BUREAU OF RECLAMATION

Boise River Basin Feasibility Study

Specialist Report: Geology and Soils

Boise Project, Idaho

Interior Region 9: Columbia Pacific Northwest

U.S. Department of the Interior

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Mission Statements

The Department of the Interior (DOI) conserves and manages the Nation's natural resources and cultural heritage for the benefit and enjoyment of the American people, provides scientific and other information about natural resources and natural hazards to address societal challenges and create opportunities for the American people, and honors the Nation's trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities to help them prosper.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Acronyms and Abbreviations

Acronym or Abbreviation	Meaning
BMP	best management practice
CFR	Code of Federal Regulations
DEIS	Draft Environmental Impact Statement
HD	Highway District
IGS	Idaho Geological Society
MSE	mechanically stabilized earth
NFS	National Forest System
NRCS	Natural Resources Conservation Service
Reclamation	Bureau of Reclamation
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey

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1. Introduction

The Boise River Basin Feasibility Study is a feasibility study to evaluate increasing water storage opportunities within the Boise River basin by expanding Anderson Ranch Reservoir. The project is located at Anderson Ranch dam and reservoir, the farthest upstream of the three reservoirs within the Boise River system and located 28 miles northeast of the city of Mountain Home in Elmore County, Idaho. Anderson Ranch Dam is a zoned earth fill embankment structure that provides irrigation water, flood control, power generation, and recreation benefits. The reservoir also provides a permanent dead storage pool for silt control and the preservation and propagation of fish and wildlife. Anderson Ranch Dam is operated by the Bureau of Reclamation (Reclamation). Reclamation, in partnership with the Idaho Water Resource Board (IWRB), proposes to raise Anderson Ranch Dam. New water storage would provide the flexibility to capture additional water when available, for later delivery when and where it is needed to meet existing and future demands. The alternatives analyzed in this document include the No-Action Alternative (Alternative A), a 6-foot raise of Anderson Ranch Dam (Alternative B), and a 3-foot raise of Anderson Ranch Dam (Alternative C).

Alternative A provides a basis for comparison with the two action alternatives, Alternative B and Alternative C. Under Alternative A, current baseline conditions would continue, without increasing Anderson Ranch Dam height or constructing associated reservoir rim projects, access roads, or facilities. The expected project duration of Alternative B is approximately 51 months and Alternative C is 44 months. Reclamation would continue existing operations of Anderson Ranch Dam. Alternative B proposes to raise the dam by 6 feet from the present elevation of 4196 feet to 4202 feet to capture and store approximately 29,000 additional acre-feet of water. Alternative B would inundate an estimated 146 acres of additional land around the reservoir above the current full pool elevation of 4196 feet. Alternative C proposes to raise the dam by 3 feet to 4199 feet, allowing for the ability to capture and store approximately 14,400 additional acre-feet of water. Alternative C would inundate an estimated 73 acres of additional land around the reservoir above the current full pool elevation of 4196 feet.

Each of the two action alternatives, Alternative B and Alternative C, includes two separate, but similar, structural construction methods for the dam raise, downstream embankment raise, or mechanically stabilized earth wall raise. Otherwise, the only difference is the dam raise elevations of 6 feet for Alternative B and 3 feet for Alternative C. Project areas and construction durations for each method are nearly identical, except for a 200-foot difference in approach road length at the right abutment and an approximate 1-month difference in construction duration. The longer road length is within the dam footprint on previously disturbed ground. Because these differences are negligible, they are not differentiated within the analysis of each alternative. Alternative analysis assumes the longer road length and construction duration, however, a final construction method will be chosen during later phases of engineering evaluation.

Chapter 1 and Chapter 2 of the Boise River Basin Feasibility Study Environmental Impact Statement (EIS) provide a detailed description of the proposed action, project's purpose and need, project area, and alternatives including design features applicable to the action alternatives. This specialist report supports the analysis of expected impacts to soils and geology as described in the EIS.

1.1 Regulatory Framework

The primary regulations that are applicable to this soils and geology resource area are as follows.

