2. CURRENT AND ALTERNATIVE WATER CONTROL PLANS

This chapter describes the current Water Control Plan (CWCP) for operation of the Mainstem Reservoir System (Section 2.1) and the process of developing and selecting alternative water control plans for study and presentation (Section 2.2). The discussion includes the features of the CWCP that are and are not being considered for change.

The search for a water control plan that better serves the contemporary uses of the Mainstem Reservoir System has focused on two primary features of the Master Manual:

1. The amount of system storage set aside for the permanent pool and the flood control and carryover multiple use zones (Section V of the Master Manual); and
2. The multipurpose regulation of storage releases for downstream needs—e.g., navigation, water supply, irrigation, power production, water quality, flood control, recreation, and environmental quality (Sections IX and X of the Master Manual).

The criteria for the exclusive and annual flood control zones were reviewed, and the Corps determined that the size of these zones should not be reduced. The current sizes of the exclusive and annual flood control zones are based on storage requirements for major flood events, the height of the dams, and the elevation and capacity of the spillways. None of these factors have changed; therefore, at least the current size of the combined flood control storage zones must be maintained to preserve the overall ability of the system to control major floods. The alternative formulation process has, therefore, focused on the apportionment of the remaining 57.1 million acre feet (MAF) that comprises the carryover multiple use zone and the permanent pool. This process includes apportioning part of the carryover multiple use zone for flood control storage.

In developing new alternatives, the following changes to storage release patterns were also considered:

- Navigation service criteria;
- Service level changes for fish and wildlife during the navigation season;
- Flood control criteria;
- Nonnavigation service criteria; and
- Intrasystem regulation criteria.

The Study focused on system storage and system releases indicated in the Master Manual. Structural changes to the Mainstem Reservoir System and downstream Lower River are not considered. Also not considered are temporary system imbalances, daily and weekly release patterns, and other intrasystem, short-term variations. The vast array of intrasystem details and daily operating specifics are appropriately evaluated in the context of the Annual Operating Plans. Operating alternatives for tributary reservoirs are also not within the scope of the Study.

2.1 CURRENT WATER CONTROL PLAN

The existing Master Manual establishes guidelines for operating the Mainstem Reservoir System for the multiple project purposes of flood control, hydropower, water supply, water quality, irrigation, navigation, recreation, and fish and wildlife. Criteria for operations include how storage in the Mainstem Reservoir System is divided and how water is released during navigation and nonnavigation periods.

2.1.1 System Storage Zones

The division of total available system storage volume into zones affects Mainstem Reservoir System operation. Zones are prescribed for flood control, multiple uses, and the permanent pool. Figures 2.1-1 and 2.1-2 show this division for the total system and individual lakes, respectively.

Exclusive Flood Control Zone

The exclusive flood control zone is the total upper volume of the mainstem lakes maintained exclusively for flood control. This zone represents the upper 6 percent of the total system storage volume, or that between 68.7 and 73.4 MAF (Figure 2.1-1). Water is released from this zone as quickly as downstream channel conditions permit so that sufficient storage remains available for capturing future inflows. The larger four lakes—Fort Peck Lake, Lake Sakakawea, Lake Oahe, and Lake Francis Case—hold most (98 percent) of the volume retained exclusively for flood control (Figure 2.1-2).

