fault lies offshore until it connects with the San Andreas fault near Bolinas. Southward from Monterey Bay, the San Gregorio fault intersects the coast at Point Sur and eventually connects with the Hosgri fault in south-central California (Dickinson et al., 2005).

The onshore segments of the San Gregorio fault at Point Año Nuevo and at Half Moon Bay show evidence of late Pleistocene and Holocene displacement (Weber and Cotton, 1981; Weber et al., 1995; Simpson et al., 1997). In addition to stratigraphic evidence for Holocene activity, the historical seismicity in the region is partially attributed to the San Gregorio fault. Due to inaccuracies of epicenter locations, the magnitude 6+ earthquakes of 1926, tentatively assigned to the Monterey Bay fault zone, may have actually occurred on the San Gregorio fault (Greene, 1977). Recent stratigraphic studies of the fault document 97 miles of horizontal offset on the fault (Dickinson et al., 2005).

Petersen et al. (1996) divided the San Gregorio fault into the "San Gregorio" and "San Gregorio, Sur Region" segments. The segmentation boundary is located west of Monterey Bay. Petersen et al. (1996) assigned the San Gregorio fault in the Santa Cruz County area a recurrence interval of 400 years. Cao et al. (2003) consider the fault capable of an Mw 7.2.

### 4.1.3.4 Monterey Bay-Tularcitos Fault Zone

The Monterey Bay-Tularcitos fault zone is based on a postulated connection between the Tularcitos fault, located on land near the Monterey Peninsula, and the offshore Monterey Bay fault zone (Figure 21). The Monterey Bay fault zone is 6 to 9 miles wide and about 25 miles long, consisting of many northwest-trending, en échelon faults identified during shipboard seismic reflection surveys (Greene, 1977). The fault zone projects toward the coastline in the vicinity of Seaside and Ford Ord. At this point, a principal offshore fault trace in the heart of the Monterey Bay fault zone is tentatively correlated by Greene (1977) with the Navy Fault, a postulated westward extension of the Tularcitos fault. It should be emphasized that this correlation between onshore and offshore portions of the Monterey Bay-Tularcitos fault zone is only tentative; no concrete geologic evidence for connecting the Navy and Tularcitos faults under the Carmel Valley alluvium has been observed, nor has a direct connection between these two faults and any offshore trace been ~~found~~identified.

Outcrop evidence indicates a variety of strike-slip and dip-slip movements associated with the onshore and offshore traces. Earthquake studies suggest the Monterey Bay-Tularcitos fault zone is predominantly right-lateral, strike-slip in character (Greene, 1977). Both offshore and onshore fault traces in this zone have displaced Quaternary age rock layers and, therefore, are considered potentially active. One offshore trace, which aligns with the trend of the Navy fault, has displaced Holocene beds and is therefore considered active (Greene, 1977).

Seismically, the Monterey Bay-Tularcitos fault zone may be historically active. The largest historical earthquakes tentatively located in the Monterey Bay-Tularcitos fault zone are two events, estimated at 6.2 on the Richter Scale, in October 1926 (Greene, 1977). Because of possible inaccuracies in locating the epicenters of these earthquakes, it is possible that these earthquakes actually occurred on the nearby San Gregorio fault (Greene, 1977).

Another earthquake in April 1890 might be attributed to the Monterey Bay-Tularcitos fault zone (Burkland and Associates, 1975); this earthquake had an estimated Modified Mercalli Intensity of VII (Table 4-3) for northern Monterey County.

The WGONCEP (1996) has assigned an expected earthquake of Mw 7.1 to the Monterey Bay-Tularcitos fault zone, with an effective recurrence interval of 2,600 years, based on Holocene offsets noted on an offshore strand of the fault. Cao et al. (2003) chose a 7.3 expected earthquake magnitude, but with a recurrence interval of 2,841 years. Their expected earthquake is based on a composite slip rate of 0.5 millimeters per year (after Rosenberg and Clark, 1994).

### 4.1.4 Study Area Geologic Setting

The geology of the geologic/hydrologic study area is complex, a result of over 100 million years of geologic history, including collisions of crustal plates and multiple cycles of tectonic upheaval and erosion of the land surface. These episodes of tectonic deformation are recorded as metamorphism of older sedimentary rocks, intrusion of plutonic igneous rocks, folding and faulting of younger sedimentary layers, and by erosional remnants of once extensive geologic formations.

The following sections reference Figures 16 through 22. Detailed geologic maps and cross sections for the geologic/hydrologic study area are included in the Geology and Hydrology Technical Appendix (Appendix F).

**4.1.4.1 Geologic Units**

Rock units in the geologic/hydrologic study area are separable into three major groups: granitic intrusive rocks of Late Cretaceous age, pre-Cretaceous metasedimentary rocks, and sedimentary rocks of Tertiary and Quaternary age. The granitic intrusive rocks form the core of Ben Lomond Mountain. These rocks formed from molten rock (magma) that melted its way ~~up into~~upward from deep in the crust and then cooled deep underground, forming granitic rock. The magma intruded older sedimentary rocks buried in the crust and metamorphosed them through heat and pressure into schist, quartzite, and marble (Geology and Hydrology Technical Appendix, Appendix F). Layering in the schist and marble expresses the original layering in the sedimentary rocks.

The younger sedimentary rocks (Tertiary and Quaternary age) occur in isolated bodies on and around the quarry property overlying the older granitic and metamorphic rock. The Tertiary rock units include the Monterey Formation, Santa Margarita Sandstone, and Santa Cruz Mudstone, while the surficial Quaternary deposits include marine terrace deposits, doline (sinkhole) fill, alluvium, colluvium, landslide deposits, and soil (residuum) (Geology and Hydrology Technical Appendix, Appendix F).

**4.1.4.2 Geologic Structure**

Geologic structure in the geologic/hydrologic study area is a result of intrusion of granitic magma at depth into the surrounding partially metamorphosed sedimentary rock during the Cretaceous period,~~resulting in metamorphism of the sedimentary rock,~~ followed by uplift and erosion of the igneous and metamorphic rock and repeated cycles of sedimentary deposition and tectonic deformation throughout the Tertiary Period. Metamorphic rocks in the geologic/hydrologic study area appear as a regularly layered, but faulted, sequence of moderately to strongly metamorphosed sedimentary rock. The layering in the metamorphic rocks shows a regular, ~~approximate east – west alignment, but~~ east-west strike, and may be tilted to the north or to the south. These rocks are, however, broken into a series of discontinuous blocks by faulting.

In areas with substantial marble, the metamorphic rocks are cut by fractures that have been etched out by water flowing along the fractures. The fractures are visible in the landscape as aligned valleys, swales, or notches in ridges (Figure 20). The fracture valleys are often short and intersecting. In areas of karst, the fracture intersections are frequently marked by sinkholes. In some cases, these fractures are clearly faults with major displacement. In other cases, the fractures appear to have had little displacement, but have been etched into the landscape by preferential dissolution of the marble bedrock by water flowing along the fracture (Figure 20).

Many faults are exposed in the quarry. These faults included both low-angle thrusts and high-angle faults, with the amount of total offset usually indeterminate, although a few of the faults were clearly associated with large ~~offsets~~displacements. A structural discontinuity was noted trending southwest to northeast through the central portion of the quarry. Layering in the marble and schist is tilted to the north or west on the northwest side of the discontinuity. Layering on the southwest side of the discontinuity is tilted to the south. Along with the change in the orientation of layering is a change in the orientation of fractures in the rock. These changes define two separate structural "domains" in the quarry that are important in analyzing the stability of the quarry walls, as will be discussed later in this section. The northerly of the two domains also appears to be separable into two less distinct structural domains.

The rocks exposed in the quarry are universally jointed (fractured). Many of the joints in the quarry show evidence of dissolution, including raspy "meringue" weathering patterns and thick linings of terra rosa sediment, a residuum left behind after dissolution of the marble. In visual inspection, concentrations of solution fractures in the walls of the quarry stand out as dark, steeply dipping zones separated by relatively lighter colored marble. The darker color of these zones derives from the concentration of terra rosa on the fracture surfaces.

Geologic structure within the Tertiary sedimentary section is relatively simple. Rocks older than the mid-Miocene, including the Monterey Formation and Lompico Sandstone, are moderately folded and faulted; these units crop out east of the quarry (Figure 19). The younger formations in the quarry area, the Santa Margarita Sandstone and Santa Cruz Mudstone, cover the older Tertiary sedimentary rocks (as well as metamorphic and granitic rocks) and are relatively undeformed, showing only a shallow tilt to the southwest (Figure 19).

**4.1.4.3 Surface Processes**

Surficial geologic processes in the geologic/hydrologic study area include weathering, erosion, and mass wasting (landsliding). Weathering of surficial materials and erosion by wind and water are the principal processes active in developing natural landscapes. When erosion leads to the development of steep slopes, landsliding may occur. In turn, landsliding breaks up the rock formations on the slope, leading to additional weathering and erosion.

Erosion related to quarrying occurs during removal of the overburden~~, that is, the~~ (soil and sedimentary rock covering the marble) and during the mining process itself. The overburden is stripped away so the marble can be mined, which disrupts drainage patterns and generates large amounts of loose sediment, which can lead to massive amounts of erosion if not carefully controlled.

The most potential for erosion probably occurs during removal of the overburden, but it also occurs during the mining process as well. During the site investigation undertaken for preparation of the project EIR, abundant turbid runoff from the quarry area was observed during storm events. The sediment carried by the runoff is derived from erosion of exposed slopes cut in the sedimentary units overlying the marble, from weathered schist or diorite exposed in and around the quarry, from residuum left behind after dissolution of the marble (terra rosa), from doline fill, and from ~~spoils~~loose soils deposited outside the quarry following removal of overburden from the marble.

**Landsliding**

Landsliding is a natural process that accompanies erosional downcutting and oversteepening of slopes. Like erosion, it can also be exacerbated by cultural activities. Road building or earth-moving results in steep cut slopes and loose fill soils, both of which can be prone to landsliding. Roads can also collect naturally dispersed runoff and concentrate it into a rapidly flowing stream that can trigger erosion or landsliding.

Nolan Associates observed two landslides of significance in the area of the quarry. One of the landslides, adjacent to Liddell Spring, has been studied extensively by Pacific Geotechnical Engineering (PGE, ~~2001~~2002), because of its potential impact on Liddell Spring. The landslide complex was classified by PGE as the combination of an earth flow and several debris flows (Geology and Hydrology Technical Appendix, Appendix F). The debris flow component is considered to have been caused in part by stockpiled spoils from the quarry. This landslide complex poses some hazard to the spring box at Liddell Spring and to the water quality of the spring.

The second landslide occurred in the winter of 2006 on the quarry face in the southeastern quadrant of the quarry (Geology and Hydrology Technical Appendix, Appendix F). This landslide was about 150 feet wide and 320 feet long. It moved as a rock and debris slide in weathered marble, along with a substantial soil component. The detachment surface exposed in the headscarp was an older shear zone of undetermined thickness, striking about N55°W and dipping steeply to the southwest (roughly parallel to prominent joints in this wall of the quarry).

A few minor rock falls or topples were also observed. The rock falls or topples generally involved several cubic yards to a few tens of cubic yards of fractured rock, usually derived from the crest of freshly worked benches.

**Karst Processes: Geologic Influence on Groundwater Flow**

The geologic/hydrologic study area has experienced alternating episodes of erosion and deposition throughout its geologic history, as indicated by the middle to upper Tertiary age sedimentary sequence overlying the granitic and metamorphic basement. Beginning during the ~~mid Pleistocene~~mid-Pleistocene (about the last 800,000 years) or earlier, the geologic/hydrologic study area was subject to sea level fluctuations of 300 to 400 feet every 100,000 years, on average, caused by worldwide climatic variations and episodic glaciation in the higher latitudes. Since about 500,000 years ago, it has been elevated hundreds of feet above sea level and exposed to erosion, based on estimated uplift rates for this section of the coastline (Bradley and Griggs, 1976). In other words, over the last 25 million years, the marble body in the geologic/hydrologic study area has had an extraordinarily complex hydrogeologic history, characterized by dramatic fluctuations in climate and base (sea) level.

Groundwater flow in areas underlain by soluble rock, such as marble or limestone, is substantially different than groundwater flow in most other types of rock. In marble, the initial permeability may be quite low, but even slight downward flow over time will gradually dissolve the rock, forming solution channels through which water can flow more readily. In some cases, the solution channels enlarge to form caverns with underground ponds and streams. These solution cavities usually begin forming along bedding planes, fractures, or faults. In the quarry area, solution of the marble is strongly controlled by the fracture patterns. The influence of the fracture system on dissolution of marble bedrock and groundwater circulation is well documented by the alignment of sinkholes along major fractures (or faults) -- and particularly by the preferential location of prominent sinkholes (open or buried) at the intersection of two or more fractures (Geology and Hydrology Technical Appendix, Appendix F).

The exposure afforded by the quarry walls provides a view of the hydrogeologic character of the marble over a vertical distance of 350 feet. Solution-widened fractures in the quarry walls are steeply dipping to vertical and commonly form continuous zones of solution channeling from the original ground surface through the quarry floor.

Although there is interbedded schist throughout the marble section (as well as igneous sills and dikes), SECOR (1997) concluded that these interbeds do not have a substantial effect on flow paths through the marble. This conclusion is reasonable because the formation of solution channels has been guided by fractures and faults that cut across the rock layering.

Prominent topographic lineaments in the Bonny Doon Ecological Preserve, an area largely underlain by the Santa Margarita Sandstone, are consistent with the pattern of fractures mapped in the marble terrane (Geology and Hydrology Technical Appendix, Appendix F). These lineaments strike northeast to east-northeast from the quarry area across the Ecological Preserve, with the two southernmost lineaments trending toward marble outcrops mapped in Laguna Creek. These lineaments imply the presence of solution-widened fractures in marble underlying the Santa Margarita Sandstone in the Ecological Preserve. Mapping in Laguna Creek indicates that marble layers within the schist are relatively common throughout this area. These observations, in conjunction with the dye tracer test results, to be presented in Section 5.0, indicate the existence of karst solution channels beneath Laguna Creek and the Ecological Preserve.

## 4.2 REGULATORY SETTING

The SMARA was passed in 1975 to balance the need for a continuing supply of mineral resources with the assurance that significant adverse impacts of mining would be mitigated. The State Mining and Geology Board provide technical information; the Board does not regulate local land use.

SMARA requires that all mining operations have an approved reclamation plan of all lands mined after January 1, 1976. Reclamation is defined by SMARA as:

> "…the combined process of land treatment that minimizes water degradation, air pollution, damage to aquatic or wildlife habitat, flooding, erosion, and other adverse effects from surface mining operations, including adverse surface effects incidental to underground mines, so that mined lands are reclaimed to a usable condition which is readily adaptable for alternate land uses and create no danger to public health or safety. The process may extend to affected lands surrounding mined lands, and may require backfilling, grading, resoiling, revegetation, soil compaction, stabilization, or other measures."

The reclamation plan must contain specific details that describe the type of mining operation, the mining boundaries, duration of mining operation, the manner in which reclamation would be accomplished, and potential uses of the site after reclamation. The plan must also reflect the characteristics of the site and surrounding area such as soil stability, topography, geology, climate, and principal mineral commodities. Reclamation Regulations (Article 9) sets forth reclamation standards for mining operations with reclamation plans approved after January 15, 1993.

Every lead agency must adopt ordinances in accordance with SMARA, which establishes procedures for the review and approval of a reclamation plan and the issuance of a permit to conduct surface mining operations. Accordingly, the County of Santa Cruz has adopted Mining Regulations that have been certified by the State Mining and Geology Board as being in conformance with state mining regulations. Provisions of the County Mining Regulations are presented in County Plans and Policies, Section 3.0.

## 4.3 PROJECT IMPACTS

### 4.3.1 Thresholds of Significance

According to the CEQA Guidelines (Appendix G), a project will normally have a significant effect on the environment if the following conditions occur:

- Exposure of people or structures to potential significant effects, including the risk of loss, injury, or death, as a result of rupture of a known earthquake fault as delineated by the State Geologist on the most recent Alquist-Priolo fault zoning maps or based on other substantial evidence; strong seismic groundshaking or seismically induced ground failure, including liquefaction; or landslides.
- Result in substantial soil erosion or the loss of topsoil.
- Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.
- Adversely impact unique or valuable geological or paleontological features or resources.
- Change in topography or ground surface relief features.
- Affect steep slopes (over 30 percent gradient).

### 4.3.2 Seismic Shaking Hazards

Seismic shaking at the project site will be intense during the next major earthquake along one of the local fault systems. It is important that seismic shaking be considered in evaluating project impacts. The intensity of seismic shaking has the potential to destabilize slopes, whether natural or man-made, and to damage or destroy structures.

The seismic shaking evaluation for the proposed Boundary Expansion Area conducted by Nolan Associates included an estimate of expected seismic shaking intensities based on both deterministic and probabilistic methods. A deterministic assessment considers the effects of the largest ground motion that can be expected at a site, regardless of the likelihood of this event occurring during the design life of the project. A probabilistic seismic analysis differs from a deterministic analysis in that it evaluates the probability for shaking of a certain intensity to occur at a particular site over a given span of time.

The intensity of seismic ground shaking can be characterized qualitatively, by its visible effects on people and structures, or quantitatively, as an instrumental measurement of the shaking intensity at a given location. The Modified Mercalli Scale (Table 4-3) is used in a qualitative way to characterize shaking intensity during an earthquake. Ground shaking intensity as determined by instrumental readings is measured in “g”, where one g is equivalent to the acceleration of the earth’s gravity.

### 4.3.2.1 Deterministic Seismic Shaking Analysis

Table 4-4 shows estimated magnitudes (Mw (MAX)) and expected type of fault motion for the maximum expected earthquakes on each of the above-listed fault systems (Petersen et al., 1996; Cao et al., 2003). Estimated mean peak horizontal ground acceleration (PGA) and mean peak plus one dispersion (PGA + ∂) horizontal ground acceleration values for the site are calculated using the estimated magnitudes and fault geometries shown on Table 4-4 and the fault distances shown on Table 4-2. The estimated accelerations are based on an attenuation relationship derived from the analysis of historical earthquakes (Sadigh et al., 1997) and are for sites founded on rock. It should be noted that the listed values are approximations, based on theoretical curves generated from a relatively small data set; actual measured accelerations may be larger. The PGA + ∂ value is a conservative design parameter intended to compensate for the uncertainty in the attenuation relationships.

The duration of strong seismic shaking shown in Table 4-4 is calculated from a magnitude-dependent formula proposed by Abrahamson and Silva (1996). The expected recurrence interval (RI), after Petersen et al. (1996), is the expected time between major earthquakes on each fault. The UBC Seismic Source Type (Cao et al., 2003) is also listed.

In summary, the San Gregorio fault, passing within 7.5 km of the site, is expected to generate the largest earthquake ground motion at the site. The characteristic earthquake on this fault (Mw(MAX) = 7.2) is expected to ~~generate~~result in estimated ground motions in the range of 0.46 to 0.67g. The duration of strong seismic shaking from this event would be about 19 seconds. The recurrence interval for this design earthquake is about 400 years.

**Table 4-4**
**Deterministic Ground Motions**

| Fault | $M_{W\ (MAX)}$ | Rupture Geometry | PGA (g) | PGA + M (g) | Duration (sec) | Recurrence Interval (years) | Seismic Source Type |
|---|---|---|---|---|---|---|---|
| San Gregorio | 7.2 | Strike-slip | 0.46 | 0.67 | 17 | 400 | B |
| Zayante-Vergeles | 7.0 | Reverse | 0.41 | 0.62 | 14 | 8,821 | B |
| Monterey Bay-Tularcitos | 7.3 | Strike-slip | 0.37 | 0.54 | 19 | 2,841 | B |
| San Andreas (1906 rupture) | 7.9 | Strike-slip | 0.31 | 0.45 | 33 | 210 | A |

Source: Nolan Associates, 2007.
Notes:
$M_{W(MAX)}$: Moment magnitude of maximum credible earthquake. San Andreas 1906 rupture after Peterson et al., 1996; San Gregorio, Zayante-Vergeles, Monterey Bay-Tularcitos after Cao et al., 2003.
Rupture Geometry and Recurrence Interval after Peterson et al., 1996.
PGA: Mean peak horizontal ground acceleration. After Sadigh et al., 1997.
PGA + M: Mean peak horizontal ground acceleration plus one dispersion. After Sadigh et al., 1997.
Duration: Abrahamson and Silva, 1996
Recurrence Interval: Peterson et al., 1996
Seismic Source Type from CBSC, 2002

It is important to note that the ground acceleration values given in Table 4-4 are not directly equivalent to seismic or pseudo-static coefficients used in slope stability analyses (CGS, 1997). Use of these values in the development of seismic coefficients for ~~use in~~pseudo-static stability analysis should be based on state and local jurisdictional regulations and on appropriate engineering standards of practice.

#### 4.3.2.2 Probabilistic Seismic Shaking Analysis

The U.S. Geological Survey and the California Geological Survey together produced a probabilistic seismic hazards assessment for the state of California (Petersen et al., 1996; revised in Cao et al., 2003). The study used a model that explicitly considered faults that are capable of generating moment magnitude 6.5 or greater earthquakes. The San Francisco Bay area, Monterey Bay area and Santa Cruz Mountains are traversed by numerous minor faults and splays, many of which may be capable of generating smaller earthquakes; to account for these seismic sources, a background source magnitude of 6.5 was also applied in the probabilistic model.

Probabilistic ground motions for the proposed Boundary Expansion Area based on this joint study are listed in Table 4-5. These estimated ground motions assume a soil profile type Sc (firm rock), per the 2001 California Building Code (CBSC, 2002). The values may need to be modified for specific site conditions prior to using them in any site-specific analysis.

The ground motion intensities shown in Table 4-5 are the seismic shaking intensities that have a 10 percent probability of being exceeded in 50 years or a ~~2mpercent~~2 percent probability of being exceeded in 50 years. The ground motion with a 10 percent probability of being exceeded, 0.43g, ~~is~~has generally been considered appropriate for residential and non-habitable structures in California. The ground motion with a 2 percent probability of being exceeded, 0.7g, is considered appropriate for critical structures such as hospitals or fire stations.

**Table 4-5**
**Probabilistic Ground Motions**

| Ground Motion Measure | 10 Percent Probability of Being Exceeded in 50 Years | 2 Percent Probability of Being Exceeded in 50 Years |
|---|---|---|
| Peak Ground Acceleration (g) | 0.43 | 0.7 |
| Spectral Acceleration (g) at 0.2 sec. | 1.01 | 1.68 |
| Spectral Acceleration (g) at 1.0 sec. | 0.43 | 0.77 |

Source: Nolan Associates, 2007.

#### 4.3.2.3 Ground Shaking Amplification

The ground motion values listed in Tables 4-4 and 4-5 are merely expected values based on uniform site conditions in firm bedrock; actual ground motions during an earthquake may vary due to unique site conditions (e.g., bedrock type or topography) or the way different portions of the earth's crust transmit seismic energy to the site. Ground motions at the crest of a very steep slope can be several times as intense as in the adjacent valleys due to topographic amplification (Hartzell et al., 1994). Topographic amplification is therefore potentially important for steep, high slopes such as quarry faces. However, the influence of topography on seismic shaking is complex, sometimes leading to pronounced disagreements between theoretical predictions and observed effects (Geli, et al., 1988; Hartzell et al., 1994). Hartzell et al. (1994) found amplification factors on a steep-sided ridge crest to be as high as fivetimes for aftershocks of the 1989 earthquake. Ashford and Sitar (2002) have developed a method for estimating seismic shaking amplification on steep slopes.

#### 4.3.2.4 Project Seismic Shaking Impacts

Very strong seismic shaking may occur during the project lifetime. Seismic shaking could damage buildings and other structures associated with the quarry operation. Because no new structures or any increase in the scale of the quarry operation is planned, the existing level of hazard due to seismic shaking is not expected to increase due to the quarry expansion. Therefore, the seismic shaking hazard associated with the project is not considered significant.

### 4.3.3 Seismically-Induced Ground Deformation

Ground deformation associated with strong seismic shaking may manifest in several ways:

- Seismically-induced differential settlement occurs when seismic shaking compacts loose soils.
- Off-fault co-seismic ground cracks or fissures may form in response to strong shaking, particularly along the crests of ridges or at the top of very steep slopes.
- Seismic shaking can trigger landslides on slopes that are ~~already marginally~~otherwise stable.
- Liquefaction occurs when generally loose, saturated, cohesionless soil (typically sand) loses strength due to seismic shaking, causing it to behave like a liquid. Ground deformations that accompany liquefaction include lurch cracking, fissuring, and lateral spreading (i.e., liquefied soils flowing laterally down very gentle slopes).

In the proposed Boundary Expansion Area, the principal hazards from seismically-induced ground failure are co-seismic ground cracking along the crests of proposed Boundary Expansion Area slopes, and seismically induced landsliding, rock falls, or topples on the quarry faces. Soil liquefaction and differential settlement are not considered to be hazards in the proposed Boundary Expansion Area. However, it is possible that liquefaction or differential settlement during a strong earthquake could impact the levees that form the settlement basins. The settlement basins ~~wouldbe~~are used to detain sediment-laden runoff from the quarry operation and may capture overflow runoff from the proposed Boundary Expansion Area ~~and prevent it~~. The basins prevent sediment laden runoff from flowing directly into local streams. Liquefaction and settlement hazards posed to the settlement basin levees are discussed below. The potential impacts of seismically-induced landsliding are discussed in the landsliding section, to follow.

#### 4.3.3.1 Liquefaction Hazard

Golder Associates (1991) evaluated the stability of the earth embankments (levees) used to construct settlement basins for the quarry operation. Their report identified specific stability concerns with these levees and made recommendations for remedial stabilization measures. Golder Associates (1991) did not include a formal, quantitative analysis of the liquefaction hazard but did note that "liquefaction could result in localized levee instability or complete failure" (1991, p. 13). In their assessment, they considered Settlement Basin 4 to be susceptible to liquefaction. A significant liquefaction hazard would exist only while there was an impoundment of water behind the embankments.

The Golder Associates (1991) report made recommendations for increasing the stability of the levees, but they concluded that even after implementing these measures the levee at Settlement Basin 4 could still be susceptible to liquefaction-related failure. No information has been ~~provided to~~ reviewed, which indicates that the Golder Associates recommendations were satisfactorily completed. Based on conversations with County staff (David Carlson, 2007), the recommended improvements have not been documented. The Golder Associates (1991) report did not discuss liquefaction susceptibility for Settlement Basin 3. The impacts of levee failure would result in release of sediment-laden water into local stream drainages and could be significant.

In their evaluation of levees for Settlement Basins 3 and 4, Golder (1991) found that the levee for Settlement Basin 4 was built directly on native materials, without any foundation preparation. There is some possibility, therefore, that the levee rests on liquefiable materials or materials that may cause differential settlement during an earthquake. For the Basin 3 levee, they reviewed construction notes by the quarry engineer. The notes indicated that the native substrate had been prepared for supporting the levee. However, they did not verify the condition of the levee substrate nor did they evaluate the in-place density of the levee fill.

The levee analysis performed by Golder Associates (1991) used seismic accelerations based on a magnitude 7.0 earthquake on the San Gregorio fault. More recent studies suggest that a larger maximum probable earthquake, Mw 7.2, is warranted for the fault (Cao, et al., 2003), which may change the estimated seismic ground motion for use in the analysis. Similarly, the method of choosing the appropriate seismic coefficient for slope stability analysis has changed since 1991. Golder Associates (1991) used a Repeatable High Ground Acceleration (RHGA) of 0.27g. While there is currently no universally accepted means of selecting the seismic coefficient used in slope stability analysis, the RHGA is not now commonly employed. Selection of a seismic coefficient using current information on the San Gregorio fault and current seismic coefficient selection criteria could result in different estimates of levee susceptibility to liquefaction.

It is possible that liquefaction or differential settlement during an earthquake could impact the embankment dams that retain the settlement basins, damaging drainage works and releasing sediment laden water into local stream drainages. In a worst-case event, rapid failure of a levee while the settlement basin is full could result in flooding of downstream areas. To the extent that ~~the increased runoff from~~mining the proposed Boundary Expansion Area would ~~increase~~ result in runoff flow to the settlement basins, the proposed Boundary Expansion Area would be associated with an impact if Settlement Basins 3 and 4 were to fail. This impact is considered potentially significant. Preparing an updated liquefaction analysis and implementing the analysis recommendations would ensure that basin levees function at current industry standards. This mitigation is identified as Measure GEO-1 and would reduce the liquefaction impact to a less than significant level.

### 4.3.3.2 Ground Surface Rupture Due to Faulting

Earthquakes are caused by slippage along faults in the earth's crust. Where the fault intersects the ground surface, this slippage causes displacement that will damage or destroy structures placed directly over the fault. The faults mapped in the area of the quarry (Geology and Hydrology Technical Appendix, Appendix F) are related to deformation accompanying metamorphism, igneous intrusion, and uplift of the basement rock, most of which took place in Late Cretaceous and early Tertiary time. These faults are not related to the current active tectonic regime of central California. Therefore, the potential for fault-related ground surface rupture within the proposed quarry Boundary Expansion Area is considered to be low.

## 4.3.4 Landsliding and Slope Instability

Broadly defined, landsliding includes any gravity driven movement of earth materials outward or downward on a slope. The associated hazards depend to some extent on the type of landslide that occurs. There are different means of classifying landslides, all generally based on type of movement, type of material, and, less often, rate of movement. The most generally applied classification scheme (Cruden and Varnes, 1996) divides landslides according to type of movement (fall, topple, slide, spread, or flow) and material type (rock, debris, or soil). These categories can be further subdivided based on other landside characteristics.

The types of landsliding that may occur in the Boundary Expansion Area are rock falls and rock topples along the quarry faces, sliding of the overburden exposed at the top of the quarry faces, large-scale sliding of the quarry face itself, or some combination of these types. These landslides may occur as a result of seismic shaking or the may occur under non-seismic conditions

Rock falls and topples are expected to involve rock masses a few feet to a few tens of feet in size. They occur as relatively intact blocks of rock fall from the quarry slopes. This type of failure appears relatively common in the quarry, owing to the blasting and ripping of the quarry face that is part of the quarrying operation. Rock falls and topples may present a hazard to quarry workers, but are not considered to present a significant environmental impact by themselves. However, ~~abundant, continuing~~ numerous, widespread rock falls or topples across the quarry slopes could damage reclamation efforts. ~~Widespread~~ A large number of falls and topples might occur as a result of seismic shaking.

Large-scale sliding of overburden slopes or the quarry face itself would create a large mass of broken rock and soil ~~while distruping~~and could disrupt drainage patterns. Very large failures could extend back from the face of the quarry tens or possibly one hundred or more feet, affecting adjacent lands. Such failures could lead to erosion and sedimentation of downstream areas or increased turbidity in groundwater under the quarry. The recent landslide in the quarry appears to have involved large-scale failure of both overburden and marble.

The principal factors controlling the distribution of landsliding are the underlying rock type, the steepness of the slopes, the existence of weak zones in the rock that may facilitate landsliding, and the presence of older landslide masses susceptible to reactivation. In particular, the steepness of the terrain greatly promotes slope instability, all other factors being equal.

Landslides are often triggered by ground saturation (due to rainfall or drainage), seismic shaking, or both.

The two landslides observed in the quarry area (described above) illustrate the potential impact of quarry operations on slope stability. Renewed movement of the landslide near Liddell Spring could impair operation of the Santa Cruz City water diversion and impact the water quality of the spring. Landsliding within the quarry could threaten quarry workers or increase the risk of erosion, downstream sedimentation, and turbidity. This impact is mitigated with Measures GEO-2 and GEO-3 (See Section 4.4).

#### 4.3.4.1 Stability Evaluation of Proposed Limestone Quarry Boundary Expansion

An evaluation of slope stability for the proposed finished quarry configuration (including the expansion) was performed by JCA (JCA, 1997; 1998; 1999). A peer review of the JCA reports was provided by a registered geotechnical engineer (Pacific Crest Engineering, Inc., 2004) and ~~is attached as Appendix D of the~~a specialist in rock mechanics ~~Geologic, Hydrologic, and Hydrogeologic Technical Appendix~~(Dr. Scott Keiffer, 2008). Nolan Associates performed a peer review of the geologic portion of these reports. The following comments summarize the results of both the geologic and geotechnical reviews.

**Proposed Slopes**

The planned development of the proposed Boundary Expansion Area calls for the final side slopes in the quarry pit to be benched with an overall inclination of 60 degrees. Individual benches are planned to be 16 feet wide and 40 feet high, with the steps between benches having an inclination of 80 degrees (Bowman and Williams, 2001a, as shown in Figure 9). Working slopes are to be slightly less steep. As proposed, the finished benches would be gently sloped to the inboard side, with inboard ditches used to collect runoff from the benches and channel it to the floor of the quarry, via down-drains.

The Use Permit 3236-U Condition III.8 requires benches of minimum 30-foot width every 60 feet vertically for slopes inclined steeper than 1:1 (horizontal:vertical), an inclination of 45 degrees. As a result of the 1996 EIR, for mined hard rock slopes the 1997 COC allows benches of minimum 16-foot width every 40 feet vertically with slopes between benches no steeper than 80 degrees for an overall slope of 60 degrees. Cut slopes in overburden (sedimentary rocks) are allowed to be no steeper than 1.5:1 gradient (horizontal:vertical). The final grading plan for the Boundary Expansion Area (Figure 9) has 16-foot wide benches every 40 feet vertically, cut on an overall slope of 60 degrees. This benching is proportionally equivalent to a bench of 24 feet wide every 60 feet vertically, so the proposed final grading plan does not meet Use Permit requirements. The Use Permit condition also limits finished slopes to an inclination not exceeding the "normal angle of repose." Although the Use Permit does not define a means for determining the normal angle of repose, the COC Condition III.A.7(2) states that "all final cut slopes completed after September 12, 1996, shall have a stability factor of safety not less than 1.2 …" Therefore, all slopes with a stability factor of safety not less than 1.2 are considered to be at or below the normal angle of repose.

Overburden slopes around the proposed Boundary Expansion Area, consisting of loose soil and Santa Margarita Sandstone, are to be cut back to an inclination of 1½:1 (horizontal:vertical), an inclination of about 34 degrees. The present plan (Figure 9) shows overburden removed from the Boundary Expansion Area, along with quarry waste (i.e., off-spec rock), placed and compacted along the western wall of the existing quarry. The plan shows the fill to be finished with a 2:1 (horizontal:vertical) slope (about 26 degrees) and benched every 40 feet vertically. In response to hydrology and water quality concerns, Measure HYD-1 recommends redesigning the overburden fill and placing it across the entire quarry floor to function as part of a filter system for recharging groundwater (see Hydrology, Section 5.0).

**Review of Existing Stability Analysis**

A geotechnical evaluation of the proposed finished grading for the quarry, including the Boundary Expansion Area (Figure 9) was performed by Jo Crosby and Associates (JCA, 1997; 1998; 1999). Jointed rock slopes within the quarry excavation were analyzed using a fracture mechanics approach, as described below. Rotational failure models were applied to soil and sandstone overburden cut slopes around the top of the quarry and to fill slopes.

A fracture mechanics approach to stability analysis recognizes that hard rock, like marble or unweathered granite, is unlikely to slide by breaking across fresh rock. Rocks like these can stand as vertical cliffs, with little risk of sliding. Therefore, the stability of rock slopes is generally evaluated by looking at the fractures or other natural planes of weakness that cut through the rocks and might induce the rocks to slide. Fracture mechanics looks specifically at fractures that are oriented so that they tilt~~directly~~ downhill. When combined with measurements of the strength along the fracture surface, this type of analysis can predict likely failures in rock slopes.

A rotational failure analysis is used for soil or rocks that are soft enough to behave like soil, such as the Santa Margarita Sandstone at the quarry site. In these types of materials, the landslide breaks directly through the material along a curving surface. The curving surface is concave upward, starting out steep at the head of the landslide and gradually flattening towards the bottom of the landslide. Because of the curvature, the landslide is said to “rotate” as it moves downhill. In a rotational failure analysis, the strength of the intact soil or rock is used in the analysis, although fractures or other types of weakness can also play a role in the analysis.

The stability analysis for both the jointed quarry faces and the sandstone slopes assumed seismic accelerations of 0.2g. This value was considered appropriate by many researchers at the time the JCA reports were prepared. Recent research, however, has prompted most current practitioners to employ higher seismic design coefficients for pseudo-static slope stability analysis in areas where very strong seismic shaking is expected (Brae and Rathje, 1998). Ashford and Sitar (2002) have developed a method for estimating appropriate seismic coefficients for analyzing the stability of very steep slopes. Although their analysis was for weakly cemented rocks, the potential for topographic amplification must be taken into account in the analysis of the planned Boundary Expansion Area slopes.

JCA concluded that the planned quarry slopes would be stable. ~~A peer review of the JCA reports was provided by a registered geotechnical engineer (Appendix D of the Geology and Hydrology Technical Appendix). A peer review of the geologic portion of these reports was performed.~~ The following comments summarize the results of both the geologic and geotechnical reviews of the JCA reports.

**Stability of Rock Slopes**

JCA performed a fracture mechanics analysis consisting of kinematic and limit equilibrium analysis of plane and wedge failures, using stereographic projection techniques, for the metamorphic and granitic rock slopes. A stereographic projection involves using a graphical tool called a stereonet for displaying fracture information (see Geology and Hydrology Technical Appendix F for examples of stereonets~~, Appendix F~~). Forty-five fracture attitudes and the lines of intersection of the different fractures, taken from different rock types throughout the quarry, were plotted on four equal-area stereonets (one for each of the four proposed quarry faces—east, south, west, and north sides of the quarry pit). No identifiable structural trends or groups exist in the JCA data, indicating that the sampled fractures represent multiple structural domains (that ~~it~~is, it mixes groups of fractures from different areas that don't belong together). The geologic mapping and fracture orientation data collected as part of this study defined at least two separate structural domains within the quarry.

A great-circle representation of the average strike and dip of each of the four proposed finished quarry faces was plotted on a stereonet with the fracture data and the fracture lines of intersection. Fracture and intersection attitudes plotted on both sides of the great circle for each of these proposed quarry faces, indicating that many of the fractures and intersections observed by JCA are kinematically~~potentially~~ unstable, and that limit equilibrium analyses are needed to resolve their stability. The material strengths required for stability were then back-calculated from an assumed potential failure surface. The JCA reports concluded that the back-calculated material strengths were reasonable, given the rock and soils types observed in the field, and that the proposed slopes are therefore likely to be stable.

