Chapter 2 - Alternatives

2.1 Alternatives Development

Reclamation considered a range of alternatives for Scofield Dam that could be implemented to achieve risk reduction for hydraulic jacking of the spillway floor. In addition, several alternatives were considered by FHWA and UDOT for the bridge replacement and improving the roadway approaches.

Under both action alternatives, work would occur within the dam primary jurisdiction zone, and normal stream-flow releases would not be affected by the proposed construction. Specific cost differences between alternatives can be found in the Scofield Dam Modification Report 2005.

2.2 No Action Alternative

The No Action Alternative requires no capital outlay and no extra operation and maintenance expenditures, because this alternative demands no changes to project features. The present deficiencies and risks at Scofield Dam, as discussed in Section 1.5 above, would remain.

Hydraulic jacking could induce catastrophic dam failure and cause major damage between Scofield Dam and Wellington, where flooding would effectively end. The flood waters would be deep and swift throughout a large portion of the floodplain.

Rapid failure of the dam would put the lives of approximately 2,800 people at risk. When transformed into the annual risk of fatalities, the outcomes from rapid failure exceed tolerable risk limits and call for action to be taken to ensure long-term safety of the dam.

2.3 Action Alternatives

The following sections describe three action alternatives that are similar in scope but differ in the final placement of the reconstructed spillway and in the location and manner of detouring traffic around the construction site. Any of these alternatives or combinations of these alternatives may ultimately constitute the preferred alternative. All construction activities would occur outside the Denver and Rio Grande Western Railroad's 200 foot wide (100 feet from centerline on either side of the tracks) right of way

2.3.1 Spillway Replacement Alternative

Spillway Replacement
The Spillway Replacement Alternative reduces the hydraulic jacking potential and involves in-kind replacement of the spillway structure and a portion of the stilling basin of Scofield Dam. The entire spillway structure and under-drain system would be removed and replaced with a new reinforced concrete structure at or within 20 feet north of its present location. Relocating the spillway to the north would require less dewatering and easier dewatering. Also, the excavation

would be safer as the contractor would not be required to excavate as far into the right abutment of the dam as the other option, and the existing spillway wall could be used as shoring for the required excavation. The floor of the existing spillway could be used as a platform to drill dewatering holes. This relocation of the spillway could save approximately 1.0 to $1.5 million in construction costs. A coffer dam would be required on the shifted alignment.

This new spillway would be similar in design concept as is currently present (uncontrolled ogee crest section). State of the art features to be added would include air-entrained concrete, waterstops in joints, shear steel through the joints and a new filtered under-drain system with perforated pipe.

All construction work would occur in the dam primary jurisdiction zone. Features of the dam referred to by the terms “right” and “left” correspond to right and left as a person faces downstream.

Under this alternative, the spillway structure would be excavated. This excavation would likely extend to bedrock. On the left side of the spillway, the dam embankment would be cut back on a slope between 2:1 and 4:1, as necessary for construction stability and access. New embankment fill would subsequently be compacted against the cut slope to ensure a good bond between old and new fill. This is critical for tying in the new impervious fill with the existing "homogeneous" embankment fill. On the right side, the excavation would probably remove all fill and slopewash between the crest structure and the rock of the right abutment. Portions of the existing cutoff wall would be removed to be replaced later, possibly at a slightly different location (likely at the upstream end of the ogee crest).

It would be necessary to excavate along both sides of the spillway chute to allow construction of a new concrete chute. The excavation would probably extend below the grade of the existing chute in order to allow for over excavation and recompaction to ensure dense material in at least the top two feet below the chute. There would need to be a flat working surface approximately 2-3 feet wide on either side of the replacement chute. The cut slopes for the spillway chute would have a 2:1 slope.

