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</tr>
<tr>
<td>Corps</td>
<td>United States Army Corps of Engineers, Omaha District, Regulatory Branch</td>
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<tr>
<td>EIS</td>
<td>Environmental Impact Statement</td>
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<td>City of Fort Collins</td>
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<td>Halligan Water Supply Project</td>
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<td>NISP</td>
<td>Northern Integrated Supply Project</td>
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<td>North Fork</td>
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<td>U.S</td>
<td>United States</td>
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<td>WEST</td>
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2 Proposed Action and Alternatives

2.1 INTRODUCTION

The National Environmental Policy Act requires the Corps to evaluate the applicant’s proposed project, a no-action alternative, and a reasonable range of alternatives that meet the proposed project’s purpose and need, are economically and technically feasible, and meet defined criteria. The Council on Environmental Quality defines reasonable alternatives as “those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant” (Council on Environmental Quality’s “Forty Most Asked Questions Concerning the National Environmental Policy Act,” Question 2a). The Council on Environmental Quality regulations also require an agency to rigorously explore and objectively evaluate reasonable alternatives, including the no-action alternative, and briefly discuss the reasons for eliminating alternatives from detailed evaluation (40 Code of Federal Regulations § 1502.14).

In addition to satisfying National Environmental Policy Act requirements, projects subject to permitting by the Corps under Section 404 of the Clean Water Act are subject to the 404(b)(1) Clean Water Act Guidelines. These guidelines specify “no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences” (40 Code of Federal Regulations § 230.10(a)); thus requiring the Corps to only permit the least environmentally damaging practicable alternative. The 404(b)(1) Clean Water Act Guidelines base practicability upon costs, logistics, and technology with consideration to the proposed project’s overall purpose. The 404(b)(1) Clean Water Act Guidelines assume that unless the project must be located in a special aquatic site to meet the project purpose (i.e. is “water dependent”), practicable alternatives that do not involve special aquatic sites are presumed to be available, and presumed to have less adverse impact on the aquatic ecosystem, unless clearly demonstrated otherwise (40 Code of Federal Regulations 230.10).

Alternatives screening required under the National Environmental Policy Act and the Section 404(b)(1) Clean Water Act Guidelines, as well as the Corps’ public interest review, can be conducted separately or integrated. The Corps elected to integrate the National Environmental Policy Act and the 404(b)(1) Clean Water Act Guidelines into the alternatives analysis. Integration of both the National Environmental Policy Act and the 404(b)(1) Clean Water Act Guidelines ensures that the alternatives selected for evaluation in the Environmental Impact Statement (EIS) provide a reasonable range of alternatives and that the alternatives are practicable.

The specific details regarding the alternatives development and screening processes are documented in the Alternatives Screening Report for the Halligan Water Supply Project Environmental Impact Statement (Alternatives Screening Report, DiNatale Water Consultants and CDM Smith 2016). The Corps directed and verified the screening process and the preparation of the Alternatives Screening Report documenting the identification of potential alternatives, screening methods, and screening results while ensuring
compliance with the requirements of the National Environmental Policy Act and the 404(b)(1) Clean Water Act Guidelines. The resulting alternatives are described in Sections 2.3.1 through 2.3.5 and an overview of the screening process is discussed in Section 2.5 this chapter of the Draft EIS.

2.2 COMMON TECHNICAL PLATFORM

As described in Section 1.3 of this Draft EIS, the Halligan Project was first jointly proposed with the city of Greeley’s (Greeley) proposal to enlarge Milton Seaman Reservoir (Seaman Project), also on the North Fork. At the same time, the Corps was developing another EIS for the Northern Colorado Water Conservancy District’s (Northern Water) proposed Northern Integrated Supply Project (NISP). NISP is a regional water supply project proposed in the same river basin as both the Halligan Project and the Seaman Project. In order to ensure that the impacts of the cumulative actions are adequately addressed as set forth in the National Environmental Policy Act (40 Code of Federal Regulations 1508.25(a)(2)), the Corps required a Common Technical Platform approach for the analysis for several key resources potentially affected by the proposed projects. As a part of the Common Technical Platform, the Corps developed a hydrology model so they could compare impacts of the three projects using the same baseline conditions and assumptions. Additional information about the Common Technical Platform hydrology modeling is provided in the Draft Hydrologic Modeling Technical Report for the Halligan Water Supply Project Environmental Impact Statement (CDM Smith, Inc. and DiNatale Water Consultants 2016). Although sharing the same technical basis for analysis, all three projects are now individual projects seeking individual permits from the Corps undergoing independent evaluation in separate EISs. The Common Technical Platform hydrology model was used in the alternatives screening process to test the viability, operations, and yield of elements, concepts, preliminary, alternatives, and final alternatives.

2.3 OVERVIEW OF ALTERNATIVES

This section provides a brief overview of Fort Collins’ Proposed Action of enlarging Halligan Reservoir, three action alternatives, and the No-Action Alternative (Figure 2-1). Action alternatives meet the purpose and need as described in Chapter 1 of this Draft EIS and represent a reasonable range of alternatives to Fort Collins’ Proposed Action. The No-Action Alternative includes a combination of non-structural measures that Fort Collins could implement to improve its water supply position in lieu of enlarging Halligan Reservoir and without the need for an individual Section 404 permit or other federal permit. However, the No-Action Alternative does not meet the purpose and need.

2.3.1 Fort Collins’ Proposed Action

Enlarging Halligan Reservoir is Fort Collins’ Proposed Action for meeting its future water supply needs. Fort Collins has contemplated enlarging Halligan Reservoir since the mid-1980s, and past conceptual studies have been performed to evaluate the feasibility of several different approaches to enlarging the reservoir. Additionally, Fort Collins’ Proposed Action has evolved in response to participants withdrawing from the project and analyses conducted during this National Environmental Policy Act process.
Figure 2-1. Overview – Location of Fort Collins’ Proposed Action and action alternatives.
2.3.1.1 Storage

Fort Collins would obtain the storage and water needed to satisfy its purpose and need by enlarging the existing Halligan Reservoir and using existing infrastructure to deliver water to its water treatment plant. Halligan Reservoir, located about 25 miles northwest of Fort Collins, is an existing storage reservoir on the North Fork of the Cache la Poudre River (North Fork) with an approximate capacity of 6,400 acre-feet. The reservoir currently supplies water to the shareholders of North Poudre Irrigation Company (NPIC), but Fort Collins acquired Halligan Reservoir in 2004 pursuant to a 1993 option agreement. Fort Collins does not own nor is able to use any water currently stored in Halligan Reservoir. Fort Collins entered the 1993 option agreement because it wanted to leave open the possibility of enlarging the reservoir if, at a later date, it was determined to be the most appropriate means of meeting Fort Collins’ water demands. The 1993 option agreement between Fort Collins and NPIC allows Fort Collins to enlarge Halligan Reservoir but requires Fort Collins to re-convey the reservoir facilities back to NPIC if Fort Collins abandons or is otherwise unable to enlarge the reservoir.

Although dam inspection reports suggest that the dam at Halligan Reservoir is currently sound, it will require rehabilitation in the near future to address safety risks (Colorado Division of Water Resources 2018). The dam is over 100 years old and seepage through the dam and freeze-thaw cycles will continue to degrade the mass of the dam and presents an increasing safety risk unless rehabilitated. These issues identified in the dam inspection reports would be addressed by Fort Collins as the dam is enlarged under this alternative.

Common Technical Platform modeling sequence was used to determine the storage volume required in Halligan Reservoir for Fort Collins’ Proposed Action, as well as inflow and release characteristics. The modeling showed that Halligan Reservoir would need to be enlarged by 8,125 acre-feet to satisfy the project purpose and need, resulting in an enlarged reservoir capacity of 14,525 acre-feet. To achieve a total enlarged Halligan Reservoir volume of 14,525 acre-feet, the existing dam would need to be raised 25.4 feet. Fort Collins assumed that Halligan Dam would be raised by enlarging the existing dam base, adding concrete on the downstream face, and raising the existing dam crest and spillway crest. Preparation for the foundation would require rock excavation along the abutments and valley bottom outside of the existing footprint by approximately eight to 12 feet. Fort Collins assumed the enlargement would be completed using mass conventional concrete produced onsite. The spillway would be reconstructed in a size and manner similar to the pre-existing spillway with a new crest elevation of 6,383.0 feet. There would be an energy dissipating structure located immediately downstream of the spillway section.

At the maximum water elevation at the crest of the existing Halligan Reservoir, which is 6,367.6 feet, the reservoir surface area is approximately 253 acres. The proposed dam improvement would result in a maximum water surface elevation of 6,393.0 feet and 386 acres of surface area. The difference in area that would be inundated by the increased reservoir surface area under Fort Collins’ Proposed Action is shown in Figure 2-2.
Figure 2-2. Halligan Reservoir enlargement – Fort Collins’ Proposed Action.
2.3.1.2 Outlet Works
The existing outlet structure would need to be modified or replaced based on the final operating conditions. The new outlet works would include a multi-level inlet structure, a pressure conduit through the dam, and an energy-dissipating structure. With a three-gated, multi-level tower, Fort Collins would be able to withdraw water from three levels within the reservoir and connect to one or more conduits within the dam allowing for temperature and quality control of the released water. The pressure conduit(s) through the dam would extend from the multi-level inlet structure to the energy-dissipating structure downstream of the spillway section. Outlet work construction would occur within the existing dam and reservoir footprints.

2.3.1.3 Conveyance
The existing Halligan Reservoir is an on-channel impoundment, and as such, the enlarged Halligan Reservoir would store flows of the North Fork. Fort Collins would make releases from Halligan Reservoir to the North Fork, and utilize releases through an exchange between the confluence of the North Fork and Fort Collins’ existing intake on the Upper Poudre (Upper Poudre refers to the portion of the Poudre River above the confluence with the North Fork) or through the Pleasant Valley Pipeline via the existing Munroe Canal (also known as the North Poudre Supply Canal) headgate, which is also on the Upper Poudre. Water exchanges are transfers of water rights from their original point of diversion or discharge to a new point of diversion. A simplified example of an exchange is provided in Figure 2-3.

2.3.1.1 Water Rights
Fort Collins would use the enlarged Halligan Reservoir to store its existing water rights, including converted Southside Ditch water rights and Water Supply and Storage Company water rights. In addition, Fort Collins’ conditional water rights, including the Halligan Reservoir Enlargement Conditional Right and half of the 1/8th fractional interest of the Grey Mountain Conditional Decree, would be stored in the enlarged Halligan Reservoir. A change of the point of diversion and place of storage of half of the 1/8th fractional interest of the Grey Mountain Conditional Decree must be obtained from water court, which includes proving that such a change would not injure any vested or conditional water rights.
Figure 2-3. Generalized concept of a water exchange.

2.3.1.2 Project Operations

Halligan Reservoir would continue to be filled with direct flows from the North Fork (Figure 2-4). Releases from Halligan would be made to the section of the North Fork downstream of the dam and would flow through Seaman Reservoir to the confluence of the North Fork with the Main Stem (Figure 2-4). From there, water would be exchanged (Figure 2-3) to the Upper Poudre where it can be diverted to the Fort Collins intakes or to the Munroe Canal intake and delivered to the Fort Collins water treatment facility through the Pleasant Valley Pipeline. The Corp’s analysis indicates that releases from Halligan Reservoir are fully exchangeable to Fort Collins’ existing intakes 94 percent of each year. NPIC would continue to operate its current storage volume in Halligan Dam for agricultural purposes as it has in the past.

Fort Collins proposed a winter release plan for all alternatives including Fort Collins’ Proposed Action. The Winter Release Plan would release three cubic feet per second of water from storage to the North Fork for subsequent diversion at the Fort Collins intakes between October 1 and April 30 of each year (Figure 2-4). The winter release plan is primarily a means for Fort Collins to meet wintertime return flow obligations. The winter releases are considered an operational means to decrease reliance on other water sources from storage in the winter (i.e., Colorado-Big Thompson Project [C-BT] or Joe Wright Reservoir), thereby preserving these sources for use later in the summer. The winter releases would have a concurrent benefit of improving stream flows in the North Fork during winter periods when river flows
are typically low. For Fort Collins’ Proposed Action, winter releases would result in an increase to stream flows in the North Fork between Halligan Reservoir and the Main Stem confluence. Winter releases from the enlarged Halligan Reservoir would be replenished to storage during the subsequent spring/summer runoff.

A Summer Low Flow Plan (Summer Plan) and a Peak Flow Bypass Program are also part of Fort Collins’ Proposed Action. The Summer Plan involves adjusting operations to maintain a minimum flow of five cubic feet per second in approximately 22 miles of the North Fork between Halligan Dam and Seaman Reservoir from May 1 to September 30 each year (Figure 2-4). Under the proposed Summer Plan, diversions of Fort Collins’ water into storage in Halligan Reservoir during summer flows would be curtailed when necessary to maintain a minimum flow of five cubic feet per second in the North Fork.

Figure 2-4. Generalized stream flow changes due to Fort Collins' Proposed Action.
When diversions are not occurring, but flows below Halligan Dam drop below the five cubic feet per second target, releases would be made from Fort Collins’ portion of the enlarged Halligan Reservoir. Common Technical Platform modeling showed that the minimum flow of five cubic feet per second could be maintained without increasing the size of the proposed reservoir enlargement. The Summer Plan would be curtailed when a water supply shortage result or operating the plan would violate Fort Collins’ storage reserve factor of 15 percent of its annual demand (5,760 acre-feet in 2065). In general, Summer Plan curtailment would occur if water data suggest that Fort Collins would require water restrictions for the coming summer or in the case of a water supply emergency.

Fort Collins also proposes a Peak Flow Bypass Program that would forgo all diversions to the enlarged pool at Halligan Reservoir for the three days that coincide with the forecasted peak runoff flow event for the North Fork (Figure 2-4). Peak flows drive many riverine physical and ecological processes, including sediment transport, aquatic habitat formation and maintenance, and riparian area inundation. The intended purpose of the Peak Flow Bypass Program is to prevent any additional attenuation of peak flows on the North Fork below Halligan Dam. Common Technical Platform modeling showed that the operating the Peak Flow Bypass Program could be done without increasing the size of the proposed reservoir enlargement. The Peak Flow Bypass Program would be curtailed when its operation would cause a water supply shortage or would violate Fort Collins’ storage reserve factor. In general, Peak Flow Bypass Program curtailment would occur if water forecasts for Fort Collins would require water restrictions for the coming summer or in the case of a water supply emergency.

The Summer Plan and Peak Flow Bypass Program would not be included in any other action alternative because the action alternatives cannot positively affect flows in the North Fork and would require pumping, making recapture of releases less certain.

With the exception of meeting winter releases and the Summer Plan, releases from the enlarged Halligan Reservoir would be made only when other sources of water are unavailable. In other words, releases from the enlarged Halligan Reservoir would be made when other Fort Collins sources are unable to meet water demands. There was no pre-determined demand or release pattern for the enlarged Halligan Reservoir. In general, releases from the enlarged Halligan Reservoir would occur: (1) to meet Fort Collins’s reusable water demand when there is a lack of other reusable water sources, or (2) in dry years or emergency water supply disruptions to meet Fort Collins’ single-use and reusable water demands when other Fort Collins water sources are unavailable.

Figure 2-4 illustrates the general change in stream flow associated with Fort Collins’ Proposed Action. The image is not to scale nor does it reflect the magnitude of the changed flow. Rather it provides a visual representation of where there is a change from current stream flow as a result of Fort Collins’ Proposed Action. Details of where the stream flow would change, when it would occur, and the magnitude of the change are presented in Section 4.3.3.3.

### 2.3.2 Expanded Glade Alternative

In the Expanded Glade Alternative, Fort Collins would meet its purpose and need through the enlargement of the proposed Glade Reservoir and constructing necessary infrastructure to deliver water to its water treatment plant. The proposed Glade Reservoir is a 170,000 acre-feet storage reservoir that was proposed as part of NISP by Northern Water on behalf of 15 Northern Front Range water suppliers. The
**NISP Final EIS** (Corps 2018) was released in July 2018, after the Expanded Glade Alternative was developed. The feasibility of the Expanded Glade Alternative is contingent on NISP being permitted and constructed.

The configuration and operation of the Expanded Glade Alternative are dependent on the ultimate configuration and operation of the NISP facilities. Finalized engineering plans for NISP facilities, including the proposed Glade Reservoir and associated infrastructure, were not available to the Corps and Fort Collins at the time of this analysis. For the definition of the Expanded Glade Alternative, assumptions were made based on the *NISP Supplemental Draft EIS* (U.S. Army Corps of Engineers [Corps] 2015), NISP technical reports, and discussions with Northern Water staff about the operation and configurations of the proposed Glade Reservoir complex infrastructure (Personal communication; meeting with Northern Water staff [Carl Brouwer, Andy Pineda, and Jerry Gibson], February 19, 2014). The *Supplemental Draft EIS* represented the most current, publicly available information at the time the Corps developed the Expanded Glade Alternative. The Expanded Glade Alternative assumes that Fort Collins could reach an agreement with Northern Water to design and construct the proposed Glade Reservoir and associated infrastructure to meet the combined NISP participants’ and Fort Collins’ purpose and need. The Expanded Glade Alternative is feasible only if Fort Collins’ needs are incorporated prior to the design and construction of the proposed Glade Reservoir; the alternative is not feasible if enlarging and retrofitting the proposed Glade Reservoir is required after it is constructed. The Expanded Glade Alternative anticipates that if the proposed Glade Reservoir was designed and constructed, it would include dedicated storage capacity of 6,075 acre-feet for Fort Collins added to the NISP participants’ storage of 170,000 acre-feet for a total capacity of 176,075 acre-feet.

### 2.3.2.1 Storage

The expansion of the proposed Glade Reservoir by 6,075 acre-feet would be 2,050 acre-feet smaller than Fort Collins’ proposed expansion of Halligan Reservoir due to the incorporation of water stored in Chambers Lake in the storage reserve factor calculation. Additionally, there was better exchange potential between the Southside Ditch and Water Supply and Storage Company headgates to the proposed Glade Reservoir inlet than there was to Halligan Reservoir. This allowed more frequent exchange of water into the proposed Glade Reservoir than into Halligan Reservoir and thereby reduced the storage capacity necessary to meet the purpose and need.