Nolan Associates concluded that fracture mechanics theory was employed incorrectly in JCA's analysis for the jointed quarry slopes. This opinion is based on the following findings:

- As discussed earlier, each structural domain requires a separate analysis. Individual structural domains were not identified, and the number of discontinuities sampled was too small to provide an adequate representation of fracture conditions at the site.
- JCA's structural data and slope-face orientations were plotted on equal-area stereonets. Analysis of angular relationships using stereographic techniques, such as a fracture stability analysis, should be performed using equal-angle stereonet projections.
- JCA concluded that rock slopes were probably stable if a majority of fractures or intersections did not daylight within the slopes. In fact, a slope is kinematically unstable if only one fracture or intersection is inclined out of slope.
- JCA performed a back-calculation for an assumed 70-degree failure surface and concluded that the rock slopes were stable. No documentation was provided as to why this failure surface was selected, or if this failure surface represents the critical surface. There is no independent assessment of the shear strength characteristics of the assumed failure surface, so the analysis remains incomplete.
- No field or laboratory tests were used to determine material strength properties. The material strengths required for stability were back-calculated from assumed failures, and these calculated strengths were assumed to be present in the rock. As stated in the geotechnical peer review (Pacific Crest Engineering, Inc. (PCEI), 2004), "Since there is no data presented showing the required strengths exist for stability, no conclusion can be drawn that the slopes are stable".
- JCA did not consider fracture strength independently of rock strength. Strength differences between clean joints and infilled or cemented joints were not considered. Sampling and laboratory testing of fractured rock, both with and without infill, is required to perform this analysis.

- In the analysis, a cohesive bond strength of 1,150 psf is calculated as necessary to provide a factor of safety of 1.2. Normally, joint surfaces have primarily frictional shear strength, so the utility of calculating the limiting failure surface cohesive strength remains unclear.
- Water pressures (i.e., open fractures filled with water during storm events) were not considered as part of JCA's analysis.
- The seismic coefficients used in the analysis do not reflect current information on seismic shaking intensities or seismic coefficient selection.

JCA considered the satisfactory past performance of the quarry slopes, as of the publication dates of their reports (1997), as evidence that the planned slopes of 80 degrees would be stable. The landslide failure observed during the winter of 2005-2006 calls this conclusion into question. Quarry slopes had not been graded to the finished slope geometry at the time of the JCA analysis and none of the quarry slopes has been subjected to the peak expected seismic shaking that would be associated with a large event on the San Gregorio fault.

**Stability of Overburden Cut Slopes**

JCA employed Bishop's Method of Slices to analyze the potential for rotational failures in the planned 1½:1 (horizontal:vertical) soil and sandstone overburden cut slopes. No laboratory testing was performed on representative samples of soil or sandstone material to determine in-situ strength parameters. Instead, JCA back-calculated strength parameters from an assumed failure surface to obtain a factor of safety of 1.2 under seismic loading, using a seismic coefficient of 0.2g. Because the back-calculated strength parameters were considered to be representative of the sandstone, JCA concluded that the cut slopes were stable.

The JCA rotational stability analysis for the proposed overburden and sandstone cut slopes was found to be in general conformance with the local engineering standard of practice at the time of publication, but it was recommended that the strength parameters of the sandstone be documented to validate JCA's conclusions (PCEI, 2004). Revisions to the stability analysis are required to meet the current standard of care, specifically:

- Field and/or laboratory testing should be used to determine overburden and sandstone strength parameters, and a forward stability analysis should be performed using those strengths.
- Updated seismic coefficients should be employed based on current information and procedures for seismic coefficient selection.

**Stability of Engineered Fill Slopes**

JCA employed laboratory results from triaxial test~~result~~s on remolded, laboratory-compacted, screened rock fines from the quarry to represent the material that is to be used as fill ~~on the west side of~~embankments in the quarry. Strength parameters from these tests were applied to double-wedge and rotational failure models.

The stability analysis for the fill slopes was found to be in general conformance with the local engineering standard of practice at the time of publication (PCEI, 2004; see Appendix C). However, PCEI (2004) noted that no strength data was presented in the report for the tests performed on compacted, screened rock fines, and no strength testing was performed on remolded sandstone overburden material or on a mixture of rock fines and sandstone material, which is also to be placed as part of the fill. The following revisions to the slope stability analysis would be required to meet the current standard of practice:

- Laboratory testing should be used to determine remolded sandstone or mixed sandstone and rock fines strength parameters. The resulting laboratory strength data should be used in an updated stability analysis.
- Updated seismic coefficients should be employed in the stability model based on current information and procedures for seismic coefficient selection.

**Stability of Settlement Basin Levees**

Under the Final Drainage Plan (Bowman and Williams, 2001b as shown in Figure 10), Settlement Basins 3 and 4 would be serving the proposed Boundary Expansion Area. Presently proposed mitigation Measure HYD-1 recommends that runoff from the quarry be retained within the quarry pit, with provision that overflow from the quarry could be routed to the Settlement Basins, should the runoff volumes overwhelm the ability of the quarry bottom to percolate water. The stability analysis performed for the levee associated with Settlement Basins 3 and 4 indicated that the levees are not stable under expected seismic shaking conditions (based on a limit equilibrium approach). Golder (1991) calculated permanent seismically induced deformations of up to 9 inches (23 centimeters) for Settlement Basin 3 if the predicted peak seismic loading (0.27g) occurred while the levee was saturated. They did not state what form the deformation would take or what the consequences of that deformation would be.

It is possible for an earthen embankment to deform without failing. However, at some point, deformation can give way to structural failure, particularly with seepage forces present in the levee and where the possibility of piping exists (piping occurs where water seeping through an earth embankment progressively washes out soil particles, eventually eroding large pipes through the embankment). Piping can be a potential hazard under any conditions, but the hazard is increased if the embankment is subject to deformation due to seismic shaking.

As discussed in the liquefaction hazard discussion, above, the levee analysis was performed based on older seismic stability methods and information. A re-analysis using current methodology and information ~~may produce different results~~is warranted.

**4.3.4.2 Summary of Quarry Slope Stability Impacts**

Landsliding in the quarry Boundary Expansion Area could occur under seismic or static (non-seismic) conditions, as indicated by the recent landslide within the quarry. The hazards associated with non-seismic landsliding are comparable to those associated with seismically induced landsliding. The types of landsliding that may occur are rock falls and rock topples along the quarry faces or large-scale sliding of the overburden or marble exposed in the quarry faces.

Until updated stability analyses are completed as recommended, the stability of proposed Boundary Expansion Area slopes and the levees for settlement basins serving the proposed Boundary Expansion Area cannot be validated. The recent landsliding near Liddell Spring and within the quarry highlights the potential hazards. Depending on the results of the updated slope stability analysis, there may be a potential for large, seismically induced landslides to impact the landscape adjacent to the Boundary Expansion Area rim, thereby elevating erosion and sedimentation hazards. Landsliding could damage the land in the 25-foot set back zone between the quarry rim and northern property line and could encroach upon the adjacent residential parcels to the north owned by CEMEX. Widespread rock falls or topples could also damage reclamation efforts after the mine is closed. These impacts are considered to be potentially significant. Ensuring stable slope gradients through updated stability analysis as required in mitigation Measure GEO-2 would reduce these impacts to a less than significant level.

Mining in the Boundary Expansion Area is a continuation of the existing mining operation. Worker safety at the Bonny Doon Quarries is regulated by Cal OSHA and the Mine Safety and Health Administration. As project Lead Agency, the County of Santa Cruz relies on the technical safety regulation by these federal and state agencies charged with worker safety at the quarry. The project does not put the risk to quarry workers beyond the reach of existing regulation. Therefore, the potential safety impacts of the project are less than significant.

The quarry wall length for the existing mining area and the Boundary Expansion Area combined is about 12 percent longer than that of the existing mining area by itself (measured as the circumference of the existing mining area compared to the circumference of the combined existing and proposed mining areas), with only a very little increase in length of the north wall of the quarry. Therefore, the net increase in steep quarry slopes due to the proposed expansion is not large. ~~In addition, the amended grading plan for the quarry (Figure 9) calls for placing spoils from the Boundary Expansion Area along the western side of the quarry. The placement of these soils in compacted form would buttress the steeper quarry walls and reduce the landslide hazard in that portion of the quarry. These tow factors together suggest~~ This factor suggests that the proposed Boundary Expansion Area mining would result in a modest increase in exposure to slope stability hazards even if the updated stability analysis indicates that the quarry walls are likely to be unstable.

An updated slope stability analysis using current information and analysis techniques is necessary for validation of previous slope stability evaluations as they affect the proposed Boundary Expansion Area slopes. The updated slope stability analysis should also help determine if the factors that caused the 2006 landslide pertain to other areas in the quarry. Should the updated analysis indicate that the proposed finished slopes in the Boundary Expansion Area (Figure 9) are unstable with respect to significant landsliding, the proposed finished slope design may have to be altered to provide a more stable profile. "Significant" landsliding would include:

- landslides of substantial size, such that they may encroach on adjacent properties (on the north side of the proposed Boundary Expansion Area) or have the potential to result in serious erosion and sedimentation; or
- a determination that the proposed Boundary Expansion Area slopes are so unstable with respect to smaller scale landsliding that the occurrence of numerous landslides could interfere with the quarry reclamation plan.

The occurrence of "significant" landsliding is considered to be a significant impact. Mitigation measures for reducing potential impacts to a less than significant level are summarized under Measure GEO-2.

#### 4.3.4.3 Liddell Spring Landslide

The Liddell Spring landslide complex has been extensively characterized by PGE (2001) (Geology and Hydrology Technical Appendix, Appendix F). Potential impacts on the Liddell Spring landslide due to quarry expansion include the following:

- Additional instability could be induced by blasting.
- Placement of additional spoils from the quarry near the head of the landslide complex could further destabilize the area.
- Changes in runoff patterns could result in increased saturation of the landslide mass.

The landslide complex includes an earthflow that PGE (2001) interprets as having occurred under natural conditions, prior to quarrying, and more recent debris flows exacerbated (if not triggered) by quarry spoils placed on the slopes above. The landslide abuts the City's spring box at Liddell Spring. The PGE (2001) geotechnical report presents their stability analysis and makes recommendations for stabilizing the landslide mass, should that become necessary. They concluded that there was a high potential for portions of the landslide to reactivate. In their opinion, however, there is a lower potential for renewed landsliding to impact the City of Santa Cruz's facilities at Liddell Spring. The landslide complex appears to have been stable since monitoring began in 2000 (Reid Fisher, personal communication, 2006).

The PGE (2001) report provides recommendations for reducing the landslide hazard at Liddell Spring, including drainage control, continued monitoring, and dewatering of the landslide mass. They concluded that blasting conducted for the quarry operation would be unlikely to induce new landslide movement at the spring site.

Renewed movement of the Liddell Spring landslide could damage the City's water diversion facility and degrade water quality at the spring. The proposed quarry expansion is unlikely to have an impact on the stability of this landslide provided that:

- no more quarry waste (e.g., overburden and off-spec rock) is placed on the slopes above Liddell Spring; and
- all concentrated runoff from the quarry or roads crossing the slope above the spring is carefully controlled and is not permitted to flow across the landslide area or across older quarry spoils above Liddell Spring.

These provisions are identified in Measure GEO-3.

### 4.3.5 Erosion

#### 4.3.5.1 Erosion Process

Erosion results in the gradual lowering of the ground surface due to the action of wind and water. Erosion by water begins with the loosening of individual soil particles by raindrop impact and mechanical transport of soil particles by surface runoff. Runoff starts as sheet flow that collects into tiny rills guided by small irregularities in the ground surface. Rills merge into streams and streams into rivers. The larger streams and rivers have more erosive power so they cut down more rapidly, leading to ridge and valley terrain.

In areas where the slope aspect and rock type promote redwood forests, the redwood canopy intercepts rainfall and helps protect the soil from raindrop impact. At the same time, the buildup of tree litter under the canopy creates a thick layer of duff that absorbs water and protects the ground surface from erosion. Erosion rates in these areas can be relatively low. In contrast, in areas of sparse vegetation, soils are exposed to direct impact by raindrops and have little protection from erosion caused by runoff. Wind erosion tends to be a more important erosion factor in arid climates, where surface runoff is minimal and sparse vegetation leaves soils exposed to the action of wind.

Cultural activities such as road building, logging, and (in some instances) wildfires can result in an increase in erosion rates, usually referred to as “accelerated” erosion. The degree to which cultural activities impact erosion rates depends on the nature of the activity, the manner in which the activity is conducted, and the natural susceptibility of the local earth materials to erosion. The creation of impermeable surfaces, such as paved roads, or the compaction of natural soils (rendering them less permeable) reduces infiltration into the soil and therefore increases runoff volumes.

Erosion can and does occur in natural settings undisturbed by human activity. However, human activities such as agriculture, timber harvesting, road building, and quarrying have the potential to increase erosion impacts by orders of magnitude over natural conditions. Removal of vegetative cover, grading, and changes in drainage courses or redirection of surface waters can cause accelerated erosion. This accelerated erosion results in loss of soil cover, which limits opportunities for the plant growth upon which natural ecosystems depend. Downstream transport and redeposition of the eroded material can destroy aquatic habitats in downstream areas.

#### 4.3.5.2 Limestone Quarry Boundary Expansion

The proposed Boundary Expansion Area is partially overlain by as much as 150 feet of Santa Margarita Sandstone, a weakly cemented sandstone. The mechanical removal of this material would create loose sand and silt that may infiltrate buried karst sinks and open fractures, thus gaining entry to the karst aquifer system. This sediment would also be entrained in runoff from the proposed Boundary Expansion Area.

Removal of the overburden and quarrying in the proposed Boundary Expansion Area would increase the amount of runoff from the quarry as a whole by creating steep slopes and a larger area of exposed rock. The proposed quarry expansion therefore has the potential to cause erosion by exposing loose sediment to erosion and by increasing runoff volumes and velocities, which lead to erosion. These effects may result in sedimentation of downstream areas and increased turbidity at Liddell Spring if sediment-laden water percolates into the karst groundwater system.

The removal of overburden from the original quarry area in 1969-70 is closely linked to instances of sedimentation and turbidity in Liddell Spring, as indicated by anecdotal accounts and turbidity data from Liddell Spring (Geology and Hydrology Technical Appendix, Appendix F). Erosion and sedimentation due to earth moving and road building during initial quarry development directed surface water flow toward Liddell Spring and other drainages. The initial erosion control problems resulted in the mine operator failing to meet the requirements of the RWQCB permit. The result of this development was that the RWQCB eventually required a three-year soil control/erosion control plan. Additional removal of overburden has reportedly occurred since then, presumably on a smaller scale. Evidence of major sedimentation or turbidity as a direct result of more recent clearing has not been reported.

Clearing of overburden from the existing quarry ultimately involved approximately 80 acres and included development of roads and other quarry facilities. Spoils were placed at several newly prepared locations around the quarry property. In contrast, the proposed expansion would involve clearing of 17.1 acres and would use existing roads and facilities. Boundary Expansion Area spoils would be placed at disposal area "C" and/or within the quarry pit. Disposal area "C" is already developed as a disposal area and is fitted with a developed drainage system and settlement basin. Runoff from the quarry pit is also contained ~~and~~or routed through settlement basins. For these reasons, the scale of the erosion and sedimentation associated with the proposed expansion is expected to be smaller than from the initial land clearing.

The Final Drainage Plan for the quarry, including the proposed Boundary Expansion Area (Figure 9), shows all runoff being captured and conducted to the quarry floor, where it would concentrate and flow to Settlement Basin 3. This drainage scheme is to be implemented at some point during mining of the Boundary Expansion Area. Prior to that time, runoff would be impounded within the quarry, as is presently the case. Potential impacts due to the expansion of mining would be different during the period that runoff is being impounded within the quarry and when the quarry outlet is graded to drain to Settlement Basin 3. Potential impacts are expected to diminish gradually over time with implementation of planned reclamation measures at the end of mining.

Under the present drainage scheme, mining of the Boundary Expansion Area would result in increased runoff and sediment volumes being impounded on the quarry floor. During this time period, soil erosion due to the quarry expansion may impact groundwater quality due to infiltration of sediment-laden water into the quarry floor. To the extent that the sediment-laden water flows to Liddell Spring, soil erosion in the Boundary Expansion Area could impact turbidity and sedimentation at Liddell Spring or in areas downstream from the spring. These issues are analyzed in the hydrology section, Section 5.0.

Under the Final Drainage Plan (Figure 10), runoff in the quarry, including the Boundary Expansion Area, would be collected on inboard-sloped benches and would then flow to down-drains leading to the quarry floor. From the quarry floor, the runoff would flow to Settlement Basin 3. No provision is shown on the plan to slope the benches toward the down-drains. Sediment-laden runoff flowing along the benches may enter the subsurface where the bench drains cross open fractures or conduits, possibly contributing to turbidity and sedimentation at Liddell Spring, but this impact should be less than that related to the impounding of runoff within the quarry. However, the Final Drainage Plan (Figure 10) would greatly increase flow to the settlement basins. As discussed in the slope stability and liquefaction sections, above, updated stability and liquefaction potential evaluations for the settlement basin levees are warranted. Should any of the levees be unstable, the increased runoff due to the proposed Boundary Expansion Area would increase the potential for sedimentation of downstream areas.

At the end of active mining, the reclamation plan would result in revegetation of the quarry and other remedial measures that would reduce the supply of loose sediment over time. Provided the reclamation plan is successfully implemented, the potential hazard due to erosion and sedimentation would diminish over time.

Under any drainage condition, the principal erosion and sedimentation impacts due to mining of the Boundary Expansion Area would be related to removal and disposal of overburden. No drainage plan for controlling runoff and erosion during the actual process of removing overburden from the Boundary Expansion Area has been provided. The removal of this overburden may have significant impacts on erosion and sedimentation, unless appropriate mitigation measures are implemented over the short term. Where runoff from the quarrying operation is detained within the quarry, the increased erosion and sedimentation could impact turbidity and sedimentation at Liddell Spring or in waters downstream from the spring. The development of a drainage plan to address the potential water quality impacts of increased sedimentation in quarry runoff is required in Measure HYD-1. The impact of increased sediment loads on water quality is further addressed in Hydrology (Section 5.0).

### 4.3.6 Cumulative Impacts

The geologic impacts of the project include slope stability of the new cut and fill slopes, stability of settlement basin levees serving the Boundary Expansion Area, and erosion. These impacts are confined to the project site. Future mining may occur in the 9.4 acres remaining within the Legal Mining Limit. Mining in this area would have ~~similar~~ geological impacts ~~as~~similar to those of the proposed project. Mitigation measures applied to the Boundary Expansion Area would also be applicable to mining the remaining 9.4-acre area. The combined geologic impacts of the proposed project and mining in the remaining area on slope stability, levee stability, and erosion can be controlled through mitigation. There are no significant cumulative impacts associated with the project.

## 4.4 MITIGATION MEASURES

The following measures would reduce significant geology impacts to a less than significant level.

***IMPACT:*** *A liquefaction assessment of the quarry settlement basin levees has not been performed. A displacement analysis for seismic shaking shows basin levees would move under seismic shaking. Mining the Boundary Expansion Area ~~would~~may result in increased runoff volumes and sediment loads entering quarry settlement basins. The project may result in sedimentation of downstream areas if settlement basin levees receiving runoff from the quarry Boundary Expansion Area fail during a major seismic event.*

**Measure GEO-1:** The Applicant shall update seismic stability evaluations and prepare liquefaction hazard evaluations for settlement basins that would be receiving runoff from the proposed Boundary Expansion Area, based on the current state of knowledge and standards of practice. The seismic stability and liquefaction hazard evaluations shall be completed and submitted to the County Planning Department as a condition of approval. The evaluations shall examine levee stability whether due to embankment deformation or liquefaction within or under the levee and shall consider the potential for piping to accompany deformation. Methodologies discussed in Blake, et al. (2002) for seismic slope stability evaluation and Seed et al. (2003) for liquefaction analysis are currently employed in Santa Cruz County, but more current analytical methods may be used. Given the proximity and 400-year recurrence interval on the San Gregorio fault, a deterministically derived maximum earthquake acceleration, magnitude, and distance based on the expected event on the San Gregorio fault may be more appropriate for analysis at this site than the probabilistic acceleration and de-aggregated magnitude and distance.

The stability and liquefaction susceptibility evaluations shall include sufficient field investigation to document the foundation condition and relative density of both levees, that is, the field investigation shall be sufficiently detailed to develop an as-built plan for the levees, upon which the analysis can be based. If the analysis predicts permanent seismically induced deformation of the levee, the consequences of that deformation with respect to the overall stability of the levee shall be clearly stated. In general, permanent deformations greater than 6 inches (15 cm) shall be considered unacceptable, but any predicted deformation shall be evaluated within the context of the levee material properties and design.

A completed liquefaction and stability analysis for the levees shall be provided to the County of Santa Cruz Planning Department for peer review. If the results of the stability evaluation indicate that there is a potential for failure of the levees and release of impounded runoff to downstream areas, the levees shall be modified by the quarry operator to satisfy stability concerns. Any modifications of the levee shall be based on sound engineering design. All design documents and evidence of satisfactory completion of the levee modifications must be provided for approval to the County of Santa Cruz Planning Department prior to inception of mining in the Boundary Expansion Area.

**Implementation:** by CEMEX
**Effectiveness:** Measure would ensure that the levee of the quarry basin receiving additional runoff and sediment from the project meets current seismic standards reducing the risk of seismic failure and the potential for release of sediment downstream.
**Feasibility:** Feasible. Any required modifications would be based on industry design standards.
**Monitoring:** Updated seismic stability evaluations for settlement basin shall be submitted to County for review and approval prior to ~~commencement of project~~inception of mining in the Boundary Expansion Area.

***IMPACT:*** *The project may result in ~~landsliding of~~ unstable slopes in the proposed Boundary Expansion Area slopes, either during quarrying or after closure of the quarry, potentially resulting in accelerated erosion, water quality impacts, or encroachment of ~~landsliding~~unstable areas onto lands adjacent to the proposed Boundary Expansion Area.*

**Measure GEO-2:** The Applicant shall prepare an updated slope stability evaluation for proposed slopes in the Boundary Expansion Area. ~~Quarry walls~~ Local (bench) scale and the overall quarry wall stability shall be evaluated based on methodology appropriate for jointed/blocky rock ~~slopes~~masses. For ~~Slopes in~~overburden materials, such as the Santa Margarita Sandstone and overlying ~~soils shall~~soils, traditional soil mechanics limit equilibrium analysis methods are considered appropriate ~~be evaluated based on translational or rotational slope stability models~~.

~~Recommended~~ Procedures for Stability Analysis of Jointed Rock Slopes

~~A stability analysis for hard rock slopes (such as granite or marble), where failure is controlled by joints, fractures, or other discontinuities, requires that the nature of these discontinuities be adequately characterized. A preliminary rock slope reconnaissance must be performed to identify structural domains with statistically homogeneous joint or fracture characteristics,~~

~~including average orientation, spacing, length, continuity, and infill or cementation characteristics. The boundaries between adjacent structural domains are usually represented by lithologic contacts, faults, or some other prominent change in the rock mass. During the quarry geologic reconnaissance, three structural domains within the quarry were identified, defined by faulted boundaries (Geology and Hydrology Technical Appendix). Where relevant to the proposed Boundary Expansion Area, these domains shall be confirmed and refined, as necessary, as part of the slope reconnaissance. Discontinuities within each domain shall be characterized in detail, using orthogonal scanline or window surveys.~~

~~Once structural domains are correctly identified and information on discontinuities has been collected, statistical methods (using stereographic density contouring or specialized software) must be applied to the measured discontinuities in each structural domain to determine averages or ranges for each set of spatially grouped discontinuities. These discontinuity averages or ranges are plotted on an equal-angle stereonet as point representations (dip and dip direction) for the plane analysis of single sets of fractures, and as intersection lineations (plunge and trend) for the wedge analysis of intersecting sets of fractures.~~

~~A kinematic fracture stability analysis must then performed comparing these discontinuities with a great circle representation of a proposed slope face, plotted on an equal-angle stereonet. Fractures and intersections that plot within the great circle are kinematically stable, meaning that these features dip steeper than -- and do not "daylight" within -- the proposed slope face. Conversely, fractures and intersections that plot outside the great circle are potentially destabilizing.~~

~~A limit equilibrium analysis, comparing driving and resisting forces, is required to resolve each potential failure scenario identified by a kinematic analysis. Forces acting on plane- or wedge-bounded failure blocks, including rock friction, infill cohesion and friction angle, hydrostatic forces, normal forces, and seismic forces, can be analyzed stereographically as part of a limit equilibrium analysis. Certain rock, fracture-infill, and fracture-cement properties required for a limit equilibrium analysis, such as cohesion and friction angles, would require laboratory testing to resolve. Seismic shaking coefficient input values shall be adjusted to account for topographic effects associated with steep slopes (see Ashford and Sitar, 1994; 2002).~~

~~The results of the limit equilibrium analysis are used to characterize expected failure modes. Given the height and steepness of the proposed quarry walls, an evaluation of sliding due to rupture through intact marble shall also be evaluated to see whether it should be included as a possible failure mode.~~ The stability of jointed hard rock excavations (such as the subject quarry) is generally controlled by the system of rock mass discontinuities (joints, fractures, faults etc.) that intersect to potentially form adversely oriented blocks in the excavation face. In such cases, discontinuity characterization (e.g. orientation, spacing, persistence, shear strength) therefore represents a key slope stability consideration. To obtain representative stability analysis input parameters, systematic discontinuity surveys shall be performed, for example using scan line and/or window mapping approaches. The discontinuity data shall be filtered in such a manner that statistically homogenous sub-domains can be identified, as the geologic reconnaissance revealed three distinct fault-bounded structural sub-domains in the quarry (Geology and Hydrology Technical Appendix F). Once structural domains have been established and discontinuity data collected, statistical methods (using stereographic density contouring or specialized software) shall be applied to determine the most likely parameter values and their associated ranges. This requires that a statistically significant number of field measurements be collected.

Based on discontinuity orientation data, kinematic analyses shall be performed to identify domains of the quarry slope, at the bench to overall scale, that may be susceptible to block sliding (along a single plane), wedge sliding (simultaneous slip along two planes), and toppling (overturning). For those areas of the quarry meeting kinematic conditions for block instability, supplemental limit equilibrium-based stability analyses shall be performed, using stereonet-based approaches or classical closed form solutions. In the stability analyses, appropriate water pressures and seismic loading conditions shall be included. The selected pseudostatic seismic coefficient shall account for topographic effects of steep slopes (Ashford and Sitar, 1994; 2002). Finally, the stability analyses shall consider the potential for rupturing through the marble rock mass in developing failure modes.

The results of rock slope stability analyses shall be used in conjunction with a systematic and documented assessment of past quarry slope behavior, in order to develop prognoses for future slope performance.

~~Recommended~~ Procedures for Stability Analysis of Soft Rock or Soil Slopes

Overburden, sandstone, and fill slopes associated with Boundary Expansion Area mining are adequately treated as classic soil slope stability problems, without specific reference to discontinuities. Typical rotational slope failure models, such as the Bishops, Janbu, or other commonly used analytical method may be employed. Rock or soil densities and strengths used in the analysis shall be based on laboratory testing of field samples of each material constituting the slope model.

The seismic coefficient used in the analysis shall be based on current methods for coefficient selection (Blake et al. (2002) or more current) and shall account for topographic amplification. Soil strengths used in the analysis shall be selected to take into account potential dynamic and strain (displacement) related reductions in strength. If a displacement rather than limit equilibrium approach is taken to evaluating slope stability in this context, displacements of 4 to

12 inches (10 to 30 cm) shall be considered potentially significant. Displacements greater than 12 inches (30cm) shall be considered unacceptable.

The results of both the jointed rock slope and soft rock or soil slope stability evaluations shall be used to define the type of slope failures expected in the proposed Boundary Expansion Area, whether deep-seated or shallow, and the degree of instability associated with the potential failures. "Significant" landsliding has been defined above as:

- landslides of substantial size, such that they may encroach on adjacent properties (on the north side of the proposed Boundary Expansion Area) or have the potential to result in serious erosion and sedimentation; or
- a determination that the proposed Boundary Expansion Area slopes are so unstable with respect to smaller scale landsliding that the occurrence of numerous landslides could interfere with the quarry reclamation plan.

Evidence for significant landslide hazard would include stability analysis results that predict large block or deep-seated circular failures with factors of safety less than 1.2 or widespread smaller failures with factors of safety less than 1.0. A factor of safety against large-scale failures of 1.2 is indicated in the 1997 Conditions of Approval. The 1997 Conditions of Approval, Part 1, III.A.7.(2) (Santa Cruz County, 1997) state that "all final cut slopes completed after September 12, 1996, shall have a stability factor of safety not less than 1.2 …"

The completed stability evaluation shall be provided to the County of Santa Cruz Planning Department for peer review. If the stability analysis indicates a potential for significant landsliding, the configuration of the working or finished Boundary Expansion Area slopes shall be redesigned by the quarry operator to mitigate the landsliding hazard. All documentation related to slope redesign shall be provided to the County of Santa Cruz Planning Department for review and approval prior to the inception of mining of the Boundary Expansion Area.

The validity of the slope stability model shall be evaluated as mining progresses based on periodic surveys of rock types, fracture orientations, and faulting. These surveys shall be documented and provided to the County of Santa Cruz Planning Department at least once annually. If any changes in earth material lithology or structure occur that might affect the conclusions of the slope stability analysis, the analysis shall be revised. Any indication of significant landslide hazard based on the revised stability analysis shall be mitigated by design.

| | |
|---|---|
| **Implementation:** | by CEMEX |
| **Effectiveness:** | Proper analysis of quarry slope stability would allow identification and mitigation of potential slope stability hazards. |
| **Feasibility:** | Feasible. These studies can be completed and proper design measures instituted based on current industry standards. |
| **Monitoring:** | Updated stability evaluations shall be submitted to County for review and approval prior to ~~commencement of project~~ inception of mining in the Boundary Expansion Area. All mitigating designs shall be submitted to the County for review and approval. |

***IMPACT:*** Renewed movement of the Liddell Spring landslide could be caused if drainage is diverted towards the landslide or dumping of overburden, off-spec rock or other waste occurs on the slopes above the spring.

**Measure GEO-3:** No quarry waste (e.g., overburden and off-spec rock) or other soil or rock shall be placed on the slopes above Liddell Spring. All concentrated runoff from the quarry or roads crossing the slope above the spring shall be carefully controlled and shall not be permitted to flow across the landslide area or across older quarry spoils above Liddell Spring.

**Implementation:** by CEMEX

**Effectiveness:** Avoidance of uncontrolled surface drainage and placement additional quarry material on slopes above Liddell Spring would protect against de-stabilizing the landslide mass and triggering renewed movement.

**Feasibility:** Feasible. Drainage can be controlled through implementation of additional controls. No dumping of quarry material is proposed in landslide area.

**Monitoring:** Routine inspections by County.

***IMPACT:*** *The project may result in accelerated erosion within the Boundary Expansion Area, potentially impacting water quality or quantity flowing to Liddell Spring.*

**Measure HYD-1:** (See Section 5.4 in Hydrology and Water Quality for a complete description).

**Implementation:** by CEMEX

**Effectiveness:** Implementation of the drainage plan provisions would control runoff in the expanded mining area, reduce runoff exposure to sediment sources, reduce exposure of rock fissures and voids to runoff containing sediment, and remove sediment from runoff entering the groundwater through the quarry floor. These measures would reduce the turbidity impacts on Liddell Spring and sedimentation of downstream drainages. Impacts would be reduced to a less than significant level.

**Feasibility:** Feasible. Movable plastic membranes can be used to line benches and collect runoff in areas not being actively mined. The runoff so collected can be conveyed to the quarry floor by temporary down-drains. The efficacy of placing a compacted fine-grained cover on the quarry floor was previously disputed (SECOR, December 1998; EMKO, August 1999). However, given proper engineering consideration, a suitable sediment filter could be designed and installed as a basal layer of the planned fill placement in the base of the quarry. The filter would have to prevent migration or collapse of fill into solution channels or voids, but should maintain some permeability to allow ponded runoff to percolate.

**Monitoring:** Drainage plan shall be submitted to the County Planning Department for review and approval prior to ~~commencement of project~~public hearing on the proposed project.

# 5.0 HYDROLOGY AND WATER QUALITY

This report section characterizes the quarry area hydrology and hydrogeology and provides a discussion of potential project environmental impacts and mitigations. This report section is abstracted from the detailed description and analysis of the quarry area hydrology and hydrogeology provided in Geologic, Hydrologic, and Hydrogeologic Technical Appendix for Draft EIR, Bonny Doon Quarry Proposed Expansion (Nolan Associates, 2007), hereafter referred to as the Geology and Hydrology Technical Appendix (Appendix F). The reader is encouraged to consult the Geology and Hydrology Technical Appendix for more detailed (and technical) discussion of topics included in this section.

In the following discussions, hydrology refers to the movement of water over the ground surface and is principally concerned with factors such as precipitation and stream or spring flow. Hydrogeology refers to the movement of water under ground, and is concerned with the ~~ground water table~~ deep and shallow groundwater zones and the direction of~~ground~~ groundwater flow. The surface water and groundwater flows are~~always~~ linked—surface water percolates into the ground to feed the groundwater supply and groundwater emerges into springs or streams--but the interaction of the two in the present area is somewhat unique because of the special qualities of groundwater flow through marble rock, such as occurs in and around the quarry.

The movement of both surface water and groundwater in the quarry and surrounding area is strongly influenced by the local geology and the following analysis of the project impacts depends on an understanding of the geologic setting, as summarized in Geology, Section 4.0. Because surface water and groundwater originate beyond the boundaries of the quarry property and flow through the quarry to areas downstream, it has been necessary to study a large area around the quarry to provide for the analysis of potential Boundary Expansion Area impacts. This larger area is ~~defined~~ referred to as the geologic/hydrologic study area, ~~bounded on the north~~defined and ~~by Ice Cream Grade, on the west by~~ discussed in Section 5.1.2. The geologic/hydrologic study area encompasses Ice Cream Grade to the north, Bonny Doon and Pine Flat ~~Roads, on the east by Laguna Creek, and on the south by an east-west line drawn approximately through~~ roads to the west, Laguna Creek to the east, and Liddell Spring to the south (Figure 16).

The following sections describe the hydrologic and hydrogeologic setting of the quarry and proposed Boundary Expansion Area based on observations of local topography, geology, precipitation, surface water flow and groundwater flow. Following the setting discussion, this chapter presents a conceptual model of the paired surface/groundwater flow system to serve as a basis for assessing the water quality and water quantity impacts expected from the proposed quarry expansion.

## 5.1 ENVIRONMENTAL SETTING

The hydrology and hydrogeology environmental setting sections of the EIR are based on:

- a review of available geologic, hydrologic, and hydrogeologic literature describing the geologic/hydrologic study area and previous hydrologic and hydrogeologic consulting reports, maps, and other documents prepared for the quarry;
- review of hydrologic data for the geologic/hydrologic study area, including rainfall records, stream and spring flow records, and water quality records;

~~review of the geologic model prepared for the geologic/hydrologic study area by the EIR geologic consultants (Geology and Hydrology Technical Appendix, Appendix F);~~

- participation in dye tracer studies performed for the quarry operator by P.E. Lamoreaux and Associates (PELA, 2005);
- drilling of one exploratory boring in the quarry to measure groundwater levels and to use as an access point for the dye tracer studies;
- monitoring of ponded water levels in the quarry pit;
- collection of well and exploratory boring records for the quarry and surrounding area;
- review of the hydrogeologic conceptual model prepared for the geologic/hydrologic study area by the EIR geologic consultants (Geology and Hydrology Technical Appendix, Appendix F);

### 5.1.1 Hydrologic Setting

The Bonny Doon Limestone Quarry is situated on the southwest slope of Ben Lomond Mountain (Figure 22, Topographic Index Map). Precipitation falling on this flank of the mountain enters a system of relatively short, steep, deeply incised, southwest flowing drainages that empty into the Pacific Ocean. The principal drainages in the area are San Vicente, Laguna, and Majors ~~Creeks~~creeks (Figure 22). The quarry and terrain immediately surrounding the quarry are situated within the watershed of Liddell Creek. Liddell Creek is fed, in part, by two springs issuing from the quarry property, Liddell and Plant ~~Springs.~~ springs.

The Bonny Doon Limestone quarry is located in an area of Mediterranean-type climate that receives most of its rainfall during the winter season. Based on various available records, mean annual precipitation in the quarry area is estimated to range between about 34 and 40 inches per year (in/yr). Annual precipitation increases with elevation to as much as 60 in/yr at the crest of Ben Lomond Mountain, north of the quarry. Most of this rain falls during the winter season between October and April.

The quarry and proposed Boundary Expansion Area occupy the headwaters of the central and eastern branches of Liddell Creek (Figure 23, Quarry and Vicinity Drainage Areas). The drainage area for the quarry and Boundary Expansion Area watershed is about 125 acres. Excavation for the quarry has created a closed basin with no outlet. Therefore, most of the runoff that falls on the quarry watershed flows to the quarry floor and percolates into the ground. ~~Only a~~ Compared to the surrounding area, a relatively small percentage of the runoff is lost to evapotranspiration. An 8-acre swale on the downhill side of the quarry leads to Liddell Spring. ~~Any overflow from the quarry would flow down this swale into Liddell Creek~~. ~~However,~~ Overflow from the quarry, if any, does not flow down this swale, but rather is routed by the quarry drainage system to an adjacent tributary branch of the East Branch of Liddell Creek. Currently, the water level in the quarry does not get high enough to overflow.

The quarry and surrounding lands are underlain by marble. The marble bedrock that underlies the quarry and large portions of the geologic/hydrologic study area is riddled with cavities, fissures, and caverns that formed due to dissolution of the marble by percolating groundwater. Other rock types in the area do not dissolve in water. The fissures and caverns formed in the marble sometimes reach the ground surface, were they form open pits called sinkholes, or dolines. Where streams flow into the sinkholes, they are called swallow holes.

Prior to quarrying, there were several sinkholes located where the quarry now is. It is likely that much of the surface runoff prior to quarrying was captured by sinkholes, although there are no specific reports of such capture in the review literature. At present, there are active sinkholes to the north and northeast of the quarry that capture surface flow (Figure 23). Whitesell Creek, which follows the northwest rim of the quarry, and Reggiardo Creek, to the northeast, are both captured (at least in part) partially by swallow holes ("sinking streams", Figure 23). Water entering the sinkholes and swallow holes becomes part of the groundwater flow regime.

