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STEVENS CREEK BASIN TRUNK SEWER

**TECHNICAL MEMORANDUM NO. 4
PRELIMINARY ALTERNATIVE ALIGNMENTS**

FINAL

November 2004



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1.0 INTRODUCTION

1.1 Purpose

The purpose of this Technical Memorandum is to present several alternative alignments for the Stevens Creek Basin Trunk Sewer. Based on the information presented herein, as well as other factors, the City will select the preferred preliminary alignment for the trunk sewer.

The alignments shown in this document are a compilation of several months of work that included personnel from the City (Planning, Engineering, Real Estate, Roads, Wastewater, and other Departments), Lower Platte South Natural Resourced District (LPSNRD), Lincoln Electric Service (LES), Carollo Engineers, E&A Consulting Group, Geotechnical Services Inc (GSI), and others. It should be noted that the alternative alignments shown are the result of a preliminary screening process that consisted of several field trips, working sessions with City staff, and public meetings to arrive at the alternatives that are evaluated as part of this work effort.

1.2 Utility Planning Zones

The City of Lincoln has developed utility planning zones. These zones are further separated into Tiers relating to the planning time frame when the need for sewage interceptors are anticipated to be needed as described in the *Wastewater Facilities Plan, Update*, October 2002. Tier I areas are defined as needing sewage interceptor service within the next 25 years, Tier II areas are defined as needing sewage interceptor service between 25 and 50 years, and Tier III areas are identified as needing sewage service 50 years or more into the future as discussed in Technical Memorandum No. 3. A summary of these Tiers and the subbasins located within them is as follows:

- Tier I includes subbasins E-1, E-2, E-3, E-11 and E-12.
- Tier II includes subbasins E-4, E-5, and E-6.
- Tier III includes subbasins E-7, E-8, E-9, and E-10.

1.3 Phases

For the purpose of this evaluation, the alternative alignments will be divided into phases. Each phase will begin and end at a junction structure. The junction structures will essentially serve as “fixed points” between which the alternative alignments will be routed. The actual location of the junction structures will be finalized during final design based on input from City staff and other factors that may be identified as the project develops.

As identified in Technical Memorandum No. 3, the west side of the Stevens Creek Basin Trunk Sewer has been divided into the following preliminary phases. The actual phasing of the construction may vary from that shown here as determined by the City as the project proceeds.

Tier I Areas (West Side of Stevens Creek):

- Phase I - NE WWTP (Existing Junction Manhole No. 1) to Fletcher Avenue (Junction Structure E-6).
- Phase II - Fletcher Avenue (Junction Structure E-6) to Murdock Trail (Junction Structure E-1) which is located approximately half way between Havelock Avenue and Adams Street.
- Phase III - Murdock Trail (Junction Structure E-1) to Holdrege Avenue (Junction Structure E-2).
- Phase IV - Holdrege Avenue (Junction Structure E-2) to near 98th and "O" Street. (Subbasin trunk sewer that will serve Subbasin E-2).
- Phase V - Holdrege Avenue (Junction Structure E-2) to just north of "A" Street (Junction Structure E-3A).
- Phase VI - "A" Street (Junction Structure E-3A) to Van Dorn Street (Junction Structure E-4).

Tier II Areas (West Side of Stevens Creek):

- Phase VII - Van Dorn Street (Junction Structure E-4) to Pioneers Blvd (Junction Structure E-5G).
- Phase VIII - Pioneers Blvd. (Junction Structure E-5G) to Pine Lake Road (Junction Structure E-5D).
- Phase IX - Pine Lake Road (Junction Structure E-5D) to Yankee Hill Road (Junction Structure E-5A).

Tier II Area (East Side of Stevens Creek):

- Subbasin E-6 is the farthest north subbasin located on the east side of the Stevens Creek which is also identified as being a Tier II Zone.

1.4 Pipe Size

Analysis of the alternative alignments will be based on the pipe sizes identified in Model Run No. 2, as previously described in Technical Memorandum 3 and as outlined in the following table. The actual pipe size may change as needed during the preliminary and final design phases based on decisions made by the City, and other factors that may become available.