The maximum water elevation of the proposed Glade Reservoir for NISP at 170,000 acre-feet would be 5,518 feet based on elevation-capacity information provided in *NISP Technical Memorandum No. 1* (GEI Consultants 2006). At 170,000 acre-feet, the proposed Glade Reservoir inundation area would be approximately 1,626 acres (GEI Consultants 2006). The additional storage of 6,075 acre-feet for Fort Collins would require an additional dam height of approximately four feet, with a resulting maximum water elevation of approximately 5,521 feet and 1,678 acres of inundated area. The footprint for the inundation was based on interpolation for a dam height increase of 3.6 feet. Geographic Information System computer shape files for analysis presented in Chapter 4 could only be generated for one-foot increments, therefore the analysis presented in the Draft EIS is based on a water elevation of 5,522 feet with a new inundation of approximately 63 acres. The inundation area footprint difference between the proposed Glade Reservoir for NISP and and proposed Glade Reservoir is shown in Figure 2-5.
Figure 2-5. The proposed Glade Reservoir surface areas for NISP and the Expanded Glade Alternative, with Fort Collins’ proposed infrastructure.
2.3.2.2 Conveyance

Due to the off-stream location and the elevation of the proposed Glade Reservoir with respect to the Main Stem, the inflows to the reservoir would need to be pumped from the Glade Forebay into the reservoir. As planned, water for NISP participants would be diverted from the Main Stem and conveyed to the Glade Forebay using the Poudre Valley Canal and a canal turnout structure, located approximately 1.8 miles from the river diversion structure.

Under this alternative, Fort Collins would expand the Poudre Valley Canal to convey its peak storable diversions (i.e., 60 cubic feet per second) from the river to the proposed Glade Forebay. The Poudre Valley Canal had a planned capacity of 1,700 cubic feet per second (Personal communication; meeting with Northern Water staff [Carl Brouwer, Andy Pineda, and Jerry Gibson], February 19, 2014) including 1,200 cubic feet per second for the NISP participants and 500 cubic feet per second for other diversions for existing Poudre Valley Canal owner purposes. The planned capacity would be expanded to 1,760 cubic feet per second for the Expanded Glade Alternative. Fort Collins would expand the canal turnout to convey the additional 60 cubic feet per second to the Glade Forebay and would enlarge the forebay by approximately 80 acre-feet to regulate the peak flow for approximately 15 hours. These assumptions are based on the current understanding of the NISP planned peak flow and Glade Forebay size. The approximate surface area of the NISP planned forebay would be 95 acres (Figure 2-5). It is assumed that the additional forebay capacity could be obtained without substantially enlarging the footprint envisioned by NISP, but rather by slightly increasing the proposed depth. The additional depth required for Fort Collins would be about 0.85 feet. Using enlargements of the planned NISP infrastructure would minimize the need for additional infrastructure dedicated to Fort Collins.

The Glade Pump Station would require the maximum power of approximately 2,850 horsepower for the Fort Collins storage operations. The additional power could be addressed by either adding an additional pump(s) with such capacities or including the additional requirements in the design of shared pumps with NISP participants.

Project components that would be solely required for Fort Collins’ purpose and need are: additional pumping capacity at the Glade Forebay, a new pipeline (48-inch diameter) to connect the proposed Glade Reservoir outlet pipeline (120-inch diameter) to Fort Collins’ existing pipeline and the Pleasant Valley Pipeline, an outflow control system, a pretreatment plant at the Glade Pump Station, and a turn out structure at the Main Stem.

Releases from the proposed Glade Reservoir for Fort Collins would be conveyed to the Fort Collins water treatment facility. This alternative would use the planned NISP outlet structure and a new pipeline that would connect the planned Glade Outlet pipeline with: (1) the Pleasant Valley Pipeline, (2) the Fort Collins existing 24-inch raw water pipeline, and (3) the Fort Collins existing 27-inch raw water pipeline. Connections would be made at a point approximately 1.5 miles southwest of the proposed Glade Dam site where the Pleasant Valley Pipeline and the existing pipeline alignments come close to each other (within 50 feet). The existing Fort Collins 24-inch and 27-inch pipelines converge to a single 36-inch existing pipeline near Bellvue. The multiple connections to existing pipelines would allow maximum flexibility in the operation of the combined proposed Glade Reservoir releases and river diversions, and would make delivering water from storage possible year-around.
The new pipeline that would connect the proposed Glade Reservoir outlet structure with the existing pipelines would be 48 inches in diameter to reduce the conveyance losses in the new section and maximize the conveyance capacity in the existing pipelines to the water treatment facility. A new pipeline connecting the proposed Glade Reservoir to Fort Collins’ existing pipelines and the Pleasant Valley Pipeline would be preferred over expanding the proposed Glade to Horsetooth pipeline because of: (1) the relatively short distance for the new pipeline as compared to the Glade to Horsetooth Pipeline; (2) potential treatment requirements of the proposed Glade Reservoir releases; and (3) potential water quality impacts from discharges to Horsetooth Reservoir. Certain NISP participants have proposed similar pipeline connections between the proposed Glade Reservoir and the Pleasant Valley Pipeline. Under the Expanded Glade Alternative, Fort Collins would explore joint construction and operation of a Glade to Pleasant Valley Pipeline with NISP participants.

Fort Collins’ releases from the proposed Glade Reservoir to the water treatment facility would be blended with water currently diverted through the existing 24-inch and 27-inch pipelines for Fort Collins and through the Pleasant Valley Pipeline for Fort Collins and the Tri-Districts when both entities divert water. The blending of the proposed Glade Reservoir releases with the other flows in the Pleasant Valley Pipeline would occur approximately 2.2 miles from the Pleasant Valley Pipeline intake at the Munroe Canal Forebay. Hydraulic conditions in the network of pipes for the release operation were analyzed for critical conditions.

The simulated condition leaves Fort Collins’ other existing pipelines available to convey any other diversions to the water treatment facility. Modeling results were analyzed to verify simulated flows in all pipes during critical conditions. At these critical conditions, there would be enough hydraulic head to provide a direct release from the proposed Glade Reservoir to Fort Collins’ water treatment facility without pumping, even when the proposed Glade Reservoir would be at its lowest elevation.

In some cases, Fort Collins would be able to make releases from the proposed Glade Reservoir to the Main Stem for exchange to its existing intake on the Upper Poudre or the Munroe Canal/Pleasant Valley Pipeline diversion (Figure 2-6). The proposed NISP river turnout would be located on the Glade to Horsetooth Pipeline; therefore, Fort Collins would require a dedicated structure with capacity to perform river exchanges. Releases from the proposed Glade Reservoir to the Main Stem for Fort Collins’ water exchange operations would be performed using a new river turnout located near the intersection of the Main Stem and the proposed pipeline that would connect the Glade Pump Station to Fort Collins’ existing pipelines (Figure 2-5). The river turnout structure would be located just upstream of the Pleasant Valley and Lake Canal diversion structure and would allow Fort Collins to operate exchanges year-round. This exchange operation would be mainly used to improve the quality of the water delivered to the water treatment facility. It was assumed that releases from the proposed Glade Reservoir to the Main Stem could be made without significantly impacting the water quality in the river, and that taking a similar amount of water from Fort Collins’ current Upper Poudre diversion points would avoid pretreatment costs for the proposed Glade Reservoir releases while improving water quality delivered to the water treatment facility. However, it was noted that future regulations could require discharges from the proposed Glade Reservoir to be treated.

Similar to Fort Collins’ Proposed Action, the Expanded Glade Alternative includes a release of three cubic feet per second to meet wintertime return flow obligations. This release would come from the
proposed Glade Reservoir into the Main Stem, but would not result in a change in stream flow as the release relates to return flow obligations.

Figure 2-6 illustrates the general change in stream flow associated with the Expanded Glade Alternative. The image is not to scale nor does it reflect the magnitude of the changed flow. Rather it provides a visual representation of where there is a change from current stream flow as a result of the Expanded Glade Alternative. Details of where the stream flow would change, when it would occur, and the magnitude of the change are presented in Section 4.3.4.3.
2.3.2.3 Pretreatment Facility

Water stored in the proposed Glade Reservoir would be expected to have a lower water quality than Fort Collins’ current water sources (i.e., river diversions further upstream on the Upper Poudre and Horsetooth Reservoir), mainly due to the water quality characteristics of flow events that would be the source of the proposed Glade Reservoir storage. In order to provide water that was of quality similar to existing sources, a 16 million gallons per day pretreatment facility would be located near the dam (Figure 2-5). Specifically, there are concerns about the high total organic carbon levels present in the Poudre River at times when diversions would be made to the proposed Glade Reservoir. High total organic carbon can lead to formation of potentially carcinogenic disinfection by-products when the water is chlorinated. Water quality regulations limit both the effluent total organic carbon (based on influent total organic carbon and influent alkalinity) as well as the formation of disinfection by-products. Under current operations, high total organic carbon levels in the Poudre River trigger the need for raw water blending with Horsetooth Reservoir water (total organic carbon less than two milligrams per liter). If total organic carbon levels become too elevated, it would require the implementation of new treatment technologies at the Fort Collins water treatment facility. In addition, the Pleasant Valley Pipeline operation would be shared with the Tri-Districts, and the Tri-Districts’ water quality would be degraded when blending untreated Fort Collins’ releases from the proposed Glade Reservoir with Tri-Districts’ diversions flowing in the Pleasant Valley Pipeline. These conditions would be addressed by pretreating releases from the proposed Glade Reservoir to approximately the quality of current source water when necessary to meet water quality objectives.

In order to mitigate increased total organic carbon levels, a pretreatment plant would be constructed that would treat the water released from the proposed Glade Reservoir such that pretreated total organic carbon levels are below 1.6 milligrams per liter, the minimum April through October total organic carbon level currently found in diversions of the Poudre River, measured at the water treatment facility. While there are a number of technologies that could be utilized for total organic carbon removal, ballasted flocculation with an integrated powdered activated carbon system is specially designed for high total organic carbon removal and is being utilized in other parts of Colorado for total organic carbon removal (e.g., Parker, Colorado). Ballasted flocculation involves the use of media (usually sand) to assist the formation of flocculant that could be removed via sedimentation (MWH 2015). In the powdered activated carbon contact chamber, total organic carbon is absorbed by the activated carbon. Ballast material and coagulant are added in a second chamber, forming flocculant that quickly settles in the sedimentation chamber. Both ballast material and powdered activated carbon are recycled, although both would require regular regeneration. The regeneration cycles would depend on flow rates and water quality.

2.3.2.4 Power Requirements

Pump Station B would be a 2,850-horsepower pump using about 676,545 kilowatt-hours per year to pump water into the proposed Glade Reservoir and about 35,841 kilowatt-hours per year to pump water out of the proposed Glade Reservoir. About 129,000 kilowatt-hours per year would be required to pretreat the water from proposed Glade Reservoir.
2.3.2.5 Dam Material and Borrow Sites

Based on the NISP Supplemental Draft EIS, alluvium available in the vicinity of the Glade Forebay area and the forebay excavation material would be used as borrow/embankment material for the construction of the Glade Dam. It is assumed that sufficient material would be available to support construction of the enlarged dam for this alternative.

2.3.2.6 Water Rights

Fort Collins would store its existing water rights, including converted Southside Ditch water rights and Water Supply and Storage Company water rights, in a proposed Glade Reservoir. Fort Collins’ conditional water rights that would be used in the proposed Glade Reservoir include the Halligan Reservoir Enlargement Conditional Right and half of the 1/8th fractional interest in the Grey Mountain Conditional Decree. These are the same water rights proposed for use with Fort Collins’ Proposed Action; however, certain changes to the points of diversion and places of storage for some of these water rights would be required from water court or through administrative approval under Colorado Revised Statute 37-87-101(3).

2.3.2.7 Project Operations

Fort Collins must have independent control and operation of its reservoir storage account and associated facilities. Adding Fort Collins to the multi-user NISP project, including its different water rights portfolios and demands from storage, could present situations requiring filling and releasing operations simultaneously. Because the proposed Glade Reservoir inlet/outlet structure would be used for both filling and releasing operations, conflicting situations could arise when Fort Collins wishes to conduct releases from the proposed Glade Reservoir at the same time the NISP participants are diverting water to the proposed Glade Reservoir, and vice versa. These simultaneous operations would require exchanges and paper storage accounting transfers in the reservoir (book-over) between the various users.

During simultaneous operations when releases either by NISP participants or Fort Collins would be made to the river (Figure 2-6), these book-over exchanges would be relatively straightforward:

- When NISP is diverting from the river while Fort Collins wishes to make releases, NISP would forego diversions and Fort Collins would book-over storage to NISP.
- When Fort Collins is diverting from the river while NISP wishes to make releases, Fort Collins would forego diversions and NISP would book-over storage to Fort Collins.

Simultaneous operations become more complex if releases were to be made to pipelines (e.g., Fort Collins releases to the proposed pipeline from the proposed Glade Reservoir to the Pleasant Valley Pipeline/Fort Collins pipeline or NISP releases to the Glade to Horsetooth pipeline or other NISP proposed pipelines). Under these situations, exchanges would be made at the Glade Forebay, and pumping would be required to accomplish the exchanged releases, since the forebay is at a lower elevation than the minimum reservoir elevation. For the critical hydraulic conditions used to examine the proposed Glade Reservoir releases, the pumping of the maximum simulated release from the forebay to Fort Collins’ water treatment facility would require approximately 85 feet of dynamic head and, for the peak flow, 540 horsepower of pumping power.
In addition to simultaneous operations, the pumping scenario discussed above would apply to the pretreated flows to be blended with the river diversions in the existing pipelines at Point C (Figure 2-5); therefore, a dedicated pump would have to be added to the NISP Glade Pumping Station to support pretreatment and the simultaneous filling and releasing operations. This pump would have the ability to pump from the forebay and pretreated water tanks into the Fort Collins release pipeline and the final NISP release conveyance structures.

The NISP proposed Glade Reservoir to Horsetooth Reservoir transfer (if constructed for NISP) would use the planned Glade Pump Station (Munroe Canal Bypass pump) to lift water into Horsetooth Reservoir when the proposed Glade Reservoir water levels are low. The simultaneous operations condition in which NISP water would be pumped to Horsetooth Reservoir from the Glade Forebay is not fully analyzed at this time. Because the Glade Forebay is lower than the minimum proposed Glade Reservoir water level, additional pumping capacity could be required to deliver water to Horsetooth Reservoir. Pumping requirements and the use of the Munroe Canal Bypass pump for NISP releases during simultaneous operations would have to be analyzed at a later time. If the use of the Munroe Canal Bypass pump was insufficient or there were operating conflicts with NPIC operations, the design of the additional pump(s) would have to accommodate both the NISP and Fort Collins releases during these simultaneous operations.

2.3.2.8 Halligan Dam Rehabilitation

The 1993 option agreement between Fort Collins and NPIC allows Fort Collins to enlarge Halligan Reservoir but requires Fort Collins to re-convey the reservoir facilities back to NPIC if Fort Collins abandons or is otherwise unable to enlarge the reservoir.

Although dam inspection reports suggest that the dam at Halligan Reservoir is currently sound, it requires rehabilitation in the near future to address safety risks. The dam is over 100 years old and seepage through the dam and freeze-thaw cycles will continue to degrade the mass of the dam, will require rehabilitation, and presents an increasing safety risk. Due to the age of Halligan Dam and its current condition, NPIC would need to develop and implement a rehabilitation plan (Colorado Division of Water Resources 2018). This may be financially difficult for the agricultural shareholders of a mutual ditch company like NPIC. Under this alternative, Halligan Dam would be rehabilitated with no change to the storage capacity to the reservoir.

2.3.3 Gravel Pits Alternative

This alternative is a combination of two separate, but similar preliminary alternatives proposed in the Alternatives Screening Report (DiNatale Water Consultants and CDM Smith 2016). Those two preliminary alternatives are the Gravel Pits Preliminary Alternative and the Mountain Reservoir Preliminary Alternative. Acknowledging that the primary new facilities associated with the alternative are gravel pits storage, the alternative is referred to as the “Gravel Pits Alternative.” This alternative was developed and configured with information publicly available at the time of the alternatives screening analysis in 2014 and 2015; development changes may have occurred since that time.
In addition to gravel pit storage, this alternative features reoperation of Joe Wright Reservoir, a facility owned and operated by Fort Collins. Storage in Joe Wright Reservoir would be maintained at a higher level for winter carryover by conducting fewer single-use water trades with NPIC.

2.3.3.1 Storage

In the Gravel Pits Alternative, Fort Collins would develop additional water storage at the Overland Gravel Pit complex (hereafter referred to as gravel pit complex) located along the Main Stem northwest of Fort Collins. Figure 2-7 shows the general location of the alternative and its features.

Fort Collins would develop 3,875 acre-feet of new storage at the gravel pits complex. The gravel pits complex consists of over 15 existing and potential gravel pit sites located south and north of the Main Stem. Greeley and Tri-Districts currently own and operate existing pits for water storage on the south side of the Main Stem; therefore, gravel pits considered for this alternative were located north of the Main Stem on existing or proposed gravel pit sites in the gravel pit complex.

The selected set of gravel pits is one of many different potential configurations that may be available to Fort Collins that incorporated pits that currently are being excavated or that had already been excavated and could be readily connected into a single storage complex. The gravel pit sites included in the selected configuration for this alternative are the North Shore Reservoirs, Taft Hill Reservoir-A, Stegner Farms, and the Home Office Mine pits. The locations of the selected gravel pits with their associated depths, acreages, and storage volumes are shown in Figure 2-7.

The selected gravel pits would have a below-grade storage potential of about 2,100 acre-feet. All the gravel pit sites selected for this alternative except portions of the Home Office Mine-B, Home Office Mine-A released, and Home Office Mine-B released sites are outside the Main Stem 100-year floodplain based on floodplain maps prepared by the Federal Emergency Management Agency (Figure 2-7). Above-grade storage at two of the pits, Stegner Farms and North Shore Reservoir 1, would be used to augment the below-grade storage to satisfy the storage requirement. Above-grade storage would be achieved by adding 20-foot high berms around those two pits. Gravel pit sites in the 100-year floodplain would only have below-grade storage, avoiding impacts to flood levels at the Gravel Pits Alternative site and adjacent properties. Therefore, gravel pit storage should be consistent with the Larimer County floodplain development ordinances. With the addition of berms, the total estimated storage volume was slightly greater than the modeled storage need; approximately 3,993 acre-feet of storage was estimated compared to the 3,875 acre-feet need determined through modeling.