Replacement of the earthfill on either side of the spillway crest structure would be necessary. Suitable, well compacted, earth material would be used as backfill below and on either side of the control structure. Special compaction would be required adjacent to concrete structures. Underneath the spillway slab, an under-drain system consisting of slotted pipe, sand, and gravel would be placed downstream of the impervious material. Riprap affected by excavation and fill operations would be temporarily removed and stockpiled for later re-use. Additional riprap, required for slope and scour protection, may be placed at the mouth of the new control structure as well as on top of any potentially erodible embankment material.

Along the chute, the excavation would likely be backfilled to the preexisting grade. Immediately adjacent to the chute walls, there would be a zone of fairly free-draining coarse sand (pervious backfill). This is to reduce pressure on the walls and help prevent frost damage from saturated ground freezing immediately against the walls. The chute would be provided with underdrains and longitudinal heels surrounded by filtered pervious backfill under and along the chute.

As there would be excavation in the vicinity of springs and a known landslide on the right side of the chute, there would need to be a dewatering program using wells or wellpoints to collect water before it seeps into the excavation and to help stabilize the sides of the excavation. This water should be relatively clean and clear, and likely would not require any treatment before discharge into the river. Water collected by sumps within the excavation would likely require time in a settling pond before being discharged. A settling pond would likely be located adjacent to the river just downstream from the dam. Discharges associated with this dewatering program would not increase flows below the dam above normal operating conditions.

It is expected that the existing concrete cutoff wall (at the upstream end of the spillway) would remain the primary barrier to seepage under the spillway structure. If it cannot be kept as is, modified, or replaced on the same alignment, it would be necessary to establish a new grout curtain in the bedrock of the right abutment. This would require drilling holes tens of feet into the rock, and pumping water-cement grout into the holes under high pressures that can force the grout into the voids and fractures of the rock.

The spillway stilling basin foundation would be dewatered and a temporary diversion structure (cofferdam) constructed in the Price River adjacent to the stilling basin. Releases from the outlet works may need to be shut off for up to a month in order to dewater both the stilling basin and outlet channel.

The Scofield Dam outlet and spillway channels are approximately 60 feet apart at the downstream toe of the dam. Between the two, there exists a small earthen berm meant to divide the flows until their confluence located further downstream. The berm, however, is built of very porous material atop an equally porous foundation. The proposed work on the spillway stilling basin includes extensive excavation at a significant elevation lower than the adjacent outlet channel. During construction of the new stilling basin it would be necessary to pass outlet flows of up to 500 ft^3/sec in the outlet channel. The outlet works can only pass this much water when the reservoir is at elevation 7617.5 feet. At lower water surface elevations the outlet works will pass less water. Because of the porous nature of the material between the two and the likelihood of a significant amount of water migrating from the outlet channel into the excavation for the stilling basin, it was necessary to consider a way of precluding the outlet channel water from flowing into the stilling basin excavation.

A number of options were considered including sheet-piling, high density polyethylene (HDPE) liners, clay liners, articulated block liners, concrete cutoff walls, etc. The final decision was reached by consensus as a combination of a 10 to 20 foot deep concrete cutoff wall below an 8 to 10 foot deep “key” trench that has an impervious rubber liner running up the side of the excavated trench and backfilled with fine –grained compacted material. The cutoff wall would run from the wall adjacent to the south side of the outlet channel, downstream to the end of the berm, and across the spillway channel mouth to the right abutment (Appendix B, Figure 1).

This option is thought to be the least cost, technically acceptable alternative to minimize the amount of water that must be pumped from the stilling basin excavation and provide a near complete cutoff of the outlet channel flow seepage.

Work on and placement of the cutoff wall must be coordinated with the stilling basin work as it appears from preliminary estimates, that the stilling basin excavation extents may interfere with the cutoff wall and placement of the coffer dam needed to prevent stream channel backflows.

A temporary access road would be constructed across the outlet channel. This would require the installation of a low profile corrugated metal pipe and placement of earthfill in the channel.