- Antiquities Act of 1906, as amended
- Clean Water Act of 1969, as amended
- Earthquake Hazards Act of 1977, as amended
- (ID-1) Idaho Disaster Preparedness Act of 1975 as amended (Idaho State Code Chapter 10, Title 46)
- (ID-2) Executive Order, 2000-04
- (ID-3) Idaho Code Title 39 Chapter 41
- 29 Code of Federal Regulations (CFR) 1926.32(f)
- Council on Environmental Quality 40 CFR 1500-1508.

2. Affected Environment

The project area relating to Alternative B and Alternative C refers to the general vicinity in and around Anderson Ranch Reservoir extending downstream to the extent of Arrowrock Dam, via the South Fork Boise River.

Idaho is a diverse state comprised of semiarid shrub- and grass-covered plains, irrigated agricultural valleys, volcanic plateaus, forested mountains, woodland- and shrubland-covered hills, glaciated peaks, lava fields, and wetlands. The state is divided into ecoregions that group areas of similar ecosystems by type, quality, and quantity.

Anderson Ranch dam and reservoir is in a narrow, steep-sided valley cut through several hundred feet of igneous extrusive and intrusive rock. The Anderson Ranch and Fall Creek basalts form rimrock above Anderson Ranch Reservoir and overlie the granitic bedrock of the Idaho Batholith, which forms the canyon walls (Howard et al., 1984). The weathering of these igneous rocks is responsible for the steep slopes around the reservoir and the South Fork Boise River.

Remnants of younger Pleistocene flows such as the Smith Prairie Basalt are also present within the Anderson Ranch Reservoir and river canyons of the South Fork Boise River; pillow basalts are visible from the Anderson Ranch Reservoir road where it climbs from Fall Creek toward the town of Pine, Idaho (U.S. Geological Survey [USGS], 2001). Alluvium, colluvium, and residual soil deposits overlie intact rock on the basalt river terraces along the river. Talus and colluvium accumulate at the base of the steep slopes of the canyon walls.

Anderson Ranch Dam is located near the southwestern edge of Atlanta lobe of the late Mesozoic–early Cenozoic Idaho Batholith. The Idaho Batholith near Anderson Ranch Dam consists of primarily granodiorite and quartz monzonite intrusions (USGS, 2001). Granite associated with the Idaho Batholith serves as the bedrock foundation at the dam. The foundation granite was intensely fractured, cut by numerous shears, and intruded by numerous irregular masses and stringers of pegmatite and many dikes of basalt, diorite and granite, normal to the canyon axis. The dikes reduce the foundation permeability and make a tight foundation.

During construction of Anderson Ranch Dam, alluvium was removed from directly beneath the dam core and the core was constructed on an intact granitic rock foundation; however, the alluvium was left in place beneath the upstream and downstream shells of the dam. The alluvial foundation material belongs to two units: Quaternary Alluvium and Quaternary Fluvial-Lacustrine. These materials form the foundation of the dam and have performed well with respect to deformation and seepage.

Rock descriptions for the units present within Anderson Ranch Reservoir discussed below were taken from the "Anderson Ranch Dam Issue Evaluation: FLAC Deformation Analyses, Boise Project, Idaho" technical memorandum and are presented from oldest to youngest (Reclamation, 2011).

Cretaceous Granite

Cretaceous granite (Kg) associated with the Idaho Batholith serves as the bedrock foundation at Anderson Ranch Dam. All the construction excavations at the dam, including the diversion tunnel, outlet works, powerhouse, and spillway, encountered the granite rock unit. The rock is extremely variable in composition, texture, and engineering characteristics. In places, it is light colored and medium grained, consisting of quartz, feldspar, and biotite mica, but within a few inches, the rock would grade into fine-grained rock, consisting principally of quartz and feldspar or into a darker rock consisting chiefly of biotite mica and feldspar. The granitic mass has been severely affected by repeated intrusions, deformation, and weathering. The granite is crosscut by numerous intrusive pegmatite, diorite, and basalt dikes. All intrusive granitic rock types discussed within this report are referred to as Cretaceous granite (Kg) or granite.

Bedrock outcrops of the granite are sparse primarily due to the cover of talus, colluvium, and terrace deposits (alluvium). Most of the granite outcrops exhibit moderate to intense weathering and are variably jointed. Construction geology maps illustrate a series of shear zones within the granite floor of the cutoff trench. The granite in the trench floor had some localized zones of intensely jointed and highly weathered rock.