Table 1 Preliminary Trunk Sewer Size and Phasing Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Phase	Description	Pipe Size
I	NE WWTP To Fletcher	72" Ø
II	Fletcher to Murdock Trail	66" Ø
III	Murdock Trail ⁽³⁾ To Holdrege	54" Ø
IV	Holdrege To "O" Street ⁽⁴⁾	24" Ø
V	Holdrege Avenue to just north of "A" Street .	54" Ø
VI	"A" Street to Van Dorn Street	48" Ø
VII	Van Dorn Street to Pioneers Blvd.	36" Ø
VIII	Pioneers Blvd to Pine Lake Road	36 and 30" Ø
IX	Pine Lake Road to Yankee Hill Road	30, 24, and 18" Ø

1.5 Level of Mapping Detail

The pipe lengths and associated construction quantities used in this evaluation are based on the City's aerial mapping and two-foot contours. The actual length of piping runs and construction quantities will be refined after the actual alignment is selected by the City and a more detailed survey has been performed.

1.6 Location of Manholes and Junction Structures

It is the design intent that flows from the subbasins be introduced into the trunk sewer at junction structures and manholes that incorporate connection points. Modifying the trunk sewer in the future by installing new connections is discouraged. This methodology will minimize the smaller service connections, particularly in the northern reaches of the sewer. The benefits to this design and operational philosophy is to maintain the structural integrity and water tightness of the original installation. It also minimizes the maintenance issues associated with allowing small collector sewers direct access to trunk sewers.

The attached drawings show approximate location of manholes and junction structures. These locations are for estimating and modeling purposes only. It is strongly recommended that during the design phase(s) of the project(s) that the actual location of junction structures and manholes be jointly located with the City staff including Sewer Maintenance. In addition to the location of manholes and structures City staff should be involved with the location and stubouts provided in the trunk sewer manholes to allow connections from future developments without the need to cut into the trunk sewer or its engineered manholes.

1.7 Probable Opinion of Estimated Project Costs

Preliminary probable opinions of estimated project costs have been generated and are to be used for comparative purposes in evaluating the different alternatives. The preliminary cost estimates developed as part of this alternative analysis represent an order of magnitude cost estimate. An order of magnitude estimate is considered a reconnaissance level estimate. Order of magnitude costs may be estimated using cost-capacity curves,

scaling factors, ratios, as well as information from other projects. An order of magnitude cost would be expected to have an associated accuracy of + 50 to - 30 percent. All of the cost estimates presented are based on the first quarter of the year 2004 values. The estimated costs are to be evaluated as an approximate because they are developed without detailed engineering data. The preliminary cost estimates in this technical memo may differ from those presented in Technical Memorandum No. 3. This can be attributed to variances in length and associated pipe size of the alignment variations, as well as increase/decrease in the number of manholes and other factors. The basin trunk sewer preliminary cost estimate in Technical Memorandum No. 3 was based upon a single alignment between junction structures that ran parallel to Stevens Creek. The preliminary cost estimates presented herein were evaluated for various trunk sewer alignments and junction structure locations. The preliminary costs for special construction, such as boring, tunneling, utilities crossings, and deeper than normal trenching, are also included in the projected construction costs shown in this technical memorandum.

The Probable Opinion of the Estimated Project Costs for the alternatives presented incorporate the following allowances:

- Twenty (20) percent estimating contingency.
- Ten (10) percent for engineering and administrative fees.
- Eight (8) percent for general conditions.
- Right of way and Easements have been included.
- Roads and stream crossings were assumed to be constructed using tunneling methods.

2.0 EVALUATION CRITERIA

2.1 Criteria Input

The evaluation criteria presented herein has been compiled with input from many parties including but not limited to:

- City of Lincoln Wastewater Department.
- City of Lincoln Engineering Department.
- City of Lincoln Planning Department.
- Lower Platte South Natural Resources District.
- Input from the community through a series of public participation meetings.
- Others.

2.2 Selected Evaluation Criteria

The following evaluation criteria has been derived with input from those parties previously mentioned. This criteria will be used in the screening process to select the preferred preliminary alignment.

Ease of Construction - Items such as topographic features, hills, and stream crossings are considered in this category. Open areas that avoid these more difficult construction areas are ranked higher than those that do not.