Gate House Replacement and Modifications to the Gate Structure
Modifications to the gate structure and gate house would be accomplished during demolition and re-construction of the spillway. Reclamation proposes to replace the existing gate house on the crest of the dam. This building is in poor condition and would be replaced with similar materials to preserve its historical integrity at its present location. The design and size of the building would remain as close as possible to that of the historic structure. A parking pad suitable for one car would be constructed beside the gate house. This space would be posted for U.S. Government use only.

Bridge Replacement and SR-96 Realignment
The section of SR-96 that crosses the dam would be removed, realigned, and replaced between mile point marker 11.33 and 11.40. A new wider bridge over the dam's spillway would be constructed. This work would be accomplished during the reconstruction of the spillway and be covered under the same Reclamation construction contract as the spillway work.

The south curve radius on the bridge approach would be lengthened, which may require placement of roughly 2000 yards of highway fill in the reservoir basin. The required fill materials for the highway alignment may be obtained from a borrow site located downstream of the dam within the primary jurisdiction zone.

Three alternatives for SR-96 re-alignment and replacement of the existing spillway bridge are being considered. Option 1 maintains the existing roadway alignment with a 32 foot wide bridge roadway supported by the reconstructed spillway foundation walls similar to the existing bridge. The bridge span length is 44 feet. This option does not meet the purpose and need since it uses the deficient existing roadway curve and is not wide enough to accommodate large trucks at the curve. Option 1a increases the roadway curve radius at the south approach to 81feet to meet AASHTO minimum standards for a 20 mph design speed. The shoulder of the road is increased to 17 feet at the inside of the curve to accommodate large trucks. The proposed bridge over the spillway is trapezoidal in shape to accommodate the new roadway curve at the south approach. The bridge roadway varies in width from 43 feet at the south end to 32 feet at the north end with a 44 foot span length. The bridge is supported by the reconstruction of the spillway foundation walls similar to the existing bridge. Option 1b has the same roadway configuration as Option 1a with the bridge supported on the relocated spillway walls 15 feet north of the existing spillway. This reduces the bridge roadway width to 39 feet at the south end while maintaining a 44foot span length. This option has the smallest bridge except for Option1. Option 2 increases the roadway curve radius at the south approach to81 feet to meet AASHTO minimum standards for a 20 mph design speed. The shoulder of the road is increased to 12 feet at the inside of the curve to accommodate large trucks. The proposed bridge over the spillway is shaped like a parallelogram to accommodate the new roadway curve at the south approach. The bridge roadway width is a constant 49 feet with a 51foot span length. This roadway configuration requires the bridge to be skewed 25 degrees to the spillway. The bridge is supported by the reconstruction of the spillway foundation walls similar to the existing bridge. However, the spillway wall support would have to be longer for the wider bridge.

The proposed replacement of the existing spillway bridge is a prestressed concrete AASHTO girder bridge with a minimum 8" thick concrete deck. The bridge would have UDOT standard concrete parapets. The bridge would have a minimum 44 foot long single span. It would be supported at each end by the reconstructed spillway walls which would be designed to meet UDOT/AASHTO requirements for seismic loading. The bridge would have 25 foot long approach slabs at each end with concrete barriers.

SR-96 Detour

Traffic would be re-routed off the existing bridge over the current spillway. A highway detour would be constructed during the summer of 2006. Traffic may be detoured anytime during 2006 through 2007; however, this detour would only occur for a duration of approximately 6 months. At least one lane of traffic would be maintained across the dam most of the time. However, traffic may experience complete closures for short periods of time. This detour would meet requirements found in the Manual of Uniform Traffic Control Devices (MUTCD 2003) for signing, roadway tapers, flaggers, and signals.