Based on Using the mean annual precipitation of 34 to 40 inches, the 125-acre drainage area of the quarry watershed plus adjacent small basins that drain to sinkholes or swallow holes (drainages 1, 2, and 3, Figure 23), watershed, thethe relatively high amount of impermeable exposed rock surface, and the fact that the quarry retains and rapidly percolates most of the runoff from this area, the expected recharge to ground water from groundwater from this area encompassing the quarry and proposed Boundary Expansion Area drainage is in the range of 200300 to 400 acre-feet per year (ac-ft/yr)( Geology and Hydrology Technical Appendix Appendix F, Section 3.2, Appendix F). 3.2 and Table 41). An acre-foot is the amount of water needed to cover an acre of land one foot deep with water. Annual recharge from the quarry and adjacent small basins that drain tosinkholes or swallow holes (drainages 1, 2, and 3, Figure 23) is estimated to be 300 ac-ft/yr. During the wettest years, this amount may be two or more times greater.

#### 5.1.1.1 Drainage BaselineBasin Description

The current Use Permit 3236-U for the Bonny Doon Limestone Quarry requires that finished excavations shall in all cases be graded in such a manner as to prevent the accumulation of storm waters or natural seepage. The Use Permit limits excavation to an elevation no lower than 750 feet above mean sea level (ft msl). In addition, maps and diagrams associated with the Use Permit indicate that the final contours of the Limestone Quarry pit would allow the pit to drain by gravity to Settlement Basin 3.

Most of the quarry pit was drained by gravity to Settlement Basin 3 until the early 1990s, when the pit was excavated below the elevation of the crusher area at the mouth of the pit creating a closed basin. The practice of allowing surface water impounded in the pit to infiltrate into the karst aquifer was recommended by EMCON Associates in 1992. This recommendation has been incorporated into the Conditions of Approval for COC and the 1996 Reclamation Plan Approval 89-0492.

The bottom of the quarry pit has reached its maximum depth over a wide, level area. The current elevation of the quarry pit floor is approximately 752 ft msl and has expanded to near maximum horizontal area. However, the location and elevation of the crusher at the mouth of the quarry pit has not changed and the highest elevation at the mouth of the pit near the crusher has remained consistent at approximately 815 ft msl.

The Under the quarry's existing permit with Santa Cruz County, the approved final contour plans would require plan requires blasting and excavation of the area at the mouth of the pit near the crusher in order to lower the elevation by approximately 65 feet, thus allowing water collected precipitation and runoff to drain by gravity as surface flow from the pit to Settlement Basin 3. These drainage measures approved during mining and for reclamationare approved for the current mining and its reclamation, would not change as a result of the proposed expansion. However, the Geology and Hydrology Appendix (Appendix F, Section 5.5.1) notes that the existing drainage system could become overwhelmed if rainfall and runoff that currently percolate into the karst subsurface beneath the quarry area were prevented as a result of mitigation measures and/or site reclamation. As presented below in Section 5.4, the Final EIR recommends modifying the existing approved drainage plan so as to maintain internal, subsurface drainage within the quarry area.

**5.1.1.2 Springs**

One of the principal potential impacts of concern within the proposed Boundary Expansion Area is the possibility that mining of the area would degrade water quality of major springs downstream from the quarry. This section summarizes information regarding the principal springs of interest, Liddell Spring and Plant Spring.

Liddell Spring is located immediately south of the Bonny Doon Limestone Quarry (Figure 23). It is the largest spring in the region and is a significant water source for the City of Santa Cruz. The City of Santa Cruz does not take the entire output of the spring, but diverts part of the flow when water quality at the spring and water demand by the City support it. The City monitors its monthly diversions from the spring for quality and quantity and has gauged total instantaneous spring flow intermittently since 1999.

Data from City of Santa Cruz records show that during water years (WYs)[2] 1999-2005, monthly average flow rates at Liddell Spring ranged between 760 and 1,720 gpm and averaged about 1,100 gpm. Peak gauged flows (rather than monthly average flows) have ranged from about 600 to 3,100 gpm. Based on the available gauging data, including the City of Santa Cruz's record of diversions, the total mean annual flow of Liddell Spring is estimated to be 1,500 ac-ft/yr (Geology and Hydrology Technical Appendix, Appendix F).

Plant Spring is about 1,400 feet east of Liddell Spring (Figure 23). From November 2002 to November 2004, flows averaged 184 gpm (about 300 ac-ft/yr) and ranged from 66 to 338 gpm (Geology and Hydrology Technical Appendix, Appendix F). CEMEX diverts up to 21 gpm (927,000 gallons/month) from Plant Spring, mostly for dust control at the quarry.

Many relatively minor springs occur elsewhere in the area.

#### 5.1.1.3 Water Production at Liddell Spring

Liddell Spring has been a source of water for the City of Santa Cruz since 1913. Historically, Liddell Spring has provided a reliable water supply in terms of both quantity and quality. About 30 percent of the City of Santa Cruz's water supply is derived from its North Coast pipeline, which conveys water diverted from Liddell Spring and Laguna, Reggiardo, and Majors creeks. Of the 3,300 ac-ft/yr diverted from all four sources, Liddell Spring has supplied 1,250 ac-ft/yr since WY 1972, or 39 percent. Liddell Spring and Majors Creek provide greater percentages of the total North Coast diversion during dry periods, whereas Laguna Creek provides a greater portion of the total during wet periods. Historically, Liddell Spring has provided a reliable water supply in terms of both quantity and quality. Stewart (March 1978) noted the following: the springbox built in 1959 never needed cleaning; during the early 1960's the spring provided the City's entire supply for up to three weeks during stormy periods when other sources were too turbid; the available diversion could be predicted many months in advance due to the springflow's gradual rise and fall. Consequently, Liddell Spring is considered to be a key source in the City of Santa Cruz's water supply system. See section 3.5 of the Geology and Hydrology Technical Report (Appendix F) for more detailed information regarding Liddell Spring.

One measure of water quality that is of importance at Liddell Spring is turbidity. Turbidity is a measure of the amount of suspended fine sediment particles within the water. Turbidity is not by itself considered a health hazard, but higher levels of turbidity can encourage the growth of bacteria. Consequently, ~~most~~ water purveyors strive to supply water with low turbidity levels consistent with current Federal standards (see Section 5.1.2.2 below). Prior to June 1994, the City's North Coast pipeline directly served some customers. This limited the allowable turbidity of diverted flows to about 2 nephelometric turbidity units (NTU). Beginning in 1994, the City began piping water directly to its treatment plant from the north coast, before

[2] A water year is the "precipitation year" from October 1 through the following September 30: e.g., WY 2006 would include precipitation from October 1, 2005 to September 30, 2006.

sending it back to its north coast customers. Since then, the practical turbidity threshold of divertible flows has risen to about 10 to 25 NTU. However, this does not appear to have resulted in a substantial shift in the overall rate of diversion.

Turbidity typically increases during storms and decreases in the time between storms, as does the overall flow at the spring. This relationship is expected and is commonly observed in streams where greater runoff during storms stirs up sediment that causes turbidity. Based on hourly monitoring data for 1997 to 2005, the turbidity of Liddell Spring increases to as much as 1,000 NTU in response to storms. Elevated turbidity currently persists for days following storm events. According to anecdotal accounts, sometime in the past these periods of elevated turbidity lasted only hours. This assertion cannot be tested given thathourly turbidity data collected have only regularly over short time intervals (e.g., every 15 minutes) have been collected only since 1997.

Another measure of water quality is specific conductance. Specific conductance is a measure of how well water will conduct electricity and it is an indirect measure of the amount of dissolved minerals that are present in the water. A large amount of dissolved minerals will result in a relatively high specific conductance. The specific conductance of Liddell Creek diversions follows a seasonal trend peaking trend—peaking during the wet season and gradually falling during the dry season. This trend is the opposite of the specific conductance variation in local streams, which show low specific conductance in the winter and higher conductance in the summer.

In streams, the low wintertime conductance is a result of the rapid runoff of non-mineralized (low conductance) rainfall in the streams. Streamflow in the summer consists mostly of surfacing groundwater or soil water that has been stored for some time, allowing it to absorb minerals. The summer streamflow therefore has a higher specific conductance. At Liddell Spring, the highest specific conductances are seen in the winter. This observation indicates that the high wet-season flows cause the discharge of more mineralized groundwater from storage than during other times of the year. The winter rainfall is "pushing" older water out of the underground aquifer system rather than simply contributing directly to springflow.

This process has been confirmed by studies of the relationship between springflow volume and annual rainfall (Geology and Hydrology Technical Appendix, Section 3.5.1.1, Appendix F). These studies indicate that springflow at Liddell Spring is more attributable to the amount of rainfall that occurred in several previous years than it is to the rainfall in the year that the springflow is being measured, i.e., springflow amounts are heavily influenced by the preceding several years' precipitation. This observation is important in understanding the overall groundwater flow system, as will be discussed later in this Chapter. chapter.

### 5.1.2 Hydrogeologic Setting

The hydrogeology of the Quarryquarry and vicinity is dominated by a localized karst groundwater system developed in marble bearing metamorphic rocks underlying Ben Lomond Mountain. The term "karst" refers to terrain underlain by limestone or marble where runoff from rainfall drains primarily through a system of underground fissures or caverns rather than in surface streams. The ground surface in areas of karst consists of hollows and pits where water enters the rock and enlarges joints and fissures by solution. The primary components of the groundwater system underlying the geologic/hydrologic study area (the quarry, proposed quarry Boundary Expansion Area, and overall Liddell Spring recharge area) are as follows:

- A large block of metamorphic rocks containing the weathered marble (i.e., karst) groundwater system tributary to Liddell Spring.
- The entire watersheds of Laguna and Reggiardo creeks above the elevation of Liddell Spring. These watersheds encompass all of the recognized karst sinks potentially tributary to Liddell Spring, as well as other nearby karst springs.
- Both large and small remnants of Santa Margarita Sandstone directly overlying the granitic and metamorphic rocks, which are important areas of groundwater recharge tributary to the karst system.

- A southern, downstream boundary consisting of granitic rock that bounds the karst aquifer on its downstream side.

### 5.1.2.1 Hydrogeologic Units and Groundwater Conditions

The hydrogeologic units of primary importance in the vicinity of the Bonny Doon Limestone Quarry include both water-bearing and non-water-bearing rocks. Water bearing units are rocks that readily store and transmit water to springs or wells. Non-water bearing units are relatively impermeable rocks that transmit water slowly, if at all. Saturated, water-bearing rocks are considered to be aquifers. In the geologic/hydrologic study area, the primary aquifers are the marble and Santa Margarita Sandstone. Units that act mostly as barriers to groundwater flow include the granitic rocks and schist. The distribution of these rocks in the study area is depicted on Figure 24, Fracture Zones Interconnecting Marble, Sinking Streams, and Springs.

**Non-Water Bearing Rocks**

The granitic rocks occur regionally in large bodies spanning several square miles, but also as smaller bodies intruded or faulted into juxtaposition with other rocks. Granitic rocks also occur sporadically as thin layers (dikes and sills) a few feet to tens of feet thick injected along faults, joints, or bedding planes in the surrounding metamorphic rock. Exposures of granitic rock surround nearly the entire karst groundwater system, which helps to contain and focus groundwater flow toward Liddell Spring.

Schist generally has low permeability and generally is not an important water-bearing unit. The schist's primary hydrogeologic importance is its association with marble inclusions. Bodies of marble occur throughout the schist and are more extensive than previously mapped. Marble may exist in the near- or sub-surface zone wherever schist is mapped or inferred. A large portion of the Santa Margarita Sandstone outcrop appears to be underlain by schist and probably some marble. The schist may transmit groundwater where sufficiently fractured or weathered. This may help explain the groundwater pathways through schist between apparently isolated bodies of marble, as will be discussed in the section on dye tracer studies, below. Also, sinkholes may form in schist underlain by marble, and karst springs may emerge from schist outcrops if marble is at shallow depth.

**Water Bearing Rocks**

The Santa Margarita Sandstone is an important aquifer in the Bonny Doon area. It is generally thin (0 to 300 feet thick) and ~~covers~~blankets underlying granitic rock, schist, and marble~~ like a blanket~~. It readily absorbs and stores water where it is exposed and transmits that water into the underlying rocks.

The approximately 1.5 acres of landslide deposits immediately east and northeast of Liddell Spring are permeable and transmit groundwater (Plate 2, Geology and Hydrology Technical Appendix, Appendix F). Given their limited volume, these deposits have limited importance with respect to groundwater yield. However, a springflow turbidity response observed during construction of a landslide monitoring well indicates a degree of hydraulic connection between the landslide and spring.

The Bonny Doon Limestone Quarry is located within a block of faulted marble roughly 4,000-foot square. It is the largest block of marble evident in the immediate area, and regionally second in size to the body of marble at the University of California Santa Cruz, about 5 miles to the southeast. A smaller body of marble occurs in the Reggiardo Creek watershed to the immediate east, which is at least partially juxtaposed with the quarry block. Other apparently smaller bodies of faulted marble occur to the north-northeast along Laguna Creek. Tracer studies discussed later in this summary suggest that these bodies are interconnected into a single karst groundwater system. The marble may be more extensive at depth and/or the individual bodies may be interconnected by fractures and marble interbeds within the schist. Areas of marble may directly underlie the large exposure of Santa Margarita Sandstone that occurs about a mile north of the quarry.

Although within generally the same body of schist as the quarry marble, marble exposed in the Fall Creek watershed is more than a mile east of the quarry area's most eastern marble outcrops along Laguna Creek, and is thus interpreted to be effectively separate from the Bonny Doon karst system due to probable limited hydraulic connectivity and/or effective gradient between watersheds. Marble occurring along the western margin of the San Vicente Creek watershed is disconnected from marble in the quarry area as a result of nearly two miles of intervening and deeply incised granitic rock.

Marble has little primary porosity and very low permeability where unfractured and unweathered (that is, it does not store or transmit water very well). Dissolution of the marble by slightly acidic percolating soil water and flowing groundwater results in substantial secondary porosity, including "macropores" such as caverns and conduits. These tend to form preferentially along fractures, leaving blocks of ~~low permeability~~ low-permeability marble between fracture zones.

A roughly diamond-shaped grid of major fracture zones cuts through the quarry area (Figure 24). The fracture zone locations are based largely on the topographic pattern of narrow valleys cutting across the terrain, with intervening ~~steep sided~~ steep-sided hills or knobs (the fractures are mapped along the valleys). The fractures are also visible in the walls of the quarry.

At least four major fracture zones occur at the quarry, they trend northeast between Liddell Spring and the quarry property's northern boundary. Another four or more major fracture zones trend south-southeast between the western edge of the quarry and Reggiardo Creek. These major fracture zones are spaced roughly 1,000 feet apart on average and form a grid over the quarry area (Figure 24). Liddell Spring is located at the southern, downstream tip of this grid.

Sinkholes tend to align with these fracture zones, with the most prominent sinkholes occurring at or near major fracture intersections. Quarrying and structural mapping reveal the occurrence of buried sinkholes along the top of the marble beneath the Santa Margarita Sandstone. These sinkholes are thought to have formed when the marble was exposed to erosion before the deposition of the Santa Margarita Sandstone, many millions of years ago. Many of the buried sinkholes coincide with active sinkholes or sinkholes that were mined out by the quarry. Swallow holes tend to form where streams flow across marble outcrops, forming sinking stream "reaches" (Figure 24). Sinking-stream reaches along Reggiardo and Laguna creeks intersect fracture zones leading toward the quarry and Liddell Spring. Karst springs tend to occur at the downstream edge of marble outcrops, but also may emerge from other rocks downstream of the exposed marble.

Solution-widened fractures are visible in the quarry walls, commonly forming continuous zones of solution channeling that extend from the original ground surface down several hundred feet to the quarry floor and below. Fractures cut across schist interbeds and igneous sills and dikes such that these rocks do not impede groundwater flow through the karst. Fractures and conduits do become blocked for periods of time when bridged with sediment or collapsed marble.

Nolan Associates reviewed 225 borings drilled for the quarry with known locations and elevations. Karst voids and porous zones comprised nearly 10 percent of all the logs, more than half of which were filled with sediment. Five boreholes drilled within or immediately adjacent to the Boundary Expansion Area encountered karst voids 10 to 40 feet ~~tall.~~ high. Based on these results, the marble's overall porosity may be as much as 5 percent (see Geology and Hydrology Technical Report, Section 4.1.3). Shallow and deep solution cavities are interconnected, consistent with the ongoing dissolution of marble simultaneous with the gradual uplift of Ben Lomond Mountain ~~(in~~(unlike some geologic ~~settings,~~ settings where solution cavities appear to be arranged in distinct layers).

**~~Ground Water~~Groundwater Levels**

Nine quarry monitoring wells have groundwater depths greater than 300 feet and five others have depths greater than 200 feet. Such great depths are rare in the region, and reflect the extraordinarily rapid and deep drainage of groundwater into the karst system supplying Liddell Spring. Water supply wells in the Bonny Doon area upstream of the quarry have water levels typically less than 60 feet deep.

~~Water table~~ Groundwater surface elevations are shown on Figure 25, Generalized ~~Ground Water~~Groundwater Surface Contours. Two ~~sets of ground water table contours~~ groundwater surfaces are shown on Figure 25 in the quarry area, ~~a shallow ground water table and a deep ground water table. The shallow ground water surface~~one for the shallow groundwater table and another for deep groundwater zones. The shallow groundwater table reflects surficial recharge into the Santa Margarita Sandstone and ~~the deep ground water~~other exposed rock whereas the deep groundwater surface reflects ~~deep conduit flow in~~ the influence of the karst ~~aquifer, mostly from stream swallow holes.~~ aquifer.

The shallow groundwater table in the Bonny Doon Area descends gradually towards the area north of the quarry (Figure 25). It then wraps around the quarry marble body in response to groundwater drainage into the karst aquifer, causing a water-level drop of several hundred feet over a relatively short distance (Figure 25).

The drop in water table elevation is achieved in a step-like manner over a transition zone a few hundred feet wide where the groundwater flows out laterally, filling local cavities in the marble above the deeper water table under the quarry. These transitional pockets of water that fill or partially fill cavities in the transition zone have been encountered during drilling and are considered to be "perched" ~~ground water, that is, ground water~~ groundwater, that is, groundwater that is being temporarily detained above the~~more~~ permanent ~~water table.~~ fully-saturated zone.

Several monitoring wells on the quarry property have groundwater levels representative of the transition between the shallow sandstone aquifer to the north and east of the quarry and the deep marble aquifer beneath the quarry. These levels vary over a 300-foot range, are fairly erratic, and only sometimes correlate to each other and the precipitation record.

A deep water table is also shown on Figure 25. The deep groundwater surface represents the ~~top~~ piezometric pressure of the permanently saturated zone and is an average of water levels found in ~~separate~~various karst conduits ~~connecting~~ that connect stream swallow holes and other sources of recharge to the quarry area and Liddell and Plant springs. ~~This surface has a southwest sloping water table, compared~~ Locally, this surface slopes to the southwest, in contrast to the overall southward regional ~~ground water slope. The~~ groundwater slope. This southwestern~~sloping ground water table~~ slope is indicative of ~~rapid flow~~ the preferential flow of karst groundwater along southwest trending fracture conduits in the marble and ~~shows the~~ demonstrates the unique and variable character of the karst aquifer.

**~~Ground Water~~Groundwater Characteristics**

A number of factors were used to characterize groundwater in the geologic/hydrologic study area: temperature, "mineral" constituents (ionic makeup), specific conductance, and stable isotope ratios (Geology and Hydrology Technical Appendix, Sections 4.31. to 4.3.4, Appendix F). Nolan Associates found that different water sources had fairly distinct signatures based on the values of these various factors.

Water temperature is an indicator of groundwater movement. Water that has been in the aquifer for a long time period will be at about the mean annual air temperature. Water that has recently entered the aquifer from winter storms will be cooler, reflecting cooler winter air temperatures. On the other hand, groundwater ~~water~~ that is nearing the surface at springs or seeps will equilibrate to seasonal temperatures (summer or winter). Water temperatures at Liddell Spring were a mixture of cool and warm waters, but generally had warmer temperatures during higher winter flows, indicating that long term groundwater storage contributes substantially to the higher flows.

"Mineral" constituents refers to the type of elements (ions) dissolved in the water. Groundwater will pick up ions from the surrounding rocks. Because rocks vary in composition, the type of ions in groundwater can vary between different rock types. Groundwater associated with the marble tended to be richer in calcium and bicarbonate, derived from its contact with marble, which is made up of calcium carbonate. Groundwater associated with the Santa Margarita Sandstone tended to be richer in sodium and chloride, probably a result of the breakdown of feldspar and other minerals in the sandstone.

Specific conductance, as explained above, is an indirect measure of the amount of dissolved minerals (ions) present in water. Rainfall and streamflow derived directly from precipitation runoff is very low in dissolved minerals. It therefore has a low specific conductance. The longer water resides in surface water or underground, the more enriched it can be in mineral constituents and the higher its specific conductance will be.

The specific conductance measured in deep wells in the quarry area generally has a lower specific conductance than water from shallow wells. The opposite is normally true: deeper water is usually more mineralized and has a higher specific conductance than shallow water, because shallow water is more directly recharged by percolating rainfall. In the quarry area, the deeper water generally has a lower specific conductance because it consists largely of stream water ~~flowing more or less directly from~~ captured by swallow holes and flowing to the springs through deep karst conduits aligned with fractures. The shallow water is more likely to be perched water ~~trapped for some time in soil or in pockets~~that is ~~in the marble.~~ migrating more slowly. The average specific conductance of discharge from Liddell Spring is mid-way between that of ~~captured stream flow in deep conduits~~ the deep conductive zones and more mineralized water from other recharge sources.

Isotopes are a result of variations in the number of neutrons in the atomic nucleus of different elements. Some isotopes are unstable, and will spontaneously degrade over time through radioactive decay. Other isotopes are stable and persist in the environment. PELA (2005) measure the ratios of stable isotopes of hydrogen and oxygen in various water samples from the geologic/hydrologic study area. Deuterium (D), an isotope of hydrogen, has one additional neutron in comparison to hydrogen (H). Oxygen-18 ($^{18}O$) has two additional neutrons when compared with oxygen-16 ($^{16}O$).

The added neutrons make D and $^{18}O$ heavier and affect their behavior. In particular, water made up of the heavier isotopes does not evaporate as fast as water composed of the lighter isotopes. Therefore, when water evaporates from surface water bodies, it has less $^{18}O$ and D than the water it leaves behind. Consequently, rainfall, derived from evaporation, has low $^{18}O$ and D amounts compared to surface water. Surface water tends to have differing amounts of the heavier isotopes, dependent on elevation, temperature, and other environmental factors. However, once the water percolates to groundwater, little evaporation is possible and the isotopic ratio thereafter generally remains relatively constant. Therefore, the amounts of heavy isotopes of hydrogen and oxygen in a groundwater sample can be used to identify its surface water source.

At the quarry area, groundwater from the Santa Margarita Sandstone and marble areas near the sandstone has lower $^{18}O$ and D ratios than stream water or water sampled from deep conduits in the marble aquifer. The stable isotope data combined with the specific conductance data have been used to group waters in the geologic/hydrologic study area into five source types. Figure 26, Interpretation of Isotopic and Specific Conductance Data, is a plot of hydrogen isotope ratio ($\delta D$) versus oxygen isotope ratio ($\delta^{18}O$) with the data points grouped according to specific conductance values.

~~These data are~~As discussed in more detail in Section 4.3.4 of the Geology and Hydrology Technical Appendix (Appendix F), the available isotope data suggest that sandstone recharge and swallow hole stream capture contribute roughly equal amounts of water to Liddell Spring, consistent with similar conclusions drawn from specific conductance and nitrate data. Conversely, the available data suggest that the flow of Plant Spring is derived mostly from captured streamflow.

**Dye Tracer Studies**

A key component used in formulation of the surface/groundwater model is the results of dye tracer tests conducted by P.E. Lamoreaux and Associates (PELA, 2005). The purpose of the dye tracer studies was to help define groundwater flow paths around and through the quarry and to identify the sources of water surfacing at Liddell Spring. Tracer tests have been previously recognized to provide a potentially critical means for evaluating Liddell Spring's connectivity to recharge and quarry operations. Four tests were performed between 1959 and 1968, with only one positive tracer detection at Liddell Spring.

The earlier tests yielded little useful information. The more recent tests by PELA (2005) took place in three phases and included approximately a year of monitoring. In the dye tracer studies, trace amounts of fluorescent dyes were added where surface water enters the groundwater system and groundwater outlets were monitored to help determine where the dye turned up and how long it took to reach each location. In this way, the connection between various entry points into the groundwater system and the springs could be determined.

Nolan Associates participated in the design and execution of the dye tracer studies. The results of the studies are summarized in PELA's final report (PELA, 2005) and in the Geology and Hydrology Technical Appendix, Section 4.4.2 (Appendix F).

The results of the dye tracer tests are summarized in diagrammatic form on Figure 27, Summary of 2004 Tracer Test Results. The physical locations of dye introduction and monitoring points are shown on Figure 24. In brief, the studies showed a strong connection between ~~sinking stream~~ sinking-stream reaches on Laguna and Reggiardo ~~Creeks~~creeks and flow at Plant and Liddell ~~Springs.~~ springs. The studies also showed a connection between Liddell

Spring and a sinkhole to the northeast of the quarry (SH-6) and a well drilled in the south central portion of the quarry (~~NZA,~~ Figure 27).

### ~~Ground Water~~Groundwater Flow Paths

The quarry and proposed Boundary Expansion Area are part of a groundwater flow system that supplies water to Plant and Liddell ~~Springs~~springs along two principal flow paths. These flow paths are identified based on information from the temperature, mineral content, specific conductance, isotopic composition, and dye tracer studies. One path (Path *A*) originates from groundwater recharge into exposures of Santa Margarita Sandstone across both the Bonny Doon plateau north of the quarry and the sandy knolls immediately east and northeast of the quarry, also underlain by Santa Margarita Sandstone (Figure 24).

A second path (Path *B*) is fed by stream water entering swallow holes along Laguna and Reggiardo creeks ~~(sinking stream~~(sinking-stream reaches, Figure 24). Each of these primary flow paths is associated with specific groundwater characteristics and each can be subdivided into more localized flow paths based on specific water chemistry signatures. Groundwater flow paths are depicted on Figure 28, Conceptual Model ~~for Ground water Flow Paths.~~ of Groundwater Occurrence. Figure 28 shows each principal flow path divided into sub-paths (A1, A2, B1, B2, etc.) and it shows a few ancillary paths (C, D, & E). A full discussion of the various sub-paths and ancillary paths is contained in the Geology and Hydrology Technical Appendix, Section 4.2.2 (Appendix F).

Path *A* originates from precipitation recharge into about 800 acres of exposed Santa Margarita Sandstone in the Bonny Doon area north of the quarry. Groundwater is mounded in the sandstone and generally occurs at shallow depths of 10 to 60 feet below ground surface. An estimated 5,000 ac-feet of groundwater may be stored in this area of sandstone. The regional water table slopes gently southward through Bonny Doon, descending from about 1,700 ft msl near Ice Cream Grade to 1,100 ft msl just north of the quarry. Groundwater table elevations are depicted on Figure 25. Groundwater also flows to the southwest and southeast toward the surrounding creeks, with some shallow groundwater discharging at small springs. This groundwater is relatively cool and has very low dissolved mineral concentrations of a sodium-chloride type. Water tables also occur locally from groundwater recharged into the sandy knolls immediately east and northeast of the quarry.

Path *A* shallow groundwater encounters the marble aquifer immediately upstream of the quarry. The aquifer's highly permeable karst features cause the groundwater level to drop 300 feet in elevation over a relatively short distance (Figure 25). The groundwater in the transitional zone has a hydrogen and oxygen isotopic signature similar to that of water in the Santa Margarita Sandstone aquifer, but it has a dissolved mineral concentration of a strongly calcium-carbonate type and a moderately high mineral content as a result of contact with the marble.

Temporary and seasonal springs and seeps have occurred as quarrying exposed groundwater zones transitional between the higher regional water table on the Bonny Doon plateau and the deeper groundwater zone under the quarry. The lack of any permanent springs as a result of quarrying is indicative of the karst aquifer's overall interconnectivity. Some of the wells drilled in the area do not encounter perched groundwater, indicating areas where vertical connectivity allows rapid, deep drainage.

Path *B* originates as streamflow in the upper Laguna and Reggiardo creek watersheds. This water has a very low dissolved mineral content and cool temperature during the wet season. Lower in the watershed, streamflow increases in mineral content and has a calcium-bicarbonate type, indicating some influence by the marble. Stream flows in Laguna and Reggiardo creeks that are available for capture by swallow holes are roughly 1,000 ac-feet/year. Flows of this magnitude are available for capture during most years.

Path *B* continues where streamflow is captured by swallow holes along Reggiardo and Laguna creeks. The groundwater tracer tests (PELA, 2005) indicate a strong hydraulic connection between the sinking-stream reaches in Reggiardo and Laguna ~~Creeks~~creeks and Liddell and Plant springs. Travel times for dyes inserted at the Reggiardo Creek swallow hole to the springs were about one to two weeks, indicating an average flow velocity of about 300 to 500 feet/day (map distance). Groundwater encountered in several monitoring wells between the swallow holes and the springs suggest that captured streamflow from swallow holes flows to the springs through relatively deep and conductive dissolution conduits in the marble, which at times may be under confined pressure. These wells are located along major fracture zones and have deep water levels relative to nearby shallower wells. The water from these wells has fairly low dissolved mineral concentrations and hydrogen and oxygen isotopic signatures similar to Reggiardo and Laguna creek streamflow. The relatively deep zones of saturation are consistent with the tendency for karst conduits to cut down to near "base level" (in this case, the level of Liddell Spring) given the low slope needed to move water through such highly conductive zones.

Groundwater moving along paths *A* and *B* flows through the marble aquifer beneath the quarry floor and undergoes some mixing as it approaches Liddell Spring, as indicated by the mixed character of the water surfacing at the spring. Percolation of precipitation falling on the quarry watershed and adjacent basins and runoff collected within the quarry pit constitutes a substantial source of additional groundwater recharge along this segment. Ranging up to 300 ac-feet/year, this recharge pulse descends through fractures and dissolution features with sufficient energy to transport sediment to groundwater. Blasts of high explosives are used to fracture and loosen marble for quarrying. Quarry blasting and "ripping" of the blasted rock by heavy equipment augments surficial and subsurface sediment supplies.

Tracer tests (PELA, 2005) showed that a monitoring well located on the quarry floor (~~NZA,~~ Figure 27) is hydraulically connected to sinkholes above the quarry and to Liddell Spring, below the quarry. The travel time from this well to Liddell Spring was approximately 7 hours, indicating an average groundwater velocity of 2,600 ft/day, the fastest rate of travel observed during the recent tracer tests. Given its location, water chemistry characteristics, and the dye tracer results, Plant Spring appears to be fed by path *B* groundwater uninfluenced by percolation from the quarry or much input from areas of Santa Margarita Sandstone.

Based on the water balance computed for the karst aquifer (Geology and Hydrology Technical Appendix, Section 4.5, Appendix F), Liddell Spring accounts for more than 80 percent of the marble aquifer's total yield and appears to be a mixture of flow paths *A* and *B* based on isotopic signature and dissolved mineral content intermediate between the two flow paths. The seasonal and year-to-year consistency of Liddell Spring discharge is evidence of the spring's connection to a large volume of groundwater storage. If the spring were being fed mostly by streamflow entering the swallow holes, its flow would vary much more according to winter storms and year-to-year variations in rainfall amounts.

Although the fairly rapid groundwater velocities documented by dye tracers between stream swallow holes and Liddell and Plant springs indicate that some groundwater flows rapidly from the swallow holes to the springs, a significant portion of captured stream flow is diverted into pore spaces and cavities marginal to the high conductivity pathways in the marble. When the inferred deep conduits between the swallow holes and the springs become fully saturated and pressurized during periods of high ~~stream flow, ground water~~ streamflow, groundwater is forced upward and outward into the unsaturated karst cavities and fissures. This water displaces more mineralized groundwater, forcing it out into the springs. This process explains why the mineral content of the Liddell Spring water increases during high flow conditions, while the mineral content of surface streams diminishes under these conditions.

#### 5.1.2.2 ~~Water~~Groundwater Quality

**Nitrate**

Potential sources of nitrate in the geologic/hydrologic study area include wastewater (sewage) disposal, fertilizers, agricultural wastes, and the explosives used in quarrying (ammonium nitrate and fuel oil [ANFO]). Nearly 400 septic systems occur within the potential source area for Liddell Spring that includes the Reggiardo and Laguna creek watersheds above the karst swallow holes and the Santa Margarita Sandstone recharge area. A turkey ranch operated immediately north of the quarry from about 1950 to the mid-1970s. Orchards that may be fertilized also occur north of the quarry.

Nitrate concentrations in quarry monitoring wells have averaged about 3 mg/L and ranged from below detection to 15 mg/L, with no clear spatial or temporal pattern (Geology and Hydrology Technical Appendix, Section 4.3.5, Appendix F). Nitrate concentrations over 45 mg/L are considered to be potentially hazardous in drinking water. Nitrate concentrations in Whitesell Spring upstream of the quarry ranged from 28 to 56 mg/L when sampled in 1992 and 1997. This suggests a concentrated source, possibly residual waste from the former turkey ranch. Because the spring flows at 10 gpm or less, the total amount of nitrogen is relatively small. Mill Creek, which drains a portion of the Santa Margarita Sandstone recharge area, had a nitrate concentration of 5 mg/L when sampled in September 1982. Previous studies have found that higher nitrate levels ~~tend to persist in~~ result from the high percolation capacities of soils associated with the Santa Margarita Sandstone ~~due to high percolation capacities~~. The nitrate concentrations of waters tested in the immediate quarry area include 2.3 mg/L in water ponded on the quarry floor, 4.2 mg/L in the discharge of Dump Spring, and 3.8 mg/L in the drainage channel leading to the quarry's detention basins.

Nitrate concentrations in the City's diversions from Liddell Spring were less than 2 mg/L prior to 1977 and have since typically ranged from about 1 to 5 mg/L, with a few spikes occurring up to 5 to 10 mg/L. The nitrate concentrations of the City's Laguna and Majors creek diversions have not experienced major trends or spikes since 1972 have been relatively stable at generally <2 mg/L.

The spring's nitrate concentration probably derives from a combination of sources, including ANFO, agriculture, and septic systems.

**Turbidity and Sediment**

Unlike other aquifers, karst groundwater systems have the capacity to transport considerable amounts of both suspended and bedload sediment due to the relatively high velocity of groundwater flow through solution channels. Furthermore, sinkholes, stream capture, and marble dissolution and collapse provide replenishable sources of sediment.

High turbidity can interfere with disinfection and provide a medium for microbial growth. As of January 2002, the Interim Enhanced Surface Water Treatment Rule requires that drinking water (treated water) turbidity never exceed 1 NTU and not exceed 0.3 NTU in 95 percent of a month's daily samples.

Liddell Spring's potential sources of sediment include eroded material and channel sediment washed into sinkholes, stream sediment intercepted by swallow holes, sediment stored or in transport within the subsurface, erosion and collapse of rocks within the subsurface, broken rock and rock dust from quarry blasting, and material fallen and washed into open fractures. Clastic ~~(coarse grained)~~ (coarse-grained) sediment that accumulates in the spring box and suspended sediment (very fine grained particles) responsible for turbidity may have distinctly different sources. Sediment pulses may be released when sediment-filled karst voids become breached and exposed to groundwater flow.

Mineralogical analysis of suspended sediment samples collected from Liddell Spring does not point to a single source and suggests that none of the local geologic formations can be ruled out as potential sources (Geology and Hydrology Technical Appendix, Section 4.3.6, Appendix F). The Technical Appendix study found that only a few cubic feet of sediment a day could be responsible for all the turbidity measured at Liddell Spring, a small amount of soil given the large area of the aquifer feeding the spring ~~(Section~~ and the volumetric rate of quarrying (Sections 1.6 and 4.3.6, Appendix F).

Records of turbidity at Liddell ~~spring~~Spring date from the late 1950s. Unfortunately,~~two factors affect the usefulness of the~~ early data~~. First, the turbidity samples~~ were collected relatively infrequently. Since turbidity can vary by a factor of 10 to 100 over several hours' time, frequent sampling is necessary to obtain a true picture of turbidity levels.~~ Second, much of the turbidity record at Liddell Spring is based on the measurements of turbidity in water diverted by the City of Santa Cruz for its use, and therefore did not include turbidity levels of water issuing from the spring when the City was not diverting water, a potential bias in the data.~~ Beginning in 1997, continuous ~~(hourly)~~ (e.g., every 15 minutes) turbidity data ~~has~~have been collected from the spring.

During the early 1970s (at the time the quarry was put into operation), the turbidity of Liddell Spring diversions commonly ranged from 1 to 100 NTU and peaked upwards to 500 NTU (Geology and Hydrology Technical Appendix, Section 4.3.6, Appendix F). From about 1980 through the mid-1990s, the turbidity of Liddell Spring diversions mostly ranged between about 0.05 and 10 NTU. Since the mid-1990s the overall turbidity trend has remained ~~flat, however~~ flat; however, the incidence of turbidities between 10 and 100 NTU has increased and the minimum level is generally above 0.1 NTU. This recent trend may reflect the City's ability to accept and handle more turbid water since 1994 (that is, the data may indicate that the quality of water diverted by the City has changed, rather than the overall quality of the water coming from the spring). A similar trend has been noted for the City's diversion from Laguna Creek, which is not affected by the quarry.

Observers have documented a strong correlation between the start of quarry operations and the ensuing years of increased spring sedimentation and turbidity in the early 1970s (Geology and Hydrology Technical Appendix, Section 4.6.2, Appendix F). A data review by

Earth Sciences Associates and Creegan & D'Angelo (May 1979) found that spring turbidity under natural, pre-quarry conditions sometimes exceeded standards later used to evaluate whether the quarry was having an impact. As such, they found that pre-December 1969 data were inadequate for establishing pre-quarry turbidity conditions. Also, changes in turbidity sampling methods and measuring techniques had occurred, complicating the interpretation of the data.

Nevertheless, Earth Sciences Associates and Creegan & D'Angelo (May ~~1979) and other observers~~1979), as well as other observers, noted a significant increase in springflow turbidity and spring box sedimentation for several years after the quarry overburden was first removed in 1969. They documented increased springflow turbidity between December 1969 and March 1974 and deemed the coinciding startup of quarry activities as the probable cause. They stated that, "Careful field inspection did not reveal any specific source of contamination of Liddell Spring. However, there are locations at which recorded 'sink holes' have been excavated and/or covered, and drainage patterns have been changed; it is possible these could have been a source of contamination in the period 1969-1970." These observations indicate that both surface and subsurface pathways were responsible for the elevated spring turbidity and sedimentation. They concluded that the City of Santa Cruz's water production from Liddell Spring declined as a result of increased turbidity during that time, not because of any reduction in springflow quantity. They provided quantitative estimates of the annual reduction in City water production from Liddell Spring for the years following the beginning of quarry operations.