Quaternary Basalt

Quaternary basalt (Qb) near the dam occurs mainly as intra-canyon flows. The basalt is hard, dense, and mostly non-vesicular. The basalt is mostly covered with talus and colluvium near the dam. The basalt has been used in the past as riprap for the dam. The basalt was not encountered during the 2009 or 2018 drilling investigations.

Quaternary Talus/Colluvium

Relatively thin deposits of Quaternary talus and colluvium (Qtc) cover the slopes of the canyon at the dam. The talus is generally composed of boulders of basalt that originated from erosion of the basalt flows along the canyon rim and represents rockfall of the columnar jointed basalt. The talus exists as minor surficial deposits adjacent to the canyon walls and consists primarily of a heterogeneous mixture of angular gravel-, cobble-, and boulder-size material.

The colluvium is a heterogeneous mixture of angular gravels, cobbles, and boulders within a matrix of clay, silt, and sand. The coarse-grained portion of the colluvium is composed of both basaltic and granitic gravel-, cobble-, and boulder-size material. This talus/colluvium appears to be interfingered with the Quaternary Alluvium at depth and only along the edge of the canyon.

Quaternary Alluvium

Alluvium is present in the stream channel of the South Fork Boise River and forms the low, fairly flat floodplains along the river on the valley floor. Quaternary river alluvium deposits consist primarily of sediment deposited from the river. In addition, alluvium was encountered high on the abutments during the dam site explorations conducted in 1940. The thickness of the alluvium varies from less than 10 feet near the abutments to 120 feet near the middle of the valley floor.

The alluvium (Qal) consists of stratified to heterogeneous deposits of low-plastic fines (silt), sand, gravel, cobble, and boulder. The coarsest fractions of this subunit (gravel, cobble, and boulder) are well-rounded and occur frequently throughout the entire subunit. Based on preconstruction explorations, construction records, and previous investigations, these coarse-grained alluvial sediments are apparently continuous over most of the foundation area.

Quaternary Fluvial-Lacustrine

This unit is composed of fine-grained sediments deposited in a lake-type environment or even a delta-type environment from water backed up by a lava dam. The lava dam formed when repeated eruptions of Quaternary Basalt related to the western Snake River Plain volcanism near the dam produced a series of intra-canyon basalt flows within the Boise River drainage. These flows blocked the river for a time, creating a lake where the fluvial-lacustrine material was deposited.

This Quaternary Fluvial-Lacustrine (Qfl) material is composed of sediments consisting mostly of sand with minor discontinuous lenses of silt and sandy silt. The sands are mostly fine- to medium-grained subangular quartz and potassium feldspar with some minor micas and other dark minerals. This subunit is stratified, exhibiting intervals of fine sand alternating with fine to medium poorly graded sands. The finer-grained intervals are well stratified, consisting mostly of low plastic silt with interbedded sandy silt and silty sand.

Faults and Soils

Major normal faulting in the region includes faults in and adjacent to the batholith, faults bounding the northeast and southwest margin on the adjacent Snake River Plain, and faults forming Camas Prairie Basin east of the dam. These faults show a low to moderate seismic activity level (Elmore County, 2012). According to the Elmore County, Idaho, Multi-Hazard Mitigation Plan (2012), Elmore County has not experienced any seriously damaging earthquakes in recorded history.

According to the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey (USDA, 2019), the most predominant soils around Anderson Ranch Dam are expected to be of the Gaib-Rubble land complex, Rainey-Schoolhouse-Oland association, Roanhide-Bauscher-Schoolhouse association, or the Elkcreek-Demast complex series. The Gaib-Rubble land complex and Elkcreek-Demast complex series are both stony loamy soils derived from loess, and/or alluvium over bedrock derived from volcanic rock. Rainey-Schoolhouse-Oland association, and Roanhide-Bauscher-Schoolhouse association series soils are sandy to gravelly loam soils derived from alluvium and/or colluvium derived from igneous rock. All these soil series are very well drained, characteristic of soils that form on steep slopes, and have moderately high to very high capacity to transmit water. Liquefaction of these soils at Anderson Ranch Dam is unlikely because they are well-drained and do not remain saturated or partially saturated for extended periods of time. Expansive or swelling soils with high clay content are not present in substantial amounts at the reservoir or dam.