Twenty-foot-high berms would be jurisdictional dams under the Colorado Division of Safety of Dams criteria (Colorado Division of Water Resources 2007) and, therefore, would require special design considerations and approvals from the State Engineer’s Office before construction. Sites for developing above-grade storage were selected to minimize the ratio between perimeter and storage volume, and to avoid berms in the 100-year floodplain. Minimizing the ratio between perimeter and storage volume minimizes the length of required berms, construction cost, permitting complexity, and the need for pumping to fill the pits. Constructing berms at some pits had several advantages:
Figure 2-7. Gravel Pits Alternative overview.
• reduced number of pits required to produce the necessary storage
• reduced property acquisition costs
• deeper storage facilities reduced the area exposed to evaporation losses, which can be substantial relative to storage volume

Table 2-1 shows the total storage as well as the above and below grade storage available in each gravel pit storage reservoir.

### Table 2-1. Total planned storage for the Gravel Pits Alternative reservoirs.

<table>
<thead>
<tr>
<th>Gravel Pits</th>
<th>Currently Excavated(^1)</th>
<th>Berm Height (feet)</th>
<th>Below-Grade Storage (acre-feet)</th>
<th>Above-Grade Storage (acre-feet)</th>
<th>Total Storage (acre-feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stegner Farm</td>
<td>Partial</td>
<td>20</td>
<td>522</td>
<td>999</td>
<td>1,521</td>
</tr>
<tr>
<td>Under the North Taft Hill Boundary-A</td>
<td>Yes</td>
<td>N/A</td>
<td>33</td>
<td>N/A</td>
<td>33</td>
</tr>
<tr>
<td>Home Office Mine-A</td>
<td>Yes</td>
<td>N/A</td>
<td>109</td>
<td>N/A</td>
<td>109</td>
</tr>
<tr>
<td>Home Office Mine-B</td>
<td>Yes</td>
<td>N/A</td>
<td>242</td>
<td>N/A</td>
<td>242</td>
</tr>
<tr>
<td>Home Office Mine-A Released</td>
<td>Yes</td>
<td>N/A</td>
<td>185</td>
<td>N/A</td>
<td>185</td>
</tr>
<tr>
<td>Home Office Mine-B Released</td>
<td>Yes</td>
<td>N/A</td>
<td>127</td>
<td>N/A</td>
<td>127</td>
</tr>
<tr>
<td>North Shore Reservoir 2</td>
<td>No</td>
<td>N/A</td>
<td>310</td>
<td>N/A</td>
<td>310</td>
</tr>
<tr>
<td>North Shore Reservoir 1</td>
<td>No</td>
<td>20</td>
<td>467</td>
<td>999</td>
<td>1,466</td>
</tr>
<tr>
<td><strong>Total Available Storage (acre-feet)</strong></td>
<td></td>
<td></td>
<td><strong>1,995</strong></td>
<td><strong>1,998</strong></td>
<td><strong>3,993</strong></td>
</tr>
</tbody>
</table>

\(^1\)Status as of February 2015: Home Office Mine- A Released and Home Office Mine- B Released were excavated and released; all other gravel pits were under active mining permits but not yet mined. N/A = not applicable

The eight proposed Fort Collins gravel pit storage reservoirs would be designed to operate as a single unit with the pits as full as possible to minimize the evaporation losses. Gravel pit bottom grades and maximum water storage levels would be designed to maximize the ability to move water through the gravel pit complex by gravity. Based on state regulations, the pits would be excavated to bedrock or an impermeable formation and, in accordance with standard practice and state regulations for gravel pit design in Colorado, be confined by an impermeable barrier (i.e., slurry wall).

#### 2.3.3.2 Conveyance

Water for storage in this alternative would be diverted at the existing Larimer County Canal Number 2 diversion structure on the Main Stem and conveyed through the existing canal using excess capacity to a new lateral structure located approximately 1.1 miles from the diversion structure (Figure 2-8). From the lateral diversion, a 1.7-mile pressurized 42-inch bi-directional pipeline would convey water to Stegner Farms Pit, which is the pit with the highest water level. The bi-directional pipe would cross underneath the Main Stem and would use topographic head to convey water to the gravel pit complex without pumping. The pipeline would be bi-directional because under the Gravel Pits Alternative water would not be delivered to the Fort Collins water treatment facility at the same time the pits were being filled.
In the gravel pit complex, water would move by gravity through culverts or pipes from higher to lower pits. The one exception is North Shore Reservoir 1, which would have to be filled by pumping from the Stegner Farms Pit under certain hydraulic conditions.

![Diagram](image)

**Figure 2-8. Generalized stream flow changes due to the Gravel Pits Alternative.**

A turnout structure would be installed where the proposed 42-inch pipeline crosses under the Main Stem. This would allow water to be released directly into the Main Stem and exchanged up to current Fort Collins diversion points on the Upper Poudre at Gateway Park or the Munroe Canal (Figure 2-8). When hydrologic conditions would be suitable to perform river exchanges, this operation would reduce the pumping and pretreatment costs for Fort Collins. It was assumed river releases would not require treatment, but future regulations may require such discharges to be treated.

Water would be released from the gravel pits complex via a 560 horsepower pump station located between Home Office Mine-B and North Shore Reservoir 2, which had the lowest water elevation of the
gravel pits. The pump station would use a set of 36-inch pipelines to connect with the 42-inch bi-directional main pipeline that would convey water to the pretreatment facility, co-located with the lateral diversion structure from the Larimer County Canal Number 2. Pretreated water would be pumped by a 1,207 horsepower pumping station using a new 36-inch pipeline that connects to the existing Fort Collins 36-inch pipeline and to the Pleasant Valley Pipeline at a valve house located at the intersection of the current pipeline alignments. Multiple connections to existing pipelines would provide operational flexibility, allowing Fort Collins to release water to the water treatment facility via the existing 36-inch pipeline when the Pleasant Valley Pipeline is flowing in the opposite direction during the winter, or via the Pleasant Valley Pipeline when there is not available capacity in the 36-inch pipeline. Connection to both the Pleasant Valley Pipeline and 36-inch pipeline would allow water from the gravel pit complex to be delivered at all times, which is necessary to maintain Fort Collins’ storage reserve factor.

Potentially feasible alignments were selected for proposed conveyance facilities, and were specified as 200-foot wide corridors (Figure 2-7). Specific pipeline locations within the corridors would have to be refined based on utility interferences, property ownership, and other factors.

Similar to Fort Collins’ Proposed Action, the Gravel Pits Alternative includes a release of three cubic feet per second to meet wintertime return flow obligations. This release would come from the Gravel Pits into the Main Stem, but would not result in a change in stream flow as the release relates to return flow obligations.

Figure 2-8 illustrates the general change in stream flow associated with the Gravel Pits Alternative. The image is not to scale nor does it reflect the magnitude of the changed flow. Rather it provides a visual representation of where there is a change from current stream flow as a result of the Gravel Pits Alternative. Details of where the stream flow would change, when it would occur, and the magnitude of the change are presented in Section 4.3.5.3.

2.3.3.3 Pretreatment Facility

Based on experience at similar gravel pit storage facilities in the project area, there would be a potential for algae formation in the Gravel Pits Alternative during storage of water that would disrupt the treatment process at the Fort Collins water treatment facility. Similar to the Expanded Glade Alternative, the water source for the gravel pit storage could have elevated total organic carbon relative to Fort Collins’ existing water treatment facility sources requiring raw water to be blended with Horsetooth Reservoir water. Or, if total organic carbon levels become too elevated, the Gravel Pits Alternative would require the implementation of new treatment technologies at Fort Collins’ water treatment facility. Pretreating water from the gravel pit complex would avoid this problem. Pretreatment would also ensure that releases conveyed via the Pleasant Valley Pipeline would not degrade water quality for other users of the Pleasant Valley Pipeline. A 28 million gallon per day pretreatment facility would be located near Larimer County Canal Number 2 (Figure 2-7).

In order to remove algae and decrease total organic carbon levels to values comparable with the low total organic carbon levels from the current diversions, the pretreatment plant would treat the water released from the gravel pits such that total organic carbon levels are below 1.6 milligrams per liter, the minimum total organic carbon level from April through October currently found in diversions from the Main Stem.
and measured at the water treatment facility. Total organic carbon would be removed in the same manner described for the Expanded Glade Alternative (Section 2.3.2.3).

### 2.3.3.4 Power Requirements

Pump Station C would be a 45-horsepower pump using about 20,000 kilowatt-hours per year to pump water into the gravel pits and a 1,290-horsepower pump using about 263,000 kilowatt-hours to pump water out of the gravel pits. Pump Stations A (483 horsepower) and G (133 horsepower) would require about 149,000 and 54,000 kilowatt-hours per year respectively. About 270,000 kilowatt-hours per year would be required to pretreat the water from the gravel pits.

### 2.3.3.5 Gravel Pit Excavation

Limited information regarding subsurface conditions in the area is available; the best available information and primary source used in this analysis was *Appraisal of Taft Hill Pits Report* (McCarty Land & Water Valuation 2001). The overburden material in the gravel pit area generally consists of sands and gravels. The depth to bedrock varies from 12 to 22 feet according to the *Appraisal of Taft Hill Pits Report*. Some of this material may be usable for transition and/or filter material in the above-grade berm. However, further geotechnical investigation is required to better identify materials that would be excavated from the site and to determine potential uses for these materials.

The amount of materials for construction of berms and reclaimed pit walls, excluding waste factors, could range from 900,000 cubic yards to 1,400,000 cubic yards (plus or minus 20 percent of the estimated volume). Assuming 50 percent of the pit would have been excavated at the beginning of the project, the estimated volume of materials required for construction was roughly equivalent to the estimated volume of materials to be excavated from the gravel pits. The design would incorporate as much of the excavated material as possible for berm construction. However, the quantity of excavated materials that is suitable for construction of the berms would be dependent on geotechnical characteristics of in-situ material. Excavated material not suitable or in excess of the construction needs would have to be sold or hauled and disposed.

The volume of material that can be used in construction, the volume of material that can be sold to a third party, and the volume of material that must be disposed of are highly dependent on further geotechnical investigation regarding the specific material type in the area and the material needed for construction of the berms.

### 2.3.3.6 Berm and Storage Facility Construction

Enlarging the gravel pits by adding 20 feet high berms around Stegner Farms and North Shore Reservoir gravel pits would make the berms jurisdictional dams under the Colorado Division of Safety of Dams criteria, and would require specific design considerations and approvals from the State Engineer’s Office before construction.

Berms would likely be constructed using a combination of material excavated from the gravel pits and material from an external source. Proposed berm dimensions for the Gravel Pits Alternative are described in the *Fort Collins Alternative Descriptions Action Alternatives Report* (MWH 2015). A low permeability
barrier would be needed to provide the water barrier element for the impoundment. This low permeability barrier would also potentially be constructed using clay from an external source or sandy gravel augmented with clay, claystone, or bentonite if adequate low permeability materials are not available at the gravel pit complex site. The berm may be constructed using zones, with a low permeability core material and a filter/drain zone to intercept seepage through the pervious shells and embankment core, as well as to control the potential for piping of the granular embankment shell material. Material excavated from the gravel pits could likely be used for the filter/drain zone if required. However, material used for construction of the filter/drain zone may require processing. Alternatively, a high-density polyethylene liner could be installed to impound water within the gravel pits. The bedrock beneath the gravel pits should be identified from geotechnical field investigation and/or verified in the field by exploratory drilling.

Excavated material could also likely be used for construction of the granular embankment shell material outside of the core zone. The geometry of berm construction is dependent upon potential construction materials excavated from the gravel pits. At this time, it is assumed that the berm can be constructed with slopes of 3:1 as described in the *Fort Collins Alternative Descriptions Action Alternatives Report* (MWH 2015).

Based on the proposed operation (i.e., maintaining individual gravel pits as full as possible) and the location of the pits with berms, the internal faces of the pits would require riprap slope protection from potential erosion at a minimum for the top five feet of the berms. Rock for construction of riprap slope protection could potentially be obtained from rock quarries in the general area. Alternatively, slope protection could be processed from the gravel pit complex excavation depending on the maximize size and percent of coarse material available on site.

### 2.3.3.7 Seepage Cutoff Construction

A slurry cutoff wall around the perimeter of each gravel pit would be required to provide a seepage cutoff. For pits without berms, the seepage cutoff would extend from the ground surface to the bedrock shale layer. For pits with berms, the seepage cutoff would extend from the embankment core through the alluvium foundation and into the underlying bedrock foundation. The cutoff wall would need to connect to the low permeability core of the berm to limit potential for seepage out of the pond.

Slurry cutoff walls would be constructed around groups of adjacent pits to reduce the length of cutoff wall to be constructed while maintaining the separation between surface water and groundwater. Alternatively, a liner system could be constructed on the internal face of the gravel pit slopes and berms and within the impoundment. The liner would consist of compacted low permeability material or high-density polyethylene liner. If a liner system is constructed, the slurry cutoff wall would not be required. Clayey material/weathered claystone in the foundation of the gravel pit site could be used to construct the berm for this alternative. However, the geometry of the berm would still remain dependent on the geotechnical properties of construction materials. A clayey berm liner in the interior of the gravel pit would be designed to resist uplift pressure beneath the liner. Installation of a geomembrane liner, exposed on the surface of the gravel pit, would be subject to uplift and damage when the gravel pit is dewatered. Therefore a liner cover would be required to provide “ballast” and prevent floating of the liner. Internal
faces of the pits would be maintained free of woody vegetation to prevent root intrusion into the berm liner, which could lead to water leakage and/or groundwater intrusion.

**2.3.3.8 Spillway**

A spillway is not assumed to be required to provide a controlled outlet from the gravel pits. Water in the gravel pits would be pumped in from external sources. Surface water runoff would be diverted around the Stegner Farms and North Shore Reservoir 1 gravel pits. An adequate freeboard would be maintained to allow for additional storage in the event of high precipitation or over pumping into the system.

**2.3.3.9 Water Rights**

Fort Collins would store its existing water rights, including converted Southside Ditch water rights and Water Supply and Storage Company water rights, in the gravel pits. Fort Collins’ conditional water rights, including the Halligan Reservoir Enlargement conditional right and half of the 1/8th fractional interest of the Grey Mountain Conditional Decree, would be stored in the gravel pits. These are the same water rights proposed for use with Fort Collins’ Proposed Action; however, certain changes to the points of diversion and places of storage would be required from water court or through administrative approval under Colorado Revised Statute 37-87-101(3).

**2.3.3.10 Joe Wright Reservoir Reoperation Plan**

In addition to constructing new storage at the gravel pit complex, the Gravel Pits Alternative includes reoperation of existing storage at Joe Wright Reservoir. The reoperation plan targets maintaining a winter carryover pool in Joe Wright Reservoir of 3,200 acre-feet. To maintain this target level, Fort Collins would reduce the amount of late summer and early fall releases of single-use water for subsequent exchange with NPIC. These single-use water releases have historically been performed to swap Joe Wright Reservoir water for NPIC’s C-BT water stored in Horsetooth Reservoir. Such swaps mutually benefited both Fort Collins and NPIC. For Fort Collins, the swap reduced the amount of single-use water stored in Joe Wright Reservoir in order to make space for additional reusable water collected the following spring from the Michigan Ditch. For NPIC, the swap allowed for water diversions at the Munroe Canal during periods when the exchange potential for moving C-BT water upstream to the Munroe Canal was low. The water swap with the NPIC provided assurance that water was available at the Munroe Canal for diversion to irrigation in late summer and early fall, which in turn allowed NPIC to set higher water allocations in spring.

Joe Wright Reservoir reoperations were determined through Common Technical Platform modeling. The targeted winter carryover volume was set at the current maximum level to avoid requiring modifications to Joe Wright Reservoir’s outlet works. Targeting any higher carryover volume would necessitate construction of improvements to the outlet works. Results from the modeling indicate an adequate balance of single-use and reusable water was maintained in Joe Wright Reservoir under the proposed reoperation.
2.3.3.11 Halligan Dam Rehabilitation

The 1993 option agreement between Fort Collins and NPIC allows Fort Collins to enlarge Halligan Reservoir but requires Fort Collins to re-convey the reservoir facilities back to NPIC if Fort Collins abandons or is otherwise unable to enlarge the reservoir.

Although dam inspection reports suggest that the dam at Halligan Reservoir is currently sound, it will require rehabilitation in the near future to address safety risks. The dam is over 100 years old and seepage through the dam and freeze-thaw cycles will continue to degrade the mass of the dam, will require rehabilitation, and presents an increasing safety risk. Due to the age of Halligan Dam and its current condition, NPIC would need to develop and implement a rehabilitation plan (Colorado Division of Water Resources 2018). This may be financially difficult for the agricultural shareholders of a mutual ditch company like NPIC. Under this alternative Halligan Dam would be rehabilitated with no change to the storage capacity to the reservoir.

2.3.4 Agricultural Reservoirs Alternative

This alternative is a modification of Alternative Agricultural Transfer Methods Preliminary Alternative as proposed in the Alternatives Screening Report (DiNatale Water Consultants and CDM Smith 2016). The Alternative Agricultural Transfer Methods Preliminary Alternative utilized transferred agricultural water supply and pro-rata storage in the ditch systems in which Fort Collins had an ownership interest. However, it was not certain that Fort Collins would have a right to pro-rata storage based solely on its ownership of shares in the ditch systems, so Fort Collins proposed the Agricultural Reservoirs Alternative. In this alternative, Fort Collins would obtain an additional water storage capacity of approximately 6,475 acre-feet by purchasing dedicated storage space in the existing NPIC Reservoirs Number 5 and 6. Water would be diverted into these reservoirs from the Upper Poudre and then conveyed, when needed, to the existing Fort Collins water treatment facility. The alternative assumed that Fort Collins would own and be able to operate its portion of the storage independently of NPIC and its operations.

2.3.4.1 Storage

Storage for Fort Collins in the Agricultural Reservoirs Alternative would be provided by acquiring dedicated space in the existing Reservoirs Number 5 and 6, a set of two interconnected reservoir units owned by NPIC that could be operated as a single unit. Reservoirs Number 5 and 6 are located approximately nine miles northeast of Fort Collins’ water treatment facility and are located low in the NPIC system, and thus were not considered the primary regulation reservoirs for the NPIC system. Furthermore, they are the closest NPIC plains reservoirs to Fort Collins’ water treatment facility, and are situated at an elevation that is conducive to filling and releasing with lower pumping requirements.

Information from NPIC indicates the combined reservoirs have an active capacity of 16,392 acre-feet, so Fort Collins would need to acquire approximately 40 percent (i.e., 6,475 acre-feet) of the assumed available storage in those reservoirs. Fort Collins’ storage in Reservoirs Number 5 and 6 would be acquired through a purchase and operating agreement. The storage would have to be independently owned, operated, and controlled by Fort Collins to count towards its storage reserve factor. NPIC has agreed to allow Fort Collins to study the use of Reservoirs Number 5 and 6 for this alternative, but has not
indicated whether such purchase and operating agreement could be completed. If acquisition is possible, it is assumed Fort Collins would need to compensate NPIC for loss of reservoir capacity, potential loss of any associated water rights, and any negative impacts to the NPIC system or shareholders.