The relatively continuous Liddell Spring turbidity record since 1997 includes springflows too turbid for the City to divert, ranging up to 1,000 NTU. On average, mean daily turbidities exceeded 2 and 10 NTU about 15 and 4 percent of the time, respectively. Mean daily turbidity correlates poorly with mean daily flow. Turbidities greater than 10 NTU have occurred on days with mean daily flows anywhere between 900 and 3,000 gpm. The highest recorded turbidities have not occurred at the highest flows, but instead are most associated with flows between 900 and 2,000 gpm (Geology and Hydrology Technical Appendix, Section 4.3.6, Appendix F). In examining records of turbidity during winter storms, it is observed that peak turbidities tend to occur prior to peak storm flow.

#### 5.1.2.3 Groundwater Movement and Sediment Transport

**~~Spring Flow~~Springflow Response to Precipitation**

Nolan Associates analyzed Liddell Spring's response to 15 storm events from January 2004 through April 2005 (Geology and Hydrology Technical Appendix, Section 4.4.3, Appendix F). This time period is the most complete period of continuous monitoring record available. WY 2004 was the fourth in a series of generally dry years whereas WY 2005 had above average precipitation. The analyzed storms represent a wide range of antecedent moisture and precipitation conditions (antecedent moisture refers to how wet the ground is when the storm of interest begins and it has a marked ~~affect~~effect on the amount of runoff generated by a storm). The analysis looked at variations in flow rate, turbidity, and specific conductance as each storm progressed. As with previous observations, the time it took for the spring to respond to rainfall ranged widely. However, the order in which the flow rate, turbidity, and specific conductance peaks occurred was very consistent between storms, as was the relative duration of each peak (Figure 29, Average Timing of Liddell Spring and Runoff Responses to Storm Precipitation, 2004-05).

Following peak precipitation, Liddell Spring turbidity peaked nearly as quickly as stream discharge (measured at Majors Creek) (Figure 29). Among all the responses evaluated, the timing of precipitation, peak stream discharge, and peak spring turbidity were the most closely and consistently linked.

The occurrence of peak stream discharge is a measure of how rapidly rainfall collects and flows into streams. The fact that peak turbidity occurs at more or less the same time and shows the same sharp peak as peak runoff in streams indicates that peak turbidity is somehow linked to surface runoff processes. Furthermore, although the power to transport sediment is greatest during peak springflow, Liddell Spring turbidity typically peaks many hours earlier (Figure 29).

One explanation is that recharge from sink and swallow holes creates a pressure pulse that quickly suspends fine-grained sediment throughout the karst system. In this case, rapid depletion of the subsurface sediment supply, even during increasing springflow, is needed to explain the occurrence of short-duration turbidity spikes coincidentally timed with the runoff hydrograph.

Another explanation is that as much or more of Liddell Spring turbidity is inherited from storm water captured and percolated (a) at relatively distant sink and swallow holes within the Reggiardo and Laguna creek watersheds, which accounts for some late-storm turbidity peaks, and (b) within the relatively nearby closed ~~the turbidity peak is linked to the same surface runoff process. Dye tracer tests indicate~~ catchment area created by the quarry, which accounts largely for initial storm turbidity peaks. This range of storm responses is consistent with the results of dye tracer tests, which showed under relatively dry conditions that several days or more are needed for water to travel to Liddell Spring from the Reggiardo and Laguna creek swallow ~~holes. In contrast, turbidity peaks about 15 hours after onset of precipitation. Therefore, the turbid runoff responsible for initial peaks in spring turbidity must be entering the ground water system closer to the spring.~~ holes, whereas groundwater flowing from the quarry reaches the spring in about seven hours.

Whereas plots of Liddell Spring turbidity and Majors Creek discharge had similar relatively steep rising and falling limbs, Liddell Spring discharge and specific conductance had more gradual rising and falling limbs. This observation suggests that, while elevated turbidity is most related to runoff processes, elevated specific conductance is related more to groundwater pressure and flow.

~~The ability of water to transport sediment increases with the volume and velocity of the water flow. Therefore, the power to transport sediment should be greatest during peak spring flow, however spring turbidity typically peaked about 6 hours earlier (Figure 29). Relatively simultaneous peaks in spring discharge and turbidity would be expected if turbidity were caused primarily by ground water picking up and moving sediment through the saturated marble aquifer. Instead, as noted above, runoff-related processes appear significantly responsible for the occurrence of peak turbidity.~~

Liddell Spring's specific conductance peaked on average ~~34 hours~~ more than a day after storm precipitation began, exhibiting the longest and most gradual storm response (Figure 29). This observation suggests that as the aquifer becomes pressurized with captured streamflow and other recharge, a higher proportion of more mineralized groundwater is temporarily discharged from the aquifer. This inferred pressurization is consistent with the observed timing of increased groundwater levels measured in a monitoring well near Liddell Spring (Farallon, August 2001).

The most delayed storm responses were secondary turbidity peaks in Liddell Spring. These secondary peaks occurred an average of 2 days after the storm began, and as long as 3 days afterward. These tend to be sharp, short-duration peaks shaped roughly similar to the initial turbidity response. These late turbidity responses may be related to recharge flowing from stream swallow holes, given roughly similar travel times for the fastest tracers to reach the springs from the nearest swallow holes during non-storm conditions.

Water levels were monitored in ponded runoff in the quarry pit through several storm cycles. The pond water levels were observed to rise and fall relatively rapidly, similar to the Majors Creek discharge record, indicating that ponds ~~levels~~ and creeks were responding to ~~runoff processes, like the creek~~ similar runoff processes (Geology and Hydrology Technical Appendix, Section 4.4.3.2, Appendix F). The turbidity of Liddell Spring began to rise about 5 to 7 hours after the pond levels began to rise, consistent with the time needed for a groundwater tracer to reach the spring from the saturated zone beneath the quarry area. Peak spring turbidity occurred about 6 to 9 hours after the beginning of the pond level rise, and about 2 to 5 hours after the peak pond water level. These results, combined with the interpretations of other data discussed above, indicate that runoff infiltration in the quarry area has a direct effect on Liddell Spring turbidity.

#### 5.1.2.4 Conceptual Groundwater Model

This section synthesizes evidence presented in preceding sections regarding surface water and groundwater flow in the context of an overall model of flow in the karst aquifer underlying the quarry and surrounding area. This conceptual model serves as the basis for discussing the groundwater response to quarrying in the next section.

Several lines of evidence support the interpretation that Liddell Spring has roughly two primary sources of water. From both hydrologic and hydrogeologic standpoints, the Santa Margarita Sandstone aquifer on the Bonny Doon plateau north of the quarry represents one major source of water, whereas captured Reggiardo and Laguna creek streamflow represents another. In terms of water quality, Liddell Spring has values of water temperature, specific conductance, nitrate concentration, and stable isotope ratios that are intermediate between these two sources. Conversely, Plant Spring is more similar in character to captured streamflow from the creeks. A third major source of water to Liddell Spring is precipitation and runoff captured by the quarry and adjacent areas drained by sinkholes or swallow holes (drainages 1, 2, and 3, Figure 23)

The recent tracer tests were only successful at demonstrating the stream capture sources. However, the apparent pattern of tracer movement was consistent with the two-source model. The interpretation of the tracer test results by Nolan Associates suggests that groundwater originating from the stream swallow holes follows high permeability pathways through fracture zones along the eastern and southern margins of the marble aquifer toward the springs, whereas groundwater flowing into the marble aquifer from the north follows fractures toward and through the quarry area to Liddell Spring. During relatively wet periods, the transmission of captured streamflow dominates more of the entire fracture system and pressures large amounts of groundwater into storage within voids higher in the marble (Figure 30, Conceptual Model of Seasonal Change in Flow Pattern).

Nolan Associates (2007) prepared a water balance for the aquifer based on:

- recorded diversions from Liddell and Plant springs and Laguna and Reggiardo creeks by the City of Santa Cruz;
- flow-gauge records for Laguna Creek and Liddell Spring; and
- estimates of drainage areas and average precipitation for watersheds contributing to the karst aquifer.

A previous study provided guidance for estimating the proportion of precipitation that becomes total streamflow (i.e., both seasonal runoff and baseflow from groundwater discharge) versus evapotranspiration, that is, precipitation lost to evaporation and uptake by plants (Geomatrix, March 1999). With this information, an estimate was made of how much water is entering the geologic/hydrologic study area via precipitation and streamflow, and how much is leaving it and where it is leaving it via streams and springs. The estimates reflect enhanced recharge from stream capture by swallow holes and relatively low evapotranspiration in sandy-soil (Santa Margarita Sandstone areas) and quarried areas, due to rapid runoff or percolation and the relative lack of plant cover. The estimated water balance is summarized in Section 4.5 of the Geology and Hydrology Technical Appendix (Appendix F).

Based on the~~water balance figures, it is~~ estimated ~~that~~ water balance, a transfer of approximately 1,300 ac-ft/yr from the Laguna and Reggiardo watersheds is needed to supply the annual yields of Liddell and Plant springs. Some of the transferred water originates from areal groundwater recharge (i.e., path *A*) and some from stream capture (i.e., path *B*). ~~The~~A balance of ~~about~~ as much as 500 ac-ft/yr is needed to match the annual combined discharge of Liddell and Plant springs, about 1,800 ac-ft/yr.~~, comes~~ This derives from more local sources, such as recharge in the quarry. Constrained by known yields, this conceptual water balance contributes to an understanding of the overall hydrologic system.

Several previous investigators concluded that Liddell Spring has one or more nearby sources (within a few hundred feet of the spring) with some connection to the ground surface (e.g., Wisser & Cox, 1960; Creegan, 1972; Watkins-Johnson, 1992; Farallon, 2001). Such sources probably account for only a small portion of the spring's discharge, and could not account for the total sediment load or timing observed in response to a storm event.

Liddell Spring's unique and complex response to storm events probably results in part from its multiple sources of water. Furthermore, Liddell Spring has multiple potential sources of sediment, some of which may be relatively independent of the primary sources of water.

~~Several~~ Although some of the initial turbidity response may be attributed to sediment mobilized by a recharge pressure pulse, this insufficiently explains short duration turbidity peaks coincident with runoff and ponding peaks. Alternatively, several lines of evidence ~~show~~indicate that sediment is being introduced into the groundwater system and/or entrained into the groundwater flow as a result of runoff-related processes at locations intermediate between the spring and the spring's primary sources of groundwater recharge (i.e., stream swallow holes on Reggiardo and Laguna ~~Creeks~~creeks and the Santa Margarita Sandstone north of the quarry). The earliest turbidity responses noted by this and previous studies generally range between 2 and 10 hours, and average about 5 to 7 hours. This timing is too slow for a source immediately nearby (e.g., a sinkhole or the landslide adjacent to the spring), and yet is too quick for travel from the Reggiardo and Laguna creek swallow holes. Tracers required at least several days to reach the springs from the swallow holes, which may be consistent with some of the later turbidity responses. Therefore, the timing of turbidity peaks is too early to be a result of turbid stream water reaching Liddell Spring from the Reggiardo or Laguna ~~Creek swallow holes.~~ creek swallow holes.

The tracer travel time to Liddell Spring from the quarry was 7 hours, and this was during a several-year period of average to below average precipitation, when ~~it might be~~ groundwater flow may have been slower than during ~~very~~more wet~~time~~ periods. The timing and character of Liddell Spring's turbidity response is similar to local streamflow and quarry-floor~~pond levels and to runoff relationships of local streams~~ ponding, and dissimilar to peak spring discharge. If the turbidity observed at Liddell Spring was simply a result of increased flow velocities entraining sediment within the karst system, more continuous, pulsed, and/or random transport would ~~occur~~ be expected at least up to the point of peak spring discharge.

The high groundwater velocities demonstrated by tracer tests and water level and quality data clearly indicate the occurrence of high permeability pathways through the marble aquifer. These pathways occur preferentially along fracture zones and consist of interconnected voids formed by dissolution of the marble bedrock. Such conduits formed continuously while the area has undergone tectonic uplift, leaving a network of interconnected, older voids above those currently forming. This network of voids lying above the permanent saturated zone provides the flow system with a large surplus capacity. This high capacity is evidenced by the system's ability to absorb recharge throughout the wettest years without the emergence of additional springs or substantial lengthening of the springs' response to storm flow. This three-dimensional network of voids provides for both pressurized flow in fully saturated conduits at depth and turbulent, cascading flow above.

Aquifer storage exists in less dynamic zones of saturation surrounding the major fracture flow paths. Since the water in storage is held for some time, it is more mineralized than water flowing more directly to the springs through the major flow paths. Release of the stored water during storm conditions is shown by the substantial rise in specific conductance observed as a relatively late response to storm events (Figure 29). Because Liddell Spring's turbidity peaks well before specific-conductance and discharge, it is unlikely that release of stored groundwater contributes substantially to sediment transport and turbidity.

Interconnected voids above the permanent zone of saturation are available for the capture and transport of runoff from locations other than the major stream swallow holes. A considerable amount of precipitation and runoff is captured by the quarry and adjacent terrain, possibly as much as ~~one fifth~~ one-fifth of Liddell Spring's average annual flow. Percolation of this drainage entrains sediment at the surface and in the subsurface created through blasting, ripping, and the disturbance of overburden, as well as naturally occurring sediment deposited in subsurface voids. Highly permeable interconnected voids have the potential to transport this water and sediment in a turbulent and cascading flow down to the zone of saturation and laterally toward Liddell Spring.

Relatively late turbidity responses that occur days after a storm likely reflect pulses arriving from where water cascaded into swallow holes along Reggiardo and Laguna creeks and entrained sediment that could then be held in suspension all the way to Liddell Spring. The spring's primary and more immediate turbidity response, however, ~~must be~~ is best explained by sources of turbid water and/or sediment closer to the spring.

#### 5.1.2.5 ~~Ground Water~~Groundwater Response to Quarrying

The Bonny Doon Limestone Quarry is a major activity within the groundwater system contributing to Liddell Spring. Some quarry operations occur as near as 500 feet from the spring; the actively mined quarry is about 1,500 to 2,500 feet up gradient and occupies roughly 80 acres. Since 1970, the quarry has mined an estimated 34 million cubic yards of marble from the same body of rock that forms the Liddell Spring aquifer. Assuming a porosity of 5 percent, the volume mined to date represents nearly 1,200 ac-ft of pore space. The quarry has lowered the marble surface several hundred feet to within as little as 50 feet of the underlying groundwater. Mining and removal of overburden have left the fractured rock exposed, and blasting disturbs the rock in the subsurface. The quarry pit and the hillslope drainage into it have no external drainage, so turbid runoff from the quarry collects in the pit. Tracer tests indicate that groundwater flowing beneath the quarry floor reaches Liddell Spring in 7 hours.

The analysis provided by the Geology and Hydrology Technical Appendix does not indicate any significant division of the marble's macroporosity (the collection of cavities, fissures, and caverns) into separate, ~~poorly connected~~ poorly-connected or unconnected zones at different depths (Appendix F). The quarry is surrounded by many sinkholes, while several former sinkholes and caverns have been excavated by mining. Major fracture zones are inferred to have a controlling influence on the distribution of high-permeability pathways through the marble, and several such fracture zones intersect the quarry and link it to Liddell Spring. Substantial volumes of runoff percolate into the quarry pit without evidence of discharge other than to Liddell and possibly Plant springs. Whatever hydraulic separation may have existed between the original ground surface and the water table, little remains now that mining has proceeded to within 50 feet of underlying groundwater.

The removal of overburden from the quarry area began in 1969 and actual mining began in August 1970. Accounts from 1969-74 link documented instances of Liddell Spring sedimentation and elevated turbidity with the removal of overburden, the initiation of quarrying, and above-average precipitation. For the most part, these early quarry activities were separated from the underlying groundwater by several hundred feet of as-yet unquarried marble. Thus, it must be concluded that there was hydrogeologic connectivity between quarry operations and Liddell Spring at that time. The connection can be no less now that several hundred feet of marble have been removed from above a groundwater zone shown through tracer testing to contribute to Liddell Spring. More recent instances of overburden removal have been relatively minor compared to the initial clearing of the quarry site.

Because the total springflow of Liddell Spring was not gauged regularly prior to 1997, the available data do not allow a definitive assessment of whether or not quarrying has affected spring yield. Nolan Associates' analysis does not show historical shifts in production other than what can be explained by climatic cycles. Quarrying may have exposed several springs over the years that did not become permanent or substantially affect Liddell Spring. The unsaturated void space of marble now quarried may have provided temporary storage for recharging groundwater. Thus, the capacity of the subsurface to absorb large recharge events may have diminished such that potential recharge is now rejected. Rejected recharge may appear as increased runoff as well as discharge from minor springs. To the extent that rejected recharge collects in the quarry pit, most of this water will eventually percolate back into the marble aquifer.

Nitrate concentrations in diversions from Laguna and Majors creeks have been relatively stable, whereas the nitrate concentrations of Liddell Spring diversions have been more erratic with some upward trend. Liddell Spring derives a substantial portion of its yield by capturing streamflow from these creeks. Therefore, the spring's other sources of recharge must be responsible for its elevated or erratic nitrate concentrations. Blasting with ANFO represents one likely source. Other sources appear to be at least as important, however, given the occurrence of elevated nitrate concentrations in monitoring wells and springs upgradient of the quarry.

Previous investigators have acknowledged that some increase in turbidity occurs as a result of blast events (e.g., PELA, 2005). These responses are highly varied, however, similar to Liddell Spring's range of responses to storm events. Twenty-two blast events during 2004-05 were evaluated by Nolan Associates as part of the study for the Geology and Hydrology Technical Appendix (Section 4.6.5, Appendix F). No turbidity peak was apparent following three of these events. Among the other 19 events, peak turbidity levels ranged from 2 to 78 NTU and occurred 2 to 7 hours after the blast. Although weather conditions varied considerably among these events, it was inferred that most of these turbidity peaks were blast related. Although the inferred turbidity responses to blasting are relatively small compared to storm-related turbidity, any increase in turbidity is undesirable from a water supply standpoint. More importantly, blast events contribute to the generation and/or mobility of sediment responsible for turbidity. Blasting may effectively increase the supply of sediment available to percolating water and groundwater flow during and following storm events.

Liddell Spring's turbidity response to precipitation occurs within hours to days. The turbidity response is complex, highly variable from storm to storm and year to year, and may include multiple turbidity peaks stretching out over several days. Because the City only measured the turbidity of ~~spring flows it actually~~ springflows on a roughly bi-~~diverted (on a roughly bi-weekly schedule)~~ weekly schedule prior to beginning continuous monitoring in 1997, the data record is insufficient to demonstrate a definitive causal, before-and-after relation between quarrying and springflow turbidity. Furthermore, sampling and measurement methods have changed, as has the City's ability to divert slightly more turbid water. Thus, an assessment of whether or not quarrying is having an effect on spring flow turbidity must rely on an interpretation of the local groundwater system. Aquifer connectivity and a subsurface source of sediment are demonstrated by the spring's turbidity response to blasting.

Under current conditions, interconnected voids above the permanent zone of saturation capture and transmit substantial volumes of incident precipitation and runoff that percolate from the quarry area into the marble. This water is generally turbid and may entrain additional sediment from the quarry surface and within the subsurface, such as that created through blasting, ripping, and the disturbance of overburden, as well as naturally occurring sediment deposited in subsurface voids. An average of only a few cubic feet of sediment per day could account for Liddell Spring's turbidity. Highly permeable interconnected voids have the potential to transport this water and sediment in a turbulent and cascading flow down to the zone of saturation and laterally toward Liddell Spring.

The average timing of Liddell Spring's initial and primary turbidity peak following peak storm precipitation is generally consistent with the observed time for tracers to reach the spring from groundwater beneath the quarry and the turbidity response to blasting in the quarry. Although the initial turbidity response may be ~~The~~ partially attributable to sediment mobilized by a recharge pressure pulse, the consistent rise and decline of spring turbidity, quarry-floor pond depth, and nearby stream discharge prior to peak Liddell Spring discharge indicates that sediment is introduced, or at least entrained, by runoff-related processes affecting groundwater in the quarry area. The timing of the main turbidity peaks appear too slow for sources immediately adjacent to the spring (e.g., the landslide or nearby sinkholes) and too fast for transport from the Reggiardo and Laguna creek swallow holes. This interpretation is consistent with the City's claim that turbidity peaks are larger and occur more quickly in response to precipitation since quarrying began. While other turbidity sources and delivery mechanisms likely exist, the available data and the characteristics of the local groundwater system strongly indicate that the quarry operation has an important contributing influence to spring turbidity.

The record of Liddell spring box sedimentation events (the filling of the City's spring box with sand and silt) is mostly anecdotal. Several observers documented substantial increases in spring box sedimentation for several years following 1969 when the quarry overburden was first removed. A cause-and-effect relationship between quarrying and subsequent sedimentation events is less certain. Clastic sediment that accumulates in the spring box and suspended sediment responsible for turbidity may have distinctly different sources. While spring box sedimentation appears to have resulted directly from the quarry's initial overburden removal, direct evidence attributing subsequent sedimentation with quarry activities is generally incomplete or lacking.

## 5.2 REGULATORY SETTING

### 5.2.1 County General Plan/Local Coastal Program

The County of Santa Cruz regulates project impacts to water resources through General Plan/Local Coastal Program (GP/LCP) policies. ~~Water related~~ Water-related policies applicable to the proposed project include policies on Water Resources, Maintaining Adequate Streamflows, Maintaining Surface Water Quality, Overdrafted Groundwater Basins, and Erosion. These policies are listed in Section 3.2.1.

### 5.2.2 County Mining Regulations

The County Mining Regulations sets forth standards governing mining operations. Mining Regulations 16.54.050 identifies required conditions and standards for Water and Drainage and Drainage and Erosion. Mining Regulations 16.54.055 sets forth performance standards for Surface Drainage Controls for quarry reclamation. These ~~policies~~ regulations are listed in Section 3.2.3 and 3.3.4.

### 5.2.3 California Water Code (Section 13000, et seq.)

The California Water Code establishes that the people of the state have a primary interest in the conservation, control, and utilization of the water resources of the state, and that the quality of all the waters of the state shall be protected for use and enjoyment by the people of the state. The California Water Code establishes the regulatory authority of the state over activities and factors that may affect the quality of the waters of the state. The California Water Code is intended to attain the highest water quality that is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible.

California Water Code declares that the health, safety, and welfare of the people of the state requires that there be a statewide program for the control of the quality of all the waters of the state and that the statewide program for water quality control can be most effectively administered regionally, within a framework of statewide coordination and policy.

### 5.2.4 Porter-Cologne Water Quality Control Act (Porter-Cologne)

The Porter-Cologne Water Quality Act of 1969 (Porter-Cologne) established the State Water Resources Control Board (SWRCB) and the nine RWQCBs. Each RWQCB was charged with developing, adopting and implementing a Water Quality Control Plan for each region. The RWQCB is responsible for implementing the federal Clean Water Act (CWA) at the state level.

Under Porter-Cologne, the regional boards regulate the "discharge of waste" to "waters of the state". All parties proposing to discharge waste that could affect waters of the state must file a report of waste discharge with the appropriate RWQCB. The RWQCB will then respond to the report of waste discharge by issuing waste discharge requirements (WDRs) in a public hearing, or by waiving WDRs (with or without conditions) for that proposed discharge.

Both of the terms "discharge of waste" and "waters of the state" are broadly defined in Porter-Cologne, such that discharges of waste include fill, any material resulting from human activity, or any other "discharge" that may directly or indirectly impact "waters of the state". While all "waters of the United States" that are within the borders of California are also "waters of the state", the converse is not true - "waters of the United States" is a subset of "waters of the state."

### 5.2.5 Central Coast Basin Plan

Section 13241, Division 7 of the California Water Code specifies that each RWQCB shall establish water quality objectives, which are necessary for the protection of beneficial uses and the prevention of nuisance. Water quality objectives have been adopted by the state and when applicable extended as federal water quality standards. Water quality objectives in the Central Coast Basin Plan satisfy state and federal requirements to protect beneficial uses. Water quality objectives are primarily achieved through establishment of WDRs.

The beneficial uses of the East Branch of Liddell Creek identified in the Basin Plan include municipal and domestic supply, agricultural supply, industrial services supply, groundwater recharge, water recreation, commercial and sport fishing, cold freshwater habitat, wildlife habitat, migration of aquatic organisms, and spawning. Additional beneficial uses further downstream in Liddell Creek include estuarine habitat, rare, threatened or endangered species, and freshwater replenishment. Objectives for all inland waters such as Liddell Creek include standards regarding color, taste and odor, floating material, settleable material, oil and grease, sediment, turbidity, pH, oxygen, temperature, toxicity, pesticides, chemical constituents, and organics, among others.

The Central Coast Basin Plan includes an implementation plan to achieve water quality objectives. The discharge or threatened discharge of soil, silt, or other earthen materials into any stream in the basin is a violation of Best Management Practices and in quantities deleterious to fish, wildlife, and other beneficial uses is prohibited. Relevant to the Bonny Doon Quarries, the waste discharge program addresses storm water management by implementation of Best Management Practices through the NPDES permit described below.

### 5.2.6 National Pollutant Discharge Elimination System (NPDES)

The U.S. Environmental Protection Agency (EPA) administers the National Pollutant Discharge Elimination System (NPDES) Permit Application regulations for storm water discharges under the CWA. The CWA uses the NPDES permitting program to monitor and control pollutants in industrial process wastewater, municipal sewage, and industrial storm water runoff and runoff from construction sites.

In California, NPDES permits are issued by the SWRCB through the RWQCB. To meet Storm Water Pollution Prevention requirements, the SWRCB issued a statewide NPDES General Permit for Storm Industrial Discharges. Dischargers who wish to be covered by the General Permits are required to submit a Notice of Intent (NOI) to the SWRCB and to the Program.

Submittal of the NOI signifies that the discharger intends to comply with the conditions of the General Permits. A Storm Water Pollution Prevention Plan (SWPPP) must be developed prior to submitting an NOI and implemented prior to construction for discharges from construction sites.

The Bonny Doon Limestone Quarry has a SWPPP on file with the Central Coast RWQCB and operates under NPDES General Industrial Permit No. 344S010829. The SWPPP is to be considered a working document and kept at the job site. All employees are to be aware of and follow practices described in the SWPPP.

### 5.2.7 Federal Clean Water Act

The implementation of the CWA is the responsibility of the EPA. That agency depends on other agencies such as the individual states and the U.S. Army Corps of Engineers (USACE) to assist in implementing the Act. The objective of the CWA is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters'. Sections 401 and 404 of the CWA apply to activities that would impact wetlands. Section 401 is implemented by the SWRCB/RWQCB. Section 404, which is implemented by the USACE, regulates the discharge of dredged of fill material into waters of the U.S. This can also include excavation and changes in drainage. The discharge of dredged or fill material into waters of the U.S. is prohibited except when it is in compliance with Section 404 of the Act.

The CWA, in Section 401, specifies that states must certify that any activity subject to a permit issued by a federal agency meets all state water quality standards. In California, the SWRCB and RWQCB are responsible for taking certification actions for activities subject to any permit issued by the USACE pursuant to Section 404 (or for any other USACE permit, such as permits issued pursuant to Section 10 of the Rivers and Harbors Act of 1899). Such certification actions, also known as 401 certification or water quality certification, include issuing a 401 certification that the activity subject to the federal permit complies with state water quality standards, issuing a 401 certification with conditions, denying 401 certification, or denying 401 certification without prejudice, should procedural matters preclude taking timely action on a 401 certification application.

## 5.3 PROJECT IMPACTS

The following project impact discussion and analysis applies to those portions of the Project that pertain to hydrology and hydrogeology. Those aspects include the Final Development Plan (Bowman and Williams, 2001a as shown in Figure 9), and the ~~previously approved (1997)~~ Final Drainage Plan (Bowman and Williams, 2001b as shown in Figure 10). This plan indicates drainage from the quarry pit flowing to Pond 3, which is the previously approved (Use Permit and 1997 COC) drainage pattern.

### 5.3.1 Threshold of Significance

Under the following Standards of Significance, based on Appendix G of the CEQA Guidelines, indicate that an impact would be significant if the project would:

- Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted);

- Affect the quality of groundwater supply, or alter the direction or rate of flow to groundwaters;
- Violate any water quality standards or WDRs;
- Substantially alter the existing drainage pattern of the site or area, including the alteration of the course of a stream or river in a manner that would modify the capacity or hydraulics of the stream or result in substantial erosion or siltation, on- or off-site;
- Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or off-site;
- Affect surface water quality (contaminants including silt, urban runoff, nutrient enrichment, pesticides, etc.);
- Create or contribute runoff water that would exceed the capacity of existing or planned storm water drainage systems or provide substantial additional sources of polluted runoff;
- Otherwise substantially degrade water quality;
- Place within a 100-year flood plain hazard area structures that would impede or redirect flood flows;
- Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam; or Inundation by seiche, tsunami, or mudflow;
- Affect a private or public water supply that results in any change in water quality or available water quantity;
- Result in inefficient or unnecessary water consumption;
- Change the amount of surface water in any water body.

~~The proposed project would affect the quantity and quality of water to Liddell Spring, a municipal water supply. It will not alter drainage patterns, expose people or structures to flooding, or result in unnecessary water consumption. Mitigation measures are recommended to reduce all significant impacts to a less than significant level.~~

## 5.3.2 Hydrologic Impacts

### 5.3.2.1 On-Site Drainage and Sedimentation

The expansion of the Limestone Quarry onto 17.1 acres would increase the impervious surface area in the quarry by increasing the area of exposed rock. This change would increase storm runoff volumes, a potentially significant impact. Under present drainage conditions, the existing quarry pit has no outlet for surface drainage; runoff from the Boundary Expansion Area would collect on the quarry floor and percolate into the marble aquifer. According to the previously approved Final Drainage Plan for the quarry (~~Bowman and Williams, 2001~~ RMC Lonestar, 1996), drainage from the quarry floor is to be directed to Settlement Basin 3 (Figure 10). This drainage is to be established by excavating a channel from the southern end of the quarry pit to an intake for Settlement Basin 3. CEMEX has submitted information to County Planning showing that Settlement Basin 3 has adequate capacity to accommodate the proposed expansion. However, the Geology and Hydrology Appendix (Appendix F, Section 5.5.1) notes that the existing drainage system could become overwhelmed if rainfall and runoff that currently percolate into the karst subsurface beneath the quarry area were prevented as a result of mitigation measures and/or site reclamation.

Percolation through the quarry floor has been historically adequate to remove collected runoff (and groundwater from excavated perched zones) with little ponding or the need for external drainage.  Sufficient subsurface drainage capacity would persist with expansion of the quarry into the Boundary Expansion Area; therefore runoff collected on the quarry floor under project conditions would continue to percolate without creating a drainage problem.

Subsurface drainage over areas of the quarry floor is potentially a source of turbidity and sedimentation at Liddell Spring. Runoff and sediment collected in the quarry pit migrates to groundwater and contributes to Liddell Spring flow. Turbidity and sedimentation impacts during the time that runoff is being retained within the quarry may impact the public water supply at Liddell Spring and are therefore considered to be potentially significant. Implementing the Final Drainage Plan to drain the quarry floor requires lowering the ingress/egress ramp on the south side of the quarry by about 50 feet. This grade change would require blasting of rock and excavation of a drainage channel immediately upstream from Liddell Spring. Excavation and blasting in the vicinity of Liddell Spring may increase sedimentation and turbidity at the spring, a potentially significant impact with respect to a public water supply. Turbidity impacts are further discussed in ~~Ground Water~~Groundwater Quality (Section 5.3.3.3) below.

~~Once~~Establishing drainage ~~of~~from the quarry pit to Settlement Basin 3 ~~is established,~~ may reduce Liddell Spring turbidity and sedimentation ~~impacts are likely to be reduced. At the same time,~~ impacts. However, this change in drainage also may result in decreased springflow quantities by removing water that would be percolating ~~toground water from the quarry. Spring flow quantity impacts after quarry drainage to Settlement Basin 3 is established~~to groundwater from the quarry, which may impact a public water supply at Liddell ~~Spring and are therefore~~ Spring, and thus constitute a potentially significant impact. The potential water quantity impacts are further discussed in ~~Ground Water~~Groundwater Quantity (Section 5.3.3.2 below). As presented below in Section 5.4, the Final EIR recommends modifying the existing approved drainage plan so as to maintain internal, subsurface drainage within the quarry area.

**5.3.2.2 Off-Site Drainage and Sedimentation**

The combined flow of Plant Spring and Liddell Spring is about 1800 acre-feet per year. The continued diversion by CEMEX of a maximum of approximately 21 gpm during the dry season (~~34~~ 13 acre-feet/year) from Plant Spring for use in quarry operations represents a relatively minor loss (~~2~~ 0.7 percent) of downstream flow and is not considered significant. In contrast, ~~the~~ average diversions by the City of Santa Cruz of 1250 acre-feet per year from Liddell Spring represents 69% of the combined springflow.

Mining of the Boundary Expansion Area would continue the existing impact of sediment from quarry activity entering Liddell Spring through percolating runoff (described above). By increasing the sediment entering Liddell Spring, the mining expansion project could indirectly increase the sediment loads discharged from the spring to downstream drainages of Liddell Creek. This impact would affect downstream water quality and increase siltation in the stream channel, a potentially significant impact. Mitigation Measure HYD-1 would reduce sedimentation impacts and protect the water quality of Liddell Spring and downstream drainages of Liddell Creek. With this measure, the project impacts to ~~off site~~ off-site drainages are less than significant.

### 5.3.3 Hydrogeologic Impacts

This section addresses the potential impacts of the proposed quarry expansion on the quantity and quality of groundwater feeding Liddell Spring. The analysis of these potential impacts has been complicated by uncertainties inherent in the complex karst hydrogeology. Furthermore, there has been a considerable difference of opinion expressed in the numerous technical studies performed to date, as well as in comments by County staff and others.

A recent study by PELA (2005) concluded that the proposed quarry expansion would have an insignificant effect on Liddell Spring because (a) the spring's primary groundwater and sediment sources lie beyond the immediate area of the quarry and (b) the quarry operation is conducted in the unsaturated zone, which has poor hydraulic connectivity to the saturated zone.

As discussed above and in the Geology and Hydrology Technical Appendix (Appendix F), several lines of evidence indicate that there is good hydraulic connectivity between the shallow and deep karst zones in the quarry area. Furthermore, the quarry operation presents a substantial source of groundwater recharge and sediment for the local groundwater system. The potential impact of ~~expanded~~existing quarry operations on groundwater quality and quantity can be expected to continue or increase with the creation of additional quarry floor within 20 feet of groundwater.

#### 5.3.3.1 Intercepted ~~Ground Water~~Groundwater

#### ~~Ground Water~~Groundwater Separation from Quarry Floor

The Santa Cruz County Code defines an aquifer as a saturated permeable geologic unit that can transmit significant quantities of groundwater under ordinary hydraulic gradients (Section 16.54.020). County mining regulations stipulate that the lowest elevation of any mining operation at any time shall be 20 feet above the peak groundwater elevation unless the Planning Commission determines that a lower or higher elevation will ultimately benefit recharge of the aquifer (Section 16.54.050).

Relatively little data exist for characterizing groundwater elevations beneath the quarry floor and the proposed Boundary Expansion Area. Among recently monitored wells, water levels in the proposed Boundary Expansion Area are generally below 750 ft msl, although some former wells now destroyed by quarrying had water levels exceeding 750 ft msl (Figure 31, Maximum Recorded ~~Ground Water~~Groundwater Surface Elevations). These higher water levels may have represented perched zones; alternatively, peak groundwater levels may have been lowered by enhanced drainage resulting from the subsequent quarrying.

Because of the difficulty in pre-determining peak groundwater elevations, given the complex hydrogeology of the quarry area, CEMEX proposes drilling shallow borings as the pit is lowered to test the depth to groundwater. If groundwater is encountered in a borehole, CEMEX proposes to pump groundwater from the boring for 12 to 24 hours. A sustained yield of 50 gpm or more would suggest that the encountered zone is part of the "marble aquifer" (see RMC Lonestar, August 1999).

The drawback of this approach is that the minimum depth to groundwater would not be known without additional, longer term monitoring. Groundwater levels fluctuate seasonally and year-to-year based on the amount of precipitation. Without long term monitoring, the maximum groundwater levels are not known with certainty and unless the groundwater test proposed by CEMEX is conducted during a wet period of a wet year, it may not determine maximum groundwater elevation. Other researchers have described groundwater levels fluctuating as much as 63 feet in 20 days, and water level records (hydrographs) presented in previous reports have exhibited large fluctuations in groundwater level, often with no obvious explanation (see Sections 4.2.3, 4.2.4, and 4.2.5, Appendix F, Geology and Hydrology Technical Appendix). In some cases these fluctuations may reflect the sudden draining of a perched zone and simultaneous filling of an underlying zone.

**Perched ~~Ground Water~~Groundwater Zones**

Substantial zones of perched groundwater may be drained by quarrying down to 750 feet msl, as evidenced by several wells with maximum water levels ranging from 800 to more than 1,000 ft msl in and around the proposed Boundary Expansion Area (Figure 31). For example, one well (Appendix F, Geology and Hydrology Technical Appendix) beyond the northeast corner of the Boundary Expansion Area had a maximum water level of 996 ft msl during the recent PELA study and was described to have "a significant connection to the marble aquifer."

The Santa Cruz County Code (Section 16.54.050) stipulating a 20-foot separation of mining elevation from peak groundwater elevation has not been typically applied to perched zones. In the case of the proposed Boundary Expansion Area, the groundwater surface is not well defined; there is little documentation of peak groundwater elevations during periods of above-average precipitation; and quarrying may remove a considerable volume of perched zone (some of which may tap into the upstream regional aquifer and/or other sources of recharge). Perched zones also may represent pockets of water remaining after deeper zones fill and overflow during wet periods. Voids at or above the water table may fill and empty several times during the rainy season, increasing their volumetric significance within the overall karst system. If these perched zones do function as temporary storage sites for groundwater entering the deeper karst aquifer, removing them may result in increased seepage into the pit from the unsaturated zone. To the extent that the quarry pit remains a closed depression with no external drainage, most of this water would eventually percolate into the aquifer. ~~When~~ Under the quarry's currently approved reclamation plan, the quarry ~~is drained~~ would drain to Settlement Basin 3, and any water flowing into the quarry from breached~~ground~~ groundwater conduits would be channeled out of the Liddell Spring drainage area.

Exposing perched zones, mining to within 20 feet or less of maximum groundwater elevations, and flushing additional water through the quarry floor would potentially impact water quality and cause turbidity at Liddell Spring by exposing groundwater to surface contamination and introducing additional natural and quarry-generated sediment into groundwater. This opportunity for contamination of the water would affect both surface and groundwater quality downstream and is therefore a potentially significant impact according to the thresholds of significance. Draining the quarry to Settlement Basin 3, as envisioned by the Final Drainage Plan (Figure 10), would lessen the potential water quality impact at Liddell Spring, but this plan would also increase the potential for the quarry to affect flow quantities at the spring.