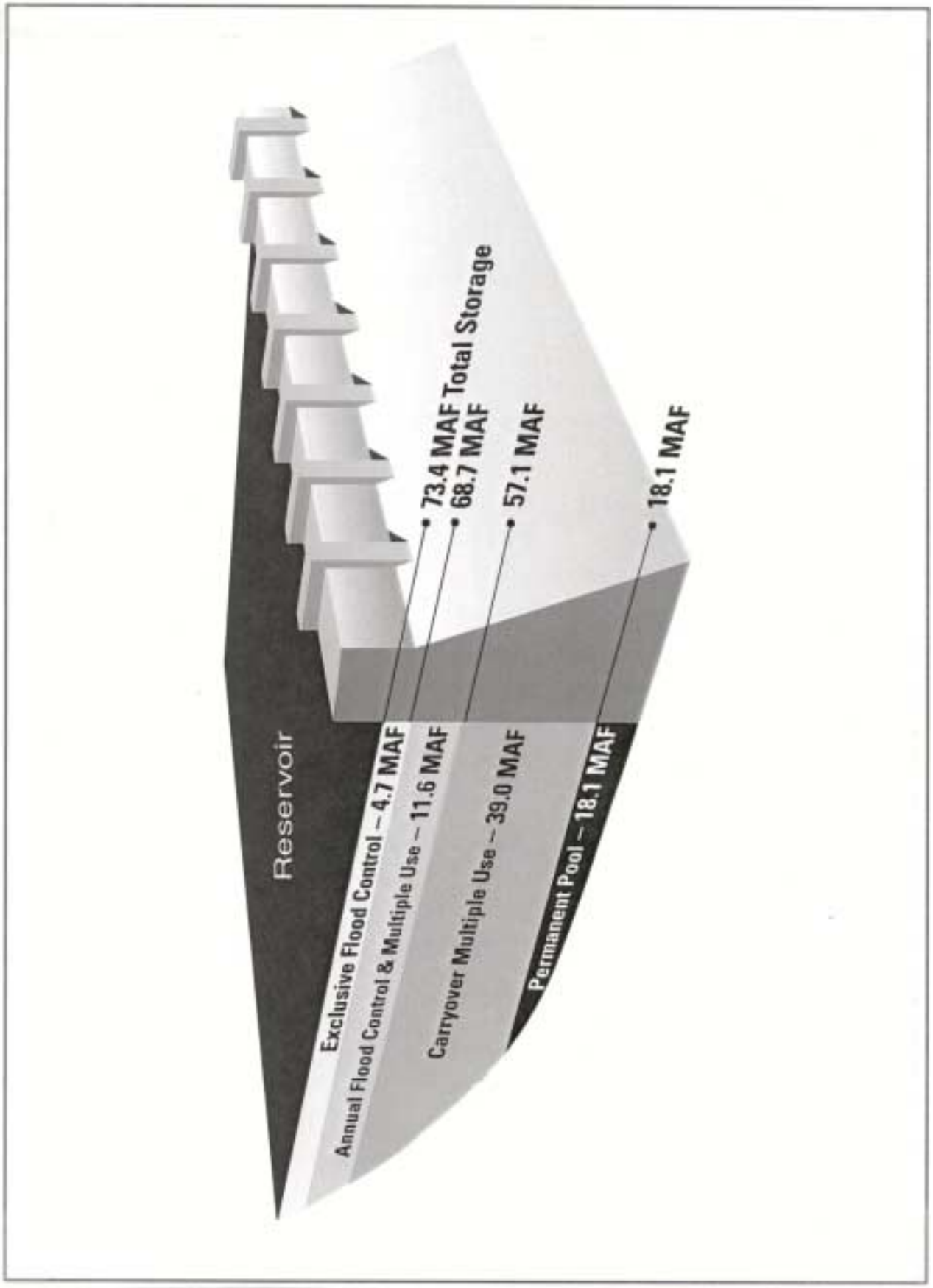

Figure 2.1-1. Missouri River Mainstem Reservoir System total storage by zone (as established in the current Master Manual).

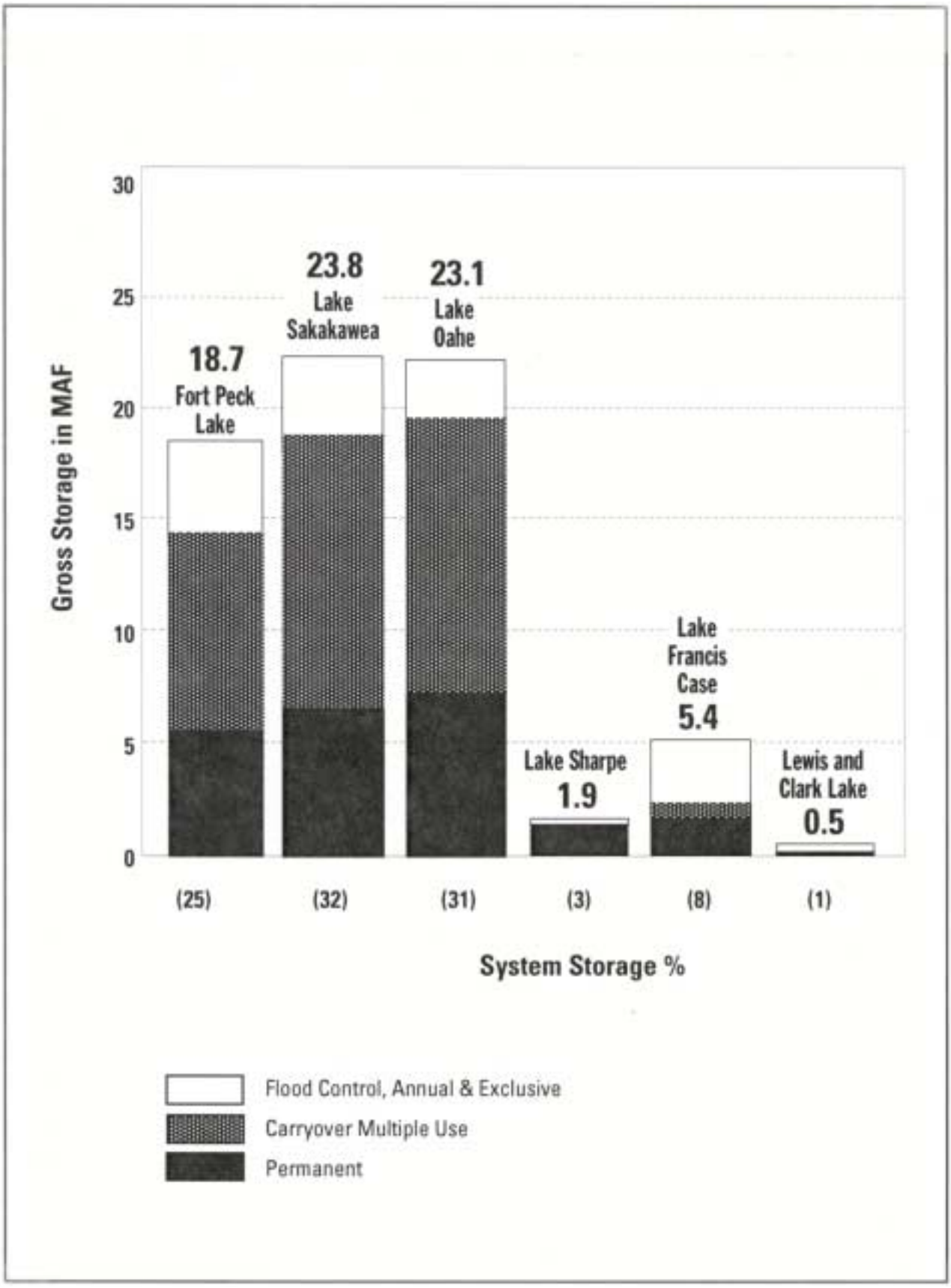

Figure 2.1-2. Missouri River Mainstem Reservoir System storage by mainstem lake (as established in the current Master Manual).