2.3.4.2 Conveyance

Water to fill Reservoirs Number 5 and 6 would be diverted from the Upper Poudre at the Munroe Canal diversion structure (Figure 2-9). It would then be conveyed by gravity to the Reservoir Number 6 outlet structure using first the Munroe Canal, then 6.8 miles of the Pleasant Valley Pipeline (beginning at Point A in Figure 2-9), and then a 9.9-mile long 48-inch proposed bi-directional pipeline from the Pleasant Valley Pipeline (Point G in Figure 2-9) to Reservoir Number 6 (Point E in Figure 2-9). The section of the Pleasant Valley Pipeline used for this alternative would be shared with the Tri-Districts. Preliminary analyses indicate there would be sufficient capacity available in the Munroe Canal and the Pleasant Valley Pipeline at the time Fort Collins would be diverting its water rights for this alternative. A dedicated 42-inch 2.5-mile long pipeline would convey water from the Reservoir Number 6 outlet structure to Reservoir Number 5 (Point H in Figure 2-9). This 42-inch pipeline would be connected at a valve house proposed at the Reservoir Number 6 outlet with the bi-directional pipeline during the reservoir filling operations from the Pleasant Valley Pipeline. This connection would maintain the pressure in the conveyance to deliver water to Reservoir Number 5 using the upstream hydraulic head. In addition, the valve house would be designed to permit NPIC releases from Reservoir Number 6 to the downstream outlet channel while simultaneously allowing Fort Collins’ filling operations through the pipeline to Reservoir Number 5 (Figure 2-10).

The pipeline alignment and the difference in elevation between the Munroe Canal lateral diversion structure and Reservoirs Number 5 and 6 would allow this filling operation to be performed without pumping. This filling operation would use the available capacity in the Pleasant Valley Pipeline for Fort Collins; therefore, the hydraulic feasibility of this operation was analyzed assuming that the maximum Tri-Districts diversion was simultaneously flowing in the Pleasant Valley Pipeline with Fort Collins’ peak flow to be stored in Reservoirs Number 5 and 6. These critical hydraulic conditions on the filling operation corresponded to a total flow of approximately 135 cubic feet per second in the Pleasant Valley Pipeline, which included 93 cubic feet per second for the Tri-Districts diversion and a daily peak flow of 42 cubic feet per second for Fort Collins.

Fort Collins would require access to stored water at all times to count towards the storage reserve factor and satisfy the project purpose and need; therefore, the 48-inch bi-directional pipeline would be connected with both the existing Pleasant Valley Pipeline (Point D in Figure 2-9) and Fort Collins’ existing 36-inch pipeline (Point G in Figure 2-9) to deliver water stored in Reservoirs Number 5 and 6 to Fort Collins’ water treatment facility under all operating conditions. Similar to the Expanded Glade Alternative and the Gravel Pits Alternative, releases from the agricultural reservoirs would require pretreatment to improve expected poorer water quality relative to current supplies. The pretreatment facility would be located along the bi-directional pipeline. While deliveries from Reservoirs Number 5 and 6 to the pretreatment plant would not require pumping, the conveyance of pretreated water to the water treatment facility would require pumping.
Figure 2-9. Agricultural Reservoirs Alternative overview.
The pump station for the design flow would require a capacity of approximately 1,000 horsepower, with a corresponding lift of 160 feet. These requirements assumed 20 feet of pressure requirement at the water treatment facility mixer. Under this operation, the maximum operating pressure over the new pipe would be approximately 70 pounds per square inch. The pump station would have to be designed with flexibility to match operating pressures in the existing Pleasant Valley Pipeline and 36-inch pipelines for combined operations.

Operating the reservoir release with the Pleasant Valley Pipeline connection would produce similar pumping requirements for the critical Pleasant Valley Pipeline flow condition. In this operation, the Pleasant Valley Pipeline was assumed to convey only the maximum Tri-Districts diversions from Munroe Canal to Point C, where it would be blended with pretreated water. The pump station would be operated to allow conveying the blended flow in the Pleasant Valley Pipeline to the water treatment facility and would meet the minimum pressure requirement at the water treatment facility.

A river turnout to the Main Stem would be constructed off the new bi-directional pipeline to allow Fort Collins to exchange releases from Reservoirs Number 5 and 6 to its existing river intakes upstream on the
Upper Poudre (Figure 2-11). It is assumed river releases would not require treatment, but future regulations may require such discharges to be treated. The location of the river turnout is shown in Figure 2-9. Based on the maximum simulated river exchanges, the capacity of the turnout would be approximately 22 cubic feet per second.

![Diagram showing generalized stream flow changes due to the Agricultural Reservoirs Alternative.](image)

Figure 2-11. Generalized stream flow changes due to the Agricultural Reservoirs Alternative.

Currently, NPIC fills Reservoirs Number 5 and 6 via diversions from the Upper Poudre at the Munroe Canal diversion structure, which are then conveyed through a series of canals, tunnels and laterals to the reservoirs. The set of canals is hydraulically connected with both reservoirs. Releases from both reservoirs for NPIC are made through the outlet works at Reservoir Number 6, and are delivered to ditches and laterals down gradient of the reservoirs. The use of NPIC’s existing canal conveyance system
to convey inflows to the Reservoirs Number 5 and 6 was discounted as an option due to the uncertainty about availability of capacity in the canal system, especially during the peak irrigating season, and the large conveyance losses through the unlined canals. To satisfy the storage reserve factor as part of the project’s purpose and need, a new pipeline connected with the Pleasant Valley Pipeline and the existing 36-inch pipeline is required to convey the water into the reservoir system from the Munroe Canal and for year-round deliveries to the water treatment facility.

Fort Collins estimated that there would be enough hydraulic head to perform the reservoir filling operation from the Munroe Canal and to make releases to the pretreatment plant from the reservoirs with a pressurized conveyance system without pumping. However, pumping would be required to deliver water from the pretreatment plant to Fort Collins’ water treatment facility, using the bi-directional pipeline and the Pleasant Valley Pipeline or the existing Fort Collins raw water pipeline. A pump station of about 1,000 horsepower would be required to deliver pretreated water to the water treatment facility, with an approximate lift of 160 feet.

Potentially feasible alignments have been selected for proposed conveyance facilities, and have been specified as 200-foot wide corridors. Specific pipeline locations within the corridors would have to be refined based on utility interferences, property ownership, and other factors.

Similar to Fort Collins’ Proposed Action, the Agricultural Reservoirs Alternative includes a release of three cubic feet per second to meet wintertime return flow obligations. This release would come from the Agricultural Reservoirs into the Main Stem, but would not result in a change in stream flow as the release relates to return flow obligations.

Figure 2-11 illustrates the general change in stream flow associated with the Agricultural Reservoirs Alternative. The image is not to scale nor does it reflect the magnitude of the changed flow. Rather it provides a visual representation of where there is a change from current stream flow as a result of the Agricultural Reservoirs Alternative. Details of where the stream flow would change, when it would occur, and the magnitude of the change are presented in Section 4.3.6.3.

2.3.4.3 Pretreatment Facility

Water stored in the agricultural reservoirs would have a lower water quality than the current Fort Collins water sources (i.e., river diversions further upstream on the Upper Poudre and Horsetooth Reservoir), mainly due to the impacts of agricultural run-off to the reservoirs and, potentially, recreational usage. Impacts to the water quality would include increased total dissolved solids, increased total suspended solids, increased total organic carbon, and increased algae formation (due to the nutrients present in agricultural runoff). Releases from Reservoirs Number 5 and 6 would require pretreatment such that, when blended with other water sources at the Fort Collins water treatment facility, the treated water is of a quality comparable to the water now delivered to Fort Collins’ customers. Pretreatment would also ensure that releases conveyed via the Pleasant Valley Pipeline do not degrade water quality for other users of the Pleasant Valley Pipeline.

High levels of total dissolved solids can lead to water hardness and a salty taste to the water. Total dissolved solids concentration data for Reservoirs Number 5 and 6 were not available. However, based on data collected from NPIC Number 3 (location is similar to Reservoirs Number 5 and 6) between April
2014 and August 2014, it was assumed that the total dissolved solids in the reservoir could be as high as 200 milligrams per liter. This is four times the average total dissolved solids in Horsetooth Reservoir or the Poudre River. Frequent sampling would be required to determine actual total dissolved solids concentrations in Reservoirs Number 5 and 6.

Total dissolved solids removal can only be accomplished through desalination; the most common desalination technology is reverse osmosis, which is capable of removing 99 percent of the ions that predominantly comprise total dissolved solids. In order to reduce the total dissolved solids from 200 milligrams per liter to 50 milligrams per liter, 75 percent of the flow (six million gallons per day) would need to be treated with reverse osmosis. In order to protect the reverse osmosis membranes, an upstream filtration process (either media or low-pressure membrane) would be required. In addition, reverse osmosis produces a concentrate that contains the removed salts. This brine (which would be approximately 7.5 percent of the influent flow or 420 gallons per minute) would need to be disposed. In inland areas, this is commonly accomplished through deep well injection, evaporation ponds, or thermal evaporation. Each of these technologies has a significant downside. Deep well injection has a complex permitting process and Colorado awards few permits. Evaporation ponds require large amounts of land and are not able to operate properly during periods of rainfall, snowfall, or freezing conditions. Thermal evaporation is very expensive from both a capital and an operational standpoint (a thermal system of a size necessary for brine disposal would likely exceed $10,000,000 in capital cost and require an estimated 500 kilowatts of power for the simulated average operation, which equates to 1,920,000 kilowatts per year).

Because of the lack of total dissolved solids concentration data for Reservoirs Number 5 and 6 and the uncertainty of the level of total dissolved solids treatment required, total dissolved solids removal was not included as a pretreatment requirement for this alternative. Additional research would be required to ascertain actual total dissolved solids concentrations in Reservoirs Number 5 and 6 and feasibility of the brine disposal methods prior to specifying reverse osmosis treatment options. If reverse osmosis treatment is required, the cost estimate provided for this alternative would require adjustment.

High total organic carbon can lead to formation of potentially carcinogenic disinfection by-products when the water is chlorinated. Water quality regulations limit both the effluent total organic carbon (based on influent total organic carbon and influent alkalinity) as well as the formation of disinfection by-products. Under current operations, high total organic carbon levels in the Main Stem trigger the need for raw water blending with Horsetooth Reservoir water (total organic carbon less than two milligrams per liter). If total organic carbon levels become too elevated, it would require the implementation of new treatment technologies at Fort Collins’ water treatment facility.

In order to remove algae and decrease total suspended solids and total organic carbon levels to values comparable with the low total organic carbon levels of Fort Collins’ current source water, a pretreatment plant would be constructed that would treat the water released from the agricultural reservoirs. Total organic carbon would be removed in the same manner described for the Expanded Glade Alternative (Section 2.3.2.3).

The pretreatment facility for this alternative was planned to handle the estimated peak day demand of 28 million gallons per day, computed by multiplying the monthly model outflows by a peaking factor of two. The pretreatment facility would consist of a pretreatment plant with capacity to directly treat about
85 percent of the expected flows and a storage tank to supply peaks above the direct treatment capacity. Three eight-million gallons per day treatment trains and a five million gallon tank are included in the pretreatment facility that is located near Larimer County Canal Number 2 (Point D, Figure 2-9).

### 2.3.4.4 Power Requirements

Pump Station D would be a 1,100 horsepower pump using about 224,789 kilowatt-hours per year to pump water from the Reservoirs Number 5 and 6 to the pretreatment plant. About 304,000 kilowatt-hours per year would be required to pretreat the water from the gravel pits.

### 2.3.4.5 Water Rights

Fort Collins would store its existing water rights, including converted Southside Ditch water rights and Water Supply and Storage Company water rights, in Reservoirs Number 5 and 6. In addition, Fort Collins’ conditional water rights, including the Halligan Reservoir Enlargement conditional right and half of the 1/8th fractional interest of the Grey Mountain Conditional Decree, would be used in the agricultural reservoirs. These are the same water rights proposed for use with Fort Collins’ Proposed Action; however, certain changes to the points of diversion and places of storage would be required from water court or through administrative approval under Colorado Revised Statute 37-87-101(3.)

### 2.3.4.6 Halligan Dam Rehabilitation

The 1993 option agreement between Fort Collins and NPIC allows Fort Collins to enlarge Halligan Reservoir but requires Fort Collins to re-convey the reservoir facilities back to NPIC if Fort Collins abandons or is otherwise unable to enlarge the reservoir.

Although dam inspection reports suggest that the dam at Halligan Reservoir is currently sound, it will require rehabilitation in the near future to address safety risks. The dam is over 100 years old and seepage through the dam and freeze-thaw cycles will continue to degrade the mass of the dam, will require rehabilitation, and presents an increasing safety risk. Due to the age of Halligan Dam and its current condition, NPIC would need to develop and implement a rehabilitation plan (Colorado Division of Water Resources 2018). This may be financially difficult for the agricultural shareholders of a mutual ditch company like NPIC. Under this alternative, Halligan Dam would be rehabilitated with no change to the storage capacity to the reservoir.

### 2.3.5 No-Action Alternative

Fort Collins developed a No-Action Alternative for evaluation in the EIS. The No-Action Alternative describes what Fort Collins would do if Fort Collins’ Proposed Action or an acceptable alternative were not permitted. According to Corps regulations, the No-Action Alternative need not meet the project purpose and need and should not require a Corps permit of any type, including a Section 404 nationwide permit (33 Code of Federal Regulations Part 325, Appendix B). Fort Collins’ No-Action Alternative consisted of three components: (1) reoperation of Joe Wright Reservoir; (2) acquisition of additional NPIC shares in order to obtain the C-BT storage component associated with each share; and (3) institution of more frequent drought restrictions. As configured, the No-Action Alternative does not meet the purpose and need due to the mandatory drought restrictions that would be necessary to provide water
through the 1-in-50-year critical drought and because, even with water restrictions, storage is 600 acre-feet short of the storage reserve factor in the 1-in-50 year drought.

The *Fort Collins Alternative Descriptions Action Alternatives Report* (MWH 2015) has additional detail about the No-Action Alternative. The report also includes additional detail on the screening process used by Fort Collins to arrive at the three components of the No-Action Alternative and additional technical details about the method used to project the number of additional NPIC shares Fort Collins could acquire and additional technical details regarding the projection of the mandatory drought restrictions.

Unlike the alternatives described above, the No-Action Alternative was not developed as part of the alternatives screening process. Instead, the No-Action Alternative was developed by Fort Collins and then independently evaluated by the Corps for reasonability and accuracy in modeling (MWH 2015).

### 2.3.5.1 Reoperation of Joe Wright Reservoir

The reoperation of Joe Wright Reservoir was included as a component in the Gravel Pits Alternative (see Section 2.3.3.10). Releases from Joe Wright Reservoir would be reduced to target a winter carryover storage amount of 3,200 acre-feet. This storage level would not require any modifications to the existing outlet facilities at Joe Wright Reservoir. The reduction in releases would be accomplished by not executing a water trade with NPIC for C-BT water under certain circumstances.

### 2.3.5.2 Acquisition of Additional North Poudre Irrigation Company Shares

As part of Fort Collins’ Proposed Action and all other action alternatives, Fort Collins projected future acquisition of additional shares of several ditch companies above and beyond the shares already owned or converted for municipal use, including shares of NPIC. For the No-Action Alternative, Fort Collins would acquire even more shares of NPIC instead of the other ditch companies. Each share of NPIC includes four C-BT units. Each unit of C-BT provides an annually variable amount of water in the C-BT system, equal to one acre-foot multiplied by an annual quota. The C-BT quota has varied historically between 50 percent and 100 percent, with an average of approximately 70 percent. In addition, NPIC assesses ditch loss charge on delivery of the C-BT units because it must deliver an equal amount of water to each share of NPIC, accounting for delivery losses incurred in ditches and laterals in route to agricultural shareholders. This ditch loss has historically averaged approximately 20 percent, but can be greater during dry years.

Fort Collins developed a conversion factor to determine how many additional shares of NPIC it could expect in lieu of other ditch sources it had previously planned to acquire. The conversion rate was based on the currently accepted raw water requirement factors used by Fort Collins for determining water rights needed to provide new water service. The computation resulted in an additional 390 shares of NPIC. In addition, Fort Collins assumed that it would purchase an additional 275 NPIC shares using an amount of funding equal to that which it would have spent on the expansion of Halligan Reservoir. Fort Collins also included the additional 189 shares of NPIC it had already planned on acquiring in the future and used in all other action alternatives modeling. In total, the No-Action Alternative contemplates acquisition of an additional 854 NPIC shares, of which, 665 additional shares were unique to the No-Action Alternative. These 665 shares represent about seven percent of the outstanding NPIC shares. Acquisition of shares under the No-Action Alternative would increase Fort Collins’ ownership to approximately 44 percent of the company.
from 37 percent and would likely reduce projected municipal ownership by other entities by the same percentages (seven percent). The additional 665 shares, assuming a low-end C-BT quota of 50 percent C-BT, would provide 1,064 acre-feet of additional storage in Horsetooth Reservoir for Fort Collins.

2.3.5.3 Mandatory Drought Restrictions

The No-Action Alternative included mandatory drought restrictions on Fort Collins’ water utility customers during periods of drought to reduce the water demands on the system. Fort Collins quantified the frequency, duration, and severity of necessary drought restrictions using Common Technical Platform hydrologic modeling.

Fort Collins developed an initial version of the firm yield model run (Run NA8) for the No-Action Alternative that included the Joe Wright Reservoir reoperation and the additional shares of NPIC. Because the C-BT carryover program discussed in Section 2.5.2.4.4 can be changed or terminated at the Northern Water Board of Directors' discretion and they are not willing to make it permanent, that storage associated with C-BT shares or the C-BT portion of shares of the NPIC were not included in Run NA8. In order to estimate the necessity and severity of the mandatory drought restriction, Fort Collins evaluated the initial model results in each May of the simulation. The analysis focused on May of each year as snowpack for the coming summer is typically known by this time. Years where restrictions would be necessary were identified based on the state of the model in each May and projected water availability for the rest of the summer using methods currently employed by Fort Collins (e.g. estimates of water rights yield based on remaining snowpack, reservoir levels, etc.).