If quarrying were to expose a significant, saturated karst water source, PELA (2005) recommended plugging, capping, or covering it, and surrounding it with a 50-foot buffer from further quarrying. The feasibility and efficacy of such measures within the active quarry is uncertain.

The water level data for the quarry area indicates the potential for large, relatively rapid fluctuations in water level. The quarterly water level monitoring proposed by CEMEX for the Boundary Expansion Area is inadequate to closely monitor the fluctuating water levels. Improved groundwater level monitoring is needed in areas proposed for new and ongoing quarrying (e.g. the northeast corner of the Boundary Expansion Area) to prevent mining from intercepting the groundwater table. More surveyed locations and a longer period of record are needed in order to determine a minimum mining surface at least 20 feet above maximum groundwater levels. The three new wells proposed for water level monitoring by CEMEX should be augmented with at least ~~one~~two additional wells drilled to coincide with the planned northeast ~~corner~~and northwest corners of the floor of the Boundary Expansion Area (approximate California Coordinate System coordinates N198000~~N1,519,3500 E198,000,~~ E1519350 and N198000 E1519000), per the Final Development Plan, (Figure 9). Continuously reading water level data loggers should be installed in all wells selected for water level monitoring. The data loggers should be programmed to record water levels at least ~~twice daily.~~ hourly. The monitoring at these wells should continue through the mining period, or at least until water levels during ~~consecutive significantly~~ two years of average or higher than average rainfall seasons are recorded. This mitigation is specified in Measure HYD-2. The improved monitoring will help ensure that mining complies with County mining regulations stipulating that the lowest elevation of any mining operation at any time shall be 20 feet above the peak groundwater elevation unless the Planning Commission determines that a lower or higher elevation will ultimately benefit recharge of the aquifer (Mining Regulations 16.54.050(3)(iii)).

#### 5.3.3.2 Groundwater Levels

Relatively shallow wells immediately upgradient of the quarry lie within a complex transition zone between 1) the shallow sandstone aquifer that occurs across much of the upgradient Bonny Doon area to the north and 2) the predominantly karst groundwater aquifer that encompasses the quarry and discharges to Liddell Spring. The configuration of the shallow groundwater system north of the quarry is fairly consistent until nearly approaching the quarry pit. Shallow groundwater encounters the marble aquifer immediately upstream of the quarry. The marble aquifer's highly permeable karst features cause the groundwater level to drop 300 feet in elevation over a relatively short distance. Because the deeper karst groundwater aquifer is separated from the shallow sandstone aquifer by this transition zone, the proposed quarrying of marble would not be expected to effect groundwater levels, or relatively shallow wells, in the sandstone aquifer upgradient of the quarry because quarrying would not take place in the sandstone aquifer.

#### ~~5.3.3.2 Ground Water~~5.3.3.3 Groundwater Quantity

Historic groundwater levels are at or above the proposed depth of mining along the northern side of the Boundary Expansion Area (Cross Sections A-A' and D-D', Plates 3 and 4 of the Geology and Hydrology Technical Appendix, Appendix F). Several major fracture zones intersect the proposed Boundary Expansion Area and these fractures may be associated with important groundwater pathways to Liddell Spring. Therefore, there is some potential for mining to intercept groundwater flowing to Liddell Spring. As long as the quarry is a closed basin, most of any intercepted groundwater eventually percolates into the aquifer from the quarry floor. Consequently, potential impacts on the quantity of groundwater reaching the spring under the existing drainage conditions are considered to be less than significant.

~~Upon implementation~~Implementation of the previously approved Final Drainage Plan (July ~~1997), water draining to~~1997) would drain the quarry ~~floor will be diverted~~area to Settlement Basin 3. Surfacing groundwater in the quarry would be diverted out of the drainage area for Liddell Spring, possibly resulting in a potentially adverse impact on springflow quantities. Mining of the proposed 17.1 acre Boundary Expansion Area would increase the amount of water captured in the quarry floor and diverted to Settlement Basin 3 upon implementation of the previously approved drainage plan. Any change in groundwater recharge is considered a potentially significant impact according to the thresholds of significance.

Quarrying of the Boundary Expansion Area could also result in some increase in groundwater recharge. Overburden removal and exposure of fractured marble may allow for more rapid percolation in places where runoff concentrated in drainage ditches along roads or benches encounters open fractures or fissures. This potential increase in recharge would diminish as the final quarry benches and floor become covered in stockpiled overburden as part of reclamation. The potential increase in recharge is not expected to counterbalance potential impacts on recharge quantities due to draining of the quarry to Settlement Basin 3.

The project impact upon groundwater quantity can be mitigated by modifying the Final Drainage Plan to retain surface drainage on the quarry floor and allow percolation for groundwater recharge to Liddell Spring. This mitigation is specified in Measure HYD-1 and reduces the project impact on groundwater quantities to less than significant.

### ~~Ground Water~~5.3.3.4 Groundwater Quality

#### Nitrate

The existing quarry may have some ongoing influence on the concentration of nitrate and total dissolved minerals in groundwater. However, substantial increases in the concentration of these compounds have not been clearly documented over time, and other sources appear to contribute as much or more than the quarry. Concentrations of nitrate and other dissolved minerals in Liddell Spring discharge are not exhibiting definite and/or significant upward trends. There is insufficient evidence to conclude that quarrying of the proposed Boundary Expansion Area would significantly worsen groundwater nitrate and total dissolved minerals. Therefore, nitrate impacts are considered to be less than significant.

#### Turbidity

The analysis presented in the Geology and Hydrology Technical Appendix (Appendix F), summarized above, indicates that Liddell Spring's primary turbidity response to storm events is related to runoff capture and percolation at the quarry. Additionally, smaller turbidity events are related to quarry blasting (PELA, 2005). Turbidity also results from runoff capture by stream swallow holes and sinkholes, and mobilization of subsurface sediment ~~during~~ as a result of recharge pressure pulses and periods of peak groundwater flow.

The hydrogeologic conceptual model and water balance estimates indicate that the quarry watershed contributes ~~up to 13 percent~~ about one-fifth of the 1,500 ac-ft/year flow from Liddell Spring (about ~~200~~300 ac-ft/yr). However, the proposed Boundary Expansion Area's contribution to overall turbidity at Liddell Spring depends not only on how much water it is or would be contributing to springflow, but how much sediment is entrained within that contribution. There are abundant sediment sources associated with the existing quarry and the proposed quarry expansion. Given the estimate that several cubic feet of sediment per day may account for all the turbidity observed at Liddell Spring, it is Nolan Associates' opinion that as much as half of Liddell Spring's overall turbidity may be directly or indirectly attributable to quarry operations.

Considerable interconnectivity exists between ~~precipitation, runoff,~~ water and sediment collected in the quarry, groundwater flow, and Liddell Spring discharge and turbidity, based on the following observations:

- Overburden removal prior to the inception of mining at the quarry resulted in elevated turbidity at Liddell Spring ((Earth Science Associates and Creegan and D'Angelo, May 1979; Geology and Hydrology Technical Appendix, Section 4.6.2, Appendix F).
- The removal of the overburden and mining of the marble reduces recharge filtering and exposes fractures and dissolution channels connected to the aquifer. Highly permeable, interconnected voids have the potential to transport water and entrained sediment from the quarry in a turbulent and cascading flow down to the zone of saturation, and then laterally toward Liddell Spring, resulting in spring turbidity (Geology and Hydrology Technical Appendix (Appendix F), Section 4.4.4).

- Observed quarry ponding and drainage into the subsurface zone, along with estimates of overall quarry recharge, indicate that the quarry represents a substantial source of groundwater recharge during and following storm events relative to other sources (Geology and Hydrology Technical Appendix (Appendix F), Section 3.2).
- The timing and nature of Liddell Spring's response to precipitation, relative to a) the timing of runoff collected in the bottom of the ~~quarry, and b) ground water~~ quarry and b) groundwater travel times from the quarry to the spring, indicate that runoff captured by—and percolated into—the quarry pit, along with sediment generated by quarrying, substantially contribute to turbidity at the spring. (Geology and Hydrology Technical Appendix (Appendix F), Section 4.6.6).
- Spring box sedimentation likely resulted from the quarry's initial overburden removal (Geology and Hydrology Technical Appendix (Appendix F), Section 4.6.7).
- ~~The~~ Much of the bulk of the sediment needed to account for Liddell Spring's turbidity (roughly several cubic feet per day, on average) could conceivably be generated by quarry operations, including blasting, ripping, and the disturbance of overburden (Geology and Hydrology Technical Appendix (Appendix F), Section 4.3.6).
- Quarry blasting appears to mobilize and possibly generate subsurface sediment that contributes to springflow turbidity, both as an immediate response to blasting and potentially during subsequent storm events (PELA, 2005).

Based on the above observations, the proposed quarry expansion could potentially have a significant impact on turbidity at Liddell Spring. The proposed expansion therefore has the potential to impact the City of Santa Cruz's water supply by affecting water quality at the spring. These impacts include: reduced production and increased operational costs as a result of halting diversions during periods of elevated turbidity and spring box sedimentation; increased reliance on other sources of water at such times, including the use of water intended for drought use; operational costs and lost production from purging pipelines and treating more highly turbid water at the Graham Hill Treatment Plant; and increased exposure to surface contamination in the event that groundwater temporarily surfaces in mined areas. Based on the thresholds of significance given at the beginning of this section, any impact on a public water supply is considered a significant impact.

The component of the total turbidity at the spring contributed by the quarry operation cannot be quantified. However, there is no evidence that turbidity caused by the quarry has resulted in any increase in frequency or length of turnouts (halting diversions) or any actual loss of water to the City Water Department as a result of elevated turbidity or spring box sedimentation (Appendix I). On the contrary, spring improvements resulting from the permit process have allowed more efficient management of this water source to maximize production, which would reduce reliance on water from other sources (Appendix H). The available data provide no evidence of any impact from quarry operations on North Coast irrigation services served directly from the North Coast Main or the pumps and valves in route from the Main to the Graham Hill Water Treatment Plant. The available data indicate that any impact on the City water supply source at Liddell Spring as a result of quarry operations is limited to potential increased treatment cost associated with an unknown, but likely very small, increment of poorer quality water. Even this conclusion appears to be of little importance, however, because there has been no loss of production and all of the water produced from Liddell Spring can be treated at the City's Graham Hill Water Treatment Plant. Any incremental increase in treatment costs attributable to poorer quality water from Liddell Spring has not been quantified.

While the impact of the existing quarry operation on the City of Santa Cruz water supply appears to be of little importance, the available data indicate that the quarry does contribute a component of the total turbidity at Liddell Spring. Continuation of the same mining operation in the expansion area is not expected to change this conclusion. As an expansion of mining operations there are aspects of the proposed project where additional measures could be incorporated to reduce the component of Liddell Spring turbidity contributed by the expanded quarry operation. There are reasonable, targeted measures that can be implemented to reduce and avoid impacts on spring water quality. Measures HYD-1 and HYD-~~3~~2 would reduce or avoid water quality impacts on Liddell Spring from increased turbidity during quarry operations and following closure and reclamation.

Records of pre-quarry turbidity at Liddell Spring are insufficient to define pre-quarry water quality with respect to turbidity. Other than a visible increase in turbidity during and shortly following the removal of overburden at the inception of quarrying (roughly the period of 1970 to 1976), no increase in overall turbidity at Liddell Spring relative to the pre-quarry conditions can be demonstrated with the available data. Consequently, the impact of the quarry operation with respect to turbidity cannot be quantified. However, the 1964 agreement between the City of Santa Cruz and the quarry operator provides mutually agreed-upon standards for judging turbidity increases. That document states that turbidity shall not exceed 0.5 NTU except for a period of 48 hours following a rainstorm, at which time it may range up to 2.0 NTU. For water exceeding these turbidity levels, the agreement requires some form of mitigation or compensation to the City.

We have analyzed turbidity data for water years 2005, 2006, and 2007 for adherence to these criteria using the 15-minute interval turbidity, rainfall, and discharge data provided by the SCCWD. Appendix H provides annual volumes of discharge from Liddell Spring, diverted by the City, that exceed the 1964 agreement turbidity standards.

Existing turbidity in Liddell Spring discharge, whether naturally occurring or due to quarry operations is presently being mitigated by the City with their own treatment system, without any demonstrated loss of production. We therefore recommend that potential impacts of the quarry operation on turbidity at Liddell Spring be mitigated by requiring the quarry operator to reimburse the City of Santa Cruz for the reasonably determined cost of treating water exceeding the standards proposed by the 1964 agreement. Measure HYD-3 would reduce water quality impacts on the City Water Department based on mutually agreed water quality standards, and a predetermined compensation formula. These measures reduce the water quality impact on Liddell Spring and the City Water Department to a less than significant level.

**5.3.3.5 Impact on ~~Spring Flow~~Springflow Production**

Springflow production from Liddell Spring could be impacted by an outright decrease in flow from the spring or by an increase in turbidity and sedimentation. An increase in the turbidity or sedimentation at Liddell Spring has the potential to impact the City of Santa Cruz's water supply in several ways: reduced production and increased operational costs as a result of halting diversions during periods of elevated turbidity and spring box sedimentation; increased reliance on other sources of water at such times, including the use of water from Loch Lomond ordinarily reserved for use during droughts; and operational costs and lost production from purging the North Coast pipeline and treating more highly turbid water at the Graham Hill treatment plant. A quantitative estimate of the potential impacts to production, based on production records before and after quarrying began, is hindered by changes in the City's diversion procedures and ability to convey and treat turbid water. The City has not provided estimates of the potential impact of elevated turbidity on its production levels or operational costs. In any event, the diversion record does not reflect a decline in production.

The initial removal of overburden from the proposed Boundary Expansion Area may impact the City's spring diversion over a several-year period as a result of sedimentation events (the filling of the Liddell spring box with sediment), based on what reportedly occurred during the early 1970s. Because the proposed Boundary Expansion Area is smaller than the original quarry operation and there are now more effective standards and oversight regarding grading, erosion control, and runoff containment than were in effect during the initial quarry development, any impacts from developing the Boundary Expansion Area are expected to be less than those associated with the original quarry. Indeed, overburden from approximately 50 percent of the current area of the quarry pit, was removed since the late 1970's with no apparent repeat of the impacts seen in the early 1970's. Nevertheless, potentially significant impacts due to sedimentation are anticipated based on thresholds of significance identified at the beginning of this section. Since sedimentation may impact the public water supply at Liddell Spring and may impact water quality downstream, sedimentation is considered a significant impact. The potential production losses and costs associated with such events have not been estimated.

Mining the proposed Boundary Expansion Area has the potential to impact flow volumes at Liddell Spring. Removal of overburden and quarrying would expose large areas of relatively ~~low permeability~~ low-permeability rock, with the likely result of increasing runoff. The quarry is estimated to contribute as much as ~~200~~300 ac-ft/yr of groundwater recharge to the 1,500 ac-ft/yr flow at Liddell Spring. In addition, mining may encounter groundwater sources, either perched or part of the deeper groundwater flow system, allowing them to drain into the quarry. If the quarry is provided with an external ~~drain,~~ surface drainage outlet, the runoff and any intercepted groundwater may be drained from the quarry, decreasing recharge available to Liddell Spring. Any impact on water quantity available for diversion at Liddell Spring is considered a potentially significant impact.

In the event that quarrying impacts the flow to Liddell Spring, PELA recommended implementing one or more of the following four mitigation measures:

1. Supplement the City's water supply with a diversion from Plant Spring.
2. Construct a detention basin within the quarry to temporarily contain any groundwater intercepted by quarrying, and divert this water to the City's intake at Liddell Spring.
3. Construct production wells that intercept karst conduits feeding Liddell Spring in the area between the quarry and the spring's recharge areas, and convey the pumped groundwater to the City's existing spring intake.
4. Prevent Reggiardo and Laguna creek streamflows from recharging the karst, and instead pipe this water to the City's Liddell Spring intake.
5. Provide the City with a water treatment facility capable of mitigating increased Liddell Spring turbidity as a result of quarrying.

There are limitations associated with each of these recommendations. Plant Spring discharges at an approximate average rate of 180 gpm, of which the quarry diverts about 20 gpm. The remaining flow equals about one-fifth of the City's average annual diversion from Liddell Spring, and as such could only partially mitigate lost production as a result of quarrying. Furthermore, the partial transfer of Plant Spring water rights to the City would need to be addressed, along with potential impacts to downstream habitat as a result of diminished flows. The quarry's development of an alternative water supply to replace any reduced use of Plant Spring could have additional, separate impacts on Liddell Spring.

Constructing a detention basin in the quarry for intercepted groundwater would essentially substitute a "new" surface water source for a springflow source, and thus involve issues related to sustainability, exposure to surface contamination, and changes in water rights.

New production wells that successfully intercept significant karst conduits may be very difficult to locate and construct. The sediment load in these conduits might cause excessive wear on the wells' pumps. In light of California's water laws, there may be some inequity in exchanging a right to divert springflow for a right to pump groundwater from a well.

Diverting Reggiardo and Laguna creek stream flows would also be a substitution of surface water for springflow. It would also result in reduced water-supply storage. Springflow yields are more sustainable during the dry season and droughts, and are generally of better quality. If this measure were implemented, it would seem more reasonable to convey these flows to the City's downstream diversions on Reggiardo and Laguna ~~Creeks~~creeks rather than its Liddell Spring intake.

Providing the water treatment facility for Liddell Spring could effectively address water quality impacts, ~~but would not address any water quantity impacts.~~ however, all of the water produced from Liddell Spring can be treated at the City's Graham Hill Water Treatment Plant. Liddell Spring historically has been the most pure, low maintenance, and dependable City of Santa Cruz drinking water source in both drought and extreme winter weather (City Water Department comment letter on the Draft EIR). Therefore, providing a water treatment facility for Liddell Spring would not be required.

The quantity and quality of established municipal water supplies are managed very conservatively in California. Any impact on water quality or quantity for a public water supply is considered to be a significant impact. As such, there is reasonable uncertainty whether the City of Santa Cruz would find any of the above measures acceptable, or logical. In any event, potentially significant impacts to water production from Liddell Spring may~~be~~ occur even with implementation of Measure HYD-1 and HYD-2, given the interconnectivity and complexity of the karst groundwater system, the unavoidable generation of sediment by quarry operations, and the capture of significant precipitation and runoff within mined areas. These production impacts would occur as a result of halting diversions during periods of elevated turbidity attributable to quarry operations. Based on the discussion in this section and in Section 5.3.3.4 any impact on spring flow production from quarry operations cannot be quantified, but the diversion record does not reflect a decline in production. On the contrary, spring improvements resulting from the permit process have allowed more efficient management of this water source to maximize production, which would reduce reliance on water from other sources (Appendix H). Continuation of the same mining operation in the expansion area is not expected to change this conclusion. ~~A suitable package of relatively indirect or direct mitigation measures (e.g., treatment, water supply replacement) would require negotiation between CEMEX and the City. Measure HYD-3 requires that CEMEX enter into an agreement with the City of Santa Cruz regarding water treatment of Liddell Spring.~~

Despite the lack of evidence for decline in production quarry operations contribute some portion of the total turbidity at Liddell Spring. The component of the total turbidity at the spring contributed by the quarry operation cannot be quantified. Measure HYD-3 would reduce water quality impacts on the City Water Department based on a presumption that the quarry operation is responsible for a predetermined portion of spring turbidity and a compensation formula based on current treatment costs. Measure HYD 3, along with measures HYD 1 and HYD-2, would reduce the water quality and quantity impacts on Liddell Spring and the City Water Department to a less than significant level. ~~This measure would reduce the water quality impact on the spring to a less than significant level.~~

### 5.3.3.6~~5.3.3.5~~ Water Quality Impacts ~~Vs~~. vs. Water Quantity Impacts

As may be seen from the foregoing discussions, there is a trade-off between potential water quality impacts and water quantity impacts that is mediated by the type of drainage scheme instituted for the proposed Boundary Expansion Area. The mining of the proposed Boundary Expansion Area is expected to generate increased runoff and sediment that would result in turbidity and entrained sediment in the runoff. To the extent that runoff is detained within the quarry pit, these impacts are likely to lead to increased turbidity and sedimentation at Liddell Spring. If the quarry pit is breached and external drainage is established to downstream settlement basins, the impact may result in a decrease in recharge to Liddell Spring.

Therefore, although it has been concluded that the proposed Boundary Expansion Area mining would have impacts related to water quality and water quantity, the precise nature of those impacts is, to some extent, a function of the proposed quarry drainage scheme. For this reason, Measure HYD-1 identifies recommendations for developing an alternate drainage scheme so as to reduce impacts of mining the Boundary Expansion Area related to both water quality and water quantity. As specified in Measure HYD-1, in addition to drainage provisions to reduce erosion and runoff during removal of overburden in the Boundary Expansion Area, overburden and spoils would initially be placed in the western portion of the quarry pit to a depth of approximately 15 feet and then extended eastward across in phases. As mining proceeds and pushes the east face of the quarry pit further eastward, the placement of overburden and spoils would also move eastward until the entire quarry floor area has been filled. When feasible, runoff from the Boundary Expansion Area would be collected in pipes and/or lined ditches and conducted to the filtration system constructed in the quarry bottom. In addition to reducing the potential impacts of the quarry expansion on Liddell Spring, this mitigation would eliminate or reduce the need for blasting a drainage channel from the quarry pit to Settlement Basin 3, as currently authorized by the previously approved drainage plan. This measure would thus further avoid or reduce ground-disturbing activities in close proximity to the spring. When incorporated into the Final Drainage Plan, these recommendations would also help restore pre-quarry hydrologic and hydrogeologic conditions over time.

The revegetation plan specified in the 1996 Reclamation Plan Amendment would establish early successional scrub/mixed evergreen forest in the mine pit upon closure. The modification to the drainage plan allowing retention of water on the quarry floor would potentially create wet conditions during winter months. Therefore, the modified revegetation plan would include species that can tolerate wet conditions for areas on the quarry floor receiving additional retention due to the modified drainage plan.

### 5.3.4 Cumulative Impacts

Cumulative hydrology and water quality impacts of the Bonny Doon Quarries Expansion Project are defined as the project impacts plus other activities occurring within the regional watershed that have a combined ~~affect~~effect on water resources.

The proposed expansion of the Limestone Quarry expansion would potentially affect the quality of surface waters in the Liddell Creek watershed by increasing sediment to Liddell Creek either through discharges from Settlement Basin 3 or through Liddell Spring. Liddell Creek is also impacted by sediment from other adjacent land uses such as adjacent agriculture. Except for future mining in the 9.4 acres remaining within the Legal Mining Limit of the quarry, there are no new projects in the Bonny Doon Planning Area identified by the County that would directly contribute to or overlap with water quality project impacts to downstream sections of Liddell Creek (see Cumulative Impacts, Section 11.4). Future mining in the remaining 9.4-acre area would bring the mining operations closer to Liddell Spring and could result in increased water quality and water quantity impacts on the ~~Spring.~~ spring.

Liddell Spring is one of four North Coast sources of water supply source for the City of Santa Cruz. The North Coast waters have excellent water quality and low production costs and are therefore used by the City to the greatest extent possible. North Coast sources combine to provide 32 percent of the City's total annual water production (City of Santa Cruz Water Department, 2005). The City of Santa Cruz is undertaking a Section 10(a) Permit and Habitat Conservation Plan (HCP) with the USFWS and NOAA Fisheries regarding impacts to listed and other sensitive species from the City's surface water diversion activities on the coastal streams. The conservation measures identified in the HCP may place limitations on the quantity of water that may be diverted from Liddell Spring or the other North Coast sources and could adversely impact the City's existing water supply.

Project impacts to production levels of Liddell Spring are identified in Section 5.3.3.2 5.3.3.3 and 5.3.3.5 above. This Bonny Doon Limestone Quarry Boundary Expansion Project could add to other possible losses of water supply the City may be facing from the pending HCP and Section 10(a) Permit. Any loss of production to a municipal water supply is considered a significant impact based on the thresholds identified in Section 5.3.1. Implementation of Measures HYD-1, HYD-2, and HYD-3 would protect the quantity and quality of Liddell Spring waters and mitigate the cumulative effects of the project to a less than significant level.

## 5.4 MITIGATION MEASURES

The following measures would reduce the hydrology, water quantity, and water quality impacts of the mining expansion project to a less than significant level.

***IMPACT:*** *Stripping of overburden material and mining the Boundary Expansion Area would result in an increase in turbidity and sedimentation at Liddell Spring. Any increase in turbidity and sediment load in the flow at Liddell Spring would also increase sedimentation and turbidity in downstream drainages. Implementation of the previously approved Final Drainage Plan would divert Boundary Expansion Area runoff from percolating through the quarry floor and reduce groundwater flow to Liddell Spring. Mining in the Boundary Expansion Area may also intercept perched groundwater zones, potentially affecting water quantity or quality at Liddell Spring. Liddell Spring is a municipal water source for the City of Santa Cruz. The Project would cause water quality or water quantity impacts to Liddell Spring resulting in the loss of water production levels for the City of Santa Cruz. Any loss of water production is a significant impact.*

**Measure HYD-1:** CEMEX shall prepare an engineered drainage plan for use during removal of overburden and mining of the Boundary Expansion Area. This plan shall be integrated with the Final Drainage Plan for the quarry. The plan shall specify disposal of no more than 4.6 million cubic yards of quarry overburden and spoils across the entire floor of the quarry pitasa filter for percolating surface water (rather than only the western half as proposed (see Figure 9).proposed) and construction of a filter for percolating surface water. Overburden and spoils shall be placed in the western portion of the quarry pit to a depth of approximately 15 feet and extend eastward across the quarry floor as mining proceeds. The entire quarry floor area shall be filled with overburden and spoils to a depth of approximately 15 feet. A detailed design shall be developed by CEMEX for approval by County Planning. The design shall be peer reviewed by the County Planning Department prior to public hearing of the project proposal. Appendix G is an engineering feasibility study for the proposed quarry bottom filter. The following basic design features shall be considered and addressed:

1. A revised drainage plan shall be prepared that will supersede the 1996 Drainage Plan (Use Permit No. 3236-U). The intent of the redesigned drainage plan is to retain surface water in the quarry pit for groundwater recharge and sediment removal.
2. An engineered graded filter bed or other sediment barrier shall be placed beneath any overburden and spoil material placed within the quarry pit to prevent sediment from reaching collapsing into the karst aquifer through fractures and other pathways. The A filter shall be designed to resist infiltration of sediment, piping, or collapseremove suspended sediment from quarry runoff and to percolate the runoff into the underlying fissures or karst conduits, but to allow ponded water to percolateaquifer. Appendix G contains preliminary design recommendations for filter construction. This provision can shall be combined with sloping of the working floor of the quarry towards the filter-lined

portion of the quarry floor and /or capture of runoff in closed pipe or lined ditches to carry runoff directly to the filter and to prevent ponding in areas with no filter. ~~The filter shall extend up the sides of the quarry to provide containment for the ponded water.~~ Ponding of water above a specified design depth shall be prevented by pumping or by providing external drainage from the quarry. (Note: this measure will be necessary regardless of the design of overburden and spoil disposal. ~~The barrier will also reduce the amount of sediment currently reaching Liddell Spring thereby complying with the intent of previous approvals to minimize water quality impacts to Liddell Spring).~~

3. ~~The fill shall be designed to retain and slowly infiltrate drainage from the quarry pit into the karst aquifer. The permeability of the overburden and spoils cover shall be evaluated during placement. If the permeability of the cover is insufficient to permit percolation of surface waters into the aquifer, local placement of higher permeability cover should be instituted, combined with grading of surface contours to achieve flow towards the higher permeability zones.~~ The filter and associated settlement ponds shall be designed to minimize water depths, and settlement pond depths shall be minimized to avoid retaining standing water except for short periods following rainstorms. The filter and ponds shall be regularly maintained during operation of the quarry.
4. ~~Retention pond depths at the end of quarrying shall not be more than several feet deep to avoid detaining water year-round.~~ After the end of active quarrying, an overflow pipe or pumping system shall be constructed to direct any overflow of the filter system to settlement basins. Alternatively, if monitoring of the filter system for a period of five years following cessation of mining indicates that it has the capacity to recharge expected runoff without further maintenance, an overflow spillway system will not be required. Should it be required, development of the spillway shall include design and construction of a fail-safe drainage system in the crusher area to prevent any runoff from flowing down slopes above Liddell Spring or onto the Liddell Spring landslide, during quarrying or after quarry closure. The drainage system shall be designed so that plugging of ditches or inlets for the settlement basins does not result in water being diverted towards the spring.

~~5.An overflow spillway shall be constructed to direct any unretained drainage to settlement basins. Development of the spillway shall include design and construction of a fail-safe drainage system in the crusher area to prevent any runoff from flowing down slopes above Liddell Spring or onto the Liddell Spring landslide, during quarrying or after quarry closure. The drainage system shall be designed so that plugging of ditches or inlets for the settlement basins does not result in water being diverted towards the spring.~~

5. Drainage provisions shall be developed to reduce erosion and runoff during removal of overburden in the Boundary Expansion Area. Drainage ~~during removal of overburden~~design shall ~~include provisions to~~incorporate the following elements: ~~a) capture or divert runoff flowing towards the quarry from uplandareas; b) stage the overburden removal during the dry season to allow drainage provisions to be instituted in working areas prior to the onset of winterrains; c) use movable plastic membranes to form temporary lined drains along inactive benches or where runoff may be intercepted by open fissures; d) develop temporary down drains at regular intervals along the benches to convey runoff to the quarry floor; and e) identify any prominent fissures or sinks exposed within the quarry as mining progresses and install drainage provisions to prevent runoff from entering the fissures. Benches shall be contoured for positive drainage. Runoff in disturbed areas shall be directed away from surface drainages leading to~~

~~Liddell Spring as well as any subsurface drains such as sinkholes and open fractures. Sinkholes, fractures, and dissolution cavities shall be identified, mapped, and maintained in such a way as to prevent any precipitation or runoff capture.~~

a. Capture or divert runoff flowing towards the quarry from upland areas. This measure shall take the form of a cut-off ditch around the perimeter of the working area, to prevent runoff from adjacent uplands from adding to direct runoff from the Boundary Expansion Area. Runoff from upland areas shall be collected and dispersed away from the quarry.

b. Stage the overburden removal during the dry season to allow drainage provisions to be instituted in working areas prior to the onset of winter rains. No overburden stripping shall take place between October 15 and April 15 of any year. A representative of County of Santa Cruz Planning Department shall inspect and approve all erosion control measures prior to October 15 each year.

c. Temporary berms shall be constructed at the contact between overburden and any exposed marble to prevent runoff carrying sediment from flowing across exposed marble. These berms shall be in place from October 15 to April 15 each year. Runoff from these areas shall be collected and carried by pipe and/or lined impermeable ditch to the filtration system constructed in the quarry bottom.

d. All areas of exposed marble shall be positively sloped to flow to runoff collection points. Benches shall be cut with inboard collection ditches that are sloped to runoff collection points. Infiltration of runoff in the ditches shall be prevented by impermeable linings where open fractures exist. On working benches, use of movable plastic membranes can be used to provide temporary lined drains. If it is not feasible to cut the marble surface to the required slopes, it is permissible to develop the required slopes with compacted soil, provided that the soil surface is protected from erosion. Alternatively, benches may be outboard sloped, provided that infiltration of runoff is prevented by impermeable membranes. Runoff from all marble areas shall be collected in pipes and/or lined ditches and conducted to the filtration system constructed in the quarry bottom

e. Identify any prominent fissures or sinks exposed within the quarry as mining progresses and install drainage provisions to prevent runoff from entering the fissures. Runoff in disturbed areas shall be directed away from surface drainages leading to Liddell Spring as well as any subsurface drains such as sinkholes and open fractures. Sinkholes, fractures, and dissolution cavities shall be identified, mapped, and maintained in such a way as to prevent any precipitation or runoff capture.

f. A representative of the County of Santa Cruz Planning Department shall review the sinkhole/fissure/dissolution cavity mapping data and inspect the quarry drainage system at least once per month between October 15 and April 15 each year.

~~7.~~6. The revegetation plan specified in the 1996 Reclamation Plan Amendment shall include hydrophytic native plant species that can tolerate wet conditions for areas on the quarry floor receiving additional retention due to the modified drainage plan. The revised revegetation plan shall be developed by CEMEX in cooperation with a qualified revegetation specialist for approval by County Planning prior to public hearing of the project proposal.

**Implementation:** by CEMEX

**Effectiveness:** Implementation of the drainage plan provisions would control runoff in the expanded mining area, reduce runoff exposure to sediment sources, reduce exposure of rock fissures and voids to runoff containing sediment, and remove sediment from runoff entering the groundwater through the quarry floor. These measures would reduce the turbidity impacts on Liddell Spring and sedimentation of downstream drainages.

**Feasibility:** Feasible. Movable plastic membranes can be used to line benches and collect runoff in areas not being actively mined. The runoff so collected can be conveyed to the quarry floor by temporary down-drains. The efficacy of placing a compacted fine-grained cover on the quarry floor was previously disputed (SECOR, December 1998; EMKO, August 1999). However, given proper engineering consideration, a suitable sediment filter could be designed and installed as a basal layer of the planned fill placement in the base of the quarry. The filter would have to prevent migration or collapse of fill into solution channels or voids, but should maintain some permeability to allow ponded runoff to percolate.

**Monitoring:** Drainage plan shall be submitted to the County of Santa Cruz Planning Department for review and approval prior to ~~commencement of~~ public hearing for the proposed project.

***IMPACT:*** *Because existing data is inadequate to define maximum water levels in the Boundary Expansion Area, there is a potential for mining to intercept groundwater. Exposing significant perched groundwater zones, mining to within 20 feet or less of maximum groundwater elevations, and flushing additional water through the quarry floor would potentially impact water quality and cause turbidity at Liddell Spring by exposing groundwater to surface contamination and by introducing additional natural and quarry-generated sediment into groundwater. This opportunity for contamination of the water would affect both surface and groundwater quality downstream and is therefore a potentially significant impact according to the thresholds of significance. Draining the quarry to Settlement Basin 3, as envisioned by the Final Drainage Plan, would lessen the potential water quality impact at Liddell Spring, but this plan would also increase the potential for the quarry to affect flow quantities at the spring, also a potentially significant impact.*

**Measure HYD-2:** Improved groundwater level monitoring is needed in areas proposed for new and ongoing quarrying (e.g. the northeast corner of the Boundary Expansion Area) to prevent mining from intercepting the groundwater table. ~~In addition to the three new wells proposed for water level monitoring, CEMEX shall~~. It is important that groundwater level information be obtained within the Boundary ~~augment the~~ Expansion Area itself, and that groundwater data be recorded through several annual cycles, so that seasonal water level changes can be assessed. CEMEX shall therefore augment the existing and proposed water level monitoring program with at least ~~one~~two additional wells drilled to coincide with the planned northeast corner of the floor of the Boundary Expansion Area and the western side of the Boundary Expansion Area (approximate California Coordinate System coordinates ~~N1,519,3500 E198,000,~~ N198,000

E1,519,350 and N197,700, E1,518,850, per the project Final Development Plan). It may be necessary to re-drill or re-develop the well in the northeast quarry corner during quarrying, or the hole may be drilled at an angle from a location outside the area to be mined. The actual well location shall be reviewed and approved by a representative of the County of Santa Cruz Planning Department prior to drilling. These wells can be substituted for two of the three additional monitoring wells proposed by the quarry operator (as described in the "Application for Approval of Amendments to Surface Mining and Reclamation Plans", August 1999, page 7). Continuously reading water level data loggers shall be installed in all wells selected for water level monitoring, to include the proposed new wells, and wells M1B, M2B, M5A, and M6A. The data loggers should be programmed to record water levels at least ~~twice daily~~hourly. The monitoring at these wells shall continue through the mining period, or at least until water levels during two average or ~~consecutive significantly~~ higher than average rainfall seasons are recorded.

Mining shall be restricted to a level no deeper than 800 feet (msl) until water levels in the proposed wells have been recorded through at least two average or higher than average rainfall years. Once mining approaches elevation 800 feet (msl), the water level data shall be reviewed by a representative of County of Santa Cruz Planning Department, who shall have the authority to determine the appropriate final depth of mining. The determination of final mining depth shall take into account the results of the groundwater monitoring proposed above, historic water level data, rainfall amounts during the monitoring period, and any new information regarding the karst aquifer that is revealed during the initial mining phase.

In addition to the monitoring proposed above, precaution shall be taken during mining to protect perched water zones uncovered by mining. The quarry operator shall cease quarrying within 50 feet of any flowing water observed exiting the walls or floor of the quarry. If the water flow persists for more than 96 hours and exceeds a discharge rate of 20 gallons per minute, a permanent means of protecting the water source shall be provided. The County of Santa Cruz Planning Department shall be informed of any discharge meeting these criteria and a Planning Department representative shall approve any proposed mitigation measure. In general, appropriate mitigation will include capturing the discharge in such a way as to protect it from contamination and recharge of the runoff to the karst system.

**Implementation:** by CEMEX

**Effectiveness:** Relatively shallow borings or blast holes that do not intercept groundwater will not provide the needed long-term record of groundwater-level variability. If 60-foot test holes are used, as has been proposed, then encountering saturation during a relatively dry time of year may indicate that that mining has already advanced too deep. Without the recommended additional data, mining may inadvertently proceed to depths later determined to be within 20 feet of maximum groundwater elevations. Nevertheless, because of the possibility of encountering isolated groundwater conduits, any water encountering in blast hole borings shall be evaluated.

**Feasibility:** Feasible. Continuously read water level meters can be installed in monitoring wells that record groundwater elevation in four-hour increments. Some of the proposed wells are within the mining area. These wells may have to be re-drilled if destroyed by the mining operation. If the new wells are constructed with steel casing, it is possible that the well casing can be cut off below the new bench level and capped each time material is mined from around the well.

**Monitoring:** New monitoring wells shall be shown on project maps. Monitoring data from ~~continuous~~ continuous-read data loggers all monitoring wells shall be included in routine monitoring reports submitted by CEMEX to the County. The County Planning Department shall review all water level data once mining reaches an elevation of 800 feet msl and make a determination of an acceptable final elevation for the quarry bottom. The County Planning Department shall be notified as soon as any water source is found exiting the walls or floor of the quarry with a flow exceeding 20 gallons per minute for a period of more than 96 hours.