Annual Flood Control and Multiple Use Zone

The next 16 percent of the system storage volume is reserved for annual flood control and multiple uses. It includes the system storage from 57.1 to 68.7 MAF (Figure 2.1-1). This zone is used to store the high annual spring and summer inflows to the lakes. Later in the year, water stored in this zone is released for riverine uses so that the zone is evacuated by the beginning of the next flood season on March 1. Evacuation is accomplished mainly during the summer and fall navigation season, because icing of the river may preclude high evacuation flows during the winter.

Carryover Multiple Use Zone

The largest portion of the system storage capacity, 53 percent, is designed to provide water for all uses during drought periods. The carryover multiple use zone includes storage between 18.1 and 57.1 MAF and is confined to Fort Peck Lake, Lake Sakakawea, Lake Oahe, and Lake Francis Case (Figures 2.1-1 and 2.1-2). It is operated so that it remains full during periods of normal inflow but is gradually drawn down during drought periods.

Permanent Pool

The remaining 25 percent of the total storage capacity is reserved as the permanent pool. Total capacity allocated for the permanent pool is 18.1 MAF. The permanent pool provides the minimal water level necessary to allow the hydropower plants to operate and to provide reserved space for sediment storage. It also serves as a minimum pool for recreation and for fish and wildlife habitat and as an ensured minimum level for pump diversion of water from the lakes.

2.1.2 Water Releases from the Lakes

The Master Manual provides criteria for releases from the flood control and carryover multiple use zones for flood control, navigation service, and nonnavigation service. Each criterion relates to the amount of water in system storage. The criteria were designed so that system storage in the flood control zone can be evacuated in an orderly manner before the beginning of the next flood season. When storage volumes fall during extended droughts, cutbacks in system releases are made to conserve water. The criteria were originally designed so that the water in the carryover multiple use zone would be adequate to provide navigation service through a drought comparable to that of 1930 to 1941.

Navigation Service Criteria

Augmenting downstream tributary flows by releasing water from the Mainstem Reservoir System provides support for navigation on the Missouri River below Sioux City. In drought periods, storage water is limited and cutbacks in releases may shorten the navigation season and reduce navigation service. The CWCP has two criteria for reducing navigation service in droughts: navigation service level and season length.

The first step in conserving water in storage is to cut back releases to those necessary to provide a full service level (approximately a minimum of 8.5 feet of draft). As storage declines in a drought, the navigation service level is reduced a maximum of 6 thousand cubic feet per second (kcfs) to minimum service (7.5 feet of draft). The full navigation service level designation for the Missouri River navigation project is 35 kcfs. The downstream target flows are a minus or plus value from this service level designation. To meet full service, target flows are set at 31 kcfs at Sioux City and Omaha, 37 kcfs at Nebraska City, and 41 kcfs at Kansas City. Minimum navigation service is designated as 29 kcfs. To meet minimum service, target flows are set at 25 kcfs at Sioux City and Omaha, 31 kcfs at Nebraska City, and 35 kcfs at Kansas City.

On March 15 of each year, the level of navigation service is checked to determine if the service level should be changed based on the amount of water in system storage (Table 2.1-1). The season is normally scheduled to begin on April 1 at the river's mouth at St. Louis. If water in storage is at least 54.5 MAF, full service is maintained by system releases. If there is 46.0 MAF or less, then minimum service is provided. Flows for navigation are proportionally set between 46.0 and 54.5 MAF, depending on the amount of water in storage.

Navigation support is suspended when the amount of water in storage on March 15 is 21.4 MAF or less. As the amount of water in system storage recovers, navigation support is restarted; this occurs when the amount of water in storage is 21.4 MAF or greater on March 15 of a succeeding year.

Table 2.1-1. Navigation service criteria for the CWCP.

Service Level—March 15 Check	
Full Service (MAF)	***Minimum Service (MAF)***
54.5	46
Service Level—July 1 Check	
Full Service (MAF)	***Minimum Service (MAF)***
59	50.5
Season Length—July 1 Check	
8-month season (MAF)	***5.5-month season (MAF)***
41	25

On July 1, after most of the inflow from the mountain snowpack has entered the system, service level and season length are checked to see what they should be in drought periods. Full service is provided if water in storage is 59 MAF or higher. Minimum service is provided if water in storage is 50.5 MAF or lower. When water in storage is between 50.5 and 59 MAF, the service level provided is set proportionally between minimum and full service, based on the amount of water in storage.

When July 1 storage drops below 41 MAF, the length of the navigation season is shortened. A full-length season, 8 months (March 23 to November 22 at Sioux City; April 1 through December 1 at St. Louis), is supported by system releases if water in storage is 41 MAF or more on July 1. From 41 to 25 MAF, the navigation season is shortened progressively from November 22 to September 7, depending on the amount of water in storage. If there is 25 MAF or less in storage and the March 15 check indicates there is enough storage to support at least some level of navigation, system releases are made to support a minimum season of 5.5 months (March 23 to September 7 at Sioux City).

Flood Control Criteria

Water Evacuation Regime

Water is released from the Mainstem Reservoir System lakes in most years to evacuate water from the exclusive and annual flood control zones. The goal is to evacuate all of the water from the annual zone by the beginning of each year's flood season (March 1). Most of the water is released during the summer and fall part of the navigation season because the potential for ice problems in the river limits the amount of evacuation releases in winter. (Ice reduces channel capacity and is subject to breakup and jamming, which could lead to flooding.)