The soils near the town of Pine and immediately downstream of the dam belong to the Haplaquolls-Xerofluvents complex series, which is a silt or fine sandy loam derived from alluvium that forms on floodplains. The soil is somewhat poorly drained and has a moderately low to moderately high capacity to transmit water.

There is physical evidence of ongoing shoreline erosion at Anderson Ranch Reservoir, although its effects are moderate and do not appear to be causing significant issues. Shoreline erosion can be seen in several places along the perimeter of the reservoir, including National Forest System (NFS) Road 120, which is built into the steep-sided canyon walls and follows along the reservoir shore. Areas can be seen where erosion has caused sloughing of rock and soil, resulting in encroachment of the bank toward the road.

The occurrence of shoreline erosion is most frequent during the early summer when reservoir water levels are at a maximum and summer storms and waves have the greatest erosive impact. Other factors that partially contribute to shoreline erosion may include large wakes from boats in confined reservoir areas during high water.

Total storage capacity of Anderson Ranch Reservoir is 474,942 acre-feet and a surface area of 4743 acres at reservoir elevation 4196. Since dam closure on December 15, 1945, the reservoir had an estimated volume change of 18,236 acre-feet below reservoir elevation 4196. This volume represents a 3.70% loss in total capacity and an average annual loss of 346.7 acre-feet per year (Reclamation, 2000). This study did not specify how much of this change was due to sediment inflow from the South Fork Boise River as opposed to shoreline erosion due to wave action.

Landslides

Within the last decade there have been several mass failures in the South Fork Boise River watershed, leading to permanent road and campground closures. Wildfires followed by significant precipitation events in 2013 led to five debris flows in the area between Anderson Ranch Dam and the Danskin Boat Launch downstream (Phillips, 2013).

Landslides have also impacted activities upstream of the reservoir. An undated post by Sawtooth National Forest that appears to be from 2018 states that the “Road is closed between Bowns Campground and Skeleton Creek due to a large landslide that has blocked the road and moved the river on the downstream side near Skeleton Creek and a mile-long washout on the upstream side near Bowns Campground. You cannot travel [NFS Road 227] between these two points. There is a single-track trail open to non-motorized travel and motorcycles that allows you access to [NFS Road 227] in between the damaged sections” (Sawtooth National Forest, 2018).

There is a known previous landslide along the right abutment approach road at Fall Creek. The landslide report noted that the log-boom that protects the slide material from wave action erosion was basically nonexistent. However, the report did note that the previous slide appears to have stabilized and vegetation is developing on the slide surface (Reclamation, 2018).

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3. Environmental Consequences

3.1 Methods for Evaluating Impacts

In general, the analysis presented in this section is qualitative and is based on general information on geology, geologic hazards, and soils. Environmental consequences associated with geologic resources that could result from implementing alternatives were evaluated qualitatively based on expected methods, environmental commitments common to all action alternatives, and the locations and durations of project activities.

The following table describes impact indicators and significance criteria for evaluating potential impacts from soils and geology.

Table 1. Soils and geology impact indicators and significance criteria.

Impact Indicator	Significance Criteria
Soil stability hazards	Catastrophic landslide damage to facilities around the reservoir or catastrophic endangerment to human life The project is 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
Soil erosion issues	An increase in erosion and sedimentation around the perimeter of the Anderson Ranch Reservoir that affects operations of the dam, or causes damage to the equipment, or reduces stability of infrastructure at the perimeter of the reservoir
Anderson Ranch Reservoir induced seismicity resulting in dangerous conditions around the reservoir or damage to facilities	Rupture of a known earthquake fault, as delineated on the Idaho Geological Society Miocene-Quaternary fault map

Crucial geology and soils issues or concerns include whether the proposed action would affect seismicity, erosion, sedimentation, or slope stability near the dam or reservoir. The geology and soils present within the project area would affect erosion and sedimentation associated with the new elevated shoreline created by the increase in reservoir levels.