***IMPACT:*** *Even with implementation of mitigation measures HYD-1 and HYD-2, impacts to water quality at Liddell Spring by continued quarrying may be significant. Based on the results of the analysis contained in the Geology and Hydrology Technical Appendix (Appendix F), as summarized above, some impacts on Liddell Spring water quality are attributable to the quarrying operation, either due to the ponding and recharge of turbid water in the quarry pit or due to blasting. To the extent the proposed quarry expansion would extend the life of the quarry operation in time, it would prolong the impacts of the current quarry operation.*

**Measure HYD-3:** ~~CEMEX shall enter into a written agreement with the City of Santa Cruz for the purposes of reducing project generated turbidity at Liddell Spring to acceptable levels set by the EPA. According to the EPA, systems that filter must ensure that turbidity (cloudiness of water) may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month (U.S. EPA 1999 & 2001). CEMEX shall implement the following measures to ensure that impacts to the City of Santa Cruz water supply at Liddell Spring are not significantly impacted by the proposed project:~~

Existing turbidity in Liddell Spring discharge, whether naturally occurring or due to quarry operations is presently being mitigated by the City with their own treatment system, without any demonstrated loss of production. The potential impacts of the quarry operation on turbidity at Liddell Spring shall be mitigated by requiring the quarry operator to reimburse the City of Santa Cruz for the reasonably determined cost of treating water exceeding the standards proposed by the 1964 agreement.

CEMEX shall therefore compensate the City of Santa Cruz for the costs of treating the water for the purpose of reducing project-generated turbidity at Liddell Spring, as previously provided for, and agreed to in the 1964 agreement. SCCWD shall furnish information to CEMEX documenting reasonably determined treatment costs, which shall, in combination with the terms of the 1964 agreement, serve as the basis for the compensation.

CEMEX and SCCWD shall conduct a joint monitoring program at Liddell Spring during the early phases of mining in the Boundary Expansion Area (at least through overburden removal) to monitor implementation of this mitigation measure and to facilitate communication and response to any turbidity or sedimentation issues that arise. The quarry operator shall also provide SCCWD with the blasting schedule, so that blast related turbidity events can be anticipated and precisely mitigated.

1. ~~Complete pilot test of centrifuge, media filtration and cartridge filtration at Liddell Spring to determine level of filtration required to achieve EPA standards cited above.~~

~~2.~~1. ~~Determine if centrifuge, media filtration and cartridge filtration are feasible when scaled up to filter all flows.~~

~~3.Enter into a memorandum of agreement (MOA) with the City of Santa Cruz as a condition of approval of the Use Permit Amendment to include terms such as maintenance, target levels for NTU, etc.~~

**Implementation:** by Planning Department, CEMEX and the City of Santa Cruz

**Effectiveness:** Implementation of the ~~MOA~~ compensation agreement between CEMEX and the City of Santa Cruz will ensure that project impacts to Liddell Spring are fully mitigated prior to project implementation.

**Feasibility:** Feasible. ~~A pilot program carried out by CEMEX and the City determined that 1,000 NTU water pulled from Liddell Spring could be reduced to 45 NTU through the use of a centrifuge and media filtration. The addition of a cartridge filter could reduce the 45 NTU water down to EPA required levels (0.3 NTU) if needed (Pers. Comm., October 10, 2007, Robert Walker CEMEX, Davenport CA).~~ Elevated turbidity levels of water diverted from Liddell Spring are currently being processed by the City of Santa Cruz Water Department.

**Monitoring:** ~~A copy of the MOA shall be submitted to the County prior to the issuance of the Use Permit Amendment. In addition, a monthly monitoring report (or at an interval determined by the City of Santa Cruz) shall be submitted to the City of Santa Cruz and the County of Santa Cruz Planning Department. Specified water quality levels are to be maintained as specified in the MOA or quarry operation within the Boundary Expansion Area will cease until the specified level of treatment is achieved.~~ The County of Santa Cruz Planning Department, using water quality monitoring data and flow rates provided by the City of Santa Cruz Water Department, will complete an annual calculation pursuant to the standards in the 1964 Agreement to determine the amount of required monetary compensation. CEMEX will annually compensate the City accordingly.

(*Eumeces skiltonianus*) and western rattlesnake (*Crotalus viridis*) can make use of these shrub-dominated communities for cover and to forage for rodents and invertebrates. Birds typical of this community include California quail, California towhee, California thrasher (*Toxostoma redivivum*) and white-crowned sparrow (*Zonotrichia leucphrys*). Birds use this community to nest and to forage for seeds, insects and other invertebrates. Small mammals that are associated with this community include brush rabbit (*Sylvilagus bachmani*), California pocket mouse (*Perognathus californicus*), California mouse (*Peromyscus californicus*) and brush mouse (*Peromyscus boylei*). Larger predators such as mountain lion and bobcat (*Lynx rufus*) are expected to forage in this community. Brush pile houses of the SFDW were found in the Boundary Expansion Area in this habitat type. Forage is available for bat species, including Townsend's big-eared bat.

**Upland Redwood Forest**

Upland redwood forest is dominant in the Boundary Expansion Area, and covers 11.4 acres. It is a relatively mature second growth stand, with a few very large trees mixed in. Old growth stumps and fire scars show the historical management by burning after clearcutting in the Santa Cruz Mountains. These redwoods are most likely from 90 to 125 years old with a few older specimens. However, no old-growth redwoods were observed during site surveys. ~~These~~ Redwood stands occur on the west facing slopes above the Limestone Quarry pit and down the slopes of the two largest ravines (where dirt roads occur) within the Boundary Expansion Area. The understory is composed of shrub species such as huckleberry (*Vaccinium ovatum*), red elderberry (*Sambucus racemosa*), and California coffeeberry. The shrub layer is open to moderately dense in places. The herb layers are dominated by sword fern and redwood sorrel (*Oxalis oregana*), but contain a complex association including orchids, such as streamside orchid (*Epipactis gigantea*), and rein orchid (*Piperia transversa*), lilies such as fairy bells (*Disporum smithii*), red clintonia (*Clintonia andrewsiana*), false Solomon's seal (*Smilicina racemosa*), and wakerobin (*Trillium chloropetalum*) and grasses such as vanilla grass (*Heirochloe occidentalis*) and oniongrass (*Melica imperfecta*).

Wildlife found in these communities includes large mammals such as the bobcat, mountain lion, mule deer (*Odocoileus virginianus*), as well numerous bird species such as northern flicker, Anna's hummingbird, California towhee, ruby-crowned kinglet, California quail and black phoebe. The upper canopy of the large trees in these stands provides abundant nesting opportunities for woodpeckers, raptors and resident songbirds. SFDW brush pile houses occur in the upland redwood forest in the Boundary Expansion Area.

### 6.1.3.2 Special Status Plant and Wildlife Species

Special-status plant and wildlife species are those that are recognized as rare and vulnerable to habitat loss or population decline. Some special-status species receive specific protection as defined in federal or state endangered species legislation. Others have been designated as "sensitive" based on the expertise of state resource agencies or organizations, or by policies adopted by local agencies such as counties, cities, and special districts, to meet local conservation objectives (see Section 6.2 Regulatory Setting). These species are referred to collectively as "special-status species" in this EIR.

A list of special-status species reported to occur within the biological study area was compiled using data in the CNDDB, consultation with the CDFG and USFWS, and a review of the CNPS sixth inventory of rare plants (CDFG, 2002; CNPS, 2001, USFWS, 2002). Appendix

C, Table 3, includes an assessment of each species that are known to occur, or have the potential to occur within the biological study area (see Section 6.1.2). In addition to the state and federal special-status species and communities identified in Appendix C, Table 3, the County of Santa Cruz has designated northern coastal scrub and coast live oak forest as locally unique biotic communities (see Chapter 16.32 of the County Sensitive Habitat Protection Ordinance).

Although the biological study area contains a number of special-status species, many of them are highly endemic and the proposed Boundary Expansion Area does not contain suitable habitat to support them. Several of the plant and animal species were identified as having a low potential to occur in the Boundary Expansion Area based on available habitat. While the presence of these species could not be unconditionally ruled out, it is highly unlikely that they are present within the Boundary Expansion Area. These species include marbeled murrelet, Cooper's hawk, American peregrine falcon, white-tailed kite, Townsend's big-eared bat, American badger, robust spineflower, Santa Cruz wallflower, Santa Cruz tarplant, Bonny Doon Manzanita, Kellogg's horkelia, Monterey pine, and Schreiber's manzanita. None of these species were observed at the site during several surveys.

Several sensitive species and sensitive vegetation communities are either known to occur in or near the biological study area, or have a medium to high potential to occur in or near the biological study area based on available habitat (see Appendix C, Table 3). The special-status species and vegetation communities that could be affected by the Boundary Expansion Area project, are described below except for coast live oak forest and northern coastal scrub, which are described in Section 6.1.3.1 above.

**California Red-legged Frog (CRLF)**

The CRLF is federally listed as threatened and is defined by the state as a CSC. This species occurs from Shasta County south to the Mexican border. CRLFs require permanent or nearly permanent bodies of water for persistence. They are known to occur within grassland, riparian woodland, oak woodland, and coniferous forests, but require quiet pools, slow-moving streams, and marshes with heavily vegetated shores for reproduction.

The CRLF ~~occasionally~~ is known to traverses ~~a~~ 1.8 miles ~~(1.6 kilometers; a mile is 5,280 feet) or more~~ though upland habitats during rainy periods when seeking out new breeding locations(Bulger et al., 1999). During warmer periods, CRLF can be found in rodent burrows in upland habitats. For this reason, CRLF requires breeding habitats (ponds/ streams) along with adjacent upland dispersal corridors between breeding habitats for long-term persistence. In addition, the juvenile frogs move away from breeding habitat and harbor in creeks or springs until reaching breeding age. These non-breeding water sources are important for species persistence since juvenile frogs are preyed upon by adult frogs at breeding ponds.

The Bonny Doon Quarries are the subject of the Bonny Doon Quarries Settlement Pond HCP (Toyon Environmental Consultants, 1999) for CRLF. This species has been monitored at the site since 1997 under the HCP. It is also known to occur in several locations within two miles of the study area, including in Liddell Creek downstream of the project and in San Vicente Creek.

In section 1.2 of the Bonny Doon Quarries Settlement Pond HCP, it states that "Quarry operations involve the removal and processing of ore, disposal of waste material, sediment pond

A total of 53 SFDW houses were detected in the Boundary Expansion Area. Of the 53 houses, 40 were determined to be active, 10 inactive, and the status of 3 could not be determined. Houses were found in 21 clumps with one to five nests per clump (see Figure 35). The majority of nests were located within the redwood forest and northern coastal scrub. SFDW houses were not found in areas where the canopy cover was so complete that shade prohibited the growth of any understory. Houses are more abundant in areas with a balance of overstory and shrub layer. The presence of these vegetative strata provide SFDW not only good foraging habitat but also concealment from predators. During the June 2006 field visit, one adult SFDW was observed foraging near a SFDW house within the coast live oak forest.

Given the fact that SFDW are known to use multiple houses, it is difficult to draw any conclusions on the number of SFDW present within the Boundary Expansion Area without physically trapping individuals. However, there was suitable habitat present in the Boundary Expansion Area that did not contain SFDW houses, thus indicating that either the population here has possibly not reached its carrying capacity, or the preferred scrub and oak woodland habitat is at capacity and the population is now using the redwood forest habitat, which may have a lower carrying capacity due to canopy cover that inhibits the growth of understory species that are used as a food source and for house building materials. Predators of SFDW within the study area include Great horned owl, barn owl, red-tailed hawk, coyote, and bobcat and these species could be keeping the SFDW population below the carrying capacity.

Habitat for SFDW occurs throughout the scrub and woodland communities in the biological study area, and houses were also observed in areas adjacent to Disposal Area B when this area was under study as a possible SFDW mitigation site.

**Central Coast Steelhead**

See Steelhead (central coast ESU) and North Central Coast California Roach/ Stickleback/ Steelhead Stream discussion in Section 6.1.3.3.

**6.1.3.3 Sensitive Habitats**

**Coho Salmon and the North Central Coast Short Run Coho Stream Habitat**

Coho salmon (Central California Evolutionary Significant Unit is listed as federal and state endangered) are known to spawn in the lower portions of San Vicente Creek, below the Shale Quarry. The species is not known to occur in Liddell Creek, however, Liddell Creek is designated as Critical Habitat for this species. The proposed mining expansion of the Limestone Quarry would not occur in the San Vicente Creek watershed and would not impact habitat values or water quality in San Vicente Creek. As a result, it is unlikely that the proposed project would directly impact the coho salmon, however it could affect critical habitat for coho. Project effects on the water quality and quantity of Liddell Creek are described in Section 5.0 Hydrology, and the discussion of biological impacts in Section 6.3.

**Steelhead (central coast ESU) and North Central Coast California Roach/ Stickleback/ Steelhead Stream**

National Oceanic and Atmospheric Administration (NOAA) Fisheries Service biologists have identified steelhead (central coast evolutionary significant unit (ESU) is federally-listed as threatened) populations in the lower portions of San Vicente Creek and in the main branch of Liddell Creek. While this is physically outside of the Boundary Expansion Area, hydrologic and water quality effects on the Liddell Spring and Plant Spring could affect Liddell Creek and its associated steelhead habitat. These effects are discussed in Section 6.3.2.3. The Boundary Expansion Area is outside of the San Vicente Creek watershed.

The Limestone Quarry is at the headwaters of the main ("middle") and east branches of Liddell Creek (called "Liddell Creek" and "East Branch" on the USGS Davenport Quadrangle). The Liddell Spring and the Plant Spring both feed the East Branch. There is also a West Branch, which enters Liddell Creek about 2,000 feet upstream of the Pacific Ocean. The Limestone Quarry is about 13,000 feet upstream of the ocean. The total watershed of Liddell Creek is about three square miles. The watershed of the Limestone Quarry is about 125 acres, or 0.2 square mile. Hence the Limestone Quarry watershed represents a small portion of the Liddell Creek watershed.

The Liddell Creek system was studied by Sam McGinnis, Ph.D, Habitat Restoration Group, and Creegan and D'Angelo in the 1980's and early 1990's. Based on these studies, the 1996 EIR includes a description of the steelhead habitat in Liddell Creek, summarized as follows.

The Liddell Creek system is typical of a small, coastal, redwood forest creek complex. It exhibits little primary production (algae) and secondary production (aquatic insect larva) in most of its branches, and there is a moderate to high degree of embeddedness in most pool and riffle areas, meaning the rocks are buried in sand or sediment. Despite limited pool availability, steelhead parr have been observed in the creek. Summer rearing habitat restricts steelhead production because refuge cover is limited. Large rocks, under which fish may hide, are rare and relatively flat and embedded in sand. Many of the undercut banks where fish can hide are out of water during low summer flows. Water quality and temperatures are typically favorable for steelhead during the low-flow months.

McGinnis (~~County of Santa Cruz, 1996a&b~~1991) sampled sediments in the settlement basins and in the creek downstream of the basins and tested them for content of limestone and granite, with the purpose of determining whether the quarry was contributing most of the sedimentation to Liddell Creek. The results were that the settlement basins were capturing most of the sediment and that the quarry was contributing a small amount to the downstream watershed. The embeddedness in Liddell Creek was attributed mainly to natural erosion and weathering in the watershed, as opposed to surface runoff from quarry operations.

Quarry operations that affect steelhead conditions in Liddell Creek include water diversion from Plant Spring, and release of water from the settlement basins in the Limestone Quarry. Also, the City of Santa Cruz diverts water from Liddell Spring for the city water system, likely affecting steelhead habitat in the creek system.

A total of seven ponds, four at the Limestone Quarry and three at the Shale quarry, collect storm water runoff within the quarries. The ponds were constructed at the commencement of quarry operations approximately 40 years ago. The purpose of the ponds is to settle out sediment from storm water runoff to protect downstream water quality. The ponds are equipped with standpipes, which allow water to drain from the ponds after maximum settling time. All of the ponds have adequate capacity, which is maintained through periodic clean out of accumulated sediment during the dry season. All of the ponds are located within drainage courses and have been created by constructing levees across the drainage course.

Prior to the 1997 COC water quality monitoring downstream of the sediment basins in the Limestone Quarry indicated that erosion and sediment control facilities and practices were inadequate resulting in siltation of watercourses downstream. During the COC process an Erosion Control Plan was developed for the Limestone and Shale quarries to address this impact. Recommendations of the Erosion Control Plan are summarized in a series of documents incorporated by reference into the COC. Based on a review of Planning Department files and site inspection all relevant aspects of the Erosion Control Plan have been implemented, including upgrades to sediment pond standpipes.

The Bonny Doon Quarries operate under a General Permit for Storm Water Discharges Associated with Industrial Activities administered by the RWQCB. As required by the General Permit, a SWPPP, which identifies Best Management Practices in place, has been submitted to the RWQCB. All storm water runoff from the quarry is captured in the settlement basins. Controlled discharge from the settlement basins is monitored in compliance with the requirements of the RWQCB. These controls help maintain water quality downstream of the Limestone Quarry. Since approval of the COC, water quality monitoring, as required by the General Permit, indicates that implementation of the Erosion Control Plan, including upgrades to the sediment basins, has been effective in preventing siltation of watercourses downstream of the quarries. Ongoing erosion control and the need for remedial work are determined during regular quarterly and annual inspections of the site.

**Northern Maritime Chaparral**

Northern maritime chaparral is listed as a sensitive habitat in the GP/LCP and in the CNDDB. Less than 2,000 acres of this habitat exist in California, and it is considered threatened in the CNDDB. This community type occurs on a ridge between the east and west forks of Liddell Creek, between Settlement Basins 2 and 3 (County of Santa Cruz 1996a&b). It consists of an overstory of knobcone pine trees and a dense understory of tall evergreen shrubs, including brittle-leaved Manzanita (*Arctostaphylos crustaceae* var. *crustaceae*), coyote brush, and warty-leaved ceanothus (*Ceanothus papillosus*). This plant community does not occur in the Boundary Expansion Area. This community was impacted under the existing mining plan and ~~is included~~ has been discussed in support of the proposed Reclamation Plan Amendment.

**Native Grassland**

The GP/LCP and County of Santa Cruz Sensitive Habitat Protection Ordinance (Chapter 16.32 of the County Code) identify native grassland in the coastal zone as a sensitive habitat. Grassland dominated by native grass species is increasingly rare in California, having been outcompeted by non-native annual grasses and more often subject to development than coastal scrub or woodlands. Native grassland is dominated by native grass species such as needlegrass (*Nasella pulchra*; *N. cernua*), and California oatgrass (*Danthonia californica*), and herbs such as blue dicks (*Dichelostemma pulchellum*), soap plant (*Chlorogalum pomeridianum*), and coast tarweed (*Hemizonia corymbosa*). The Boundary Expansion Area does not contain native grassland. This community was impacted under the existing mining plan ~~occurs in the biological study area,~~ and has been discussed in support of the proposed Reclamation Plan Amendment~~includes native grassland~~.

### 6.1.4 1996 Reclamation Plan Amendment

In accordance with the SMARA and County of Santa Cruz Mining Regulations (see Section 3.0), the two Bonny Doon quarries are operated under a reclamation plan. The purpose of the reclamation plan is to return areas impacted by mining to a stable state through soil and vegetation management. The Bonny Doon quarries reclamation plan has a complicated history, summarized in Section 2.0. The reclamation plan that is being implemented ("Reclamation Plan") combines elements of the original 1996 plan, mitigation required in the EIR on that plan (adopted as 1997 Conditions of Approval for the COC and Reclamation Plan Approval; see Appendix B), and comments by the State Board of Mining and Geology (incorporated 1999).

While the Reclamation Plan identifies revegetation goals, one of the tasks in the Plan is to establish test plots to refine the methodology for achieving re-establishment of particular vegetation communities (see Figures 33, Limestone Quarry Existing Vegetation (2003) and Figure 34, Shale Quarry Existing Vegetation (2003) for the locations of individual test plots). These plots were established, and the results indicated that it may not be feasible to establish needlegrass grassland and maritime chaparral because of low-nutrient soil conditions. In 2001, CEMEX proposed a revised revegetation strategy as an amendment to the Reclamation Plan. The revised strategy takes into account natural vegetation communities at the site and in the region, and un-weathered, low-nutrient post-mining soil conditions. It proposes a simpler seed mix than the previous revegetation plan adopted in 1996 and finalized in 1999 (see Table 2-3 in Section 2.0), and initial establishment of just two habitat types. The strategy is that the less-weathered reduce the loss of wildlife habitat through in-kind replacement of sensitive vegetation communities and the revegetation of all other areas with native species.

Raptors are protected by state and federal law. Raptor nesting activity was not observed in the Boundary Expansion Area during site surveys. However, it is feasible that raptors could establish nests in this forested area before timber harvest/mining expansion activity begins. Impacts to nesting raptors (including those that are species of concern (Cooper's hawk, long-eared owl, ~~golden eagle,~~ and sharp-shinned hawk), ~~and/or fully protected (white-tailed kite))~~ would be considered a significant impact.

Nongame birds are protected under California Fish and Game Code Sections 3500 and 3800, which prohibit the removal of nests and require a mitigation plan for mining operation impacts on nongame birds. Migratory birds and other avian species are also protected under the MBTA. The MBTA prohibits removal of nests, eggs, or birds, and prohibits activities that result in nest abandonment.

Impacts to nesting birds, including raptors and nongame birds, can be reduced to a less than significant level through pre-construction surveys or by scheduling timber harvesting and overburden removal for late summer/early fall, outside of the breeding season. These steps are identified in Measure BIO-4 below. In addition, the preservation of habitat for SFDW would also protect nesting habitat for birds, and the revegetation of impacted areas of the quarry would restore native habitat that could be used by nesting birds. With the implementation of these measures, impacts on nesting birds would be less than significant.

#### 6.3.2.3 Special Status Species

#### Special Status Plant and Vegetation Communities

The Boundary Expansion Area does not contain special-status plant species, and would not impact them either directly or indirectly. Although the Boundary Expansion Area contains a diverse and intact assemblage of the native flora, no rare or endangered plant species were located during several field surveys of the 17.1-acre Boundary Expansion Area. These surveys were conducted during both the late and early flowering season.

The Boundary Expansion Area contains 2.5 acres of northern coastal scrub, and 0.9 acre of coast live oak forest. These are identified as locally unique biotic communities in the GP/LCP and are protected under the County's Sensitive Habitat Protection Ordinance. Because of their status as sensitive habitats, the loss of northern coastal scrub and coast live oak forest would be considered a significant impact. These communities would be replaced on the site under the Mitigated 1996 Reclamation Plan Amendment, which reduces the impact to less than significant (see Table 6-3 and Measure BIO-3).

**Table 6-3**
**Comparison of the Approved and Proposed Reclamation Plans by Vegetation Community (Acres)[10]**

| Vegetation Community[1] | 1996 Reclamation Plan (Approved) [2] | | 1996 Reclamation Plan Amendment (Proposed Project) [2] | | Mitigated 1996 Reclamation Plan Amendment[2, 6] | |
|---|---|---|---|---|---|---|
| | Shale Quarry | Limestone Quarry | Shale Quarry | Limestone Quarry | Shale Quarry | Limestone Quarry |
| Needlegrass Grassland & Northern Maritime Chaparral | 59.8 | 50.0 | -- | -- | -- | -- |
| Needlegrass Grassland, Northern Maritime Chaparral & Mixed Evergreen Forest | 19.1 | -- | -- | -- | -- | -- |
| Needlegrass Grassland | 7.4 | -- | -- | -- | 4.0 | -- |
| Diverse Native Grassland | -- | -- | -- | -- | 3.0 | 9.0 |
| Mixed Evergreen Forest & Northern Maritime Chaparral | 8.3 | -- | -- | -- | -- | -- |
| Mixed Evergreen Forest | -- | 34.8 | -- | 7 | -- | -- |
| Redwood Forest | -- | 11.2 | -- | -- | -- | -- |
| Redwood Forest & Northern Maritime Chaparral | -- | 9.6 | -- | -- | -- | -- |
| Northern Maritime Chaparral | -- | 7.1 | -- | -- | 4.5 | -- |
| Northern Coastal Scrub | -- | -- | 96.8 | -- | -- | -- |
| Northern Coastal Scrub & Mixed Evergreen Forest | -- | -- | -- | 211.4[7] | 85.3 | 208.5[7,8] |
| Redwood Forest | -- | -- | 1.5 | -- | 1.5 | -- |
| Riparian | -- | -- | 0.85 | 4.6 | 0.85 | 4.6 |
| Coast Live Oak Forest | -- | -- | -- | -- | -- | 0.9 |
| Limestone Pit[3] | -- | 56.0 | -- | -- | -- | -- |
| Other Area[4] | -- | 18.0 | -- | -- | -- | -- |
| Area C Expansion[5] | -- | 20.0 | -- | -- | -- | -- |
| **Subtotal in Acres** | **94.6** | **206.7** | **99.2** | **223.0** | **99.2** | **223.0** |
| **Total Acres** | **301.3** | | **322.2[9]** | | **322.2[9]** | |

Notes:

1. For consistency, community groupings adapted from revegetation plan maps and community names adapted from: Holland, Robert F., 1986. *Preliminary Descriptions of the Terrestrial Natural Communities of California*. Prepared for the California Department of Fish and Game, Sacramento, California.
2. Mitigation Measure VEG-5 from 1996 EIR specifies minimum acreages for specific vegetation communities: Needlegrass Grassland (4), Diverse Native Grassland (12), Mixed Evergreen Forest (46), Northern Maritime Chaparral (4.5), Northern Coastal Scrub (2.5), Riparian (0.5), Redwood Forest (1.5). A subsequent revegetation plan incorporating the 1996 EIR mitigation was never approved by the Planning Department. However, the entire 71 acres of mitigation required by Measure VEG-5 is contained in the total acreage.
3. Vegetation community(s) not specified in 1996 Reclamation Plan.
4. Estimate of mapping margin of error in 1996 Reclamation Plan for Limestone Quarry.
5. Estimate of additional area represented by expansion of Disposal Area C in Limestone Quarry in 1996 Reclamation Plan.
6. The 2005 Alternative Revegetation Plan has been incorporated as mitigation (see Measure BIO-3).
7. The northern coastal scrub/mixed evergreen forest acreages do not include the 9.4 acres of remaining area included in Figures 13 and 32.
8. Acreage includes unspecified area of created seasonal wetlands within the quarry floor (see Measure HYD-1).
9. Total acreage incorporates mitigation for 17.1 acres of impacts associated with the proposed Boundary Expansion Project. The remaining difference is attributed to advances in mapping accuracy since 1996.
10. Acreages do not include 26.58-acre reclamation of conveyor line that would occur with approved or proposed plans.

Source: County of Santa Cruz, 2007.

Creek by the mining expansion. In addition, Measure HYD-1 prevents a reduction in water quantity into Liddell Spring by continuing to hold water in the quarry floor rather than diverting it to Settlement Basin 3.

A semi-quantitative assessment of sediment loading at Liddell Spring has been conducted (Appendix I). The assessment indicates that the Liddell springflow that by passes the City's diversion is of much higher quality than typical surface streamflow, even with the quarry in operation. The City's spring box appears to act as an effective sediment trap. Provided that the City follows its proposed guidelines for maintenance of the spring box, downstream impacts of the quarry due to sedimentation of Liddell Spring are not considered to be significant.

The quarry expansion project would extend the life of the Limestone Quarry for three years resulting in the continuation of Quarry water diversions at Plant Spring. CEMEX diverts up to 21 gpm (927,000 gallons per month) during summer months mostly for dust control purposes. The current rate of water use would not be changed by the expansion project.

Both Plant Spring and Liddell Spring contribute flows to Liddell Creek steelhead habitat. Plant Spring has an average flow rate of about 300 acre-feet per year (184 gpm, with a range of 66 to 338 gpm) and the mean average flow of Liddell Spring is about 1,500 acre-feet per year or 930 gpm (range of 760 to 1,720 gpm; Hydrology Section 5.1.1.1). While the Plant Spring reacts to yearly seasonal rainfall, the Liddell Spring does not and its water supply is more consistent. Plant Spring is about 1,400 ft east of Liddell Spring. In summary, Plant Spring contributes one-fifth of the amount of Liddell Spring, and the contribution occurs mainly during and just after the rainy season.

Maximum level of water use can be characterized using current maximum rate of water use and flow data for Plant Spring. Available data for 2003, which was an average rainfall year, includes diversion rate, spring flow and creek flow in East Branch Liddell Creek downstream of the confluence with flow from Plant Spring and upstream of the confluence with flow from the City's Liddell Spring. The quarry diverts water from Plant Spring for use in dust control. Diversion does not occur year-round, it occurs during dry periods (typically June through October) with maximum diversion of approximately 21 gpm during August when maximum dust control is needed. This represents approximately ten percent of the spring flow and approximately eight percent of the creek flow as measured at the nearby location in the East Branch of Liddell Creek. Plant Spring is located near the headwaters of the East Branch of Liddell Creek. For further comparison, according to a City of Santa Cruz report, the City diversion at Liddell Spring in August 2003 represented more than twice the flow from the entire remaining Liddell Creek watershed as measured on the mainstem downstream of the confluence with the West Branch (City of Santa Cruz 2004).

Liddell Spring and Plant Spring are not the only sources of water for Liddell Creek. The watershed drains about three-square miles of area, and other springs and surface flow contribute to the creek.

The Liddell Creek steelhead habitat suffers from low base-flow conditions during summer months. The project's extension of water diversion at Plant Spring for three more years would continue current project effects on low summer base-flows for steelhead in Liddell Creek, but would not increase them. The Plant Spring provides less water to Liddell Creek than the Liddell Spring. Since its flow naturally drops in the summer, it may never have supplied significant summer flow to Liddell Creek, although cumulatively the contribution could have been important. It is unlikely that quarry diversion of Plant Spring flows in the summer by itself would adversely affect steelhead rearing habitat. However, the diversion does have an existing cumulative effect with the City's considerable diversion of flows from Liddell Spring (1,250 acre-feet per year since water year 1972 out of a total mean annual flow of 1500 acre-feet per year).

Given the small contribution of Plant Spring to base-flows of Liddell Creek, and the small quantity of water diverted from Plant Spring for quarry operations, the continued water use by the quarry under the proposed mining expansion project would not significantly impact steelhead habitat.

### 6.3.3 1996 Reclamation Plan Amendment

Based on the species list and communities included in the 1996 Reclamation Plan Amendment, the quarries would be revegetated with coastal scrub and mixed evergreen forest. In addition, areas of sensitive redwood forest and riparian woodland would be preserved. The revised plan does not mitigate for the loss of all of the sensitive habitats known to occur at the site as required in COC Conditions of Approval (see Section 3.6). Specifically, it does not address northern maritime chaparral or native grasslands (either needlegrass grassland or diverse native grassland).

**Table 6-4**
**Comparison of Vegetation Communities and Species Specified in the 1996 Reclamation Plan Amendment and the Mitigated 1996 Reclamation Plan Amendment**

| 1996 Reclamation Plan Amendment | Mitigated 1996 Reclamation Plan Amendment |
|---|---|
| **Common Name (Scientific Name)** | **Common Name (Scientific Name)** |
| **Early Successional ~~Scrub~~Shrub Mix** | **Early Successional Scrub/Mixed Evergreen Forest** |
| California sage (*Artemisia californica*) | California sage (*Artemisia californica*) |
| Coyote brush (*Baccharis pilularis*) | Coyote brush (*Baccharis pilularis*) |
| Coffeeberry (*Rhamnus californica*) | Coffeeberry (*Rhamnus californica*) |
| Sticky monkey flower (*Mimulus aurantiacus*) | Sticky monkey flower (*Mimulus aurantiacus*) |
| Bush lupine (*Lupinus arboreus*) | Bush lupine (*Lupinus arboreus*) |
| Blue blossom (*Ceanothus thyrsiflorus*) | Blue blossom (*Ceanothus thyrsiflorus*) |
| Lizard tail (*Eriophyllum staechadifolium*) | Lizard tail (*Eriophyllum staechadifolium*) |
| **~~Mid-successional Mixed Evergreen~~ Forest Mix** | Deerweed (*Lotus scoparius*) |
| Douglas fir (*Pseudotsuga menziesii*) | Madrone (*Arbutus menziesii*) |
| Tanoak (*Lithocarpus densiflorus*) | Yellow Yarrow (*Eriophyllum confertiflorum*) |
| Coast live oak (*Quercus agrifolia*) | Tanoak (*Lithocarpos densiflorus*) |
| Madrone (*Arbutus menziesii*) | California wax myrtle (*Myrica californica*) |
| Sticky monkey flower (*Mimulus aurantiacus*) | Coast redwood (*Sequoia sempervirens*) |
| Bush lupine (*Lupinus arboreus*) | Douglas-fir (*Pseudotsuga menziesii*) |
| Lizard tail (*Eriophyllum staechadifolium*) | Knobcone Pine (*Pinus attenuata*) |
| | Blue ~~widl~~wild rye (*Elymus glaucus*) |
| | **Diverse Native Grassland** |
| | California brome (*Bromus carinatus*) |
| | Blue wild rye (*Elymus glaucus*) |
| | Meadow barley (*Hordeum branchyantherum*) |
| | Purple needlegrass (*Nassella pulchra*) |
| | California oat grass (*Danthonia californica*) |
| | California aster (*Lessingia filaginifolia var. filaginifolia*) |
| | California poppy (*Eshscholzia californica*) |
| | Pursh's trefoil (*Lotus purshianus*) |
| | Annual lupine (*Lupinus nanus*) |
| | Blue-eyed grass (*Sisyrinchium bellum*) |
| | Yellow Yarrow (*Eriophyllum confertiflorum*) |
| | **Needlegrass Grassland** |
| | California brome (*Bromus carinatus*) |
| | Blue wild rye (*Elymus glaucus*) |
| | Meadow barley (*Hordeum branchyantherum*) |
| | Purple needlegrass (*Nassella pulchra*) |
| | California oat grass (*Danthonia californica*) |
| | Pursh's trefoil (*Lotus purshianus*) |
| | Annual lupine (*Lupinus nanus*) |
| | Blue-eyed grass (*Sisyrinchium bellum*) |
| | Yellow yarrow (*Eriophyllum confertiflorum*) |
| | **Northern Maritime Chaparral** |
| | Knobcone pine (*Pinus attenuata*) |
| | Brittle-leaved manzanita (*Arctostaphylos tomentosa crustacea* |
| | Chamise (*Adenostoma fasciculatum*) |
| | Warty-leaved ceanothus (*Ceanothus papillosus*) |
| | Deerweed (*Lotus scoparius*) |
| | California sage (*Artemisia californica*) |
| | Madrone (*Arbutus menziesii*) |
| | Coyote brush (*Baccharis pilularis*) |
| | Yellow yarrow (*Eriophyllum confertiflorum*) |
| | Buckwheat (*Eriogonum latifolium*) |
| | Tanoak (*Lithocarpos densiflorus*) |

**Table 6-4**
**Comparison of Vegetation Communities and Species Specified in the 1996 Reclamation Plan Amendment and the Mitigated 1996 Reclamation Plan Amendment**

| 1996 Reclamation Plan Amendment | Mitigated 1996 Reclamation Plan Amendment |
|---|---|
| **Common Name (Scientific Name)** | **Common Name (Scientific Name)** |
| | Coast live oak (*Quercus agrifolia*)<br>Sticky monkey flower (*Mimulus aurantiacus*)<br>California brome (*Bromus carinatus*)<br>Blue wild rye (*Elymus glaucus*) |
| Sources:<br>Madrone Landscape Group, 2001.<br>Madrone Landscape Group, 2006 (Appendix D). | |

The proposed 1996 Reclamation Plan Amendment should also be revised to reflect modified planting conditions on the quarry floor resulting from drainage changes made in response to hydrology and water quality concerns. Under Measure HYD-1, overburden would be placed across the entire quarry floor and constructed with a drainage retention area and filter. Part 7 of Measure HYD-1 states:

> The revegetation plan specified in the 1996 Reclamation Plan Amendment (as modified by the 2005 Alternative Revegetation Plan per Measure BIO-3) shall include species that can tolerate wet conditions for areas on the quarry floor receiving additional retention due to the modified drainage plan. The revised revegetation plan shall be developed by CEMEX for approval by County Planning prior to public hearing of the project proposal.

Thus, Measure BIO-3 includes a recommendation that the proposed 1996 Reclamation Plan Amendment be modified to incorporate vegetation suitable for the quarry floor.

### 6.3.4 Cumulative Impacts

"Cumulative impacts" refers to two or more individual effects which, when considered together, are considerable or which compound or increase other environmental impacts. The individual effects may be changes resulting from a single project or a number of separate projects. The cumulative impact from several projects is the change in the environment, which results from the incremental impact of the project when added to other closely related past, present, and reasonable foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time (Section 15355 of the CEQA Guidelines). A cumulative impact consists of an impact that is created as a result of the combination of the project evaluated in the EIR together with other projects causing related impacts (e.g., removal of sensitive habitat).

According to County records (see Appendix E), there are no current or proposed projects in the Bonny Doon community planning area that would result in a substantial impact to biological resources with the exception of the Bonny Doon Limestone Quarry Boundary Expansion Project. In addition to the proposed project, the Limestone Quarry contains an unmined balance of 9.4 acres within the Legal Mining Limit that could potentially be mined in the foreseeable future. However, development of that acreage would be required to undergo a separate environmental review if an application were filed with the County. The possible future expansion of the Limestone Quarry into the remaining 9.4 acres would contribute incrementally to impacts on biological resources in the project vicinity. Of particular concern are the effects on determine whether the redwood forest vegetation community provides suitable foraging habitat in addition to other habitat requirements (e.g., breeding).

- If lab results from fecal analysis are ambiguous or inconclusive, the use of telemetry and tracking of selected animals shall be conducted for a period of 30 days to determine where SFDWs in the Boundary Expansion Area are foraging (i.e., what vegetation communities).
- If the data collected under No. 2 indicate that the redwood forest vegetation community provides suitable nesting and foraging habitat for SFDW, then preservation of redwood forest habitat in the adjacent buffer zone east of the Boundary Expansion Area (APN 063-132-08), or an alternate parcel with suitable habitat, is an acceptable measure to reduce the impacts to below a level of significance.
- If the data collected under No. 2 indicate that the redwood forest vegetation community does not provide suitable breeding and foraging habitat for SFDW, then a site containing coyote brush scrub, and/or northern coastal scrub, and/or coast live oak forest, and/or chaparral shall be used.

| | |
|---|---|
| **Implementation:** | By CEMEX, through a qualified biologist. |
| **Effectiveness:** | Habitat set-asides would conserve suitable habitat acreage and provide for long-term habitat needs of SFDW in the project vicinity. |
| **Feasibility:** | Feasible. CEMEX has tentatively approved the location of the relocation site and habitat set-aside options. |
| **Monitoring:** | The results of the surveys shall be submitted to County Planning Department for review and approval and coordinated with CDFG prior to start of land clearing, and the selected conservation easement shall be established. |

**Measure BIO-2:** In addition to Measure BIO-1, up to 40 SFDW shall be actively and passively relocated from the Boundary Expansion Area prior to land-clearing activities that will impact SFDW houses. Two potential relocation sites have been identified. The first relocation site is located immediately north of the Boundary Expansion Area on parcel 063-122-05. A second site is located northeast of the Boundary Expansion Area near the San Vicente Quarry (APN 058-011-01); a habitat evaluation of these sites will be provided under Measure BIO-1. Any remaining houses/animals shall be passively relocated.