Evacuating for flood control also benefits navigation up to a point, since flows for a 9-foot draft (about 3 kcfs above full service flows) are desirable. Water is evacuated during the navigation season by increasing flows in the river above those necessary to maintain full navigation service. The service level is increased above the full navigation service level of 35 kcfs; the amount of the increase depends on storage level, remaining evacuation time, and the estimated amount of water to be evacuated.

Limiting Navigation during Flooding

Gavins Point Dam releases exceed the navigation targets at Sioux City in at least three different circumstances. First, the navigation target location may be at either Nebraska City or Kansas City (the two downstream locations) when inflows between Sioux City and these two locations are not adequate to meet navigation target flows. Second, in years when excess water in the flood control storage zones needs to be evacuated at a rate greater than just meeting the navigation targets will allow, flows in excess of the Sioux City navigation target value result from the higher Gavins Point Dam releases. Third, if inflows increase fairly quickly upstream from Sioux City, the navigation target flow may also be exceeded. In any of these cases, Gavins Point Dam releases do not have to be reduced unless the flow at three downstream target locations exceeds specified levels that are indications that the downstream flooding potential has increased and actions should be taken to reduce the flooding potential. The specified levels, or flows, are referred to as flood control constraints. When these flood control constraint values are met or exceeded, Gavins Point Dam releases are reduced to provide full navigation service. The two sets of flood control constraint targets are specified in the Master Manual. The lower constraints at the flood control target locations are as follows: Omaha – 41 kcfs; Nebraska City – 47 kcfs; or Kansas City – 71 kcfs. At higher specified river flows, or flood control constraint values (46, 57, and 101 kcfs, respectively, for the three target locations), the navigation support is reduced to the minimum service value or it is reduced by the amount the flow exceeds the flood control constraint target value,

whichever results in the higher Gavins Point Dam release.

During high inflow years in nondrought periods, the specified values for the flood control constraints can be increased to correspond to higher service levels. For example, in flood storage evacuation periods, a higher service level is established to allow the increased releases from Mainstem Reservoir System storage. If the service level increase is 5 kcfs, the specified flow values at the three target locations are raised 5 kcfs. On rare occasions, releases from Gavins Point Dam are reduced to 6 kcfs (which is the level required to meet the Yankton water intake requirement); this was done during the 1993 Missouri River flood because flood flows on the Lower River forced the suspension of navigation.

Nonnavigation Service Criteria

The CWCP specifies minimum releases to the Lower River in times of drought when navigation releases are suspended. During the winter nonnavigation season (usually December 1 through March 30 at St. Louis), a reduced service level is maintained in the Lower River by flow releases from Gavins Point Dam. Under the CWCP, if the water in system storage is 58 MAF or higher on September 1, a minimum of 15 kcfs is released from Fort Randall Dam for the Lower River. If the amount of water in system storage is 43 MAF or less on September 1, the Master Manual specifies that 5 kcfs be released. These releases translate to 16 and 6 kcfs, respectively, from Gavins Point Dam. Releases vary proportionally for storage levels between 43 and 58 MAF.

The CWCP also specifies that in all seasons "releases from Gavins Point will be reduced to the minimum necessary for water intake or water quality requirements" (Corps, 1979). Changes in the river channel below Gavins Point Dam have necessitated nonnavigation service levels higher than 6 kcfs. A minimum target flow of 9 kcfs is currently considered necessary from spring through fall to meet stage requirements for water supply intakes when navigation service is suspended to conserve water during extreme drought. During the winter, when ice forms on the Lower River, an average service level of 12 kcfs is considered necessary for water supply intakes. Because there is very little tributary inflow in the winter, the releases from Gavins Point Dam are essentially equal to the downstream target flows.

Intrasystem Regulation of Water

Although the current Master Manual does not provide specific rules for water releases from dams other than Gavins Point Dam, general water release criteria are presented for the other five dams. Internal regulation of the system to meet the needs for power generation follows a seasonal pattern at each of these dams. Demands for water releases for navigation generally set the seasonal intrasystem regulation patterns. The gain or loss in water stored at each lake must also be considered in scheduling the amount of water transferred between lakes to achieve intrasystem balance while generating power.

The largest amounts of water are released from Gavins Point Dam during the navigation season. Because there is little multiple purpose storage in Lewis and Clark Lake, water for releases from Gavins Point Dam must be provided through releases from Fort Randall Dam. Fort Randall Dam, in turn, requires similar support from Big Bend Dam releases, and Big Bend Dam requires support from Oahe Dam releases. Here the chain is interrupted because Lake Oahe has sufficient annual flood control and multiple use and/or carryover multiple use storage to supply all downstream demands. During the fall, navigation demands are met for a short time by releases from Fort Randall Dam. The space evacuated in Lake Francis Case is then used to store water released from Oahe and Big Bend Dams in the winter. Water is released from these dams to produce hydropower during the daily peak power demand periods without causing ice-affected flooding in the downstream reaches, particularly downstream from Gavins Point Dam.

In winter, Gavins Point Dam releases are generally at their lowest level, and power demands are predominantly met with generation at the four upper dams. Increased winter power releases from Fort Peck and Garrison Dams allow refilling of Lake Oahe before the next navigation season.

In general, the movement of water in storage from one lake to another follows a basic pattern each year, but short-term adjustments in intrasystem regulation are occasionally necessary. Heavy runoff may raise river stages or lake levels at one project, necessitating cutbacks at another project. Very hot or cold weather may create sharp increases

in demand for power and, therefore, require higher releases of water.