Evaluation of the bedrock geology and seismic hazards included review and summary of the geologic information and geographic information system data available from the Idaho Geological Society (IGS). This included both an evaluation of the bedrock geology, local faults, and historical earthquake epicenters that have been mapped by IGS. Scientific journal articles describing the local bedrock geology, local faults, and potential seismic activity were reviewed. Review was limited to existing data and is anticipated to be appropriate for analysis.

Evaluation of soils and erosion potential included review and summary of the USDA NRCS soil survey for soils, and slope information. Review was limited to existing data and is anticipated to be appropriate for analysis.

Additional peer-reviewed publications related to the geology and seismicity of the area were included in the evaluation where appropriate. Previous Reclamation studies of sedimentation at the reservoir were reviewed and evaluated. Studies and evaluations performed as part of the Boise River Basin Feasibility Study have also been included in this report where appropriate.

The Elmore County Multi-Hazard Mitigation Plan (2012) was reviewed to ensure that the proposed action would not impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan.

3.2 Direct, Indirect, and Cumulative Impacts

3.2.1 Alternative A – No Action

Under Alternative A, Reclamation would not modify Anderson Ranch Dam to increase storage capacity, storage levels would remain at the current capacity, Reclamation would continue to operate Anderson Ranch Dam under current standing operating procedures, no impacts to water resources from the project would occur, and existing water resource characteristics would be maintained. Under the No Action Alternative, the reservoir and associated dam/water operations would continue as it does today. No substantial changes to infrastructure or operations would occur. Current shoreline and slope erosion rates would continue and would not be expected to shift existing conditions over the long-term No planned operation and maintenance activities to Reclamation facilities are currently planned to occur that would directly or indirectly result in any increase in seismicity, erosion, sedimentation, or decreased slope stability in the project area. The No Action Alternative would not result in direct or indirect impacts to soil or geologic resources.

3.2.2 Alternative B – Anderson Ranch Dam Six-foot Raise

Activities associated with Alternative B are not expected to contribute to increased seismicity or sedimentation. No mitigation is therefore necessary. However, there may be potential impacts related to slope stability and erosion. These are discussed below. Direct and indirect effects were evaluated where construction would be performed at the dam and as part of projects around the rim reservoir, as well as for the detour route on Highway District (HD) 131.

Potential Impacts Related to Slope Stability

Shoreline erosion could be exacerbated by the encroachment of the new shoreline bank towards road segments along the reservoir perimeter. Shoreline erosion would be minimized upon the placement of rip rap along existing roadways as part of the proposed action to prevent erosion and protect existing roadway infrastructure.

Stream and riverbank erosion, road building, or other excavation can remove the toe or lateral slope and exacerbate landslides. Road and dam construction activities near slopes between 14° and 30° (25%–60%) are at risk of landslides (Elmore County, 2012). Slopes within this range are common around the reservoir at the dam itself and along HD 120 from Anderson Ranch Dam to Fall Creek Marina. Although there is no construction planned at the location of the 2018 landslide, it occurred within this stretch of road. Ten rim projects are planned along this stretch of road. These slopes also exist along HD 61 north of Lime Creek Bridge where 13 rim projects are planned, and along the South Fork Boise River at Cow Creek where the detour route is planned.

Core BMPs to address related to slope instability as described in Environmental Commitments Section 3.28 of the EIS under Erosion Control, Water Quality and Shoreline Protection section would be further defined in final design and outlined as Reclamation contracting requirements. Landslides are generally associated with large precipitation events. Reclamation and its contractor would follow the specifications in the project's final design for weather and climate, soil classification, depth and slope of cut, water content of soil, and other operations in the vicinity. Reclamation would implement these conservation measures during project construction to minimize potential hazards from geology and soils. Implementation of minimization measures and BMPs would reduce adverse effects on soil erosion due to construction activities and effects would not persist in the long-term, therefore, would not be significant.