The specific implementation methods for this mitigation measure shall be described in a SFDW Mitigation Plan. All relocation and tracking data collected under the SFDW Mitigation Plan shall be compiled into a report for submittal to CDFG and the County Planning Department. The SFDW Mitigation Plan shall at least include:

- Safety measures to avoid transmittal of Hantavirus and Arenavirus. Both the Hantavirus and Arenavirus are typically found in rodent populations and are shed in their saliva, urine, and feces. Humans can become infected after inhaling aerosolized droplets of urine or particulates contaminated with rodent excreta. Appropriate safety measures shall be taken including protection against inhalation of contaminated particulates, protection against particulates coming into contact with conjunctiva (eyes), and protection against fleabites. Those handling house materials ~~should~~ shall use appropriate respiratory, eye and skin protection (e.g., use of a hazardous materials suit).
- Data collection at each house to be dismantled (under either passive or active relocation) to identify house-building materials, contents of house cavities (particularly stored food

plants), the percent and type of ground cover immediately around each house, the tree and shrub species surrounding the house, and what the house is built on (e.g., ground, crotch of tree).

- Trapping method and length of time an animal can be held during house relocation
- New house design: for example, a wine barrel or similar receptacle staked into the ground, upside down and at an angle in appropriate microhabitat (based on data collected above and in Measure BIO-1), with materials from the nest chamber of the dismantled house placed inside, and other house materials placed over and around the barrel, including a long tunnel-shaped entrance that leads only into the receptacle so that when released the SFDW can only enter the house and cannot exit except through the tunnel. Food and house building materials ~~should~~ shall be provided. Slash generated during land clearing activities within the Boundary Expansion Area could be spread throughout the mitigation site to provide additional house building materials.
- Releasing method (how the trapped SFDW is released into the new house)
- Tracking of the relocated animals with radio telemetry for a period of 30 days following their release to determine the success of the relocation effort.
- Methods of passive relocation, including whether animals are to be trapped and released locally prior to house dismantling, and what time of day passive relocation ~~should~~ shall occur.

**Implementation:** By CEMEX, through a qualified biologist.

**Effectiveness:** Dismantling houses and relocating impacted animals prior to land clearing increases the potential for survival of directly impacted individual SFDW.

**Feasibility:** Feasible. Similar studies have occurred in the SFDW range with oversight by CDFG.

**Monitoring:** The Mitigation Plan shall be submitted to County Planning Department for review and approval and coordinated with CDFG prior to start of land clearing. The results shall be submitted to CDFG and the County Planning Department

***IMPACT:*** *The 1996 Reclamation Plan Amendment would eliminate the 1:1 replacement requirement of all habitat types previously impacted in favor of vegetation communities that can be more easily re-established in reclaimed quarry areas. Replacement of maritime chaparral, needlegrass grassland, and diverse native grassland would not occur, and test plots would not be continued. This does not reflect current knowledge and would result in the permanent loss of sensitive habitats. The 1996 Reclamation Plan Amendment does not replace the 0.9 acres of coast live oak forest occurring in the Boundary Expansion Area that would be removed by the project.*

**Measure BIO-3:** Revise the proposed 1996 Reclamation Plan Amendment to incorporate sensitive habitats, a test plot system and to update the vegetation maps. This can be accomplished by incorporating the approach provided in the "2005 Alternative Revegetation Plan", referenced as Appendix D. The "Mitigated 1996 Reclamation Plan Amendment" shall also include 0.9 acre of coast live oak forest, and a suitable mix of hydrophytic (growing wholly or partially in water) vegetation species to revegetate a portion of the quarry floor in accordance with Part 7 of Measure HYD-1. A suitable mix of hydrophytic species for a seasonal wetland may include such species as rush (*Juncus* spp.), bulrush (*Scirpus* spp.), sedge (*Carex* spp.), etc. The revised revegetation plan shall be developed by CEMEX in cooperation with a qualified revegetation specialist for approval by County Planning prior to public hearing of the project proposal.

**Implementation:** by CEMEX

**Effectiveness:** This measure would restore sensitive communities within areas impacted by mining. This mitigation measure will ensure a no net loss of sensitive habitat from the GP/LCP Area as a result of quarry activities.

**Feasibility:** Feasible.

**Monitoring:** Amended 1996 Reclamation Plan submitted to the County for review and approval.

***IMPACT****: The removal of 17.1 acres of forest and shrub-dominated upland habitat has the potential to impact or disturb nesting raptor and migratory bird species that may establish nests within the Boundary Expansion Area, resulting in a violation of state code and the MBTA.*

**Measure BIO-4:** Tree removal or land clearing that removes nesting habitat shall be conducted outside of the breeding season (February 15 to August 15) for raptors and migratory birds. Alternatively, the mining Boundary Expansion Area shall be surveyed for nesting birds by a qualified biologist using established CDFG protocols no more than 30 days prior to tree removal or land clearing, if these activities are to occur during the breeding season. If nesting birds are detected within the construction zone, methods of avoiding active nest sites (e.g., establishment of a buffer area around the active nest until hatchlings have fledged) shall be developed in coordination with CDFG. Surveys ~~should~~ shall be completed between February 15 and August 15 of any given year.

**Implementation:** by CEMEX

**Effectiveness:** Conducting tree removal and land clearing activities outside of the breeding season will avoid impacts to nesting birds including raptors and nongame birds. If tree removal or land clearing activities are to occur during the breeding season, pre-construction surveys would decrease the potential for adverse impacts to ~~regionally occurring~~ nesting birds. ~~special-status raptors that are known to forage or nest in habitat types within the Expansion Area.~~ Consultation with and recommendations provided by CDFG would ensure the minimization of potential impacts to nesting birds, including ~~special-status~~ raptors and non-game birds.

**Feasibility:** Feasible. The spring and summertime restriction limits the amount of time left for clearing work, and may result in rushed work, or an extension of clearing into additional season(s).

**Monitoring:** The tree removal and land-clearing schedule shall be provided to the County. If done, the survey report shall be submitted to CDFG and the County prior to the tree removal.

***IMPACT:*** *Overburden removal and mining in the Boundary Expansion Area could increase sediment levels entering Liddell Spring and discharged downstream to Liddell Creek. The project could also reduce the quantity of water in Liddell Spring. Central coast steelhead habitat could be impacted by increased sediment loads in lower reaches of Liddell Creek, and decreased flows.*

# 7.0 Air Quality

## 7.1 ENVIRONMENTAL SETTING

### 7.1.1 Topography and Meteorology

The Bonny Doon Limestone and Shale Quarries are located in Santa Cruz County in the northwest sector of the North Central Coast Air Basin. The basin is dominated by the Santa Cruz Mountains and includes large agricultural, grazing and forested areas, but relatively less industry or urban density compared with the San Francisco Bay Area to the north.

The semi-permanent high-pressure cell in the eastern Pacific is the basic controlling factor in the climate of the air basin. In the summer, the high-pressure cell is dominant and causes persistent west and northwest winds over the California coast. The onshore air current passes over cool ocean water to bring fog and cool air into the coastal valleys. In the fall, the surface winds become weak and occasionally air flow is reversed in a weak offshore movement. During the winter, the Pacific high-pressure cell migrates southward and has less influence on the air basin.

The quarry site is well ventilated even under low wind conditions due to the coastal location and the elevated terrain. Indeed, previous attempts to model the Quarry at various area sources predicted ground level concentrations higher than were actually found in field measurements, which suggests that there is probably a great deal more vertical mixing due to the rugged terrain in the site vicinity and the steep walls of the quarry pit.

The pit has effectively a 100 to 200 percent wall slope at the down-wind perimeter so that emissions generated within the pit mix with the air volume in the pit before being pushed over the quarry rim. When the air mass passes out of the pit, it is pushed up at a 45 to 60 degree angle significantly increasing vertical mixing. The surrounding terrain and dense vegetation increase surface roughness and further increase vertical mixing and more rapid pollutant dilution.

### 7.1.2 Air Pollutants

The principal relevant air pollutants expected to be generated by the Bonny Doon Limestone Quarry Boundary Expansion Project include particulate matter 10 microns in diameter ($PM_{10}$), ozone precursors, and toxic air contaminants (TACs).

#### 7.1.2.1 Particulate Matter ($PM_{10}$ and $PM_{2.5}$)

Particulate matter is solid particles or liquid droplets suspended in the air. Particulate matter may be produced by natural causes or by human activity. $PM_{10}$ consists of "respirable" particulates smaller than or equal to 10 microns in diameter that can cause adverse health effects.

In July 1997, the EPA adopted a new National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$, which represents the "fine" fraction of inhalable particulate matter (particles smaller than or equal to 2.5 microns in diameter), and is primarily a product of combustion. $PM_{2.5}$ causes health problems by penetrating deeply into the lungs, and is responsible for most of the visibility reduction attributable to particulate matter. The EPA has not promulgated enforcement measures for this pollutant class.

In June of 2002, the California Air Resources Board (CARB) adopted new, revised particulate matter standards for outdoor air, lowering the annual $PM_{10}$ standard from 30 µg/m3 to 20 µg/m3 and establishing a new annual standard for $PM_{2.5}$ of 12 µg/m3. The new PM standards became effective in 2003. The North Central Coast Air Basin is currently designated as an attainment area for $PM_{2.5}$.

#### 7.1.2.2 Ozone Precursors: VOC-NOx

Ozone (the main component of "smog") is not emitted directly into the atmosphere but is a secondary air pollutant produced in the atmosphere through a complex series of photochemical reactions involving volatile organic compounds (VOC) and nitrogen oxides (NOx). Ozone is a regional air pollutant because its precursors are transported by wind concurrently with ozone production by the photochemical reaction process.

#### 7.1.2.3 Toxic Air Contaminants (TAC) – Diesel Particulate Matter (DPM)

TAC includes a broad class of compounds with specific toxic or carcinogenic risk. Particulate matter associated with diesel exhaust (DPM) is recognized to pose a hazard to the general population and exposure is associated with increased cancer risk.

### 7.1.3 Existing Ambient Air Quality

In Santa Cruz County, the coastal mountains exert a strong influence on air circulation resulting in generally good air quality. The North Central Coast Air Basin is a non-attainment area for $PM_{10}$: concentrations exceeded the state $PM_{10}$ Ambient Air Quality Standard (AAQS) at MBUAPCD monitoring stations throughout the air basin on 7 days in 2003, 7 days in 2004, 2 days in 2005, and 2 days in 2006 (California Air Resources Board, 2007). There were no recorded violations of the federal $PM_{10}$ 24-hour AAQS at MBUAPCD monitoring stations since 1999.

The North Central Coast Air Basin is a moderate non-attainment area for state ozone AAQS. Based on monitoring data from ambient monitoring stations, ozone concentrations exceeded the state AAQS on 3 days in 2003, 0 days in 2004, 2 days in 2005, and 2 days in 2006. Ozone concentrations exceeded the federal 8-hour ozone standard on 2 days in 2003, 0 days in 2004, 1 day in 2005, and 2 days in 2006 (California Air Resources Board, 2007). These exceedances occurred at the Pinnacles or the Hollister-Fairview Road monitoring stations, downwind from the urban emissions of Monterey/Salinas or the Santa Clara Valley. Although ozone levels at the coastal are low, precursor emissions (VOC and NOx) travel inland and would contribute to elevated ozone downwind.

There have been no recorded violations of the federal or state carbon monoxide AAQS at District monitoring stations.

The air monitoring station nearest to the Bonny Doon project site is at Davenport, 1.6 miles west of the Limestone Quarry. From 2004 through 2006, there were no exceedances of the state NAAQS for ozone (California Air Resources Board, 2007). In the same period, fine particulate matter ($PM_{10}$) exceeded the state 50 ug/m3 24-hour standard two to seven times per year. There were no exceedances of the federal 150 ug/m3 standard. It is likely that some of the exceedances are due to natural particulate matter form ocean surf action or from transient local sources as well as from the nearby CEMEX Portland cement plant. The annual average over this period ranged from 24.3 to 28.6 ug/m3. The state annual $PM_{10}$ standard is 20 ug/m3.

$PM_{2.5}$ data are collected at Santa Cruz-2544 Soquel Avenue. From 2000 through 2002, the average was 8.5 ug/m3 and the 24-hour maximum was 23.3 ug/m3. Santa Cruz County is not in the area recommended to EPA by CARB for $PM_{2.5}$ non-attainment designation (California Air Resources Board 2004).

### 7.1.4 Sensitive Receptors

A sensitive receptor is a location where a population may be exposed to air pollutants. These typically include residences, hospitals, and schools. The nearest sensitive receptors are residences owned by CEMEX adjacent to the northern property boundary and other residences to the northeast and east. See Figure 38, Sensitive Receptors and Table 7-1, Distance to Sensitive Receptors.

The residences to the north are located 830, ~~and~~ 950 and 1,180 feet away from the northern property line and current mining plan boundary. The expansion of the mining plan boundary 400 feet east would not bring operations closer to these northern residences than currently permitted. Five~~Three~~ additional residences are within 2,000 feet of the proposed Boundary Expansion Area (Figure 38). These residences are located between ~~1300~~1,250 feet and ~~1500~~1,520 feet to the northeast and east of the proposed mining boundary on the quarry property.

**Table 7-1**
**Distance to Sensitive Receptors**

| | Parcel | Residence Distance to Existing Mining Area (feet) | Residence Distance to Expanded Mining Area (feet) | Parcel Distance to Expanded Mining Area (feet) |
|---|---|---|---|---|
| CEMEX Parcels | | | | |
| | C1 | NA | NA | 950 |
| | C2 | 1,180 | 1,500 | 600 |
| | C3 | 950 | 900 | Adjoining |
| | C4 | 830 | 980 | 670 |
| | C5 | NA | NA | Adjoining |
| | C6 | NA | NA | 1,100 |
| Residences | | | | |
| | R1 | 1,900 | 1,520 | 1,220 |
| | R2 | 1,850 | 1,410 | 1,060 |
| | R3 | 1,650 | 1,320 | 1,140 |
| | R4 | 1,900 | 1,340 | 1,220 |
| | R5 | 1500 | 1,250 | 1,100 |

Note: NA: Not Applicable, no residence on parcel.
Source: Bowman & Williams, 2001a&b, TRA Environmental Sciences, Inc., 2007. (See Figure 38)

### 7.1.5 Previous Air Quality Studies

#### 7.1.5.1 Bonny Doon Quarries Certificate of Compliance and Reclamation Plan EIR

Air Quality impacts of the Bonny Doon Quarry operations were assessed previously in the Bonny Doon Quarries Certificate of Compliance and Reclamation Plan EIR (County of Santa Cruz 1996a&b). This study incorporated pollutant dispersion modeling by Engineering Science, 1993. Engineering Science and TRA found that the large uncertainty in emissions factors for blasting dominated air pollutant model results. The predicted exceedance of state ambient air for air quality attainment planning and monitors and enforces MBUAPCD, State of California, and federal air quality standards.

The MBUAPCD administers a series of Permits to Operate for the Quarry and its associated cement plant. These permits include the Limestone Quarry Mobile Drill Rig, Shale Quarry System, Mobile Rotary Drill Rig #2, Overland Conveyor System, and Limestone Quarry Crushing and Screening System. The MBUAPCD participates in land use review through the CEQA process, which covers all aspects of air pollution. The off-road heavy equipment involved in site preparation and ongoing mining are not subject to MBUAPCD permits. A modification of the Quarry Permit to Operate existing emissions-producing equipment would not be required for the proposed Boundary Expansion Area. No new emissions-producing equipment are being proposed.

The MBUAPCD regulates TAC through Rule 1000. Construction equipment or processes would not result in significant air quality impacts if they would comply with Rule 1000 (MBUAPCD ~~June~~ February ~~2004~~2008, Guidelines p. 9-3). Rule 1000, however applies to new or modified sources and the proposed project does not trigger that review because it would not result in a net increase in the potential to emit any TAC and no MBUAPCD Authority to Construct or a Permit to Operate is required.

The MBUAPCD Rule 440, Mineral Processing Facilities, was adopted on March 19, 2008. The rule requires that the operator apply due diligence in mitigating the off-site drift of fugitive dust, such that opacity beyond the property line does not exceed five percent for three minutes in any given hour. In addition to standard work practices, the operator would be given discretion to apply specific measures found to be most appropriate for the circumstances to stay within this limit. This would include limiting offsite drift of fugitive dust following blast events. The following requirements apply to the existing operation and proposed project:

**Visible Emissions**

*Visible emissions shall not exceed 5% opacity or equivalent Ringelmann ¼ for a period or periods aggregating more than three minutes in any given hour beyond the property line of the facility.*

***Work Practice Standards***

*The following work practice standards shall be followed:*

- *For all plant operations, including stockpiles, sufficient natural or added moisture shall be contained in process materials to prevent excessive fugitive dust emissions.*
- *Haul roads, access roads, and general plant areas shall be paved, sprayed with chemical stabilizers, kept sufficiently moist, or otherwise maintained to prevent excessive fugitive dust emissions from on and off road equipment.*
- *Limit vehicular speed on unpaved roads to prevent excessive fugitive dust emissions.*
- *Sweep or wash down paved areas, or install wheel washers to reduce track out to prevent excessive fugitive dust emissions.*
- *Control spills in bulk loading areas to prevent excessive fugitive dust emissions.*

### 7.2.4 County of Santa Cruz

The County Mining Regulations 16.54.050 (c)(2) sets forth required conditions and standards for air pollution applicable to the Bonny Doon Quarries. In addition, Use Permit Condition Part III.23 and COC Conditions of Approval III.G.2 through G6 and Conditions III.I through I.5 specify dust control measures and blasting control measures, which affect dust emissions. These measures are summarized in County Plans and Policies, Section 3.0 and fully presented in Appendix B.

## 7.3 PROJECT IMPACTS

### 7.3.1 Thresholds of Significance

A project would normally have a significant effect on the environment if it would violate any ambient air quality standard, contribute substantially to an existing or projected air quality violation, or expose sensitive receptors to substantial pollutant concentrations.

Thresholds for substantial contribution are set by the MBUAPCD and are listed in MBUAPCD CEQA Guidelines (~~June~~ February ~~2004~~2008). The thresholds of significance for the pollutants addressed in this analysis are shown in Table 7-4.

The MBUAPC guidelines recognize the difficulty of accurately estimating fugitive emissions from earth moving and apply general area guidelines as a screening value. In Guidelines Table 5-2, Construction Activity with Potentially Significant Impacts, MBUAPC assumes that up to 8.2 acres may be graded with minimal earthmoving or 2.2 acres may be graded and excavated without exceeding the $PM_{10}$ threshold of significance of 82 lbs/day.

| Table 7-4<br>Thresholds of Significance for Criteria Pollutants of Concern<br>Operational Impacts* | |
|---|---|
| **Pollutant** | **Threshold(s) of Significance** |
| VOC | 137 lb/day (direct + indirect) |
| NOx | 137 lb/day (direct + indirect) |
| $PM_{10}$ | 82 lb/day (on-site)** |
| | AAQS exceeded along unpaved roads (off-site) |
| CO | LOS at intersection/road segment degrades from D or better to E or F or V/C ratio at intersection/road segment at LOS E or F increases by 0.05 or more or reserve capacity at intersection/road segment at LOS E or F decreases by 50 or more. |
| | 550 lb/day (direct)*** |
| SOx | 150 lb/day (direct)** |

Notes:
* Projects that emit other criteria pollutant emissions would have a significant impact if emissions would cause or substantially contribute to the violation of state or national AAQS. Criteria pollutant emissions could also have a significant impact if they would alter air movement, moisture, temperature, climate, or create objectionable odors in substantial concentrations. When estimating project emissions, local or project-specific conditions should be considered.
** MBUAPCD-approved dispersion modeling can be used to refute (or validate) a determination of significance if modeling shows that emissions would not cause or substantially contribute to an exceedance of state and national AAQS.
*** Modeling should be undertaken to determine if the project would cause or substantially contribute (550 lb/day) to exceedance of CO AAQS. If not, the project would not have a significant impact.
Sources: MBUAPCD, ~~2001~~2004. CEQA Guidelines, ~~June~~ February ~~2004~~2008.

If the 82 lbs/day threshold is exceeded, then dispersion modeling can be used to demonstrate that predicted particulate concentrations are below the ambient air quality standards.

The guidelines address non-particulate emissions from construction in section 5.3, Criteria For Determining Construction Impacts: " Construction projects using typical construction equipment such as dump trucks, scrappers, bulldozers, compactors and front-end loaders which temporarily emit precursors of ozone [i.e. volatile organic compounds (VOC) or oxides of nitrogen (NOx)], are accommodated in the emission inventories of State- and federally-required air plans and would not have a significant impact on the attainment and maintenance of ozone AAQS."

The MBUAPCD guidelines address Toxic Air Contaminants, and state that "emissions of a carcinogenic TAC that can result in a cancer risk greater than one incident per 100,000 population are considered significant." (MBUAPCD, op. cit. p. 9-3) This so-called 10 E-5 risk level is for continuous exposure projected over a 70-year lifetime.

### 7.3.2 Site Preparation

The proposed eastward extension of the mining boundary has a site preparation component and a quarrying component. In both cases, heavy equipment is used to strip and transport material and the PM generation potential is similar for both components.

### 7.3.4 Diesel Particulate Toxic Air Contaminant

The original air quality analysis in 1996 was conducted before DPM became regulated as a TAC by the CARB in August 1998 or by the MBUAPCD. The concern for DPM is for its increased cancer potential from long-term exposure. Diesel sources both on- and off-highway is believed to contribute substantially to the overall DPM risk.

A screening level TAC risk from the existing operation was done to estimate the significance of extending the existing DPM TAC for an additional three years. The screening is based on an equipment use inventory and fuel use data supplied by CEMEX and previous air pollutant modeling by Engineering Science, December 1990. Fuel use levels indicate that the heavy equipment operates at a fairly low average power level (25%) compared with conventional earthmoving for construction; this is presumably due to empty travel, loaded travel downhill, and high idle time. The equipment inventory does not indicate age or emissions standards, but based on models listed, most of the equipment is presumed not to meet the newer CARB standards. At a fleet average of 0.20 g/bhp-hr emissions, full operation would produce an estimated 1,733 lbs/year or 7.2 lbs/day of DPM.

Engineering Science used the ISC model assuming flat terrain and normal vertical dispersion to model annual average $PM_{10}$ around the quarry. Engineering Science modeled the full, unmitigated particulate emissions including engine exhaust and fugitive dust for an annual average area source emission of 88,303 lbs/yr, dominated by fugitive dust from unpaved haul roads and blasting. The model results shown in Figure 38 plot a line of equal concentration for 1.0 ug/m3 of $PM_{10}$ stretching around the Quarry and extending to the east, down wind for the prevailing wind at the site. The estimated DPM emissions are 2.0 percent of Engineering Science's annual total $PM_{10}$, so the Engineering Science 1 ug/m3 line corresponds to a modeled DPM concentration of 0.020 ug/m3.

The California Office of Environmental Health Hazard Assessment (OEHHA) has established a unit risk value for DPM as 300 in a million per microgram per cubic meter. The unit risk value is the increased probability of contracting cancer from this specific factor if exposed to an average concentration of one microgram per cubic meter (µg/m3) continuously over a 70-year lifetime. Dividing the ~~unit risk factor by the~~ one in 100,000 MBUAPCD significance criterion by the unit risk factor yields 0.033 ug/m3 as the DPM concentration corresponding to one incident per 100,000. Continuous exposure to DPM concentrations below this level are presumed to pose less than significant incremental risk.

The 1.0 ug/m3 concentration line modeled by Engineering Science in the 1996 EIR corresponds to an exposure of 0.020 ug/m3 DPM, which is slightly less than the significant risk concentration, and the line of Quarry DPM corresponding to the significant risk concentration falls well inside that 1.0 ug/m3 concentration line. Thus, despite the substantial DPM emissions associated with the existing operation, the line of predicted significant DPM TAC risk extends only a short way off-site.

Actual risk is likely to be far less than predicted risk for three reasons:

1. Actual dispersion is greater than modeled dispersion. As discussed above, the DRI field measurements show that the steep pit walls, rugged, heavily vegetated surrounding

terrain, and the strong daytime winds at the site produce far more rapid dispersion and dilution of emissions from the Quarry pit. Although DRI specifically looked at 24-hour samples, the findings are applicable to annual average $PM_{10}$ concentrations in the prevailing downwind direction. The modeled 1ug/m3 line shown on Figure 38 is conservative.

2. DPM emissions will be reduced by regulation in the affected timeframe. Because the proposed project extends future operations in the time frame 2012 to 2015, the DPM emissions would decline as existing equipment is replaced by newer equipment that complies with DPM emissions standards, and because newer fuel regulations would be in full effect. In the future time frame corresponding to project effects, DPM emissions would be between 20 and 40 percent of the present emissions estimate, depending on the rate of equipment replacement.
3. The project would extend operations by only three years. The DPM ~~unit~~cancer risk ~~factor~~ is given in terms of the additional probability that cancer will occur in a person remaining at a single location for 70 years. This risk is the risk over and above existing risks from other causes. For example, a risk of one per 100,000 indicates the individual's added risk of cancer (due to exposure to this source) is one chance in 100,000. ~~is based on a full 70-year lifetime exposure.~~ When the three-year increased project life is factored in (at 3/70 = 4 percent), the future risk level outside the property drops to less than significant.

### 7.3.5 1996 Reclamation Plan Amendment

The proposed amendment to the 1996 Reclamation Plan would modify the target vegetation communities, but not the techniques used to provide final revegetation. The difference in air pollutant emissions would be less than significant.

### 7.3.6 Cumulative Impact

Previous studies examined Quarry emissions along with emissions from other sources (DRI, 1999). Even with the short term increase in emissions from site preparation, the cumulative effect of the proposed Boundary Expansion along with the existing mining operation and other area background sources would not be likely to result in a violation of an ambient air quality standard and would be less than significant.

A complete discussion of Global Climate Change is provided in Section 11.4.3 of the Final EIR.

## 7.4 MITIGATION MEASURES

The following measures reduce the air quality impacts of the project to a less than significant level:

***IMPACT:*** *Site preparation including vegetation clearing and overburden removal would occur in several stages over the initial 2-year period. These activities would result in increased emissions of fugitive dust in addition to existing mining operations.*

**Measure AQ-1:** CEMEX shall limit active work areas for site preparation to less than 8.2 acres for vegetation clearing or 2.2 acres for overburden stripping at any point in time.

Variable noise is described as the level exceeded for a portion of the time. Thus, the L25 is the level exceeded 25 percent of the time during the sample period and L90 is the level exceeded 90 percent of the time and usually corresponds to the background sound level. Section 16.54.050 (c) of the County Mining Regulations specifies a 60dBA L25 hourly limit (See Section 8.2, below). Construction type equipment such as that used at the Quarry produces a fairly steady sound level so that the L25 is not appreciably different than the Leq or average sound level.

#### 8.1.1.3 Attenuation

As a sound wave travels away from the source, the energy is dissipated in space and absorbed by the environment. The impact of a noise source depends on both how inherently loud the source is and how far away the receptor is from the source. For community noise analysis, the inherent loudness of a source is indicated by giving its sound level measured at a reference distance such as 50 or 100 feet from the source; this allows the level at other distances to be calculated.

Theoretically, the sound level drops by 6 dB with each doubling of distance from a stationary noise source. For a roadway line source, attenuation is 3 dB for distance doubling. Over long distances, there is also a loss of 1 dB for each 1,000 feet due to air adsorption.

In actual experience, sound is often more attenuated because of non-reflective ground, intervening dense vegetation, or topographic and structural barriers. With line-of-sight transmission in open country, attenuation proves to be somewhat greater than theoretical loss due to absorption of soft ground and approaches 9 dB per doubling of distance for point sources and 4.5 dB for line sources.

Terrain has a significant attenuating effect. An earth berm such as a hill or the edge or a terrace close to the source and projecting more than 20 feet past the line-of-sight will add as much as 20 dB loss to the attenuation from free-field distance effects. Vegetation absorbs sound in proportion to its density. A thinly planted screen has little attenuation effect, but a 100-foot deep strip of woodland will adsorb 10 to 20 dB of acoustic energy as the tree trunks cumulatively obscure direct transmission and increase sound loss.

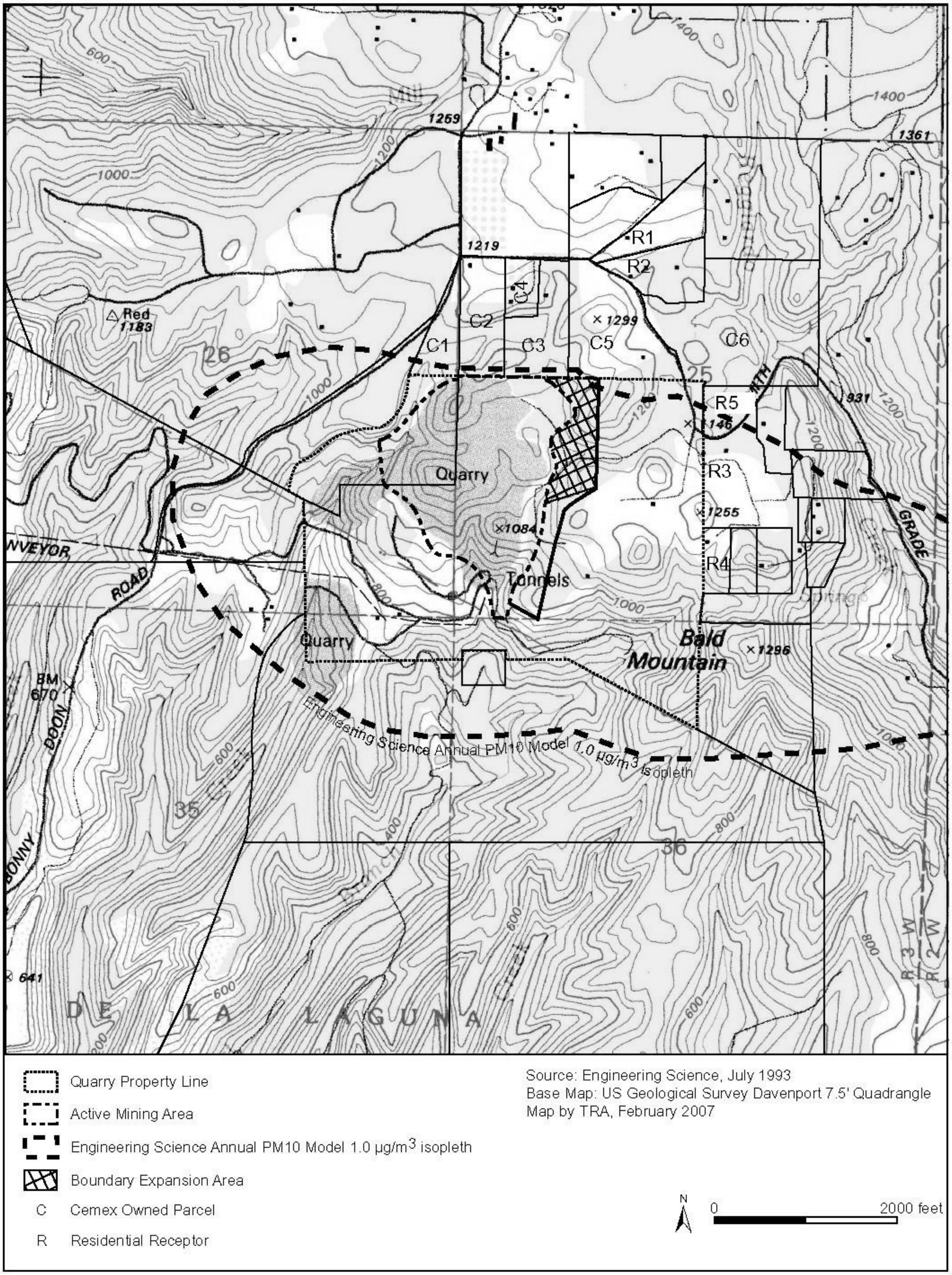
### 8.1.2 Sensitive Receptors

As a whole the quarry is fairly isolated. Figure 38, Sensitive Receptors, shows adjoining parcels within 2,000 feet of the Boundary Expansion Area; parcels are coded “C” to indicate properties owned by CEMEX and “R” to indicate other properties with residences. The distance between these residences and the project are shown in Table 7-1 (above).

The nearest homes (C3, C4) are located off Smith Grade Road north of the quarry, 950 and 830 feet north of the northern property line and current mining plan boundary and 3,500 feet from the crusher. These properties are owned by CEMEX and rented to quarry employees.

Five ~~Four~~ other residences within 2,000 feet of the Boundary Expansion Area are identified on the proposed mining plan and shown in Figure 38. These residences are northeast and east of the current mining plan boundary.

**Figure 38. Sensitive Receptors**



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### 8.1.3 Ambient Noise Levels and Existing Operations

In 2003 and 2006, TRA measured noise levels in project vicinity to confirm the noise analysis in the prior EIR and to corroborate the annual noise monitoring conducted for CEMEX permit compliance. Noise from the current operation at the Limestone Quarry for drilling and blasting, loading and hauling, crushing and conveying activities is part of the baseline condition.

#### 8.1.3.1 Monitoring Results

Annual noise monitoring is conducted by Consultants in Engineering Acoustics (CIEA) since 1997 for CEMEX and submitted to the County of Santa Cruz in the Quarry's annual report. CIEA reported ambient noise levels at the quarry rim when the quarry is inoperative as are typically 37 or 38 dBA, increasing to the range of 50 to 54 dBA when quarry operations commence. CIEA measured individual pieces of equipment and show a consistent noise source (See Table 8-2).

In 1993, 2003, and 2006, TRA measured background noise levels in the project vicinity as very low, typical of a low-density rural setting. In calm weather, ambient noise is below 35 dBA, with wind in the trees, ambient rises to 45 dBA. Noise from human sources includes light vehicular traffic on Bonny Doon and Smith Grade Roads, the Bonny Doon Quarries, and occasional aircraft overflights.

**Table 8-2**
**Limestone Quarry Equipment Noise Levels (Leq)**
**Normalized to a Distance of 50 Feet**

| Equipment Type | Dec 2000 | Dec 2001 | March 2003 | March 2004 | March 2005 |
|---|---|---|---|---|---|
| Bulldozer | 81.0 dBA | 82.0 dBA | Not Measured | Not in Use | Not Measured |
| Front-end loader | 76.7 dBA | 80.0 dBA | 79.9 dBA | 83.3 dBA | 83.1 dBA |
| Hole driller | 88.0* dBA | 81.9 dBA | 69.2-78.9** | 87.6 dBA | Not in Use |
| Rock breaker | Not in use | In repair | 89.5 dBA | 92.5 dBA | 92.1 dBA |
| CAT Haul truck#1 | 83.0 dBA | 78.3 dBA | 78.9 dBA | 85-55 dBA | 85.5 dBA |
| Hitachi shovel | 85.2 dBA | 83.9 dBA | 85.0 dBA | Not in Use | 86.1 dBA |
| CAT Haul truck#2 | Not present | Not present | Not present | Not present | 84.5 dBA |
| Volvo Haul truck#3 | Not present | Not present | Not present | Not present | 78.4 dBA |

* Noise level 50 feet from two drillers operating concurrently. Estimated level from single driller at 50 feet = 85.0 dBA.
** This drill (DM43E) was not in operation last year; the older drill was. The higher noise level was measured on the radiator fan side of the drill system; the lower noise level was on its exhaust side.
Source: Consultants in Engineering Acoustics, 2000 through 2005

#### 8.1.3.2 Excavation

Use permit conditions limit quarry operations to the hours between 7:30 am and 5:00 pm, Monday through Friday. Heavy equipment usually ceases operation at about 3:30 pm each day. The Limestone Quarry is in operation 5 days per week, year round. The Shale Quarry is in operation typically two or three days per week on an as-needed basis. Haul trucks do not travel on public roads.

The major noise sources are the diesel powered heavy equipment used to move overburden and harvest rock. Operating equipment includes two bulldozers (Caterpillar, Model D10), wheeled loaders (Caterpillar Model 988F), several 50-ton trucks (Caterpillar Model 773), two hydraulic drills and a pneumatic rock breaker that operate on the quarry benches in the northern portion of the quarry, and several other pieces of equipment. The crusher and conveyor system are in the southern portion of the quarry.

Typical diesel engines used on D10 bulldozers and in equipment of similar power ratings (400 to 700 bhp) have a sound level of 81 to 85 dBA at 50 feet. Much of the sound comes from the engine fan and exhaust. Mechanical noise from metal-on-metal contact from cat-tracked equipment puts a source at the high end of the scale. A warning back-up beeper is intermittent but adds 3 dB to momentary sound levels and significantly contributes to the audibility of the equipment at a distance. Sound level varies only slightly with load, dropping 5 dB for idling and peaking 4 dB for impact noise and the beeper. The L25 of typical quarry equipment is 82 dBA at 50 feet.

Special equipment is needed to drill holes for blasting and to break rocks too large for the crusher. The drill is similar in noise potential to the conventional heavy equipment. The rock breaker is a pneumatic tool, basically a large jackhammer, mounted on an extensible back hoe type arm. The impact frequency is around one blow per second. The engine and compressor noise are constant at around 82 dBA at 50 feet. The impacts of the breaker are frequent enough to contribute significant acoustical energy so that the L25 is around 95 dBA at 50 feet.

The crusher is a diffuse source producing an ambient sound level of 80 to 85 dBA in the immediate vicinity, with an effective noise strength of 85 dBA at 50 feet, roughly equivalent to a bulldozer. The conveyor line is usually an insignificant noise source, less than 60 dBA at 50 feet with an occasional louder noise from a bad roller bearing.

#### 8.1.3.3 Blasting

Blasting is a special case, not readily analyzed in the context of the Mining Regulations noise limitation. None of the sound sources associated with blasting last as long as 15 minutes in the hour. Blasting operations consist of a single blast two days per week scheduled at 11:30 a.m. or 3:30 p.m. Prior to detonation of the explosives; the two nearest neighbors are called. At 15 minutes and then 5 minutes before detonation, the warning siren above the crusher sounds two or three times. The warning siren sounds for 9 seconds and has a source strength of 105 dBA at 100 feet. This produces a level of 84 dBA at the northern property line and is audible well off-site. This high sound level is needed for safety to alert the work area and must be audible to workers with heavy equipment who may be in high noise environments.