Prior to about 1984, there was no purposeful effort to enhance the resources in one of the upper three lakes at the potential expense of resources in the other two lakes. More recently, opportunities to provide such a benefit have been considered and sporadically implemented. Had the Missouri River basin not entered another drought in 2000 and 2001, the Corps would have begun the implementation of a prescribed pattern for intrasystem regulation in 2001. This prescribed pattern is described in Section 2.2.

Daily Water Release Patterns

At all projects except Gavins Point Dam, hourly release rates may be varied widely to meet power demands. Minimum release rate restrictions apply to Fort Peck and Garrison Dams to protect downstream water supply intakes and some fish species. Minimum Oahe Dam releases are provided on weekends during the fishing season to enhance the tailwater fishery. A uniform peaking release pattern has been established during the summer from Fort Peck, Garrison, and Fort Randall Dams to protect endangered birds nesting along the river below the dams. At Oahe and Big Bend Dams, there are no constraints and hourly flows generally vary from 0 to 56 kcfs at Oahe Dam and 0 to 110 kcfs at Big Bend Dam. Minimum hourly release constraints are prescribed for Fort Peck and Fort Randall Dams during fish spawning periods.

Water Release Constraints for Threatened and Endangered Species

At Gavins Point Dam, release constraints for threatened and endangered birds during the mid-May through mid-August nesting season take the form of additional releases to encourage nesting at higher island elevations. The higher steady releases begin in mid-May to ensure the flexibility needed for meeting downstream navigation targets through the summer. Historically, the releases were increased from mid-May through late August to compensate for the generally lower contributions from downstream tributaries during this period. The current higher steady release can be reduced for 2 days during the nesting season if the downstream flood control targets are exceeded. By the third day, the sand becomes dry and the birds may nest in the dry sand. By ensuring that the reduced release does not continue for more than 2 days, the Corps limits the possibility that a tern or plover will nest below the level that would be covered with water at the specified higher release. During the 1987 to 1993 drought, the specified higher release was made every third day instead of continuously to conserve water.

Average daily releases cannot exceed the specified level during any day of the nesting season except during required flood storage evacuation. Fort Randall Dam releases follow a similar pattern to ensure that river levels and Lewis and Clark Lake levels do not fluctuate excessively during the nesting season. Fort Randall Dam and Garrison Dam releases have hourly peaking limitations because of these constraints.

2.2 ALTERNATIVES FORMULATION

In addition to the CWCP, numerous other alternatives were simulated using the Daily Routing Model (DRM) and included in a list of water control plans from which the revised Master Manual Water Control Plan may be selected. These alternatives were evaluated to identify potential impacts. The impacts of the new alternatives were compared to those identified for the CWCP, which is the baseline for this National Environmental Policy Act evaluation. This section of Chapter 2 provides information on the alternative formulation criteria.

Alternatives to the CWCP considered in this version of the Environmental Impact Statement (EIS) have varying system storage and release criteria. The changes in the system storage allocation criteria being considered are the size of system flood control storage and a reduction in the amount of water used from the carryover multiple use zone. The changes in the system release criteria being considered are:

- Navigation service criteria,
- Nonnavigation service levels,
- Flood control constraints,
- Changed service levels during the navigation season to benefit fish and wildlife,
- Intrasystem regulation of storage water among the upper three lakes, and
- Release modifications at Fort Peck Dam to benefit downstream endangered species.

Alternatives to the CWCP in the post DEIS period were developed by varying the above factors and running various combinations through the DRM. Details on the average annual impacts of the specific alternatives on Mainstem Reservoir System uses and resources are described in the Preliminary RDEIS (Corps, 1998a) and in this RDEIS. The following is a summary of the range of each factor considered in the DRM analyses.

2.2.1 System Storage Allocation Criteria

The key feature of the Master Manual being evaluated for change is a reduction in the size of the carryover multiple use zone. This reduction could be accomplished through increasing the total size of the flood control zones or decreasing water used during droughts.

Changes to the amount of storage designated to be used during droughts would have an effect on lake levels and water releases from dams during extreme drought periods. Increasing the current permanent pool of 18 MAF or decreasing the amount of water used for navigation would reduce the amount of storage water available in the carryover multiple use zone for release during drought periods for downstream beneficial uses (e.g., navigation, water supply, and river recreation), while retaining water in the lakes. Retaining water in the lakes provides water for beneficial uses associated with the lakes (e.g., recreation, hydropower, and water supply).

Of the total possible range of 0 to 57 MAF for a permanent pool, only the range from 18 to 44 MAF is being studied at this time. Levels below 18 MAF are not being considered because the hydroelectric generators at the three largest lakes cannot be operated effectively at lower levels. Permanent pools above 44 MAF are not being considered because there was no support expressed for these relatively high levels in the public comments on the DEIS.

Adverse flooding, interior drainage, and groundwater impacts occurred in parts of the Lower River as a result of extremely high runoff into the Mainstem Reservoir System and the Lower River in 1993, 1995, 1996, and 1997. Individuals adversely affected asked the Corps to reconsider its earlier decision not to examine alternatives that include increased flood control storage. In response to this request, alternatives with an extra 2 MAF of flood control storage are now being considered.

2.2.2 Release Criteria for System Water in Storage

Navigation Service Criteria

Navigation Service Criteria (Drought Periods)

Three types of changes to navigation criteria were considered as part of the alternative formulation process. The first involves changes to the navigation guide curves, the curves that identify the navigation service level and season length based on the amount of water in system storage. A second set of criteria being considered is based on a combination of a higher minimum navigation service level during most years in drought periods with an earlier reduction in season length using a set of two "triggers," the storage levels for March 15 and July 1. Finally, a special set of navigation criteria is being considered for "extreme" drought years or years when there is no gain in the system storage level between March 15 and July 1. During extreme drought years, there would be an automatic reduction to the current minimum service level of 6 kcfs less than full service for the next 10 normal navigation months (July 1 through August 31 of the next year).