Potential Impacts Related to Erosion

Increasing the pool elevation at Anderson Ranch Reservoir by 6 feet would increase shoreline erosion in some areas as the new shoreline is established. The estimated additional inundated area is approximately 146 acres. The current full pool height is maintained for an average of 14 days a year. Under Alternative B, the shoreline would be inundated above the current full pool elevation of 4196 for approximately 18 days under typical spring operations. The majority of the year, the water height would be within the existing shoreline. Shoreline erosion could be exacerbated by the encroachment of the new shoreline bank towards road segments along the reservoir perimeter.

Surface sediments in the newly inundated area are classified as stony loamy soils and sandy to gravelly loam soils. Eroded material would contain those types of material as well as trees and vegetation. The eroded material would travel into nearshore areas where the coarsest material, such as cobbles and large gravel, would form an armor layer on the newly eroded shoreline. Finer material, such as loam and silt, would be carried farther away from the shoreline and either deposited in deeper areas or be carried as suspended sediment out of the reservoir. Sand and small gravel would likely form part of a sub-armor layer below the cobble and large gravel armor layer or be carried away from the shoreline to areas below the reservoir's low operating level not subject to major erosion.

This new shoreline may exacerbate the effects of shoreline erosion at locations around the perimeter of the reservoir. Encroachment of the bank toward the roads could potentially increase in this area. Five roadway segments, varying in length from 50 feet to 600 feet, were identified in a preliminary investigation completed by Reclamation as areas for consideration that could potentially be impacted or require improvement due to the proposed increase in reservoir water surface elevation at Anderson Ranch Reservoir. The review of roadway embankment slopes and proximity of the proposed full pool inundation also indicated locations that required riprap. Generally, most of the existing shoreline slopes are anticipated to remain stable and maintain the historical existing angles of natural repose. However, in some locations, riprap should be considered to armor the existing shoreline and roadway embankment slopes and protect existing roadway infrastructure. These areas would be addressed as part of the design of the alternative. Twelve locations around the perimeter of the reservoir, measuring in length from 100 feet to 800 feet, require riprap roadway embankment and/or shoreline stabilization to prevent erosion and protect roadway infrastructure. Total estimated volume of riprap required is 12,241 cubic yards with 6900 feet of mechanically stabilized earth (MSE) wall.

The following steps were taken to establish proposed feasibility-level design improvements related to shoreline and roadway embankment stability (6-foot Dam Raise Engineering Summary, Appendix C).

- Review the horizontal proximity of the proposed top of active reservoir water surface along the roadway embankment slopes for the roadway segments that were identified in the Engineering Summary.
- Determine slopes that require armoring or stabilization to prevent erosion or undermining of the current toe of existing slope where the proposed waterline would be closer to the existing infrastructure.
- Provide feasibility-level designs for rock armoring (riprap) or MSE walls to improve shoreline and roadway embankment stability.

Where the roadway profile needs to be raised or the shoreline/embankment armored or MSE wall constructed, the current roadway widths and surface treatments would be maintained. Criteria for the design of roadway or slope improvements were based on guidelines from American Association of State Highway and Transportation Officials Green Book; Low Volume Road Design, Idaho Transportation Department Design Manual and Standard Specifications; and Mountain Home Highway District and Glenns Ferry Highway District standards.

Dam construction (including installing and removing coffering), roadway construction (including bridge and culvert work), and other infrastructure construction activities that disturb soils and vegetation may increase erosion. Adverse effects on soils as a result of ground disturbance would occur for a short duration and would not persist beyond the construction period. BMPs to address erosion, as described in the Environmental Commitments Section 3.28 in the EIS under Erosion Control, Water Quality and Shoreline Protection measures, would be further defined in final design and implemented as Reclamation contracting requirements. The project Stormwater Pollution Prevention Plan would include earthmoving-related erosion minimization measures that would reduce adverse effects on soil erosion. These measures would be implemented in association with all activities within the project area, including all waste and source material sites. Implementation of minimization measures and BMPs would reduce adverse effects on soil erosion due to construction activities and effects would not persist in the long-term, therefore, would not be significant.

3.2.3 Alternative C – Anderson Ranch Dam three-foot Raise

Activities associated with Alternative C are not expected to contribute to increased seismicity or sedimentation. No mitigation is therefore necessary. However, as identified for Alternative B, there may be potential impacts related to slope stability and erosion. These impacts are identical to Alternative B and were discussed in section 3.2.3.