If a shortfall was projected for a given summer, Fort Collins assigned a drought restriction level to reduce demands through the following modeled October. In years with no projected shortfall, no drought restrictions would be implemented. Fort Collins used a tiered system of drought restrictions, with Level 1 as the least restrictive and Level 4 as the most restrictive. The restriction levels are defined in the Fort Collins’ Water Supply Shortage Response Plan (Fort Collins 2014) and summarized in Table 2-2.

Table 2-2. Fort Collins Water Supply Shortage Response Plan water restrictions.

<table>
<thead>
<tr>
<th>Restriction Level</th>
<th>Restriction Trigger</th>
<th>Projected Demand Reduction* Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>1-10% water supply shortage</td>
<td>5</td>
</tr>
<tr>
<td>Level 2</td>
<td>11-20% water supply shortage</td>
<td>15</td>
</tr>
<tr>
<td>Level 3</td>
<td>21-30% water supply shortage</td>
<td>25</td>
</tr>
<tr>
<td>Level 4</td>
<td>Greater than 30% water supply shortage</td>
<td>35</td>
</tr>
</tbody>
</table>

*Fort Collins’ ability to achieve the water demand reductions shown has not been proven in practice.

The model was re-run with reduced demands in years that a drought restriction was required. The model results indicated that restrictions would be necessary in five of the 86 simulated years, including four years of Level 1 restrictions, and one year of Level 3 restrictions. The storage reserve factor was not met through the critical drought even with the Level 3 restrictions. The storage reserve factor is designed to provide Fort Collins with water to counteract an emergency, such as failure of one its raw water lines or the Horsetooth Reservoir intake. Although under the No-Action Alternative Fort Collins would be able to
meet its future demands, it would not meet the storage reserve factor – a critical aspect of the project need and purpose – and would be at risk of not having enough water to counteract these types of emergency situations during a drought.

The No-Action Alternative is unique in that it is the only alternative presented that would not meet the purpose and need. Under the No-Action Alternative, water restrictions are required and the storage reserve factor is not met during the critical 1-in-50 year drought.

Figure 2-12 illustrates the general change in stream flow associated with the No-Action Alternative. The image is not to scale nor does it reflect the magnitude of the changed flow. Rather it provides a visual representation of where there is a change from current stream flow as a result of the No-Action Alternative. Details of where the stream flow would change, when it would occur, and the magnitude of the change are presented in Section 4.3.7.3.

Figure 2-12. Generalized stream flow changes due to the No-Action Alternative.
2.3.5.4 Halligan Dam Rehabilitation

The 1993 option agreement between Fort Collins and NPIC allows Fort Collins to enlarge Halligan Reservoir but requires Fort Collins to re-convey the reservoir facilities back to NPIC if Fort Collins abandons or is otherwise unable to enlarge the reservoir.

Although dam inspection reports suggest that the dam at Halligan Reservoir is currently sound, it will require rehabilitation in the near future to address safety risks. The dam is over 100 years old and seepage through the dam and freeze-thaw cycles will continue to degrade the mass of the dam, will require rehabilitation, and presents an increasing safety risk. Due to the age of Halligan Dam and its current condition, NPIC would need to develop and implement a rehabilitation plan (Colorado Division of Water Resources 2018). This may be financially difficult for the agricultural shareholders of a mutual ditch company like NPIC. Under the No-Action Alternative, Halligan Dam would be rehabilitated with no change to the storage capacity to the reservoir.

2.4 CONSTRUCTION ACTIVITIES FOR ALL ACTION ALTERNATIVES

The designs of Fort Collins’ Proposed Action and all action alternatives are conceptual and will be further developed and refined based on terms and conditions of various permitting decisions and processes. Construction-related specifics such as schedules, equipment, and manpower have been estimated based on best available information and assumptions (MWH 2015) and are adequate for the purposes of this environmental analysis.

2.4.1 Schedule

Construction of project components would occur year-round. Construction times have been estimated between 12 and 24 months for all action alternatives. Construction activities would occur during the day; however, multiple shifts would be also possible depending on the length of the construction schedule and circumstances outside of Fort Collins’ control, such as weather conditions and availability of materials. Some construction activities may require non-stop work until the task is completed. For example, concrete placement for the proposed raised Halligan Dam or rehabilitation of the dam may need to occur across multiple continuous shifts. Construction activities would be performed concurrently wherever possible to expedite the completion of the project. Work hours for construction would be consistent with applicable local ordinances. Fort Collins anticipates that final design and scheduling would begin upon receipt of the Section 404 permit. Construction would begin as soon as possible after final design is approved, and operation of facilities would begin at the completion of construction or as infrastructure comes online.

General construction activities common between all action alternatives are briefly described in the following sections.

2.4.2 Mobilization/Demobilization

Mobilization includes equipment mobilization, temporary road construction and maintenance, establishment of field offices, home office support, procurement of bonds and insurance, as well as demobilization from the site upon completion of the project. Mobilization and demobilization levels
would vary somewhat among the different alternatives. Fort Collins’ Proposed Action would have all construction at Halligan Reservoir, while the other action alternatives would have construction distributed across larger areas for pipelines, pumps, and pretreatment plants.

### 2.4.3 Construction Disturbance Areas

There are several areas around each action alternative that can be expected to be disturbed during construction for borrow material, staging of materials, field offices, and other activities. The selection of suitable construction areas is dependent on further geotechnical investigations and field reconnaissance. The actual construction disturbance area will vary in location and size dependent on the alternative. Each alternative was analyzed using the areas depicted on their general layouts (Figure 2-2 through Figure 2-10). The disturbance areas shown in these figures depict the maximum extent for each alternative. The actual extent of disturbance areas would be expected to be far less and to fall within the boundaries of the depicted disturbance areas.

### 2.4.4 Access Roads

Existing paved and unpaved roads would be used for general access to individual action alternative areas. Some existing roads may require improvement by the contractor based on the size and type of equipment anticipated for construction. Additional temporary access roads may be required during construction depending on the final selected alternative, final alternative layout, and other specifications to be determined.

### 2.4.5 Standard Operating Procedures for Construction

Fencing would be placed around the construction areas to reduce impacts on existing wetlands, riparian zones, and other sensitive areas.

Construction activities would include mitigation measures to minimize, avoid, or rectify the adverse environmental impacts associated with construction of the alternatives. A construction management plan would be prepared to address how to minimize impacts to the project area from construction activities. It would be updated as project features are refined during preliminary engineering and design phases.

### 2.4.6 Sediment and Erosion Control

Prior to any construction activity, coverage under Colorado’s general construction stormwater discharge permit would be requested from the Colorado Department of Public Health and the Environment. The permit would require development of stormwater management plans to control erosion from stormwater runoff for each construction site. Sediment and erosion control best management practices such as sediment catchment basins, sediment barriers, erosion control logs, hay bales, temporary vegetation, and mulching would be incorporated to minimize the release of soil and sediment into receiving waters during construction.
2.4.7 Stockpile and Staging Areas

Dedicated staging areas would temporarily store materials, equipment, resources, stockpiled sand and gravel, and excavated borrow material prior to and during construction. Entry and exit of earth moving equipment along with pipeline construction, trenching, and excavation related activities would be supported by the staging areas as well.

2.4.8 Power Supplies

Alternatives would require power supplies to operate water treatment plants, pump stations, reservoir valves, and other equipment. New transmission lines or connections to existing lines could be used for power supplies. New power poles or towers would be erected as needed and conductors would be installed to connect to the power source.

2.4.9 Utility and Transportation Relocations

Existing utilities like water, sewer, electric, telephone, and other cables would be relocated as needed for each action alternative. Relocation of utilities and roadways would occur simultaneously with other construction activities. Service outages associated with relocation of utilities would be minimized and affected people would be notified in advance. Utility relocations would be designed as per the requirements of the affected utility company and design of any new permanent roadways would be in accordance with standard engineering practices and requirements of the Colorado Department of Transportation.

2.4.10 Utilities, Lighting, and Fencing

Lighting facilities could be required for potential nighttime construction activities. Temporary systems, portable systems, and mobile equipment-based lighting systems would be used as needed. Lighting systems would be used in compliance with the specifications set by Colorado Department of Transportation. Barricade fencing would be used to establish the boundary of the disturbance areas associated with the project facilities.

2.4.11 River Diversion

A river diversion would be required to facilitate dam foundation preparation and develop work platforms during construction of the enlarged Halligan Dam for Fort Collins’ Proposed Action or rehabilitation of the existing dam under the other alternatives. River diversions would also be necessary for all action alternatives during pipeline installations unless the pipeline were to be directionally drilled under the channel. All proposed pipeline crossings of streams, ditches or canals would be constructed using an open trench method per standard practice and to minimize cost. This construction method includes excavating a trench on the river bottom, installing a prefabricated pipe under the river bottom and backfilling the trench. A coffer dam would be used to create a temporary water barrier for constructing a river or canal crossing and piping would be used to divert flows from work areas. Additional dewatering systems (e.g., pumps) would be used to maintain the work area in a state that is as dry as necessary to complete the task, whether the task was dam foundation construction or pipeline installation.
In addition, each action alternative would include construction activities unique to that alternative or shared only with a few alternatives. Those specific construction details can be reviewed in the *Fort Collins Alternative Descriptions Action Alternatives Report* (MWH 2015).

### 2.4.12 Construction Equipment

A variety of equipment and machinery, including but not limited to bulldozers, loaders, dump trucks, back hoes, and rollers, would be needed for the construction of Fort Collins’ Proposed Action and all action alternatives (Table 2-3). This equipment would not travel off-site or would only travel a limited distance off-site on public roads.

**Table 2-3. Estimated maximum construction equipment necessary per alternative.**

<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>Fort Collins’ Proposed Action</th>
<th>Expanded Glade Alternative</th>
<th>Gravel Pits Alternative</th>
<th>Agricultural Reservoirs Alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pick-up truck</td>
<td>5</td>
<td>17</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Mechanic truck</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Lube truck</td>
<td></td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Fuel truck</td>
<td></td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Flat bed truck</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bull dozer</td>
<td>2</td>
<td></td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Skid steer</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loader</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Articulated dump truck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scraper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grader</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Back Hoe</td>
<td>2</td>
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<td>7</td>
<td>4</td>
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<td>Sheep’s footer compactor</td>
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<tr>
<td>Smooth drum roller (72 inches to 84 inches)</td>
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<tr>
<td>Smooth drum roller (22 inches)</td>
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<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Crawler crane</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Diesel compressor</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Water truck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic drill</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batch plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generators</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>Water pump</td>
<td>1</td>
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<td>1</td>
</tr>
<tr>
<td>Diesel welder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 2.4.13 Construction Manpower Estimates

Construction manpower requirements for each alternative were estimated based on experience with other projects. Because no geotechnical investigations or engineering designs have been performed, each preliminary estimate reflects a range of accuracy of approximately -50 percent to +100 percent. Estimates of construction staff hours and peak personnel for each alternative are shown in Table 2-4.
Table 2-4. Estimated completion time, man hours, and peak work force for each action alternative.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Completion Time (months)</th>
<th>Man Hours</th>
<th>Peak Work Force (people)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fort Collins’ Proposed Action</td>
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<td>150</td>
</tr>
<tr>
<td>Expanded Glade Alternative</td>
<td>12</td>
<td>80,000</td>
<td>70</td>
</tr>
<tr>
<td>Gravel Pits Alternative</td>
<td>12</td>
<td>100,000</td>
<td>90</td>
</tr>
<tr>
<td>Agricultural Reservoirs</td>
<td>12</td>
<td>80,000</td>
<td>70</td>
</tr>
</tbody>
</table>

2.5 PRELIMINARY ALTERNATIVES SCREENING PROCESS

There are a variety of potential ways of providing additional water to meet Fort Collins’ stated need. The Corps developed a list of alternatives through a tiered process (Figure 2-13). The Corps’ approach to identifying water supply alternatives was to identify infrastructure options (elements) and water source options (concepts). The Corps identified elements including reservoirs, groundwater aquifers, gravel pits (reclaimed mined gravel pits), and pipelines that could be constructed, expanded, rehabilitated, or operated in a different manner. The Corps identified concepts including potential water sources for the Halligan Project available through various water supply strategies, such as the purchase of agricultural water rights or full use of existing water rights. The screening process began with the development of long-lists of potential elements and concepts to be considered, which were then screened through a number of tiers based on specific screening criterion (Figure 2-13).

Figure 2-13. Schematic of the alternatives screening process.
At each tier in the screening process, specific criteria based on ability to meet the project purpose and need; environmental effects; and practicability in terms of technology, logistics, and cost; were developed to screen the elements, concepts, and combinations of elements and concepts. When multiple remaining elements, concepts, or combinations had no discernible difference in impact to aquatic resources, the best fitting option was selected based on proximity to Fort Collins’ existing system’s features and potential impacts to other resources. Elements, concepts, or combinations not selected through a best fit analysis remained eligible for reconsideration in the event that a selected element, concept, or combination was screened out at a later stage in the alternatives formulation process.

The results from the elements and concepts screening processes were combined to form the long-list of preliminary alternatives that would meet the project purpose and need as specified in the *Purpose and Need Report for the Halligan Water Supply Project Environmental Impact Statement* (Purpose and Need Report; Western EcoSystems Technology, Inc. [WEST] et al. 2016) and summarized in Chapter 1 of this Draft EIS. Those preliminary alternatives were provided to Fort Collins so that it could develop operational and engineering configurations for each alternative. The Corps then reviewed and verified Fort Collins’ configurations during the development of the final alternatives. Fort Collins documented and submitted suggested modifications in advance to the Corps for consideration and approval of the final alternatives. Once the Corps determined the final alternatives, Fort Collins conducted the hydrology modeling for each of the approved final alternatives. The No-Action Alternative was developed and modeled by Fort Collins, independent of, but verified by the Corps. The final alternatives are independently evaluated in this Draft EIS.

The *Alternatives Screening Report for the Halligan Water Supply Project Environmental Impact Statement* (DiNatale Water Consultants and CDM Smith 2016) provides additional details on the screening process, criteria used, and the results from the application of each screen. Additionally, the report documents the process of developing alternatives from the elements and concepts.

### 2.5.1 Elements

The Corps classified each element on the long list as one of four element types: a reservoir, gravel pit, alluvial aquifer underground element, or an operational element. The long list of 220 reservoir elements was developed utilizing the reservoir elements considered in other water supply projects, including Denver Water’s Moffat Collection System Project, the Windy Gap Firming Project, NISP, and the Seaman Reservoir Expansion Project. A database of Colorado mine sites registered with the Colorado Division of Reclamation Mining and Safety was used to identify potential gravel pits within the state. Approximately 6,431 mine sites in Colorado that were registered with the Colorado Division of Reclamation Mining and Safety as of May 2010 were incorporated into the gravel pit element long list. The long list of 36 underground elements was determined using delineations from the Colorado Water Conservation Board’s Underground Water Storage Study (Colorado Water Conservation Board 2007). Then each element class was screened through a two-tiered screening process involving a variety of criteria and concluded with a best-fit analysis.
2.5.1.1 Reservoir Elements

Tier 1 reservoir elements screening criteria included geographic area, perennial streams, special designated land use, and whether the reservoir element was integral to water development plans of other agencies. Tier 2 reservoir elements screening criteria included storage capacity, inundated wetlands, and a refined geographic location screen. Screening resulted in five remaining elements as alternatives to Halligan Reservoir: the proposed Glade Reservoir with NISP, Cactus Hill Reservoir with NISP, NPIC Reservoir Number 15, Rawhide North Reservoir, and Upper Black Hollow Reservoir. The remaining five elements have identical impacts to the aquatic environment at the reservoir sites. None include a new dam on a perennial stream and none would inundate any wetlands. Due to the identical impacts to aquatic environment at these five reservoir sites, a best-fit analysis was used to select a reservoir element that is most practicable from Fort Collins’ perspective and that would be carried forward into the preliminary alternatives formulation process. These five elements were individually evaluated and compared to each other based on practicability aspects. Reservoir elements not selected through this best fit analysis remained available for use in the event the selected reservoir element was determined not to be viable through further analysis.

The proposed Glade Reservoir with NISP element was selected as the best fit of the remaining reservoir elements due to several practicability considerations and was retained for the Fort Collins preliminary alternatives formulation process. The proposed Glade Reservoir with NISP element would be located significantly closer to the Fort Collins water treatment plant and may be able to use existing pipelines to the treatment plant, thereby decreasing the infrastructure costs and ground disturbance impacts associated with the longer pipelines to other reservoirs. All other reservoir elements would require more than 10 miles of new pipelines and most would require pumping to deliver water either into or out of the reservoir. Of the remaining reservoirs, water quality is likely better at the proposed Glade Reservoir with NISP element due to the diversion point from the Poudre River in the Poudre Canyon, and a shorter conveyance distance that does not pass through large amounts of agricultural areas. Furthermore, both the proposed Glade Reservoir with NISP and Cactus Hill Reservoir with NISP elements rely on that reservoir to be used for NISP. Since Cactus Hill is not the proposed action for NISP, it is less likely to be constructed. The proposed Glade Reservoir with NISP element could provide services to Fort Collins water supply systems similar to Halligan Reservoir with no additional wetlands inundated and the least amount of additional pipeline construction and pumping required compared to the other four reservoir elements.

2.5.1.2 Gravel Pit Elements

Tier 1 gravel pit elements screening considered geographic area, mine type, permit status, and commodity produced. Tier 2 gravel pit elements screening criteria included a practicability screen that evaluated the location of the gravel pit relative to Fort Collins’ reusable effluent or converted water rights, conveyance loss, and ability to divert and regulate the converted water rights. Six gravel pit elements remained after the Tier 1 and Tier 2 screening and had no identified difference in impact on aquatic resources. A best-fit analysis compared the locations of the six remaining gravel pit elements with respect to the location of existing infrastructure, and infrastructure that would need to be constructed. The Timberline Resources site and the North Taft Hill Expansion Site are located farther from the Poudre River and would each require approximately a one-mile pipeline and pumping from the river; the remaining four gravel pit elements are all located in the area near a group of mine sites, collectively called the Overland Gravel
Pits. Because of their geographic proximity, these four elements were aggregated into a single Overland Gravel Pits gravel pit element. Water storage in the four individual mines could be used in any combination to achieve the same results.