Changes to navigation service guides—service level and season length guide curves—that increase the system storage level required for providing navigation service are being evaluated. Such changes would lower the amount of storage water released to support navigation earlier in drought periods, thus potentially increasing the prospect for some navigation service in more years during periods of extreme drought, such as the 1930 to 1941 drought.

Three sets of navigation service level guide curves were considered following the distribution of the DEIS and the subsequent comment period. The current set continues to be considered, along with two sets of higher limits—one set at an intermediate level and one at a high level. Full and minimum service levels are currently supported in spring (April through June) when March 15 system storage exceeds 54.5 and 46.0 MAF, respectively, for alternatives with an 18-MAF permanent pool (see

Table 2.1-1). In summer and fall, full and minimum service levels are supported when July 1 storage exceeds 59.0 and 50.5 MAF, respectively. At the intermediate level, the limits are 56.3 and 50.2 MAF for spring and 60.2 and 55.0 MAF for summer and fall for alternatives with an 18-MAF permanent pool. At the highest level, the limits are 57.5 and 54.5 MAF for spring and 62.5 and 60.5 MAF for summer and fall for the alternatives with an 18-MAF permanent pool. These limits are somewhat higher when combined with higher permanent pools. These values are presented in the Daily Routing Model Studies Report (Corps, 1998b).

Three season length guide curves were also considered: the current, an intermediate, and a high guide curve. Currently, a full 8-month season is provided if the July 1 system storage level exceeds 41 MAF (Table 2.1-1). For alternatives with an 18-MAF permanent pool, a 5.5-month season is provided if July 1 storage is less than 25.0 MAF. Shortened (less than 8 months but more than 5.5 months) season lengths are provided for storage levels between 25 and 41 MAF. The new criteria being considered for alternatives with an 18-MAF permanent pool have limits of 51.5 and 42.0 MAF for the intermediate level and 60.0 and 52.0 MAF for the high level (Table 2.2-1). As with the service level guide curves, higher permanent pools require somewhat higher limits on navigation season length. The limits for the higher permanent pool alternatives are presented in the Daily Routing Model Studies Report (Corps, 1998b).

In 1999, a towing company owner asked the Corps to investigate the merits of changing the navigation criteria to eliminate minimum service (-6 kcfs) during drought years. The basis for this request was the negative impacts the navigation industry was facing with minimum service during future droughts. Under these criteria, the lowest service level normally would be set at 3 kcfs below full service. In exchange for this change, the navigation industry would accept an earlier shortened season length. Instead of using guide curves to gradually reduce service level and season length, as described above, the changes would occur at set storage levels (or "triggers"), one storage level for the March 15 check and a second for the July 1 check. Ultimately, the modeling led to using the top of the CWCP guide curves for service level 54.5 and 59 MAF, respectively, for the two storage level check dates. Season length for a specific alternative was found to vary, depending on the amount of water used in the drought. The objective of the modeling done for this set of criteria was to ensure that the combination of service level and season length included in the criteria met the prescribed minimum storage of about 43 MAF in the 1987 to 1993 drought. Minimum season lengths of 7 to almost 8 months were required to have the model runs meet the minimum storage criterion.

A third navigation service criterion was formulated to provide additional conservation to be combined with either set of the above navigation service criteria. In extreme drought years, basically those that fall in the lowest 10 percent of runoff above Sioux City, system storage gains do not occur during the normal snow pack runoff period prior to July 1. Thus, the system storage level on July 1 is at or below the March 15 storage level. This situation would trigger minimum navigation service of 6 kcfs below full service for the remainder of the navigation season (generally 7 to almost 8 months for the alternatives run to date) and the next navigation season from April 1 through August 31. This criterion was combined with the "trigger" criteria to eliminate storage level declines below 42.5 MAF (rounds off to 43 MAF) during the 1987 to 1993 drought.

In addition to the navigation season length, service level, and extreme drought criteria, a fourth navigation drought conservation criterion was included in all alternatives as an additional conservation criterion. A navigation "preclude" was included in the DRM simulation of every alternative. Navigation service would not be provided in years that the March 15 storage level was less than the specified storage volume. For example, this criterion equates to the 21.4-MAF value discussed for the CWCP earlier in this chapter. Navigation would be reinitiated when the March 15 storage in a subsequent year is greater than the preclude value.

Navigation Season Length (Normal Periods)

The navigation season during normal inflow periods is 8 months long, beginning on April 1 and ending on December 1 at the mouth of the river at St. Louis. Normal navigation seasons as short as 6 months were considered for the Draft EIS (DEIS), and such short navigation seasons continue to be considered. Several options for normal navigation

season length considered after the DEIS are to have a 7-month season with November being the nonnavigation month and to have a nearly 6-month season by suspending navigation service in late June through August. These options are included for consideration because they would provide benefits for fish and wildlife on the Lower River. Implementation of the options would be accomplished by changing the annual hydrograph on the Lower River to more closely mimic the hydrograph for the river before the construction of the Mainstem Reservoir System.

Missouri River Targets

The CWCP has four target locations for implementing the specified full and minimum service levels: Sioux City, Omaha, Nebraska City, and Kansas City. Releases at Gavins Point Dam in support of navigation are set to meet the target flow at all four locations. Eliminating the Sioux City and Omaha targets was considered, which could reduce the amount of stored water released to support navigation at the expense of navigation service near these locations.