Accessibility for Maintenance - Accessibility to critical locations such as junction structures, siphons structures, metering manholes and other locations is very important. These locations require Sewer Maintenance and Operating staff to access the trunk sewer for cleaning and inspection. Sewer cleaning equipment is very large and is generally mounted on trucks. Locating these special structures near roads or other areas that allow vehicular access, during all weather conditions is very important. The preliminary location of the junction structures has been located such that access will be similar for all of the alternatives evaluated. Therefore, accessibility for maintenance will not be discussed separately for each phase.

Conflicts with Existing Utilities - To date, over 20 different utilities and governmental agencies have been contacted and informed of this project. Maps showing the alternative alignments were distributed to these utilities and agencies. As of this time not all utilities and agencies have responded to our request for utility location along the affected areas. However, the major utilities including electrical transmission lines, major water distribution lines, fiber optic cable, and high pressure gas transmission lines have been preliminarily identified.

Environmental Factors - Emphasis was placed on minimizing the removal of remnant native vegetation and habitat along the pipeline route and within the riparian setback. The team has strived to locate the alignments in such a manner to avoid areas that have been identified as having environmental significance. If these areas are crossed it is recommended that the final design addresses methods to minimize the impacts of the project. These areas include:

- Wetlands.
- Declared parks.
- Areas of remnant vegetation.
- Areas of botanical and zoological significance.
- Riparian setbacks.
- Grasslands.

Stream Geomorphology - The effects that the project has on the bank stability of the stream and its tributaries is included in the evaluation. The information to evaluate these concerns has been provided to us by the City's Watershed Study Team that is currently performing a watershed master plan. During Final Design stream geomorphology including bioremediation, bank stability, pipe protection, and other stream stability issues should be addressed.

Impact on Potential Development - This factor relates to future land planning and zoning, and what effect the location of the trunk sewer will have on future development. For example an alignment located in the floodway, where development will not be allowed is more desirable than an alignment located in prime developable land.

Traffic Disruption/Inconvenience to Public - Alignments that minimize construction inconvenience are more desirable than those alignments that will cause additional traffic disruption and inconvenience to the public. For this study it has been assumed that all street crossings will be accomplished using trenchless technologies. During Final Design the actual crossing details should be determined jointly with City staff and the road, street or highway owner.

Right - of - Way Acquisition - The cost of right of way acquisition has been included in the estimated project costs. In addition to right of way costs, as part of the evaluation, the alternative alignments have been selected to minimize passing through existing farm buildings, residential acreages, commercial development and similar areas. Where possible, the alignments were located in the floodway and floodplain. Disrupting existing residential, commercial, and industrial improvements was avoided to the greatest extent possible. Due to the inclusion of Right-of Way costs in the cost estimate it will not be addressed separately for each phase.

Geotechnical Factors - The alignment all has the similar geotechnical features as discussed below. Due to this similarity in geotechnical features throughout the alignment, geotechnical issues will not be discussed in each of the following alternative analysis since they all possess the same features as briefly discussed below. The alignments lie in the loess mantled, glaciated region of Nebraska. A generalized subsurface profile for this region consists of wind deposited soils (Peoria and Loveland age Loess deposits) overlying Kansas Age Glacial deposits which in turn overly bedrock formations. Erosion of the loess mantle has created the surface topography common to this area of Nebraska. This erosion of the surface soils has created alluvial (water transported) deposits at the lowest elevations of the stream channels and colluvial (gravity transported) deposits along the edges of the stream channels. Typically the alluvial soils are very recent deposits with very little strength that develops over time due to consolidation and surcharging. Bedrock in the area of this phase is generally Dakota Sandstone or Shale. These Dakota formations would be expected at a depth of 50 feet or greater and most likely closest to the surface near stream channels.

Estimated Overall Project Costs - As discussed above these costs are considered order of magnitude costs. Alignments that are direct from point to point, cross open areas and avoid

construction difficulties such as hills, streams, railroads, and other obstacles will have the lower costs associated with them.

3.0 PHASE I - ALTERNATIVE ALIGNMENTS

3.1 Phase I Alternative Alignments

The Phase I alignment begins at the existing Junction Manhole No. 1 located upstream from the NE WWTP Raw Wastewater Pumping Station. This manhole is designed to accept flows from two 60-inch diameter sewers. Currently the 60-inch diameter Dead Mans Trunk Sewer enters the manhole from the southwest. A 60-inch stubout for future connection is located to the southeast. The flow leaves Junction Manhole No. 1 through a 60-inch sewer to the north where it conveys the flows to the Raw Wastewater Pumping Station.