The Overland Gravel Pits are located two miles northeast of the Fort Collins Water Treatment Plant on the Poudre River. The diversion points for Southside Ditches are in the vicinity and the Overland Gravel Pits potentially could be filled from the Larimer County Canal Number 2 or the New Mercer Canal. A portion of the site is currently being mined for use by Greeley and the Tri-Districts to support their water supply operations. In order for Fort Collins to utilize the Overland Gravel Pits in its storage reserve factor, a pipeline from the Overland Gravel Pits to the water treatment plant would be required. Fort Collins may be able connect a shorter pipeline from the Overland Gravel Pits to one of the two raw water supply lines serving its water treatment plant in the vicinity of the Overland Gravel Pits in order to reduce cost and earth disturbance impacts. Although Fort Collins may exchange water from the Overland Gravel Pits to its upstream intakes in the Poudre River Canyon, a pipeline connection would be needed to satisfy the Fort Collins storage safety reserve criteria of a direct connection to the treatment system. The Overland Gravel Pits site was the only gravel pit element selected for the preliminary alternatives formulation process.

2.5.1.3 Underground Elements

Tier 1 underground elements screening considered the geographic location of each underground and alluvial aquifer element. Tier 2 underground elements screening criteria included the hydrogeologic properties of the alluvial and bedrock aquifer using hydraulic conductivity, transmissivity, residence time, total available pore space, and total aquifer storage capacity, and left only five remaining alluvial aquifer elements for preliminary alternatives development. Bedrock and alluvial aquifers are not part of the aquatic environment protected under the Clean Water Act or considered in the Section 404(b)(1) Clean Water Act Guidelines. However, the Section 404(b)(1) Clean Water Act Guidelines require consideration of the effects of discharges from those aquifers into wetlands, rivers, and streams which are part of the aquatic environment. Under Colorado water law, an aquifer storage and recovery plan for any of the alluvial aquifers would be required to replace any depletions to the stream with either lagged accretions caused by storage in the aquifer or other sources that can be delivered to the stream in the amount, time, and location of the pumping depletion. Therefore, impacts from depletion on the aquatic environment in any of the alluvial aquifers would be minimal and the differences are not discernible. Infrastructure associated with underground storage elements (e.g., well heads, pump houses, pipelines, etc.) could be located such that impacts to the aquatic environment are completely avoided or minimized to such a level that direct impacts associated with some infrastructure are very minor and differences are not discernible. Differences to impacts to the aquatic habitat at the different remaining alluvial aquifers could result from the location where water is diverted from the river and delivered into recharge facilities. At this stage in the alternatives formulation process, the source of recharge water was not yet determined. The source of recharge water would in part determine the point of diversion.

Since the five elements remaining after the Tier 2 screen had no identifiable or discernible impacts to the aquatic environment as well as design characteristics, the best fit among the remaining alluvial aquifer elements for Fort Collins was identified by qualitatively evaluating big-game habitat, urban development, continuous alluvial width, and water quality of the alluvial aquifer elements. Three elements – Rawhide
Creek, Old Alluvium Lone Tree, and Lone Tree Creek – were either not covered with the big-game habitat or only small portions were covered, which would result in very small impacts to big game. These three elements are experiencing urban development over a portion of their area but none of the elements are completely urbanized, which would not eliminate the possibility of utilizing spreading basins in some locations. Impacts to aquatic habitat at the recharge facilities and well heads could be avoided by locating those facilities away from riparian areas. Due to the non-identifiable or indiscernible impacts to aquatic habitat at the three sites, the best-fit analysis selected the Rawhide Creek aquifer to be carried through to the next step in the alternatives formulation process due to its proximity to Fort Collins’ infrastructure.

2.5.1.4 Operational Elements
The Corps identified operational elements as a fourth type of element that could potentially increase Fort Collins’ firm yield through operational changes without requiring new storage facilities. Operational elements were facilities that currently exist and that would not need to be constructed or enlarged to provide firm yield to Fort Collins. Two operational elements were identified: Joe Wright Reservoir and storage rights through NPIC and the Water Supply and Storage Company. Fort Collins owns Joe Wright Reservoir at the headwaters of the Poudre River Basin and could modify how it operates the reservoir to increase winter carryover storage and firm yield, including modifying the outlet works to allow for higher winter carryover storage that could increase firm yield to Fort Collins. Fort Collins also owns shares in NPIC and the Water Supply and Storage Company and could meet a portion of the needed firm yield if Fort Collins were able to use a portion of those ditch companies’ storage in proportion to the portion of the ditch companies’ shares owned by Fort Collins (pro-rata agricultural storage).

2.5.1.5 Best Fit Analysis between Element Types
After the screening process for each type of element was complete, it was apparent that the Rawhide alluvial aquifer element and the pro-rata agricultural storage operational element using NPIC plains reservoirs had no identifiable or discernible difference in impacts on the aquatic ecosystem. Both elements would divert water at the same location because the aquifer and the NPIC reservoirs are located in approximately the same area. Alternatives using either element would divert approximately the same volume of water. Direct impacts to aquatic habitat at the aquifer site or the existing reservoir site are anticipated to be minimal or non-existent. The Rawhide alluvial aquifer element, like a reservoir, was not considered a new source of water, because water would have to be recharged into the aquifer to provide the water supply. This need was evidenced by the lack of center pivot irrigation wells up-gradient of the Munroe Canal, indicating a lack of sufficient supply of naturally occurring water in the upper portions of the aquifer. The increase in the number of wells below the Munroe Canal indicated it (and other ditches that cross the aquifer) provides a source of recharge. The water that would be recharged and stored in the aquifer would be diverted from the stream in a similar manner as water that would be stored in the reservoir pro-rata agricultural storage operational element.

Neither element would have direct impacts to wetlands, and conveyance infrastructure required to deliver water to Fort Collins would be nearly identical, since the elements are located in nearly the same area. Although evaporative losses would likely be less for the Rawhide alluvial aquifer compared to an agricultural reservoir, aquifer storage and recovery plans incur some evaporative loss during infiltration, other losses associated with a timing mismatch between lagged stream accretions from recharged water,
lagged stream depletions from well pumping, and potentially other water treatment losses, depending on groundwater quality.

Based on these factors, the difference in impacts to the aquatic habitat is considered to be non-identifiable or indiscernible between the Rawhide alluvial aquifer underground element and the pro-rata agricultural storage operational element. This determination allowed use of a best-fit analysis and selection of one of these elements for further analysis in the alternatives formulation process by considering factors other than criteria specified in the 404(b)(1) Clean Water Act Guidelines, such as cost and complexity.

Under Colorado water law, storage in an alluvial aquifer is significantly more complicated than is storage in a surface water reservoir. In addition, water stored in and then extracted from the alluvial aquifer would likely also be of lower quality with high levels of dissolved solids compared to water stored in the agricultural reservoirs. This groundwater would likely require an advanced water treatment process such as reverse osmosis. A byproduct of reverse osmosis is concentrated brine that must be disposed of properly. Brine disposal is one of the chief hurdles to effectively using reverse osmosis in Colorado. The accounting, permitting, water rights, and water treatment issues associated with the alluvial aquifer element were considered significantly more complex and less feasible than using an existing surface water facility. The best-fit analysis between the two elements led to selection of the pro-rata agricultural storage element for use in the preliminary alternatives screening.

2.5.1.6 Final-List of Elements

The element screening process resulted in the retention of four element alternatives to Halligan Reservoir: the proposed Glade Reservoir with NISP, Overland Gravel Pits, Joe Wright Reservoir, and Pro-Rata Agricultural Storage (Figure 2-14). The four retained elements were considered in the alternatives formulation process.

<table>
<thead>
<tr>
<th>Element Type</th>
<th>Reservoirs</th>
<th>Gravel Lakes</th>
<th>Underground</th>
<th>Operational</th>
</tr>
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<tbody>
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<td>Initial Long List</td>
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<td>6431</td>
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<td>Geographic Area</td>
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<td>Perennial Streams</td>
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<td>Integral to Other Development</td>
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<tr>
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<td>1</td>
<td>0</td>
<td>2</td>
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Excerpt Source: Alternatives Screening Report (DiNatale Water Consultants and CDM Smith 2016)

Figure 2-14. Summary of element screening results.
2.5.2 Concepts

A concept was defined as a potential operational or water supply strategy that was able to contribute to Fort Collins’ water supply firm yield. Most concepts must be matched with a storage element to produce firm yield. The Corps developed a long list of concepts to identify potential water supply and operational strategies for Fort Collins based on Fort Collins’ water supply system and operations, identification of strategies and water sources used by other water providers in the region, and review of other EIS projects in the region (NISP, Windy Gap Firming Project, and Moffat Collection System Project). Concepts were limited to the South Platte River Basin (including tributaries) upstream of the Weld-Morgan County line and downstream of the confluence with the Saint Vrain River. No concepts involving water sources located in other states were considered due to the wide range of potential concepts available within the study area in Colorado, logistics and costs associated out-of-state sources, and the substantial challenges associated with interstate water compacts and U.S. Supreme Court decrees.

Concepts were screened to meet the regulatory requirements of the National Environmental Policy Act and Section 404(b)(1) Clean Water Act Guidelines. The screening criteria focused on ensuring that the concepts alone or when combined with an element met the following purpose and need and practicability criteria:

- The purpose and need criterion required that a concept would be capable of providing a reasonable amount of firm yield through the 1-in-50-year critical drought either as a stand-alone concept or when combined with a storage element. The concept must also allow Fort Collins to meet its projected 2065 municipal and industrial demands with water of a quality comparable to the water now delivered to its customers.

- The practicability standard criterion required that a concept must conform to federal, state, and local laws, rules, and ordinances. The concept must also not utilize and interfere with lands or specific concepts known to be currently used by other water suppliers in the region unless the other party expressed an interest in discussing a mutual project with Fort Collins. Lastly, the concept must be able to utilize existing and proven technology for construction, operation, and maintenance to reduce the risk in obtaining the firm yield.

The Corps categorized concepts into similar concept classes including conservation, hydrologic alteration, other water rights, C-BT operations, traditional agricultural transfers, alternative agricultural transfers, system efficiency, re-regulation of agricultural reservoirs, and reuse. Many of these concepts were considered as part of the NISP EIS Alternatives Evaluation Report (HDR 2007) and Supplemental Draft EIS (Corps 2015) and the analysis carried out as part of the NISP is applicable for the Halligan Project as well.

2.5.2.1 Conservation

Current and future conservation by municipal and industrial customers of Fort Collins as described in Fort Collins’ state approved 2015 Water Efficiency Plan (Fort Collins 2015) was already considered in determining Fort Collins’ 2065 water demands. The 2015 Water Efficiency Plan incorporates those long-term measures recommended in the Guidebook of Best Practices for Municipal Water Conservation in Colorado (Colorado WaterWise and Aquacraft 2010) and the 2010 Statewide Water Supply Initiative
Conservation Levels document (Colorado Department of Natural Resources 2010). Conservation measures above and beyond those included in the 2015 Water Efficiency Plan were not considered as alternatives because they are not practicable or sustainable and would not meet the project purpose and need. For more information on conservation considerations for Fort Collins’ municipal and industrial demand, see Section 5 of the Purpose and Need Report (WEST et al. 2016).

The conservation concept class included agricultural conservation for both the C-BT and non-C-BT agricultural water use, and the foothills/plains storage transfer concept.

2.5.2.1.1 Agricultural Conservation – Non-C-BT
The non-C-BT agricultural conservation concept relied on the idea that by reducing losses within agricultural water systems, the savings could be transferred to other uses. The concept of non-C-BT agricultural water conservation would produce no firm yield and failed to meet the firm yield and recipient criteria due to the legal precedent that requires salvaged or saved water to be returned to the river for distribution in order of priority and cannot be made available exclusively to Fort Collins.

2.5.2.1.2 Agricultural Conservation – C-BT
The concept of C-BT agricultural water conservation is similar to the concept of non-C-BT agricultural water conservation described in the previous section in that it relied on the assumption that increases in agricultural water use efficiency could make water available for use by Fort Collins. The concept of C-BT agricultural conservation failed to meet the institutional criterion for Fort Collins because it is currently subject to the C-BT municipal cap and cannot directly acquire additional C-BT units, and also because it is not able to show the immediate need required by Northern Water for an agricultural-to-municipal transfer. This concept failed to meet the firm yield criterion due to the necessity of developing another source of firm supply to augment for the injurious reduction of return flows of non-C-BT water that would result from implementation of this concept.

2.5.2.1.3 Foothills/Plains Storage Transfer
The foothills/plains storage transfer concept relied on the assumption that evaporative losses can be reduced by storing water in higher-elevation foothills reservoirs rather than plains reservoirs, and that the volume of water by which the evaporative losses are reduced could be used by Fort Collins. The potential firm yield that could be developed by the foothills/plains storage transfer concept was estimated by comparing the volumes of evaporation for the same volume of stored water at different foothills reservoirs and plains reservoirs. The maximum storage of Timnath, Terry, and Big Windsor reservoirs is approximately 36,000 acre-feet. If these plains reservoirs could be replaced with 36,000 acre-feet reservoir in the foothills, such as the Halligan Reservoir site, approximately 1,200 to 1,600 acre-feet of annual firm yield could be produced from the reduced evaporative losses. The measurement error associated with common methods of measuring or estimating conveyance losses, actual evaporation rates at the plains and foothills facilities, and flow rates may be approximately the same magnitude as the potential reduction in evaporation. Therefore, the foothills/plains storage transfer concept could not be operated with available measurement technology and could not reliably deliver water to Fort Collins and was eliminated from consideration for failure to meet the existing technology and recipient criteria.
2.5.2.2 Hydrologic Alteration

The hydrologic alteration concept class included options for the alteration of local hydrologic processes, specifically cloud seeding, forest management, and phreatophyte removal, with the goal of making water available to Fort Collins.

2.5.2.2.1 Cloud Seeding

Cloud seeding, also known as weather modification, has been used in Colorado since 1951. The process is designed to stimulate the formation of ice crystals and snowflakes by introducing a silver-iodide and acetone vapor into clouds (Vonnegut 1947). Any increases in stream runoff from precipitation developed from cloud seeding would be administered according to the prior appropriation system and could not be directly claimed by the entity performing the cloud seeding. Therefore, water generated under a cloud seeding program by Fort Collins would not be directly available to Fort Collins and therefore failed the firm yield and recipient criteria and was eliminated from further consideration.

2.5.2.2.2 Forest Management

The forest management concept relied on the assumption that an increase in runoff volume could be achieved by thinning trees from the forests of a watershed, and that this increase in runoff volume could be made available to Fort Collins. The concept of forest management would produce no firm yield and failed to meet the firm yield and recipient criteria because any quantity of increased stream flow attributable to forest management would be available to all water users in order of priority and not directly to Fort Collins. Additionally, the concept of forest management would be unlikely to be selected as the least environmentally damaging practicable alternative considering the adverse effects on water quality associated with its implementation.

2.5.2.2.3 Phreatophyte Removal

Phreatophytes are plants and trees that grow in riparian areas and consume water from the shallow groundwater aquifer. Common phreatophytes in Colorado include cottonwoods (*Populus* spp), willows (*Salix* spp), and salt cedars (*Tamarix ramosissima*). Removal of such plants and trees would reduce the amount of consumption of water from the shallow groundwater aquifer. However, similar to the cloud seeding and forest management concepts, any increases in flow due to removal of phreatophytes would be considered salvaged or saved water under Colorado water law, would revert to administration under the prior appropriation system, and would not be available directly to Fort Collins. Increases in flow would be difficult to quantify and would accrue to all water users in the basin, not just to Fort Collins. Therefore, the concept would produce no firm yield and failed the firm yield and recipient criteria and was eliminated from further consideration.

2.5.2.3 Other Water Rights

The other water rights concept class included transbasin projects, development of groundwater, purchasing conditional water rights, and new water rights appropriations.
2.5.2.3.1 *Transbasin Projects*

Transbasin water is diverted from one river basin for use in another basin. Fort Collins already makes use of transbasin water through the C-BT system, Windy Gap Firming project, and Michigan Ditch system. New transbasin projects could be developed to provide additional water supply to Fort Collins. The feasibility of several larger scale transbasin projects, including the Colorado River Return Project (also known as "The Big Straw"), the Yampa River Pumpback Project, and the Flaming Gorge Pipeline Project, was described in Appendix I to the *NISP Alternatives Report* (HDR 2007). All three projects were speculative and outside of the Halligan Project study area and were therefore eliminated from further consideration due to their speculative nature and the wide range of practicable concepts within the study area.

The two neighboring basins most suitable for transbasin projects capable of providing additional firm yield to Fort Collins are the Laramie and North Platte basins. The potential additional transbasin diversion amount available from the Laramie and North Platte basins under the U.S. Supreme Court decisions was evaluated in the *NISP Alternatives Report* (HDR 2007). If existing collection systems could be expanded, the increased dry year yield would likely be low or non-existent because diversions into the expanded collection system would be made under a new junior priority that would likely not be in priority in dry years. In many average and wet years, the diversion limit is met by existing diversions and no additional diversions could be made by Fort Collins. Therefore, new transbasin projects produced no new firm yield and failed the firm yield criterion and were eliminated from further consideration.

2.5.2.3.2 *Groundwater Development*

The groundwater development concept relied on the assumption that development of groundwater sources from either unconfined shallow alluvial aquifers underlying the Poudre basin, or the deeper Denver Basin bedrock aquifers, could be expanded to provide additional water for Fort Collins.

There has been significant development of groundwater sources in the Poudre Basin for irrigation purposes, with over 1,800 decreed groundwater rights. Fort Collins does not hold groundwater rights, and the wells would be pumped under new junior water rights. Due to the junior water rights priority that new wells would obtain, stream depletions would be out of priority most of the time. Thus, development of water sources from shallow aquifers would not produce a firm yield since the water pumped from the aquifer would have to be augmented with other firm supplies in order to replace the depletions caused by pumping. This concept essentially becomes equivalent to the ‘new water right appropriation’ concept.

Water providers who have relied on the Denver Basin bedrock aquifers in the productive regions in the south Denver metro area are in the process of developing surface water supplies to reduce the draw on the aquifer due to concerns about long-term sustainability of the aquifer. Thus development of the Denver Basin bedrock aquifer groundwater produced no firm yield and failed the firm yield criterion and was eliminated from further consideration.

2.5.2.3.3 *Purchase Conditional Rights*

This concept relied on the assumption that Fort Collins could purchase conditional water rights to provide for its future supply. Fort Collins proposed to acquire one sixteenth of the Grey Mountain conditional right that has a 1980 priority date. In addition, Fort Collins intended to use the Halligan Reservoir...
enlargement water right with a 2013 priority date. Both of these conditional water rights were incorporated into Fort Collins' Proposed Action. There are no significant conditional rights that could be acquired by Fort Collins in the Poudre Basin that were senior to the Grey Mountain right. Modeling showed that a more junior right would not provide additional yield that could reasonably be used as a dry year water supply. Thus, purchasing of additional conditional water rights produced no firm yield and failed the firm yield criterion and was eliminated from further consideration.