Upon evaluation for the DEIS, no target location was eliminated because studies indicate that this alternative would save little water and cause a significant loss in navigation use value. Studies of eliminating the upstream two target locations indicated that navigation service would change little during a drought similar to the 1930 to 1941 drought. Only a small improvement in season length and service level would occur and not enough storage water would be saved to improve navigation at other locations. The loss of navigation use value at Sioux City and Omaha would greatly outweigh any improvements gained at Nebraska City or Kansas City (Corps, 1994b).

Mississippi River Targets

Adding Mississippi River targets for navigation was reconsidered once the DRM was being used for Mainstem Reservoir System modeling. There are, however, some concerns regarding the successful implementation of such alternatives. First, Mississippi targets may require releases in summer that would exceed limitations set to protect the threatened and endangered birds nesting on sandbars in the river below Fort Randall and Gavins Point Dams. Second, Mississippi release requirements would need to be known well in advance of the low-flow occurrence because it takes 11 days for a release from Gavins Point Dam to reach St. Louis. Unless the low-flow period was relatively long, the water may reach St. Louis well after the need occurs. Prior to the preparation of the DEIS, a monthly routing model (LRS Model) was used, and these concerns could not be adequately addressed to forecast the likelihood of a successful operation using a Mississippi River target. With the completion of the DRM, these problems are better addressed. Two target levels at St. Louis were considered: 66 kcfs (-1 foot on the gage) and 90 kcfs (+2 feet on the gage).

Service Level Changes for Fish and Wildlife During the Navigation Season

Currently, the service level in normal to high Mainstem Reservoir System inflow years is full service to navigation from April 1 to December 1 (December 10 for the higher inflow years). Higher service levels can be provided for various reasons; most commonly, higher levels are used to evacuate water from the flood control storage zones. For example, if the navigation service level is at full service (35 kcfs) and the flood storage evacuation requirements are 10 kcfs, the service level is 45 kcfs.

Higher spring service levels to emulate the natural spring rise in flows that benefit native river fish continue to be evaluated. Service level increases as high as 32 kcfs were initially evaluated for April, May, and June. Increases of 10, 20, and 30 kcfs for these months were evaluated in the DEIS; however, increases of 5 to 30 kcfs were considered in studies performed following the DEIS review and comment period. These service level increases were provided unless either the navigation service criteria dictate a reduction in service level or flood control constraints require a cutback in service. The flood control constraint target flow values increase by an amount equal to the spring service level increase, much like the target values increase during flood storage evacuation periods. Different periods were also considered. In addition to the April 1 through mid-June period included in some of the alternatives, increases from May 1 through mid-June and mid-May through mid-June were considered.

Decreased service levels during the remainder of the navigation season were included in the

alternatives with spring increases for two reasons. First, in many years there is only enough inflow of water into the Mainstem Reservoir System on an annual basis to provide the required water for an 8-month, full-service season. In these years, decreased flows are required on the Lower River to ensure that water would not be needed from the carryover multiple use zone to support navigation in a "normal" year. Second, native river fish benefit from this change because the higher flows followed by much lower flows cause the annual flow pattern for the Lower River to more closely mimic the natural hydrograph.

Reduced service levels were included in alternatives in a variety of ways. In some alternatives, the service level drops to full service to navigation (service level of 35 kcfs) in late June or July and then to minimum service to navigation (service level of 29 kcfs) for 1 or more months during the remainder of the season. In some alternatives, the drop was directly to minimum service in late June. Approximately 2 to 2.5 nonnavigation months were also included in some alternatives because flows lower than minimum service after the spring increase are beneficial to native river fish. Nonnavigation months included in the alternatives were August to September, October to November, and November alone. Following the review and comment period for the DEIS, mid-July through mid-August, late June through August, and August through November alone were included as nonnavigation months.

As discussed above, in some years excess water is stored in the Mainstem Reservoir System. This water requires evacuation through service levels increases. These increases, typically in the July through early December timeframe, coincide with the same period that lower service levels are of benefit to native river fish. To allow reduced summer service levels, evacuation in these months was restricted. This condition was included with alternatives considered for the DEIS in which August and September were nonnavigation months. Following the DEIS review and comment period, some of the alternatives include this restriction of evacuation in a portion or all of July through August whether minimum service navigation or no navigation service is provided.

To allow for the required service level increase from the March value to the higher April value, flow increases begin about 5 to 10 days before the specified increase is to be in the upper reach of the Lower River. Similarly, to allow for the decrease to the full navigation service level or lower, flow decreases begin prior to the time the increased flows are to be suspended.

Flood Control Criteria

Water Evacuation Regime

The current water evacuation scheme provides considerable flexibility and ensures that the flood control zones are evacuated appropriately to reduce flooding potential along the Lower River. Generally, water is evacuated in the summer and fall navigation season. Limited exceptions to this scheme are modeled as discussed above. Winter evacuation is minimal because of ice-induced flood problems on the river. Alternatives with higher spring service levels reduce the need for summer and fall flood zone evacuation. Conversely, alternatives with low summer service levels increase the need for fall and sometimes spring flood zone evacuation.

Limitations of Navigation During Flooding

The CWCP provides for a cutback in navigation service level whenever flows become high in the Lower River from Omaha to Kansas City. Depending on the extent of downstream flooding, Gavins Point Dam releases are currently reduced to provide full or minimum service at the navigation target location and also to ensure that Mainstem Reservoir System releases contribute minimally to downstream flooding. In extreme cases, such as in the 1993 flood when the extent of flooding precluded any navigation, Gavins Point Dam releases are cut back severely and no navigation service is provided.