Figure 2 (Appendix B) shows the alignment of the proposed detour of SR-96 on the dam's right abutment. This detour alignment would be upstream of the spillway inlet and would begin near the right abutment of the dam (as the detour passes south to north). Construction of this detour would entail construction of a berm and a bridge just upstream from the current spillway structure. A large cofferdam, which would both contain the reservoir water and prevent it from entering the spillway during construction, would need to be constructed at the location of this proposed detour regardless of how the traffic is ultimately diverted around the project. Enlarging this cofferdam to enable the construction of a detour roadway surface on its crest would provide a diversion and safely route traffic around the spillway and bridge during construction. This option would consist of cut and fill earth sections and a temporary bridge section. The detour would be a one-lane, one-way detour with low speeds. Traffic delays would occur. The length of this gravel detour is estimated at 2,600-feet. The road would be a minimum of 15-feet wide and have a maximum grade of 6%. Construction of this detour would require placement of about 3,000 yards of fill in the reservoir under the ordinary high water line.

The detour road alignment would skew off from the highway approximately 300 feet upstream of the dam centerline. The earthfill road embankment gradually drops in elevation heading towards the spillway inlet area. As the road approaches the spillway area, the alignment could change and shift to the north. Along the area upstream of the spillway inlet, the roadway would be constructed utilizing temporary bridge structures. The bridge section of the highway detour is estimated to be 200 feet long. Each bridge section would require a concrete block for a foundation support. As the bridge approaches the dam, the road would convert back to an earthfill road embankment. Due to the need for trucks to negotiate the alignment, the road would be wider at the points where the bridge begins and ends. Upon construction completion, the embankment sections, bridge supports and bridge sections would be removed and contoured to the original grade.

Private land owners on the south side of the dam have access rights. Reclamation would maintain access for these owners during all phases of the proposed project.

Land Disturbance
Areas near the dam site that would be affected by the spillway reconstruction have previously been disturbed by the original dam construction and by subsequent construction and maintenance. The affected lands, all within the primary jurisdiction zone, include areas of treatment, contractor use, staging/stockpiling, and material sources (Appendix B, Figure 3). All materials for construction would come from commercial sources and from source areas near the dam that have already been developed in previous work. All areas of construction would be rehabilitated as described in Chapter 4.

Reservoir Level
Maintaining an appropriate reservoir level during construction is of primary concern. The reservoir water elevation would not be allowed to rise above elevation 7607.5 feet, which is10 feet lower than the reservoirs maximum elevation under normal operating conditions. This elevation restriction would provide safe conditions during SOD construction activities. Actual reservoir restrictions; however, may be significantly less stringent depending upon snowpack, temperatures, and other climatological factors.

2.3.2 Downstream Detour of SR-96 Alternative

This action alternative is similar to the Spillway Replacement Alternative described in section 2.3.1 except in the way that traffic would be detoured around the construction site. A new, temporary detour road would be constructed downstream of the dam (Appendix B, Figure 6). This route would direct traffic just north of the existing dam tender's residence (currently abandoned) along an existing unimproved road which heads downhill towards the river. This alignment would continue to an open area on the south side of the existing "fisherman's bridge." The road and new bridge would cross the river upstream of the existing fisherman's bridge and public restroom where it would connect to the existing fisherman's access gravel road and return to the main highway. As a clarification, the existing fisherman's bridge would not be part of the detour route. The fisherman's bridge is a foot bridge only.

Construction of an embankment within the stream channel would be required. Culverts through the embankment would be needed to pass river flows. The culverts would be sized to pass the maximum outlet works release of approximately 500 ft^3/sec.

This detour road would be a one-lane, one-way detour requiring passage at low speeds. Traffic delays would occur as a result. The length of this gravel detour is estimated to be 450 feet. The road would be 15 feet wide and have a maximum grade of 6%. It would require 3,700 yards of material to be cut from the alignment and 480 yards of fill placement.

Constructing this road would require widening and improving existing gravel roadways to a level suitable for a temporary state highway detour. It is also expected that gravel surfacing would be required as the detour may be in effect for approximately 4-5 months. Upon construction completion, the embankment across the river and the culvert(s) would require removal. The improved roadway would also require restoration and stabilization.

On the south side of the river, from the foot bridge to the right abutment, approximately 60% of the proposed alignment either does not exist or is a dirt road. On the north side of the river, the proposed alignment from the left abutment to the foot bridge would not require very much improvement since a road already exists on this side of the river.