Potential Impacts Related to Slope Stability

Construction activities within Alternative C are similar to Alternative B and are subject to the same potential slope stability impacts including a soil or geologic unit that is unstable or could become unstable as a result of project activities. Alternative C has a general reduction in fill required for many of the identified rim projects. More information on specific differences between the alternatives is included in the 3-foot Engineering Summary, Appendix D of the EIS.

Potential Impacts Related to Erosion

This section evaluates potential impacts due to erosion caused by construction activities, as well as shoreline erosion.

Alternative C requires earthwork and ground-disturbing activities as identified in Alternative B. Appropriate BMPs and techniques to prevent erosion caused by stormwater would be implemented according to the project Stormwater Pollution Prevention Plan. Using BMPs as described for Alternative B will reduce impacts related to construction activities. Impacts would not be significant, and no mitigation is necessary.

Increasing the pool elevation at Anderson Ranch Reservoir by 3 feet would increase shoreline erosion in some areas as the new shoreline is established. The estimated additional inundated area is approximately 73 acres. The current full pool height is maintained for an average of 14 days in years full pool is reached. Under Alternative C, the reservoir would be inundated above the existing full pool elevation of 4196 for approximately 9 days under typical spring operations. The majority of the year, the water height would be within the existing shoreline. Similar to Alternative B, this new inundation would create a new shoreline along the reservoir at the new high-water mark. Impacts due to the new shoreline and rim projects are as described for Alternative B.

Overall, under Alternative C, construction activities would cause short-term direct minor effects by increasing erosion potential, but using BMPs, impacts to soils from construction activities would not be significant. Long-term, direct, minor effects would occur from shoreline erosion at the new full pool height; however, BMPs to address erosion, as described in the Environmental Commitments Section 3.28 under Erosion Control, Water Quality and Shoreline Protection measures, would be further defined in final design and implemented as Reclamation contracting requirements. Reclamation would avoid and minimize impacts through bank stabilization measures and BMPs, therefore, impacts to soils would not be significant. Slope stability would be ensured through project design and BMPs, therefore no significant impacts are expected.

3.2.4 Cumulative Impacts

Cumulative impacts are analyzed for Alternatives B and C. Cumulative impacts are those which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. The cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable. Reclamation has identified two past projects: Pine Bridge replacement and the 4-foot Anderson Ranch dam crest raise for security enhancement. Reclamation has also identified two potential future projects to be considered for the cumulative impact analysis: Cat Creek Energy Project and South Fork Boise River Diversion Project. Additional project proposal information for these, as known by Reclamation to date, is provided in Chapter 2 of the EIS.

The 2018 construction of the Pine Bridge and 2010 crest raise are well removed in time from the proposed 2025 rim projects and dam construction. Any potential soil disturbance from construction of the new Pine Bridge or dam raise would not be additive, no cumulative effects are identified for past actions.

If the South Fork Boise River Diversion Project and Cat Creek Energy projects were to happen in conjunction with the Anderson Ranch Dam raise, it would be anticipated that the surface water elevation of the reservoir would minimally fluctuate based on pumping operations by one or both of the projects. Using the diversion rates from the water right permits (Table 2 in the Water Rights Specialist Report, Appendix B), for each project, it can be assumed that diverting water from the reservoir would have minimal impact on the surface water elevation of the reservoir. Because the water drafted by South Fork Boise River Diversion or Cat Creek Energy projects would be flood control water, it would be assumed that in high water years, downstream flows would be closer to average water year flow levels. No actions proposed with either project have plans to increase water levels above the established full pool elevation at Anderson Ranch Reservoir; therefore, cumulative impacts to soils from instability and shoreline erosion would be negligible.

In summary, due to the water right stipulations limiting the diversion rates of each project, and construction activities for each proposed project not thoroughly detailed at this time, any cumulative impacts to soils and geology would be expected to be negligible.

3.2.5 Mitigation

No mitigation is required for Alternative B or Alternative C. Although potential geology and soils effects were identified related to slope stability and shoreline erosion, BMPs would be implemented as part of the proposed action that would address potential impacts due to slope stability issues; potential impacts from shoreline erosion would be addressed in the design of the alternative.

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