Two additional flood control criteria were evaluated in the DEIS for water control plans with high spring service levels: (1) maintaining at least the minimum navigation service level (29 kcfs); and (2) maintaining the higher service levels despite the severity of downstream flooding. These criteria would ensure that spring flows remain higher in the Lower River for the benefit of fish and wildlife while increasing the potential for downstream flooding. None of the alternatives developed since the DEIS have these flood control criteria as plan components.

Nonnavigation Service Level

In drought periods, navigation service is not always supported by releases of system storage water. When it is not supported, a minimum service release at Gavins Point Dam is specified to protect other beneficial uses, particularly water supply. Nonnavigation service levels (based on target flows at Sioux City, Omaha, and Kansas City in the spring through fall months and at Gavins Point Dam in the winter months) ranging from 6 to 25 kcfs were considered in the Study. Levels below 9 kcfs were dropped from further consideration because such low flows do not provide adequate stages for water supply intakes along the Lower River below Gavins Point Dam. For the DEIS, service levels in the range from 9 to 25 kcfs were evaluated for the spring, summer, and fall seasons. In winter, a range of 9 to 18 kcfs was evaluated. Winter service levels above 18 kcfs were dropped from consideration because they would exceed the winter releases in normal and wet periods. In combination with river icing, higher levels also contribute to potential flooding problems. Spring through fall service levels (as high as 25 kcfs) were considered because the extra flow helps to reduce the effects of thermal loading on the river by once-through cooling powerplants located along the river. Subsequent to the DEIS, the winter services levels are limited to 12 kcfs, the spring/fall service levels to 9 kcfs, and the summer service levels to 18 kcfs.

Intrasystem Regulation

The current method of intrasystem regulation of stored water (described earlier under Intrasystem Regulation of Water) provides for an annual balanced regulation of storage among the upper three lakes. Although storage among these lakes is unbalanced seasonally, an effort is made to follow a consistent pattern for the balance of stored water among the lakes on an annual basis. An alternative to this scheme was developed that unbalances annual storage on a scheduled basis among the three lakes to provide more optimal conditions for fish production in the lakes. This modified regulation has little or no effect on river flow or storage levels below Oahe Dam.

The modified regulation scheme occurs over a 3-year cycle. This cycle includes a lower lake level than normal the first year, higher lake levels than normal the second year, and declining lake levels (a "float" year) the third year. For modeling purposes, Fort Peck Lake is low in the first year of the period of analysis, while Lake Sakakawea floats and Lake Oahe is high; this is followed by Lake Sakakawea being low in the second year, while Fort Peck Lake is high and Lake Oahe floats. In the third year, Fort Peck Lake floats, while Lake Sakakawea is high and Lake Oahe is low. This cycle continues through the period of analysis, which is 1898 through 1997.

Associated with the changing lake levels is a change in river flows from those under the current balanced operation. The lake level fluctuations cause greater year-to-year fluctuations in river releases between the lakes than occur under the current balanced regulation. The overall modified intrasystem regulation routine is now based on prescribed lake level changes, whereas it was based on a prescribed sequence of river flow changes for the DEIS. Because the flow-based modification resulted in severe lake level changes in many years (variation in the natural inflows to each lake was also a primary factor), a decision was made to base the regulation among the upper three lakes on lake level changes. The goal is to have the lake levels in the low year be at least 3 feet lower than normal. This mode of modified intrasystem regulation moderates the change in river flows from year to year as well.

Fort Peck Flow Modification

Unbalancing the system, as prescribed above, results in higher spring flows out of each of the two most upstream lakes, Fort Peck Lake behind Fort Peck Dam and Lake Sakakawea behind Garrison Dam. Various fish and wildlife interest groups have requested that a "spring rise" be made out of Fort Peck Dam to better mimic what may have occurred historically in the 204-mile downstream reach. In its Missouri River Biological Opinion (U.S. Fish and Wildlife Service, 2000), released on November 30, 2000, the U.S. Fish and Wildlife Service included a springtime flow modification for the Fort Peck releases. This is one component of its Reasonable and Prudent Alternative to ensure that three listed species, the endangered pallid sturgeon, the endangered least tern, and the threatened piping plover, would not be jeopardized.

The prescribed flow modification would have a peak discharge of 20 to 25 kcfs (approximately 19 kcfs from the spillway and 4 kcfs from the powerhouse), which was modeled for some of the alternatives developed after the DEIS as a 23 kcfs release. This release would be made for a minimum

of 3 weeks plus an appropriate ramp up and ramp down period, and it would be made sometime from mid-May through the end of June (modeled as a 30-day total rise beginning in mid-May and ending in mid-June). There are two reasons for splitting the release between the powerhouse and the spillway. First, the total release of 23 kcfs exceeds the powerhouse capacity of about 14.5 kcfs. Second, one objective of the release is to provide a flow with a temperature of 64.4 degrees Fahrenheit (18 degrees Centigrade) at Frazer Rapids, which is about 25 miles downstream from the powerhouse. All of the alternatives modeled with a "Fort Peck spring rise" had the 23-kcfs release occurring in the years in which Fort Peck was to go from the high year in the modified regulation mode of operation to the float year. Because the modified regulation was discontinued in an extended drought, the rise would not occur every third year as part of the modified regulation. It also occurred periodically as extremely high runoff into Fort Peck was moved on down to Lake Sakakawea and, subsequently, further downstream. Overall, the objective was to have a rise in about one-third of the years.

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