All disturbed areas outside of existing roadways would be recontoured and reseeded with native plants. The river channel would be brought back to natural conditions.

Private land owners on the south side of the dam have access rights. Reclamation would maintain access for these owners during all phases of the proposed project.

2.4 Alternatives Considered but Eliminated from Further Analysis

The following alternatives could reduce the risks created by the dam's safety deficiencies as discussed in Section 1.5 above. These alternatives were considered but eliminated from further study because they did not meet the purpose and need of the SOD modifications as outlined in Section 1.2 above, or were determined to be too costly, environmentally unacceptable, or too disruptive to dam operations and project purposes.

2.4.1 Non Structural Alternatives

2.4.1.1 Permanent Restriction of the Reservoir Elevation

This alternative would permanently reduce the maximum water elevation or drain the reservoir to a level that would eliminate the possibility of spillway discharges. Studies show that for spillway discharges greater than approximately 250 ft^3/sec, the risk for initiating a dam failure is unacceptable (Stanton 2004[1]). Historical data have shown that in some years the reservoir has filled after being nearly empty at the beginning of the runoff season. Thus, the only way a spill might be avoided over the long term would be to permanently lower the reservoir's maximum water level to 7598.5 feet above sea level. This would result in a loss of 69% of the current reservoir storage. This alternative was not considered appropriate for further analysis because it would eliminate project benefits including recreational benefits derived from the state park that surrounds the reservoir.

2.4.1.2 Abandoning Scofield Dam and Draining Scofield Reservoir

Abandoning Scofield Dam would involve draining the reservoir, permanently maintaining the outlet gates in an open position, restricting public access to the abandoned structures, and seeding the reservoir area. The reservoir basin would still slightly fill depending upon inflows from spring snowmelt; therefore, much of the incidental flood control benefit would be preserved. During a large flood, however, the reservoir could fill significantly and pose a safety risk similar to that described under the No Action Alternative. If this were to occur, lost project benefits under dam abandonment would be similar to those for dam removal, except that under dam abandonment the incidental flood control benefits would continue. Dam abandonment would incur high capital costs, needed mainly to mitigate environmental impacts. The dam abandonment alternative is deemed to be unacceptable because of the large capital cost and loss of project benefits, and was therefore precluded from further analysis.

2.4.1.3 Breaching and Removing the Dam

Breaching and removal of Scofield dam would incur high capital costs, mainly for mitigating environmental impacts. Dam removal would involve dismantling and disposing of the embankment and significant sediment accumulations within the reservoir. This alternative would also involve extensive restoration of the dam site and reservoir basin. In addition to removing the dam, the alternative would require demolishing parts of present structures that extend above final grade, including the outlet works intake, spillway chute, and stilling basin.

The section of SR-96 that currently crosses the length of the dam crest would need to be relocated. Material removed from Scofield Dam would be returned to the preconstruction-era borrow areas. All disposal areas would be contoured to natural shapes, and native vegetation would be planted in areas above the river. Because Scofield Dam contains about 204,000 cubic yards of material, finding a suitable place for disposal of the waste material (including soil, rock, reinforcing steel, concrete rubble, and mechanical and electrical equipment) as well as obtaining the necessary permits would present major difficulties.

Dam removal would eliminate the economic benefits presently realized: M&I and agricultural water use, recreation, flood control, and fish and wildlife benefits. Because of the complete loss of project benefits and the high capital cost, this alternative is considered unacceptable and was not considered for further analysis.