The explosion itself is only of about 0.25 second duration. The three or four tons of explosive produce an intense, low frequency ground shock with only minor airborne sound energy. The A-weighted measurements referenced in the Mining Regulations do not apply to explosions because they are a short impulse source and contain predominantly low-frequency noise too low to hear. The audible noise varies from blast-to-blast with some louder and less muffled by the depth of the charges and the pit faces. At a distance of 1,000 feet the sound of a blast is similar to the sound of a single handclap across a room.

As required under the existing permit, the quarry monitors each blast with a seismograph at the quarry and, occasionally, at neighboring residences. A qualified professional consultant to the quarry reviews the data and provides a summary report each year. Conclusions each year have been consistent: provided that no major changes are made to the blast design or procedures, there is no risk of any blast-related damage to structures located beyond the boundaries of the quarry. This conclusion is based on maximum vibration and air blast levels established by Federal regulations for residential structures.

However, neighbors of the Limestone Quarry do hear and feel blasts. In 2004 several blast–related complaints were received by the Planning Department, for example. Based on the annual report for 2004 the maximum-recorded ground vibration, while in the distinctly perceptible range based on studies of human response to blast vibration, was still a factor of 15 below the Federal level for residential structures.

#### 8.1.3.4 Sound Levels Off-site

Under current operations, sensitive receptors are not significantly affected by quarry operations. According to annual monitoring, noise levels at the Limestone Quarry north property

GP/LCP Policy 6.9.1 on Land Use Compatibility Guidelines is a guide to potential significance of off-site impact.

> Require new development to conform with the Land Use Compatibility Guidelines (Figure 6-1). All new residential and noise sensitive land developments should conform to a noise exposure standard of 60dB Ldn (day/night average noise level) for outdoor use and 45dB Ldn for indoor use. New development of land, which cannot be made to conform to this standard, shall not be permitted. Assure a compatible noise environment for various land uses through site planning, building orientation and design, interior layout, and physical barriers, landscaping, and buffer areas where appropriate.

## 8.3 PROJECT IMPACTS

### 8.3.1 Thresholds of Significance

According to Appendix G of the CEQA Guidelines, a project will normally have a significant effect on the environment if it will result in:

- Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies. Section 16.54.050 (c) of the County Mining Regulations (60 dBA for a cumulative period of 15 minutes during any hour of operation i.e. L25) and General Plan Policy 6.9.1 Land Use Compatibility Guidelines (60 dB Ldn) serve as the principal standards of significance.
- Exposure of ~~persons~~ structures to or generation of excessive ~~groundborne vibration or groundborne noise levels~~ air blast or ground vibration exceeding Federal standards for residential structures (30CFR816.67). Essentially, the maximum ground vibration shall not exceed one inch per second at any dwelling;
- ~~A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project;~~
- ~~A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project;~~

### 8.3.2 Site Preparation

Vegetation clearing and overburden removal in the Boundary Expansion Area prior to the start of mining would commence at grade, level with adjoining properties and thus would not have acoustic shielding by the quarry rim for at least several months during the two-year site preparation period. Noise from this preparation stage would be comparable to routine earthmoving for construction and would be audible at distances of 1,000 feet.

Receptor parcels C3 and C5 are located along the northern quarry property boundary. Noise levels on the portion of these parcels immediately adjoining the Boundary Expansion Area would routinely exceed 75 dBA during site preparation activities. This is above the 60 dBA L25 standard set forth in Mining Regulation 16.54.050(d).

As overburden is removed, the heavy equipment activity would gradually drop below the newly forming rim of the quarry and noise levels at the property line would fall. Once overburden removal is complete and the upper bench of the expanded quarry pit is established, the noise level of the mining operation would again comply with 60 dBA standard at the property line.

The five four easterly residences (R1-R54) are now 1,500 1,650 to 1,900 feet from active mining; the project would reduce that distance by 300 to 400 feet or roughly 20 percent of the present distance. Theoretically, the decrease in sound attenuation due to reducing distance by 20 percent is 2 to 3 dB; this level of increase is not usually considered significant. Because of the distance and shielding effect of the quarry configuration, these four easterly residences would not be significantly affected by noise from expanded quarry operations.

Provided that no major changes are made to the blast design or procedures, there is no risk of any blast-related damage to structures located beyond the boundaries of the quarry. Based on the results of current monitoring, which indicates vibration levels are well below federal standards, this conclusion is not expected to change during mining of the Boundary Expansion Area.

With the expansion project, the Quarry would continue mining both the Shale and Limestone Quarries at their current rates; there would be no change in equipment or intensification of operations. Mining the 17.1-acre Boundary Expansion Area would add approximately three years of additional life to the quarry operation, effectively in the time frame from 2012 to 2015. Although this extends the ongoing impact of the Quarry, monitoring has shown that the current operation meets Mining Regulation noise standards and the noise impact of extending the Quarry operating life is less than significant.

CEMEX implements several noise control measures in accordance with the COC Conditions of Approval (see Appendix B, COC Conditions III.H.1 through III.H.3). These measures include locating the rock breaker more than two levels below the quarry rim, maintaining vehicles and equipment in proper order, and notifying nearby neighbors prior to blasting. These conditions would be applied to the mining operations in the Boundary Expansion Area through project amendment of the COC.

### 8.3.4 1996 Reclamation Plan Amendment

The proposed amendment to the 1996 Reclamation Plan would modify the target vegetation communities, but not the techniques used to provide final revegetation. The difference in noise impacts would be less than significant.

### 8.3.5 Cumulative Impact

There is no significant cumulative noise impact. The noise produced by site preparation would be superimposed on the noise from the ongoing Quarry operation. The excavation equipment acts as point sources operating in a broad area. The sound level perceived at a source is determined mainly by the sound of the loudest, and in this case, the closest equipment. The impacts of site preparation would dominate the immediate surroundings and the additional noise from ongoing quarry operation would not be appreciable.

Noise from operation of the Expanded Mining Area would not add to noise from increased traffic, construction, or habitation that would result from foreseeable development in the Bonny Doon planning area.

## 8.4 MITIGATION MEASURES

None required.

# 10.0 PROJECT ALTERNATIVES

CEQA Guidelines Section 15126.6 states that and EIR shall describe a range of reasonable alternatives to a project or location of the project which, would feasibly attain most of the basic objectives of the project but would avoid or substantially ~~lesson~~ lessen any of the significant effects of the project. The discussion of alternatives is to focus on alternatives that are capable of avoiding or substantially reducing any significant effects of the project even if these alternatives would impede to some degree the attainment of the project objectives. Factors that may be taken into account when considering feasibility are site suitability, economic viability, availability of infrastructure, general plan consistency, other plans or regulatory limitations, jurisdictional boundaries and whether the proponent can reasonably acquire, control or otherwise have access to the alternative site.

## 10.1 CONSIDERED AND REJECTED ALTERNATIVES

Several potential alternatives have been identified and rejected from further consideration in the Project Alternative analysis due to infeasibility, not achieving project objectives, or not avoiding or substantially lessening environmental impact. These alternatives include Alternative Project Locations, Full Boundary Expansion, Modified Legal Mining Limit, and Reduced Boundary Expansion Area. In addition, a Modified Overburden and Spoils Disposal Alternative was considered and ultimately accepted as project mitigation.

### 10.1.1 Alternative Project Locations

Alternative unmined project locations are infeasible because the nature of the project is mineral resource extraction, which ties the project location to where the limestone marble occurs. Also, CEMEX does not have vested mining rights in other locations. An alternative existing quarry location is the San Vicente Limestone Quarry. The San Vicente Quarry is owned by CEMEX and ceased operations approximately 35 to 40 years ago when mining commenced in the Bonny Doon Quarries. The 1964 use permit (1941-U) for San Vicente Quarry authorizes the continuation of mining of limestone; however a Certificate of Compliance and Reclamation Plan approval is required pursuant to SMARA and the County Mining Regulations in order to reactivate mining. A Mining Approval may also be required depending on the effect of the significant time lapse on any vested rights. Reactivation of the San Vicente Quarry would be subject to new environmental review under CEQA. The status of limestone resources in the previously permitted quarry and the transportation corridor (rail line) between the quarry and the cement plant has not been studied. Due to these factors, the reactivation of the San Vicente Limestone Quarry is not a feasible alternative for the Bonny Doon Limestone Quarry Boundary Expansion EIR.

### 10.1.2 Full Boundary Expansion Alternative

Full boundary expansion, or mining all remaining 26.5 acres of the vested rights area, was initially considered by CEMEX at project application but was rejected in favor of the proposed 17.1 acre project in order to reduce or avoid potential water quality and water quantity impacts to Liddell Spring. This larger full boundary expansion alternative does not reduce any environmental impact of the project and therefore does not meet the CEQA purpose of a project alternative.

### 10.1.3 Modified Legal Mining Limit Alternative

Modifying the Legal Mining Limit of the Limestone Quarry to expand operations toward the north is infeasible due to general plan and zoning constraints of the adjacent properties; the Quarry does not have vested mining rights outside of the established Legal Mining Limit.

### 10.1.4 Reduced Boundary Expansion Area Alternative

Reducing the size of the Boundary Expansion Area to less than the proposed 17.1 acres would offer less than the 3-year extension of quarry life provided by the project. This reduction in quarry life is not practical for the quarry operation. Additional slope stability analysis is required as project mitigation (Measure GEO-2). If the analysis shows that the minimum factor of safety ~~of 1.2~~ cannot be met, the slope gradient must be reduced until the minimum safety factor is achieved. Any reduction in slope gradient would reduce the 3-year extension of quarry life. A Reduced Boundary Expansion Area coupled with a reduced slope gradient (if determined to be necessary) would so reduce the quarry life extension as to make the project infeasible.

### 10.1.5 Modified Overburden and Spoils Disposal Alternative

Modifying the proposed placement of overburden and spoils on the quarry floor was considered during the environmental review for the purpose of reducing water quality impacts to Liddell Spring. As currently designed, the proposed expansion would dispose of quarry overburden and spoils by placing them in the western half of the existing quarry pit. Because of the depth of this fill (approximately 250 feet), the material would likely compact over time, ultimately inhibiting percolation of runoff into the karst system on the portion of the quarry floor covered by the overburden. This, in turn, would reduce the amount of water flowing into Liddell Spring. Fines from the overburden and spoils fill area would also be washed into the karst system, impairing water quality at the spring. As an alternative to the proposed fill design, overburden and spoils could be placed across the entire quarry floor at a depth of approximately 15 feet to retain and slowly infiltrate drainage from the quarry pit into the karst aquifer. This approach would enable the overburden to be constructed as a filter for percolating surface water. This modified design to overburden disposal was determined to be feasible and was adopted as project mitigation (Measure HYD-1).

## 10.2 NO PROJECT ALTERNATIVE

Under the No Project Alternative, the Use Permit amendment, COC amendment, Coastal Development Permit, and the proposed 1996 Reclamation Plan Amendment would be denied. The limestone reserves within the Boundary Expansion Area of the Legal Mining Limit of the quarry would not be mined. The 1996 Reclamation Plan as conditionally approved in 1997 would remain in effect. Quarry life would not be extended by three years. The Limestone Quarry ~~has~~ is within a few years of reaching~~ed~~ its final contours under the existing approved mining plan perimeter. Therefore, the denial of permits under the No Project Alternative would result in closure of the quarry~~ and likely closure of the associated cement plant in Davenport~~.

**County Plans and Policies**

The proposed Boundary Expansion Area is located within the Legal Mining Limit, and CEMEX's right to mine the Boundary Expansion Area is protected under vested rights. The County's authority to restrict the proposed mining expansion into the Boundary Expansion Area is limited to public health and safety concerns. Unless the proposed project causes public harm that cannot be abated, denying the Limestone Quarry expansion under the No Project Alternative is not a legally viable option for the County to consider.

The Quarry operations are subject to applicable GP/LCP policies, Mining Regulations, Use Permit 323~~2~~6-U Conditions, and COC Conditions of Approval. The proposed project requires mitigation (see Section 3.4) to be compliant with these regulations. Under the No Project Alternative, the non-compliant conditions would not occur and mitigation would not be necessary.

**Geology**

Under the No Project Alternative, the Limestone Quarry pit would not be expanded by 17.1 acres. The north wall of the quarry, which has shown some area of instability, would not be expanded. Waste material from the Boundary Expansion Area would not be placed in the quarry pit along the west wall. The new fill placed on the quarry floor would not stabilize slopes subject to landsliding on the west wall. Increased erosion sedimentation impacts related to the overburden removal in the mining Boundary Expansion Area would not occur. ~~The potential for increased sediment loads to be released downstream in the event of seismic failure of the sediment basin levees would also be eliminated.~~ The seismic shaking and seismic ground deformation impacts (surface rupture, liquefaction, landsliding) are not increased by the project and would remain the same under the No Project Alternative. Protective measures to avoid renewed movement of the Liddell Spring landslide and updating the seismic stability analyses for the sediment basins would ~~not be implemented~~ remain the same under the No Project Alternative. Potential project impacts on geology are reduced to less-than-significant through mitigation. Under the No Project Alternative, the project's less than significant geologic impacts would be eliminated.

**Hydrology**

Under the No Project Alternative, mining operations would not expand beyond the present mining plan boundary. No vegetation clearance or overburden removal would occur on the 17.1 project acres. There would be no increase in storm runoff volumes generated by the quarry. Sediment loads in the storm drainage entering the quarry sediment basins would not be increased. New sediment loads would not enter the ground water system potentially increasing the turbidity levels of Liddell Spring. Impacts to water quality and quantity of Liddell Spring would not be increased above existing conditions. ~~Any new agreements between the City of Santa Cruz and CEMEX to protect or improve water quality at Liddell Spring may not occur. Project m~~Mitigation Measures HYD-1 and 2, which are designed to avoid and reduce turbidity impacts at Liddell Spring to a less than significant level would not be implemented. Implementation of HYD-3, which compensates the City of Santa Cruz pursuant to the terms of an existing agreement, would remain the same under the No Project Alternative. ~~Potential project impacts on hydrology and water quality are reduced to less-than-significant through mitigation.~~ The project's less than significant water quality and water quantity impacts to Liddell Spring or water quality impacts to downstream Liddell Creek would not occur.

**Biology**

Under the No Project Alternative, the 17.1 acres of forest and scrub habitat would not be removed. There would be no loss of biological resources. No loss of habitat or potential harm to the San Francisco dusky-footed woodrat, a California species of special concern, would occur. Raptors, non-game birds and bat species of concern, which could nest in the area, would not be impacted. Potential project impacts upon wildlife species are potentially significant but reduced through mitigation. Under the No Project Alternative, these less than significant impacts would be eliminated.

With denial of the 1996 Reclamation Plan Amendment, the planting strategy specified in the approved 1996 Reclamation Plan would remain in effect.~~and would continue into the future. The existing efforts to plant climax vegetation would continue as required with limited success due to harsh undeveloped soil conditions. Native topsoil is available for approximately 12 acres, which would still be planted with diverse native grassland as currently planned by CEMEX. The 1996 revegetation requirements for northern maritime chaparral, needlegrass grassland, mixed grassland, central coast scrub, riparian forest, and redwood forest would be met by the success of previous and current revegetation work (Table 6-1). The 1:1 replacement requirement for 46 acres of mixed evergreen forest would remain in effect. However, revegetation efforts to establish this climactic plant community can only be successful after years of soil development that may not occur until after the reclamation planting period is completed~~. The 1996 Reclamation Plan Amendment incorporates a strategy of establishing earlier successional stages of vegetation in order to build the soil and would likely show better success in establishing climax forest vegetation in reclaimed areas over time. Under the No Project Alternative this strategy in the 1996 Reclamation Plan Amendment would not be implemented.

**Air Quality**

Under the No Project Alternative, mining operations would continue until the final mining configuration of the current mining plan boundary is achieved. Dust and equipment emissions generated by current mining operations would continue until operations cease. The quarry life would not be extended by approximately three years and therefore the air pollutant emissions associated with the quarry operation would not be prolonged. The additional emissions associated with the removal and transport of overburden from the mining Boundary Expansion Area would not occur. The source location of air pollutant emissions within the quarry would remain within the same boundary and would not shift by several hundred feet to the east. The project would not lead to a projected violation of an ambient air quality standard or a significant adverse impact beyond the Quarry property boundary, as long as the active work areas remain below the acreage limits set by the Monterey Bay Unified Air Pollution Control District as identified in Measure AQ-1. Therefore, under the No Project Alternative, the project's less than significant air quality impacts would be eliminated.

**Noise**

Under the No Project Alternative, mining operations would not expand into the northeast corner of its vested rights mining area. Mining occurs within 25 feet of the northern property boundary. Elevated noise levels along the property line would continue as they presently occur and would not be increased. The potential noise increase from the project is not significant, and would be approved by the Planning Commission as permissible by the Mining Regulations (see Measure NOI-1). Under the No Project Alternative, the less than significant noise impact would not occur.

**Energy and Natural Resources**

Under the No Project Alternative, mining operations would not expand and 17.1 acres of timberland resources would not be removed. The loss of this timberland resource by the proposed project is not considered a significant impact, and does not require mitigation. Therefore, under the No Project Alternative, the project's less than significant impact on Natural Resources would be eliminated.

## 10.3 ENVIRONMENTALLY SUPERIOR ALTERNATIVE

CEQA requires that the EIR analysis of project alternatives identify an "environmentally superior" alternative. If the environmentally superior alternative is the "No Project" alternative, the EIR shall also identify an environmentally superior alternative from among the other alternatives. The No Project Alternative eliminates the environmental impacts associated with the project and is the environmentally superior alternative. Although the No Project Alternative does not achieve the project objective of continuing the limestone mining operation, as explained above in Considered and Rejected Alternatives, there are no other Project Alternatives available to the Quarry that can meet the project objectives.

within the Legal Mining Limit. This expansion would cumulatively add to the project's impact on the San Francisco dusky-footed woodrat, steelhead, coastal sage scrub and oak woodland. Mitigation measures identified in the EIR (Section 6.4) reduce the project impacts on biological resources to a less than significant level. Similar mitigation applied to the future mining in the remaining 9.4 acres would also reduce the cumulative impacts on these biological resources to a less than significant level. There are no other projects in the Bonny Doon Planning Area identified by the County that would significantly add to cumulative biological impacts of the Bonny Doon Quarries Expansion Project. As a result, there are no significant cumulatively considerable impacts associated with the project.

**Air Quality.** The proposed project is consistent with land use designations in the GP/LCP. In compliance with CEQA Section 15183, the cumulative air quality impacts of the project have been addressed by the EIR for the GP/LCP and do not need to be discussed further.

**Global Climate Change**

Global climate change is a problem caused by combined worldwide greenhouse gas emissions, and mitigating global climate change will require worldwide solutions. Greenhouse gases (GHGs) play a critical role in the Earth's radiation budget by trapping infrared radiation emitted from the Earth's surface, which could have otherwise escaped to space. Prominent GHGs contributing to this process include water vapor, carbon dioxide ($CO_2$), nitrous oxide ($N_2O$), methane (CH4), ozone, and certain hydro- and fluorocarbons. This phenomenon, known as the "greenhouse effect" keeps the Earth's atmosphere near the surface warmer than it would be otherwise and allows for successful habitation by humans and other forms of life. Increases in these gases lead to more absorption of radiation that warm the lower atmosphere further, thereby increasing evaporation rates and temperatures near the surface. Emissions of GHGs in excess of natural ambient concentrations are thought to be responsible for the enhancement of the greenhouse effect and to contribute to what is termed "global warming", a trend of unnatural warming of the Earth's natural climate. Climate change is a global problem, and GHGs are global pollutants, unlike criteria air pollutants (such as ozone precursors) and TACs, which are pollutants of regional and local concern.

The Intergovernmental Panel on Climate Change (IPCC) has been established by the World Meteorological Organization and United Nations Environment Programme to assess scientific, technical and socio- economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. The IPCC predicts substantial increases in temperatures globally of between 1.1 to 6.4 degrees Celsius (depending on scenario) (IPCC 2007a).

Climate change could impact the natural environment in California in the following ways, among others:

- Rising sea levels along the California coastline, particularly in San Francisco and the San Joaquin Delta due to ocean expansion;
- Extreme-heat conditions, such as heat waves and very high temperatures, which could last longer and become more frequent;
- An increase in heat-related human deaths, infectious diseases and a higher risk of respiratory problems caused by deteriorating air quality;

- Reduced snow pack and stream flow in the Sierra Nevada Mountains, affecting winter recreation and water supplies;
- Potential increase in the severity of winter storms, affecting peak stream flows and flooding;
- Changes in growing season conditions that could affect California agriculture, causing variation in crop quality and yield; and
- Changes in distribution of plant and wildlife species due to changes in temperature, competition from colonizing species, changes in hydrologic cycles, changes in sea levels, and other climate-related effects.

These changes in California's climate and ecosystems are occurring at a time when California's population is expected to increase from 34 million to 59 million by the year 2040 (California Energy Commission [CEC] 2005). As such, the number of people potentially affected by climate change as well as the amount of anthropogenic GHG emissions expected under a "business as usual" scenario are expected to increase. Similar changes as those noted above for California would also occur in other parts of the world with regional variations in resources affected and vulnerability to adverse effects.

Climate change is a global problem, and GHGs are global pollutants, unlike criteria air pollutants (such as ozone precursors) and Toxic Air Contaminants, which are pollutants of regional and local concern. Worldwide, California is the 12th to 16th largest emitter of $CO_2$ (CEC 2006), and is responsible for approximately 2% of the world's $CO_2$ emissions (CEC 2006).

GHG emissions in California are attributable to human activities associated with industrial/manufacturing, utilities, transportation, residential, and agricultural sectors (CEC 2006) as well as natural processes. Transportation is responsible for 41% of the state's GHG emissions, followed by the industrial sector (23%), electricity generation (20%), agriculture and forestry (8%) and other sources (8%) (CEC 2006). Emissions of $CO_2$ and $N_2O$ are byproducts of fossil fuel combustion, among other sources. Methane, a highly potent GHG, results from off-gassing associated with agricultural practices and landfills, among other sources. Sinks of $CO_2$ include uptake by vegetation and dissolution into the ocean. California GHG emissions in 2002 totaled approximately 491 million metric tons of $CO_2$ eq.

No inventory of emissions has been completed to date for Santa Cruz County. Sources of greenhouse gas emissions in Santa Cruz County include (but are not limited to): on road vehicles; offroad vehicles and equipment (construction, agriculture, water pumps, etc.); electricity consumption (resulting in indirect emissions at electricity generation locations); natural gas consumption (for heating and other uses); industrial processes; release of certain commercial and vehicle refrigerants; methane from landfill activity (indirect contributions due to waste disposal); and loss of carbon sinks (like forests that absorb carbon dioxide) due to conversion.

Regulatory Setting

The current regulatory setting related to climate change and GHG emissions is summarized below.

*Federal Regulations*

Twelve U.S. states and cities (including California), in conjunction with several environmental organizations, sued to force the U.S. Environmental Protection Agency (EPA) to regulate GHGs as a pollutant pursuant to the Clean Air Act (Massachusetts vs. Environmental Protection Agency et al. [U.S. Supreme Court No. 05–1120. Argued November 29, 2006 – Decided April 2, 2007]. The court ruled that the plaintiffs had standing to sue, that GHGs fit within the CAA's definition of a pollutant, and that the EPA's reasons for not regulating GHGs were insufficiently grounded in the CAA.

Despite the Supreme Court ruling, there are no promulgated federal regulations to date limiting greenhouse gas emissions. However, the EPA posted an advance notice of proposed rulemaking (ANPR) on July 30, 2008 in the Federal Register that presents information relevant to, and solicits public comment on, how to respond to the U.S. Supreme Court's decision in Massachusetts v. EPA. In view of the potential ramifications of a decision to regulate GHGs under the CAA, the notice reviewed the various CAA provisions that may be applicable to regulate GHGs, examined the issues that regulating GHGs under those provisions may raise, provided information regarding potential regulatory approaches and technologies for reducing GHG emissions, and raised issues relevant to possible legislation and the potential for overlap between legislation and CAA regulation. In addition, the notice described and solicited comment on petitions the EPA had received to regulate GHG emissions from ships, aircraft and non-road vehicles such as farm and construction equipment. Finally, the notice discussed several other actions concerning stationary sources for which EPA had received comment regarding the regulation of GHG emissions.

*State Regulations*

California Executive Order S-3-05 established the following greenhouse gas emission reduction targets for California:

- by 2010, reduce GHG emissions to 2000 levels;
- by 2020, reduce GHG emissions to 1990 levels; and
- by 2050, reduce GHG emissions to 80 percent below 1990 levels.

California Assembly Bill (AB) 1493 required ARB to develop and adopt the nation's first greenhouse gas emission standards for automobiles. The legislature declared in AB 1493 that global warming was a matter of increasing concern for public health and environment in the state. It cited several risks that California faces from climate change, including reduction in the state's water supply, increased air pollution creation by higher temperatures, harm to agriculture, and increase in wildfires, damage to the coastline, and economic losses caused by higher food, water energy, and insurance prices. Further the legislature stated that technological solutions to reduce greenhouse gas emissions would stimulate California economy and provide jobs.

California AB 32, the Global Warming Solutions Act of 2006, codifies the State's GHG emissions target by requiring the State's global warming emissions be reduced to 1990 levels by 2020 and directs ARB to enforce the statewide cap that would begin phasing in by 2012. AB 32 was signed and passed into law by Governor Arnold Schwarzenegger on September 27, 2006. Key AB 32 milestones are as follows:

- June 30, 2007 – Identification of "discrete early action greenhouse gas emissions reduction measures."

- January 1, 2008 – Identification of the 1990 baseline GHG emissions level and approval of a statewide limit equivalent to that level. Adoption of reporting and verification requirements concerning GHG emissions.
- January 1, 2009 – Adoption of a scoping plan for achieving GHG emission reductions.
- January 1, 2010 – Adoption and enforcement of regulations to implement the "discrete" actions.
- January 1 2011 – Adoption of GHG emission limits and reduction measures by regulation.
- January 1, 2012 – GHG emission limits and reduction measures adopted in 2011 become enforceable.

CARB identified early actions in its April 20, 2007 report:

- Group 1 - Three new GHG-only regulations are proposed to meet the narrow legal definition of "discrete early action greenhouse gas reduction measures" in Section 38560.5 of the Health and Safety Code. These include the Governor's Low Carbon Fuel Standard (adopted on April 23, 2009), reduction of refrigerant losses from motor vehicle air conditioning maintenance, and increased methane capture from landfills. These actions are estimated to reduce GHG emissions between 13 and 26 million metric tons of carbon dioxide-equivalent ($MMTCO_2$ eq) annually by 2020 relative to projected levels. If approved for listing by the Governing Board, these measures will be brought to hearing shortly and take legal effect by January 1, 2010. When these actions take effect, they would influence GHG emissions associated with vehicle fuel combustion and air conditioning, but would not affect project implementation. Thus, the project is consistent with these measures.
- Group 2 - ARB is initiating work on another 23 GHG emission reduction measures in the 2007-2009 time period, with rulemaking to occur as soon as possible where applicable. These GHG measures relate to the following sectors: agriculture, commercial, education, energy efficiency, fire suppression, forestry, oil and gas, and transportation.
- Group 3 - ARB staff has identified 10 conventional air pollution control measures that are scheduled for rulemaking in the 2007-2009 period. These control measures are aimed at criteria and toxic air pollutants, but will have concurrent climate co-benefits through reductions in $CO_2$ or non-Kyoto pollutants (i.e., diesel particulate matter, other light-absorbing compounds and/or ozone precursors) that contribute to global warming.

Many of these measures have not yet been adopted. Some proposed measures will require new legislation to implement, some will require subsidies, some have already been developed, and some will require additional effort to evaluate and quantify. Applicable early action measures that are ultimately adopted from Groups 2 and 3 will become effective during implementation of the proposed project.

*Local Regulations*

The Monterey Bay Unified Air Pollution Control District (MBUAPCD) presently has no guidance concerning CEQA evaluation of greenhouse gas emissions and no regulatory requirements.

Significance Criteria

Under CEQA, an environmental impact report must identify and focus on the significant environmental effects of a proposed project. Significant effect on the environment means a substantial, or potentially substantial, adverse change in the environment (Public Resources Code § 21068). CEQA further states that the CEQA guidelines shall specify certain criteria that require a finding that a project may have a significant effect on the environment. However, as of the writing of this Final EIR, the agencies with jurisdiction over air quality regulation and GHG emissions such as the ARB and the MBUAPCD have not established regulations, guidance, methodologies, significance thresholds, standards, or analysis protocols for the assessment of greenhouse gas emissions and climate change. Thus, the methodology to establish an appropriate baseline, to develop a project-level inventory for the program, or to evaluate the significance of GHG emission changes has not yet been established that would allow for an specific analysis of the impact of the program on climate change. However, it is addressed here to provide disclosure of potential impacts.

Cumulative Impact Analysis

The analysis examines overburden removal and project operational emissions in isolation first and then total project emissions in a cumulative context.

Overburden removal would result in GHG emissions from the following mining-related sources: (1) heavy equipment emissions during overburden removal; (2) emissions from worker's vehicles traveling to and from the mine site during overburden removal; (3) mining equipment emissions during mining operations; and (4) emissions from blasting during mining operations. The primary emissions occur as $CO_2$ from diesel and gasoline combustion, with more limited vehicle tailpipe emissions of nitrous oxide and methane as well as other GHG emissions related to vehicle cooling systems.

While globally, climate change is, by any definition, a significant cumulative environmental impact and the impacts of climate change on California human and natural systems could also be significant, as noted above, there currently is no agreed-upon methodology to adequately identify, under CEQA, when project-level GHG emissions contribute considerably to this significant cumulative impact. Thus, at this time, it would be speculative to determine if the potential GHG emissions associated with the Bonny Doon Limestone Quarry Boundary Expansion Project would or would not contribute considerably to this significant cumulative impact. However, the project offers the following GHG emission reduction features.

Project and Applicant Greenhouse Gas Emission Reduction Features

Table 11-1 identifies several management practices already being implemented by Cemex and a number of features included in the proposed project that would help to reduce future greenhouse gas emissions.

## Table 11-1
## Applicable Global Climate Change Strategies

| Strategies for Reducing Greenhouse Gas Emissions[1] | Conformance |
|---|---|
| Vehicle Climate Change Standards. AB 1493 (Pavley) required the state to develop and adopt regulations that achieve the maximum feasible and cost-effective reduction of climate change emissions emitted by passenger vehicles and light duty trucks. Regulations were adopted by the CARB in September 2004. | Following project approval, the majority of the vehicles that access the project would be expected to be in compliance with any vehicle standards that CARB adopts. |
| Other Light Duty Vehicle Technology. New standards would be adopted to phase in beginning in the year 2017 model year. | The proposed project would likely be completed by 2017; and therefore, would no longer be operational during the implementation of such technology. |
| Diesel Anti-Idling. In July 2004, the CARB adopted a measure to limit diesel-fueled commercial motor vehicle idling. | All vehicles, including heavy diesel equipment operating at the project site, would be subject to the CARB measures and would be required to adhere to the 5-minute limit for vehicle idling. |
| Measures to Improve Transportation Energy Efficiency. Builds on current efforts to provide a framework for expanded and new initiatives including incentives, tools and information that advance cleaner transportation and reduce climate change emissions. | The project promotes fuel conservation by providing a continued local source of limestone for use in cement production. Trucking or rail hauling of limestone ore from out of county would increase the production of greenhouse gasses. |
| Afforestation/Reforestation. Preserving and restoring open space would comply with this strategy. | The Mitigated 1996 Reclamation Plan Amendment would reclaim both the Bonny Doon Limestone and Shale quarries through the planting of primarily Northern Coastal Scrub and Mixed Evergreen Forest. A total of 322 acres would be reclaimed as part of the mining reclamation plan upon closure. |
| Forest Management. Strategies for storing more carbon through forest management activities can involve a range of management activities such as increasing either the growth of individual trees, the overall age of trees prior to harvest, or dedicating land to older aged trees. With roughly 4 million acres of private managed forestland in California, changes in forest management can produce significant amounts of climate change emission reduction benefits for the state. | The project applicant currently implements a sustainable forestry management program that is situated on approximately 9,000 acres of land adjoining the Bonny Doon Limestone Quarry. The forestry management program includes selective timber harvesting and planting of 20,000 redwood seedlings each year. Harvesting select mature trees when their growth rate declines to make room for faster-growing younger trees helps absorb carbon; and reduces the threat of catastrophic wildfire by removing excessive trees from overcrowded forests. The forestlands managed by the applicant have received accredited certifications from the Forest Stewardship Council (FSC). The Forest Stewardship Council is an international, independent, non-profit organization that promotes responsible forestry. FSC Certification is awarded when an independent evaluation of a forest company's practices meets the highest standards for environmentally and socially responsible forestry. A summary of the CEMEX sustainable management practices is provided below.<br>• Extensive timber stand improvement projects have been implemented in Santa Cruz County by the applicant.<br>• The applicant harvests less than half of the new growth. Light cuts (30-35%) are conducted every 15 to 17 years, which is less than the regulatory threshold allowance of 60% cuts.<br>• The applicant has planted over one million seedling conifer trees within Santa Cruz County.<br>• The applicant's managed forestlands are SmartWood Certified as a sustainable forest in accordance with the strict standards under the Forest Stewardship Council, Rainforest Alliance.<br>• Best management practices and strict standards to protect wildlife, plant, water and archeological resources are implemented in accordance with the Timber Harvest Plan (THP) approved by the California Department of Forestry.<br>• The applicant performs ongoing road maintenance by upgrading the road network for each harvest. Upgrades to roads include rocking road segments; realignment of roads for better drainage; providing larger stream buffers than what is required; repair and maintenance of roads for fire access; and developing shaded fire fuel breaks.<br>• In 2008, the applicant initiated a new stewardship project that consisted of retaining Pacific Watershed Associates, Inc. (PWA) to conduct a comprehensive watershed and road assessment to ensure the protection of the watershed associated with the managed forestlands. PWA assessed 22 miles of forest roads in the watershed of the San Vicente Creek and developed a long-term prioritized action plan for cost-effective erosion prevention and control, which included plans for various treatment and improvement installations. The applicant has begun implementing portions of the plan that includes installations of road improvements and replacement of culverts to ensure sustainability of the watershed, preservation of salmonid habitat and protection of domestic water supplies. |

| **Table 11-1 (Continued) Applicable Global Climate Change Strategies** | |
|---|---|
| **Strategies for Reducing Greenhouse Gas Emissions[1]** | **Conformance** |
| Forest Conservation. Conservation projects are designed to minimize/prevent the climate change emissions that are associated with the conversion of forestland to non-forest uses by adding incentives to maintain an undeveloped forest landscape. California is losing forestland at increasing rates: 35,000 to 40,000 acres of private forestland is converted annually to non-forest uses (Bill Stewart, 2005), which could contribute as much as 12 million tons of $CO_2$ emissions annually. | Please see discussion under Forest Management above for a complete discussion. |
| Note: 1 – Only the applicable strategies for reducing greenhouse gas emissions were included. Source: California Environmental Protection Agency, Climate Action Team Report to Governor Schwarzenegger and the Legislature, March 2006. | |

The applicant has been proactive in reducing greenhouse gas emissions in its Bonny Doon Quarry operations through the replacement of Tier 0 engine units with Tier 3 or higher units. The applicant initiated this program in 2008, several months prior to being required by regulation. In 2008, the quarry replaced three CAT 773B haul trucks (Tier 0) with three 773F haul trucks (Tier 3), which reduce NOx emissions by 3,707 kg and $PM_{10}$ emissions by 212 kg annually. The applicant also replaced one CAT 988F loader (Tier I) with a 988H loader (Tier 3), which further reduces NOx emissions by 1,450 kg and $PM_{10}$ emissions by 84 kg annually. The applicant will continue to ensure that replacement mobile plant equipment meets new emission standards.

The applicant also implements quarry fuel efficiency through its operational management of the quarry. For example, the quarry continually reduces greenhouse gas emissions through its use of a 3.5-mile overland conveyor system that transports limestone to the cement plant. This practice eliminates truck traffic onto the public roadway and significantly reduces exhaust emissions from the use of quarry mobile equipment.

In 2009, the applicant was named Energy Star Partner of the Year by the U.S. EPA for outstanding energy management and reductions in greenhouse gas emissions. Since 2004, the applicant reduced its total energy use equal to reducing 115,000 metric tons of $CO_2$ emissions (equivalent to providing electricity to at least 1,500 American homes for a decade or avoiding about 21,000 passenger vehicles $CO_2$ emissions for a year). In addition, the applicant has an Energy Management Program in place, employs a Corporate Energy Management Team and a Site Energy Team at each plant, has received numerous local and national energy and environmental awards, and is a strong advocate for energy conservation and sustainable manufacturing practices.

Consistency with AB-32

State action on climate change is mandated by AB-32. The County of Santa Cruz along with other planning agencies throughout the state, will be monitoring the progress of state agencies in developing approaches to address GHG emissions. As agreed-upon approaches for project-level CEQA analysis, land use planning, and project development are established, it is expected that climate change will be a key environmental consideration in future County determinations. The County will be required to adhere to any future applicable mandatory regulations regarding global warming resulting from the passage of AB 32, but the exact character of such future implementing strategies are not known at this time. Given the GHG reduction measures incorporated in the project and the application of AB 32 mandates over time, there is no reason to find that approval of the proposed project is inconsistent with AB 32, nor would it interfere materially with the ability of agencies subject to AB 32 to meet the mandated GHG emission reductions by 2020.

**Noise.** There are no cumulative impacts associated with noise (see Section 8.3.5). The project impacts of noise are site specific and do not combine with other projects in the Bonny Doon Planning Area to create increased offsite impacts.

**Energy and Natural Resources.** The cumulative loss of 17.1 acres of timberland in Santa Cruz County is less than significant (see Section 9.3.5).

## 11.5 EFFECTS FOUND TO BE NOT SIGNIFICANT

The County of Santa Cruz prepared an Environmental Review Initial Study for the Bonny Doon Limestone Quarry Boundary Expansion Project (Appendix A). The Initial Study concluded that the project would have less than significant or no impacts on Aesthetics, Cultural Resources, Energy and Natural Resources, Services and Utilities, Traffic/Transportation, Land Use/Housing, and Hazards.

### 11.5.1 Aesthetics

The project site is not visible from adopted scenic highways or corridors and would not alter or block views from scenic vistas.

### 11.5.2 Cultural Resources

A surface reconnaissance site survey was conducted in November 1990. No cultural resources were found in the Boundary Expansion Area.

### 11.5.3 Energy and Natural Resources

Mining the Boundary Expansion Area eliminates 17.1 acres of timber resources. The acreage is small relative to the amount of habitat in the surrounding area, which includes over 1,000 acres in CEMEX's management.

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