2.5.2.3.4 New Water Right Appropriation

This concept relied on the yield generated from a new water right appropriation. The Poudre and Big Thompson Rivers currently have many water rights dating back to the 19th century. A new water right would be junior to the conditional water rights described in the previous section and would therefore have a yield less reliable than the conditional water rights Fort Collins already anticipates acquiring in its proposed action. Therefore, a new water right appropriation produces no firm yield and failed the firm yield criterion and was eliminated from further consideration.

2.5.2.4 C-BT Options

The C-BT operations concept class included options for changing C-BT operations or for long-term leasing of the Windy Gap Firming Project water.

2.5.2.4.1 C-BT Re-Operation

The concept relied on reoperation of C-BT facilities to create capacity for a new West Slope water right to be used to supply Fort Collins, using C-BT facilities to convey the water. Fort Collins did not hold any West Slope water rights that could be used for this purpose and would have to adjudicate new Western Slope water rights. The junior status of the necessary new water rights, along with the lack of a Western Slope storage location combined to make the feasibility of realizing a firm yield from C-BT re-operation practically zero for Fort Collins. Therefore, the concept failed the firm yield criterion and the recipient criterion and was eliminated from further consideration.

2.5.2.4.2 Lease of Excess Windy Gap Firming Project Shares

This concept relied upon the assumption that leases of Windy Gap Firming Project water could be made available for use by Fort Collins once the Windy Gap Firming Project was completed. The purpose and need statement for the Windy Gap Firming Project stated that no long-term yield from the project would be available for non-Windy Gap Firming Project participants. Fort Collins is not a Windy Gap Firming Project participant (although it uses Windy Gap water in its Reuse Plan; see Reuse Plan in the Alternatives Screening Report, DiNatale Water Consultants and CDM Smith 2016), so this concept could not be considered to provide long-term yield to Fort Collins. Permanent leases are also not permitted under Windy Gap Firming Project policies (Gibbens 2003). Any lease would be a temporary lease while long-term reliability and permanency is inherent in the definition of firm yield. Therefore, the concept of Windy Gap Firming Project leasing produced no firm yield and failed to meet the firm yield and was eliminated from further consideration.
2.5.2.4.3 Permanent Lease of C-BT Units
This concept relied on securing a permanent lease of C-BT units from current C-BT unit allottees. Potential acquisition of additional C-BT units was evaluated for the NISP Draft EIS and in response to an alternative proposed during public comments on the NISP Draft EIS by an organization named “Save the Poudre: Poudre Waterkeeper,” and was determined to be limited (MWH 2010 and Hydros 2012). Therefore, this concept produced no firm yield and failed the concept firm yield and institutional criteria and was eliminated from further consideration.

2.5.2.4.4 Permanent C-BT Carryover Program
Northern Water currently has a C-BT carryover program in place that allows C-BT unit holders to carryover up to 20 percent of a full allocation from year to year (for Fort Collins, 6,166 acre-feet maximum, less the 10 percent storage loss). This amount of additional storage would meet approximately 71 percent of the Fort Collins purpose and need. However, this concept failed the firm yield criterion because the program cannot be made permanent and is not a permanent source of firm yield. It also failed the institutional criterion because the program is at the Northern Water Board of Directors’ discretion and is beyond Fort Collins’ institutional authority and was eliminated from further consideration.

2.5.2.4.5 Acquire Additional C-BT Units Directly
Another concept is acquiring additional C-BT units directly. Fort Collins exceeds the municipal cap limit set by Northern Water on the number of C-BT units that can be owned outright by a municipal water provider and is therefore prohibited from purchasing more C-BT units directly. This concept failed the firm yield and institutional criteria and was eliminated from further consideration.

2.5.2.4.6 Acquire Additional C-BT Units via Purchases of North Poudre Irrigation Company Shares
Fort Collins could also acquire additional C-BT units via purchase of NPIC shares. Each share of NPIC stock includes the use of four C-BT units. However, about 85 percent of NPIC shares are projected to be owned by non-agricultural water providers in the future. Acquisition of the remaining 15 percent, if possible, would result in additional firm yield of approximately 2,700 acre-feet. Given the competition for water rights in the Poudre Basin and NPIC’s intent to preserve agricultural production within its service area, the ability to acquire all remaining shares is improbable. Therefore, the concept failed the firm yield criterion and was eliminated from further consideration.

2.5.2.4.7 Require Developers to Bring C-BT Units
The Northern Water municipal cap on the purchase of C-BT units permits developers to dedicate C-BT units to the municipal and industrial providers even if the provider is already over the municipal cap. It is not clear that there are sufficient C-BT units left that could be acquired by developers to form a substantial portion of the firm yield. Therefore, this concept failed the firm yield criterion and was eliminated from further consideration.
2.5.2.4.8  **Store Excess C-BT Water in Available Storage at the End of the Irrigation Year**

The last C-BT option is storing excess C-BT water in available storage at the end of the irrigation year. Fort Collins could store excess C-BT water in the Overland Gravel Pits and South Gravel Pits or other final storage elements at the end of the irrigation year and produce a reasonable contribution to the system firm yield in excess of the 600 acre-feet firm yield threshold. Delivery of C-BT water to non-C-BT storage facilities is already common practice in the Poudre Basin and therefore the practicable criterion is satisfied. Thus this concept satisfies all concept criteria and is retained for the preliminary alternatives formulation process.

2.5.2.5  **Traditional Agricultural Transfers**

The traditional agricultural transfer concept class included various methods of utilizing water transferred from irrigation use to municipal use. Agricultural transfers have been successfully implemented throughout Colorado and are therefore considered an existing technology and conform to Colorado water law, thereby satisfying two of the practicable criteria. There is approximately 13,500 acre-feet of consumptive use supply available from agricultural water rights in the critical year of the synthetic drought which satisfies the firm yield criterion threshold. Any water rights changes would require storage to meet the storage reserve factor that is part of the Fort Collins need, or combined with other concepts that preserve water in storage in earlier months by using transferred water instead of stored water.

2.5.2.5.1  **Transfer New Agricultural Water to Intakes or Reservoirs**

The concept of acquiring and transferring new agricultural water rights to intakes or reservoirs is a common practice in Colorado and has been successfully implemented by Fort Collins in the past through its Southside Ditch transfers among others. Agricultural rights are generally in priority during the irrigation season (April through October) and would therefore only be available to Fort Collins during those times. However, Fort Collins must deliver water to its customers year-round. Modeling showed that during some months of shortages in the critical drought year, there was not enough consumptive use water available in the entire Poudre Basin to meet the Fort Collins need even if all the water could be used by Fort Collins. Transfer of agricultural rights without some amount of storage would not fully satisfy the storage reserve factor. Nonetheless, even without additional storage or a smaller amount of storage, transferring new water rights could meet a significant portion of the Fort Collins need. The amount of water potentially available from additional agricultural transfers satisfied the purpose and need and practicable criteria and was retained for the preliminary alternatives formulation process.

2.5.2.5.2  **Acquire Water to Meet Return Flow Obligations Only**

This concept relied on increasing the diversions of existing transferred agricultural water rights at the Fort Collins diversions by acquiring a different source of water to meet return flow obligations. Under Colorado water law, an entity that transfers an absolute water right to a new use or location must maintain the return flows in the time, location, and amount as the historical use and the consumptive use of the transferred right may not exceed the historical consumptive use of the original water right. Fort Collins already diverted a significant portion of the converted water right in excess of the historical consumptive use and additional water rights acquired solely to meet return flow obligations would produce between
100 and 400 acre-feet of firm yield, this concept failed the firm yield criterion and was eliminated from further consideration.

2.5.2.5.3 Full Utilization of Existing Rights

Full utilization of existing rights is another concept. Fort Collins currently owns and has transferred a significant amount of agricultural water rights. The firm yield of these water rights can be increased by storing water in excess of demand when in priority and releasing at a later time when demand exceeds other supplies. This concept, in conjunction with the proposed Expanded Halligan Reservoir storage element, is Fort Collins' Proposed Action and has already been shown to meet the purpose and need criteria through the Common Technical Platform hydrology modeling process. The concept also met the practicable criteria as this is a standard method used in Colorado to develop a firm supply and was retained for the preliminary alternatives formulation process. Therefore, this concept was carried forward to the next stage of the alternatives formulation.

2.5.2.5.4 Deliver Transferred Water Rights to a New Advanced Water Treatment Plant on the Plains

This concept was similar to other agricultural transfer concepts, but would deliver raw water to a plains water treatment plant. The plains water treatment plant would deliver water to the eastern end of the Fort Collins potable distribution system, and could require upsizing or installation of new treated water mains and storage tanks to obtain proper hydraulic characteristics within the distribution system. Water quality would be a concern because it degrades as it moves downstream due to a number of factors, including irrigation runoff, urban runoff, wastewater effluent discharges, temperature, and changing streambed sediments. However, in response to scarcity, water providers in the region have turned to advanced water treatment technologies in order to utilize source supplies of lower quality while still delivering high quality potable water to their customers (e.g., city of Aurora, city of Brighton, town of Lochbuie, city of Sterling, East Cherry Creek Valley Water and Sanitation District).

Modeling showed that the firm yield criterion would be satisfied if associated with additional storage. The evaluation of the recipient criterion relies on the assumption that the Fort Collins potable water distribution system could be modified or improved to accept a new source of water on the eastern end of the system. For the concept screening, this is a reasonable assumption, even if new infrastructure such as potable water tanks to blend supplies and additional transmission mains are required. All concept criteria are satisfied and the concept of delivering transferred agricultural water to a new advanced water treatment plant was retained for the preliminary alternatives formulation process.

2.5.2.5.5 Deliver Alternate Supply to Town of Wellington to Free Up Additional Supply for an Interruptible Supply Agreement

This concept relied on Fort Collins being able to provide 2,000 acre-feet per year to the town of Wellington in lieu of Wellington's normal delivery from NPIC and thus making this water available to Fort Collins through an interruptible supply agreement with NPIC. This concept may produce more than 600 acre-feet on an annual basis, but on a monthly basis, this yield would likely be much less than 600 acre-feet, and thus the firm yield criterion is not satisfied. Furthermore, Fort Collins does not have the authority to modify a contract between NPIC and Wellington and therefore violated the integral to others.
criterion. Thus, the Alternate Supply to the Town of Wellington concept failed the concept screening and was eliminated from further consideration.

2.5.2.5.6 Change the Native Portion of Fort Collins' North Poudre Irrigation Company Shares
This concept utilized the native portion of the shares of NPIC owned by Fort Collins as a new supply. Fort Collins currently owns 35.5 percent of the NPIC shares and projects future ownership at 37.4 percent of the NPIC shares. Each NPIC shareholder is entitled to the use of four C-BT units and an equal allocation of other NPIC supplies, including native direct flow and storage rights. Fort Collins currently uses only the water from the C-BT portion of NPIC shares, and leases the native portion back to NPIC irrigators. NPIC relies on this leased supply to meet its future demands. Analysis showed that conversion of the native portion of the NPIC shares alone would not meet the purpose and need. Instead, Fort Collins would have to match the native portion with additional storage in order to utilize the NPIC yield in the early summer for use in the later part of the summer when it experienced shortages in the critical year drought. This concept, when combined with a storage element, would provide a reliable amount of water over 600 acre-feet and satisfied the firm yield criterion. The recipient criterion was satisfied because Fort Collins could take delivery of its water through exchanges with other water users. While a decision by Fort Collins to change the native portion would negatively impact the yield of the NPIC agricultural users who currently lease this supply from Fort Collins, this is within Fort Collins’ legal rights as a share owner and is not contrary to the ‘integral to others’ criterion. This concept met all purpose and need and practicability criteria and was retained for the preliminary alternatives formulation process.

2.5.2.6 Alternative Agricultural Transfers
The alternative agricultural transfer concept class included permanent interruptible supply agreement, shared water banking, and rotational fallowing.

2.5.2.6.1 Permanent Interruptible Supply Agreements
A permanent interruptible supply agreement is an agreement between two parties in which one party enters into a contract for the right to take delivery of the second party's water supply under defined conditions. For the purposes of this concept, the agreement would be between Fort Collins and NPIC, in which Fort Collins would have the right to take delivery of the native portion of its NPIC shares in dry years. The native yield of Fort Collins' NPIC shares through the driest year of the critical drought (consumptive use only) was 4,398 acre-feet (DiNatale Water Consultants and CDM Smith 2016). Therefore, the purpose and need criteria were satisfied because the yield of the water rights is greater than 600 acre-feet, Fort Collins is the owner of the shares, and the water can be delivered to the Fort Collins intakes. This concept was more favorable than the traditional agricultural transfer because it preserved water for agriculture in years that Fort Collins does not need the water, meeting an internal Fort Collins water policy goal. As the owner of the water rights, Fort Collins would have the right to use the water once transferred to municipal and industrial use and therefore the concept satisfied the institutional criterion and the existing technology criterion. The concept therefore satisfied all concept screening criteria and was retained for the preliminary alternatives formulation process.
2.5.2.6.2 Shared Water Banking

The concept of shared water banking relies on Fort Collins using available capacity in others' reservoirs to store excess supplies for future use. As was described in WEST et al. (2016), Fort Collins' water portfolio has water available in excess of demands in wet and average years, and even in some months of dry years, that is lost to Fort Collins due to its inability to store this water. Shared water banking would allow Fort Collins to use available storage capacity in others' facilities to store its excess supplies and later take delivery of this water during critically dry times. In return, Fort Collins would pay the owners of the storage facilities either monetarily or with water for the benefit of storing water.

Fort Collins owns over one third of the shares of NPIC and could possibly reach a permanent agreement with NPIC to store Fort Collins’ surplus water supplies in available capacity of NPIC reservoirs. Reservoirs higher in the NPIC system would be preferred to store Fort Collins surplus water because in dry years Fort Collins would utilize its remaining water in storage by delivering water to agricultural users from these reservoirs in exchange for NPIC river headgate diversions. Delivery to Fort Collins would be the same as described in the permanent interruptible supply agreement concept, thereby satisfying the recipient criterion.

Common Technical Platform modeling sequence results indicated that there would be a large amount of available storage capacity in NPIC reservoirs during the seven-year critical drought and that Fort Collins has at least 1,000 acre-feet of excess water supply to store there in all years (typically during the peak runoff), including the driest of the critical drought. The firm yield criterion was satisfied if Fort Collins develops the infrastructure needed to deliver water to its treatment plant year round.

Fort Collins currently has the legal ability to store most of its excess water (Southside Ditch and C-BT) in NPIC reservoirs, and could reasonably obtain such a right for its Water Supply and Storage Company supplies; therefore, the institutional criterion was satisfied.

Shared water banking involves no new technology, and, because most of the source of water placed into storage had already been decreed for storage at these locations, there would be far fewer other institutional or proven technology challenges to its implementation. Thus, shared water banking satisfied all concept screening criteria and was retained for the preliminary alternatives formulation process.

2.5.2.6.3 Rotational Fallowing

The concept of rotational fallowing involves setting up a group of agricultural land owners who agree to fallow their land on a rotating basis. The water that would have otherwise been used to irrigate the fallowed land would be made available for municipal use. The benefit of a rotational fallowing program is that irrigated acreage is not permanently removed from production and therefore may have fewer socioeconomic and environmental impacts to the rural areas that are common in traditional agricultural transfers.

Fort Collins owns a large percentage of NPIC shares that could provide a firm yield of 1,100 acre-feet with a one-in-four-year fallowing program. This yield was relatively small for the complexity required to administer a rotating fallow program, but was more than the 600 acre-feet threshold for firm yield and therefore satisfied the firm yield criterion. Hydros (2012) concluded for the NISP Supplemental Draft EIS that in Colorado, rotational fallowing was not a proven technology because no large-scale rotational
fallowing program had been implemented in Colorado and pilot projects (the best-known being the Super Ditch in the Arkansas River Basin) have to-date been unable to provide a reliable supply of water to municipalities. The lack of an existing functional rotational fallowing program in Colorado and other institutional challenges associated with such a program caused the concept to fail the existing technology criterion and therefore was eliminated from further consideration.

2.5.2.7 **System Efficiency**

The system efficiency concept class included various changes to system operations that result in meeting a portion of the Fort Collins purpose and need. All of the concepts involve modifications to current operations in the Fort Collins system and therefore would be able to deliver water to Fort Collins. The concepts were not integral to the plans of others, unless specifically noted for operations that potentially impacted other entities. All concepts relied on proven strategies that utilize proven technology, and were not contrary to federal, state, or local laws. The remaining criterion to be evaluated was firm yield. The following sections describe the potential firm yield from various system efficiency operations for the concept screening.

2.5.2.7.1 **Use Water Stored in Chambers Lake towards Storage Reserve Safety Factor**

As part of the Joint Operations Plan, Fort Collins makes minimum releases from Joe Wright Reservoir to meet minimum stream flow targets. Under the Joint Operations Plan, Fort Collins releases 600 acre-feet every October from Joe Wright Reservoir to Chambers Reservoir. Chambers Reservoir is owned by Water Supply and Storage Company and is a participant of the Joint Operations Plan. Water Supply and Storage Company releases the 600 acre-feet of Fort Collins' water from Chambers Reservoir at a constant rate of two cubic feet per second from November through March and Fort Collins diverts this water at its intake on the Upper Poudre. Fort Collins does not account for the Joint Operations Plan water stored in Chambers Reservoir as part of its storage reserve factor. However, the water is stored in a reservoir that can deliver water by gravity to Fort Collins and therefore should be included in the storage reserve factor calculation. Because the storage shortage is largest in October of the critical drought year, this concept would result in an increase in firm yield of 600 acre-feet with no additional infrastructure, no new water source, and no change in operations and therefore satisfied the firm yield criterion and was retained for the preliminary alternatives formulation process.

2.5.2.7.2 **Re-Operation of Joe Wright Reservoir, Including Winter Carryover**

This concept relies on meeting a portion of Fort Collins’ need by maintaining a higher level of water in storage and thereby meeting a portion of the storage reserve factor. Fort Collins owns and operates Joe Wright Reservoir located at the headwaters of the Poudre River. Joe Wright Reservoir is a key component of the Fort Collins system and can store water native to the Poudre River and transbasin water from Michigan Creek. At the time of the development of the Common Technical Platform model sequence and the alternative screening process, the Corps understood the total storage capacity of Joe Wright was 6,474 acre-feet. Subsequent investigations by Fort Collin’s indicated that the reservoir capacity is approximately 600 acre-feet greater than 6,474 acre-feet. However, the Corps determined that changing the Common Technical Platform model sequence with this incremental increase would not likely change the alternative screening outcome that ultimately identified a reasonable range of alternatives and thus
maintained the original capacity (6,474 acre-feet) for the EIS analysis. In the winter, Fort Collins lowers the reservoir storage to approximately 3,200 acre-feet to avoid icing problems in the outlet works. This concept relies on the ability of Fort Collins to carryover more water through the winter, which was counted towards the storage reserve factor. If the reservoir were kept near full through the winter, more than half of the approximately 5,800 acre-feet storage reserve factor would be met (additional 3,200 acre-feet). This amount translated almost directly into firm yield for the Fort Collins system. In conjunction with other concepts, water normally delivered from Joe Wright Reservoir could be kept in storage, further increasing the potential firm yield amount of this concept. Therefore, the firm yield criterion was satisfied and the concept was retained for the preliminary alternatives formulation process.