2.4.2 Structural Alternatives Eliminated from Further Analysis

2.4.2.1 Remove Damaged Concrete

This alternative would remove damaged concrete from all joints and walls that could create a hazard leading to dam failure during hydrologic events. Such concrete removal would likely be done via sawcutting the affected areas. However, considering the extent of the damage, this alternative would likely involve 30% to 40% of the entire spillway. Removed sections would then be replaced with new concrete. Under this alternative, all joints would be replaced with new, current state-of-the-art features including waterstops and shear steel. Only the current horizontal underdrains could be replaced in this option. The new drains would then need to be tied in to the existing clay tile drains. The technical drawbacks for this option include: the underdrain system would only be partially replaced; the reliability of the bond from old to new concrete would be questionable; and all the existing concrete would eventually need to be replaced at some time in the future. This option would not meet the purpose and need for the project since it would not provide a current state-of-the-art spillway structure that would function as a long term fix of safety issues.

2.4.2.2 Protection of Concrete Joints

This option would protect the joints from possible exposure to spillway flows. Metal plates would be bolted over the joints as a seal. This option was initially considered as an emergency action to seal the joints in the event that operating the spillway could not be avoided. It is only considered potentially acceptable from a temporary emergency standpoint. We are not aware of any long term applications such as this. The old underdrain system would still be in place and the plates could cause some hydraulic issues. Thus, this option is not considered a good long term solution.

2.4.2.3 Lining the Spillway Chute with Steel

This alternative would involve lining the entire existing spillway chute with steel to prevent the potential for water to enter the joints and initiate stagnation pressures. Steel plate would likely have to be welded in place and anchored to the concrete in some fashion. The entire crest structure would need to be replaced under this alternative, since the new bridge could not be supported by the existing structure. The existing inlet and crest structures would be completely replaced. The existing structure downstream from the inlet and crest structures would remain and would be steel lined and tied into the new structure. Many technical issues are evident such as temperature accommodation, anchorage questions, coatings, underdrains, wall connection and structural details. This alternative is considered both impractical and unproven from a technical standpoint. This alternative would also not address the highway safety issue and was therefore eliminated from further analysis.

2.4.2.4 Replacement of the Crest and Bridge

This alternative would remove and replace only the crest structure and bridge. Replacement would consist of a gated control section; thus, surcharging all floods and never opening the gates unless an emergency occurs.

In lieu of gates, an option would be to remove the crest structure and replace it with embankment material thus storing all floods and only passing flows through the outlet works.

Both of these options are considered unrealistic due to the fact that the current outlet works would likely not be able to control floods and dam overtopping risks would significantly increase. This alternative, in conjunction with an empty reservoir (non-structural option), would provide more protection than the restriction with the spillway in place and would also eliminate virtually all project benefits. Impacts to lands where Reclamation does not own a flood easement could occur. Therefore, this alternative was eliminated from further analysis.

2.4.2.5 Construction of a Permanent Road Over the Old Dam Site

Permanently removing SR-96 from the crest of Scofield Dam and relocating it over the old dam structure upstream of the current dam would have benefits for dam security and future construction projects on or near the dam. However, this alternative would require the draining of the reservoir. This alternative would not meet the purpose and need for this project since it would cause the complete loss of the reservoir's fishery and significantly reduce recreational opportunities in the area.

2.4.2.6 Rehabilitate Existing Bridge

This alternative would include rehabilitating the existing bridge over the spillway. However, this alternative was eliminated because it did not meet the project's purpose and need. As discussed in Chapter 1, the bridge has a sufficiency rating of 21.8 percent. As part of the bridge's evaluation, the physical condition of its structural members received a 'serious' condition rating and a recommendation for "requiring a high priority of corrective actions". Functionally obsolete bridges are those with deck geometry (e.g., lane width), load carrying capacity, clearance, or approach roadway alignment that no longer meet the criteria for the system of which the bridge is a part. The deck geometry meets minimum requirements as established by UDOT and AASHTO. However, the approach railing and ends do not meet current standards.

Rehabilitating the existing bridge was not considered due its documented structural deficiency. The concrete and other structural elements have deteriorated to a point that rehabilitation is not a viable alternative. Rehabilitation rather than replacement would also limit the range of alternatives for reconstructing the spillway. For these reasons, rehabilitating the existing bridge is not considered a reasonable alternative.