2.5.2.7.3 Re-Operation of C-BT Trade with North Poudre Irrigation Company Executed with Joe Wright Reservoir Releases

Under current and projected future operations, Fort Collins executes two water trades with NPIC by delivering water from Joe Wright Reservoir to NPIC via the Munroe Canal in exchange for NPIC's water in Horsetooth Reservoir. This concept relies on not executing the C-BT Trade with NPIC in selected years that were identified as either low supply years or low storage years and would allow Fort Collins to maintain more water in storage and carry water over from year to year in Joe Wright Reservoir. Common Technical Platform modeling sequence showed that Joe Wright Reservoir was empty at the lowest point in the critical drought, but that the C-BT trade was executed in all seven years of the critical drought, though at a reduced level in some years. By not executing the C-BT trade in some years, Fort Collins would be able to keep more water in storage, thereby meeting a portion of the storage reserve factor. Fort Collins would not violate the integral to others criterion, even though this concept may result in fewer deliveries of Joe Wright Reservoir water to NPIC as NPIC can execute exchanges with other water suppliers. Therefore, the concept firm yield criterion was satisfied and the concept was retained for the preliminary alternatives formulation process.

2.5.2.7.4 Enhanced Use of Overland Gravel Pits and South Gravel Pits including Exchanges

Fort Collins considered future storage in a portion of the Overland Gravel Pits and the South Gravel Pits in the future conditions modeling scenarios. The gravel pits were configured in the Common Technical Platform modeling sequence to meet return flow obligations associated with transferred water rights. This concept relies on using the gravel reservoirs to meet both potable demands and non-potable demands in order to free up other supplies for potable use, or to preserve water in higher storage reservoirs. Common Technical Platform modeling sequence results showed that Fort Collins draws approximately 650 to 800 acre-feet of water from storage May through June to meet the Reuse Plan demand, and at higher levels at other times of the year. If water stored in the gravel pits could be used to meet this demand rather than a release from storage in Horsetooth Reservoir, water would be kept in storage in Horsetooth Reservoir and count towards that storage reserve factor. Thus the firm yield criterion was satisfied and the concept was retained for the preliminary alternatives formulation process.

2.5.2.7.5 Overland Gravel Pit Releases for Non-Potable Demands

Fort Collins uses a portion of its Southside Ditch and C-BT water supply to meet non-potable demands, such as irrigation of parks and golf courses. These supplies are delivered to the historical headgates of the
Southside Ditches, located near the Overland Gravel Pits diversion point. This concept relies on delivering water from the Overland Gravel Pits to these non-potable demands and simultaneously using additional Southside Ditch water for other uses, such as meeting the reusable or single-use large contractual user demands, as an alternate source of reusable water for the Reuse Plan, storage, or simply to satisfy traditional residential and commercial demands. Similar to the exchanges of Overland Gravel Pits and South Gravel Pits water to the municipal intakes, additional firm yield would be developed by this concept if the use of water stored in the Overland Gravel Pits offset other uses of storage in the Fort Collins system or would allow Fort Collins to utilize otherwise lost sources of water at a different time of year. Any C-BT raw obligations met from a release of Overland Gravel Pits water would be simply kept in storage in Horsetooth Reservoir and would add directly to the firm yield through the storage reserve factor. On average, the amount of Southside Ditch water dedicated to raw water use was 2,450 acre-feet (based on the 40-year decreed limitation) and was approximately 1,300 acre-feet through the critical drought year. Annual C-BT raw obligations were 843 acre-feet. Combined, there would be potentially more than 2,000 acre-feet of water through the critical drought available and thus satisfied the firm yield criterion and the concept was retained for the preliminary alternatives formulation process.

2.5.2.8 Re-Regulation of Agricultural Reservoirs
The re-regulation of agricultural reservoirs concept class included the single concept of re-regulating ditch company reservoirs to provide storage for Fort Collins’ use. Fort Collins anticipates that it will own approximately 37 percent of NPIC shares in the future and 4.4 percent of Water Supply and Storage Company shares. This concept relies on Fort Collins being able to take advantage of a portion of the storage in these agricultural systems to store both its pro-rata share of water from converted shares in those ditch companies and any other excess supplies (e.g., excess Southside Ditch or excess C-BT). For the purposes of this concept, the Corps assumed that Fort Collins could obtain storage in proportion to its ownership in NPIC and Water Supply and Storage Company reservoirs. Since both companies have a majority of non-agricultural water provider shareholders, it was not unreasonable to assume that these shareholders can operate the ditch company assets in a manner that benefits non-agricultural shareholders as well as the remaining agricultural users.

Water Supply and Storage Company owns two major mountain reservoirs (Long Draw Reservoir and Chambers Lakes) and NPIC owns the existing capacity in Halligan Reservoir. Fort Collins’ pro-rata storage in these three reservoirs alone would result in approximately 3,250 acre-feet of storage. Re-regulation of this storage space, particularly operating to keep this capacity full through the critical drought, would result in approximately an equal amount of firm yield, thus satisfying the firm yield and recipient criteria. This action would not be contrary to state or federal laws and similar agreements are already in place in Colorado. Because non-agricultural water providers would own the majority of shares in NPIC and Water Supply and Storage Company, implementation of this concept would likely align with the plans of other municipal providers that own shares in those ditches. Thus, this concept satisfied all concept criteria and was retained for the preliminary alternatives formulation process.

2.5.2.9 Reuse
The reuse concept class evaluated possibilities for reuse of wastewater effluent.
2.5.2.9.1 Direct Reuse for Non-Potable Applications

Direct reuse refers to treating wastewater effluent to the applicable reuse standards and distributing this water for non-potable uses, such as irrigation of parks, golf courses, and street medians. Many municipalities in the Front Range have developed such systems and are easily recognizable by 'do not drink' signs, purple pipes, and purple irrigation valve boxes where the reuse water is used. In order to reuse wastewater effluent, the water must be a legally consumable return flow. Not all water sources are consumable. The Fort Collins system has a relatively small amount of unused consumable effluent, varying between approximately 50 and 300 acre-feet per year depending on the scenario. Fort Collins has a large fully consumable water demand from large contractual users that utilizes most of Fort Collins’ consumable water. Thus, the firm yield criterion of 600 acre-feet was not satisfied for a direct reuse system and was therefore eliminated from further consideration.

2.5.2.9.2 Meet Additional Non-Potable Demand from the Platte River Power Authority Pipeline

This concept relies on meeting any future non-potable demand along the Platte River Power Authority pipeline corridor rather than supplying these areas with potable water. Fort Collins delivers treated wastewater effluent to the Platte River Power Authority power plant via a pipeline that runs north from the Drake wastewater treatment plant to the Platte River Power Authority power plant located 20 miles north of the Drake wastewater treatment plant. At the time of this report, there were no readily identified future non-potable demands in the area, and thus the concept failed the firm yield criterion and was eliminated from further consideration.

2.5.2.10 Final List of Concepts

The concept screening process resulted in the retention of 13 concepts (Figure 2-15). The following concepts were retained and considered in the alternatives formulation process:

- Store excess C-BT water in available storage at the end of the irrigation year
- Transfer new agricultural water to intakes or reservoirs
- Full utilization of existing rights
- Deliver transferred water rights to a new advanced water treatment plant on the plains
- Change the native portion of Fort Collins NPIC shares
- Permanent interruptible supply agreements
- Shared water banking
- Use water stored in Chambers Lake towards storage reserve safety factor
- Re-operation of Joe Wright Reservoir, including winter carryover
- Re-operation of C-BT trade with NPIC executed with Joe Wright Reservoir releases
- Enhanced use of Overland Gravel Pits and South Gravel Pits including exchanges
- Overland Gravel Pit Releases for non-potable demands
- Re-regulation of reservoirs
<table>
<thead>
<tr>
<th>Concept Class</th>
<th>Concept Description</th>
<th>Purpose and Need</th>
<th>Practicable</th>
<th>Integral to Others</th>
<th>Existing Technology</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation</td>
<td>Conservation of non-C-BT agricultural water</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>Conservation of C-BT agricultural water</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>foothills/plains Storage Transfer</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
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<tr>
<td>Hydrologic Alteration</td>
<td>Cloud Seeding</td>
<td>X</td>
<td></td>
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<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>Forest management</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>Phreatophyte removal</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
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<tr>
<td>Other Water Rights</td>
<td>Transmountain projects</td>
<td>X</td>
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<tr>
<td></td>
<td>Groundwater development</td>
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<td>X</td>
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<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>purchase conditional rights</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>new water rights appropriation</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td>C-BT Options</td>
<td>C-BT Project reoperation</td>
<td>X</td>
<td></td>
<td></td>
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<td>FAILED</td>
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<tr>
<td></td>
<td>leases of excess Windy Gap shares</td>
<td>X</td>
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<td></td>
<td></td>
<td>FAILED</td>
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<tr>
<td></td>
<td>permanent lease of C-BT units</td>
<td>X</td>
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<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>permanent C-BT carryover program</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>acquire additional C-BT units directly</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>acquire additional C-BT units via purchases of NIPC shares</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>require developers to bring C-BT</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>store excess C-BT in available storage at end of water year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td>Traditional Ag Transfers</td>
<td>transfer new water to intakes or reservoir</td>
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<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td></td>
<td>acquire water to meet RPOs only</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>full utilization of existing rights using storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td></td>
<td>deliver transferred water rights to a new advanced water treatment plant on the plains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td></td>
<td>deliver alternate supply to Town of Wellington to free up additional supply for an interruptible supply agreement</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>change native portion of Fort Collins NIPC shares</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td>Alternative Ag Transfers</td>
<td>permanent interruptible supply agreement (ISA)</td>
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<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td></td>
<td>shared water banking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td></td>
<td>rotational falling</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td>Increased System Efficiency</td>
<td>use water stored in Chambers toward storage reserve safety factor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td></td>
<td>re-operation of Joe Wright reservoir, including winter carryover</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td></td>
<td>re-operation of C-BT trade with NIPC executed with Joe Wright Reservoir releases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td></td>
<td>Enhanced use of Overland Gravel Pits and South Gravel Pits including exchanges</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td></td>
<td>Overland Gravel Pits releases for non-potable demands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td>Reregulation of Reservoirs</td>
<td>re-regulation of ditch company reservoirs to provide storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>RETAINED</td>
</tr>
<tr>
<td>Reuse</td>
<td>direct reuse for non-potable applications</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td>meet additional non-potable demand from Platte River Power Authority pipeline</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
</tbody>
</table>

Excerpt Source: Alternatives Screening Report (DiNatale Water Consultants and CDM Smith 2016)

X denotes a concept that failed the indicated screening criterion

Figure 2-15. Summary of concept screening results.
2.5.3 Preliminary Alternatives Development

The preliminary alternatives were developed by combining concepts with elements, screening the various concept-element combinations, and then grouping the retained combinations into preliminary alternatives that would fully meet the Halligan Project’s purpose and need (DiNatale Water Consultants and CDM Smith 2016).

Combinations of concepts and elements were generated from the final elements retained and listed in Section 2.5.1.6 and the final concepts retained and listed in Section 2.5.2.10. The concept-element combinations were then screened using a concept-element compatibility criterion, duplication criterion, firm yield criterion, and an environmental criterion that assessed the length of river reach affected as well as the severity of likely flow decreases under each concept-element combination. Concept-element combinations that were retained through the screening were grouped into preliminary alternatives by grouping concept-element combinations that together were likely to fully meet the purpose and need and maintained a reasonable range of practicable alternatives (DiNatale Water Consultants and CDM Smith 2016). In some instances, multiple concept-element combinations with no identifiable or discernible differences in impacts to the aquatic environment could have been incorporated into a preliminary alternative. In those cases, a best fit analysis was used to select the combination that would likely have the lowest capital costs and best operational efficiencies.

Preliminary modeling was performed to estimate the yield from various concept-element combinations as each preliminary alternative was expected to fully meet the purpose and need. The preliminary alternatives developed by the Corps are described in the Alternatives Screening Report (DiNatale Water Consultants and CDM Smith 2016) and were provided to Fort Collins for more detailed modeling and evaluation. The more detailed modeling was used to refine the preliminary alternatives and formulate the final alternatives carried through to the EIS analysis and described herein.

2.5.3.1 Concept-Element Combinations and Screening

In addition to the list of final elements, a “no new storage” element was included in the process of combining concepts and elements to allow for a concept that can operate without use of one of the final storage elements. Thus, 13 concepts and six elements were combined for 78 concept-element combinations (Figure 2-16). The Corps developed a matrix whereby concepts were listed in rows and elements were listed in columns.

Every possible combination of the concepts and elements that advanced to the alternatives formulation process was screened using the criteria described in Table 2-5. In order to maintain a reasonable range of practicable alternatives, the screening criteria were applied sequentially, but ensuring that at least one concept-element combination remained within each concept class.
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Excerpt Source: DiNatale Water Consultants and CDM Smith 2016

Figure 2-16. Concept-element combination matrix showing all possible combinations of final concepts and final elements and results of screening.

Table 2-5. Concept-element combination screening criteria presented in order of application.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatibility</td>
<td>Concept-element combinations must be compatible</td>
</tr>
<tr>
<td>Duplication</td>
<td>Concept-element combinations must not be duplicates of other concept-element combinations</td>
</tr>
<tr>
<td>Firm yield</td>
<td>Concept-element combination must contribute at least 600 acre-feet of firm yield</td>
</tr>
<tr>
<td>Aquatic environment impacts</td>
<td>Eliminate concept-element combinations that would most negatively impact streamflows based on length reach and severity of the impact.</td>
</tr>
</tbody>
</table>

2.5.3.2 Preliminary Alternatives Configuration

The concept-element screening resulted in 25 retained combinations (Figure 2-17). Preliminary alternatives were configured by combining the retained concept-element combinations that share the same element. If the concept-element combinations associated with a single element were unlikely to meet the purpose and need, other combinations utilizing other elements were added to the preliminary alternative configuration.
In some cases, multiple concept-element combinations could reasonably be included in the preliminary alternative configuration. In those cases, the Corps selected the combination that appeared to have fewer impacts to the aquatic environment. In cases where the impacts to the aquatic environment had no discernible difference, a best-fit analysis was used to select the combination that was estimated to have lower capital costs or the best operational efficiencies. This process resulted in a wide range of preliminary alternatives that utilized all the final elements and at least one concept from each concept class.

The grouping of concept-element combinations in this manner produced five preliminary alternatives, including Fort Collins’ Proposed Action. Of the 25 retained concept-element combinations, 18 were used in at least one of preliminary alternatives, and the remaining seven were not selected through a best-fit analysis. In addition to the five preliminary alternatives, Fort Collins produced a No-Action Alternative. The 25 retained Fort Collins concept-element combinations are summarized in

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**Figure 2-17. Concept-element combination matrix showing the preliminary alternative in which the concept-element combination was used.**

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Figure 2-17. Each cell in Figure 2-17 with an abbreviated preliminary alternative name indicates that a combination of a concept and element was incorporated into that preliminary alternative. Cross-hashed cells indicate a combination of a concept and element that was not selected through a best fit analysis.

## 2.6 Final Alternative Identification

Because of Fort Collins’ intimate knowledge of its system and to have a more efficient modeling process, the Corps directed Fort Collins to refine the technical detail for the final alternatives and to conduct the detailed modeling effort (Corps 2012). The Corps performed an independent review of the added technical detail and modeling performed by Fort Collins, and then the Corps selected the final alternatives.

In general, the following steps comprised the Corps’ process of identifying and developing the final alternatives:

- Meetings held between Fort Collins staff and the Corps to discuss preliminary alternatives and preliminary modeling in depth.
- Fort Collins developed detailed modeling or other analyses to incorporate the preliminary alternatives into the Fort Collins system model and evaluated the technical aspects of some concept-element combinations from the preliminary alternatives.
- Fort Collins developed documents that described each final alternative (termed “alternative definitions” by Fort Collins) that served as proposals for final alternatives to be approved by the Corps. The alternative definitions identified the portions of the preliminary alternatives Fort Collins proposed to retain and omit for technical reasons in the final alternatives. These alternative definitions were reviewed and approved by the Corps.
- Fort Collins produced an *Fort Collins Alternative Descriptions Action Alternatives Report* (MWH 2015) that documents the final alternatives. The alternative definitions are provided as an appendix to the Fort Collins Alternatives Report.
- Fort Collins performed the full Common Technical Platform modeling sequence for each final alternative. Modeling files were transmitted to the Corps for verification, including detailed quality control and quality assurance review and testing.
- Fort Collins refined infrastructure sizing, location, and costs associated with each final alternative based on model results. The results of this refinement were provided to the Corps in the *Fort Collins Alternative Descriptions Action Alternatives Report* (MWH 2015) and included mapping needed for the comparative effects analysis for the EIS. The Corps reviewed and verified results of the *Fort Collins Alternative Descriptions Action Alternatives Report* (MWH 2015).
- The Corps completed the final alternatives selection and the screening report based on the above information.

The alternatives screening process resulted in Fort Collins’ Proposed Action, three alternatives to the Proposed Action, and the No-Action Alternative. The *Fort Collins Alternative Descriptions Action Alternatives Report* (MWH 2015) documents the final alternatives, with the alternative definitions provided as an appendix to the report.
Alternatives Report (MWH 2015) contains much of the detailed technical information related to each alternative. An overview of alternatives is presented in Section 2.3 of this Chapter.

2.7 REFERENCES


40 Code of Federal Regulations (CFR) 1500-1508. Title 40 - Protection of Environment; Chapter V - Council on Environmental Quality; Parts 1500-1508. 40 CFR 1500-1508.


Colorado Division of Water Resources. 2007. Rules and Regulations for Dam Safety and Dam Construction.


Fort Collins Staff. Meeting with Northern Water Staff (Carl Brouwer, Andy Pineda and Jerry Gibbens). February 19, 2014.


SCREENING CRITERIA