The trunk sewer will begin at the southeast stubout from Junction Manhole No. 1 and continue generally east to Junction Structure E-12. This Junction Structure will perform two primary functions. The first is to accept flows from the 72 or 84-inch Stevens Creek Basin Trunk Sewer and the 24-inch Subbasin E-12 sewer and direct it west through a 60-inch diameter sewer to existing Junction Manhole No. 1. The second function will occur in the future where it will direct the flows north to the new Headworks. Both the 24-inch stubout to the south and the stubout to the north will be plugged for future connections. The actual location of Junction Structure E-12 will be finalized during the design phase.

Junction Structure E-11 is a separate structure for alignments 1A and 1C. For alignment 1B it is combined with Junction Structure E-6. Regardless the flows from Subbasin E-11 will enter the Junction Structure through a 30-inch diameter sewer.

This alignment will end near at Junction Structure E-6. At this structure, flows from Subbasins E-6 (lower east side) enters the Junction Structure through a 36-inch diameter sewer. To the south a 66-inch diameter stubout will be provided for the beginning of the Phase II portion of the project. All three of the stubouts will be plugged for future use.

The exact location for Junction Structure E-6/E-11 will be finalized during the final design process.

Three alternative alignments have been identified for this phase of the trunk sewer as shown in Drawing C-001. The results of the analysis for these alignments is summarized below.

3.2 Alternative Evaluation

Construction Issues - Generally, all of the alignments are located in open agricultural areas with no hills or other construction obstacles. South of Highway 6, Alignments 1A and 1C will require an additional boring to get under 84th Street. Of the three alignment 1B is slightly favored since it requires one less boring.

Conflicts with Existing Utilities - All three of the alignments must cross the BNSF railroad, US Highway 6, existing 36 waterline located on the north side of Highway 6, and a 48-inch diameter waterline located on the south side of Highway 6. To determine the location of the waterlines the City located the waterlines at each alternative alignment crossing location. This exercise revealed that the Alignments 1A and 1B will conflict with the existing 36 and 48-inch waterlines. To avoid the waterlines the Trunk sewer would need to be constructed as a siphon or depressed sewer at these locations. This not only adds cost to the project, but it is undesirable from an operations point of view. Alignment 1C is the preferred alignment as it passes under these waterlines, and other conflicts along the Highway 6 corridor without the need for a siphon. Regardless, the trunk sewer will be constructed in a trenchless manner under the Highway 6 corridor to avoid disruption to the BNSF and Highway 6 traffic.

Alignment 1B on the north side of Highway 6 crosses under LES 115 kv overhead power lines which will require special attention.

Alignment 1B south of Highway 6 passes behind existing businesses and substation. In this area there are several overhead power lines. In addition, there is a septic tank leach field behind the businesses on the corner of 84th Street and Highway 6 that will require special attention. As this alignment passes under Fletcher Avenue it interferes with an existing 54-inch waterline that was located by the City.

South of Highway 6, Alignment 1A and 1C pass under an existing 16-inch waterline located on the north side of Fletcher Avenue. On the south side of Fletcher Avenue the two alignments turn east and share the same alignment as they pass under 84th Street. Located on the east side of 84th Street is are LES 125 kv overhead power lines. In addition a 48-inch waterline is located in the middle of the 84th street. Based on recent utility search the trunk sewer can pass under the 48-inch waterline in this area without the need for a siphon. The installation of the trunk sewer under the 84th Street corridor will be by trenchless construction, avoiding disrupting traffic on 84th street, the overhead power, and the 48-inch waterline.

Of the three alignments, Alignment 1C is favored due to the lower potential for existing utility conflicts which ultimately will result in lower construction costs.

Environmental Factors - The alignments do not cross any identified environmentally sensitive areas during this phase. Additionally, they are located out of the riparian corridor along Stevens Creek.

Stream Geomorphology - In this reach, the proposed alignments do not cross the main creek. However, north of Highway 6 they do cross a small and an incised drainage channel. The banks of this small drainage channel are fairly stable. Construction of the pipe in this area will require bank stabilization and pipe protection.

Recent construction activities at Fletcher Avenue have severely degraded the main channel, with bare soil banks and a recently graded trapezoidal shape. Approximately, 20

feet downstream from the bridge at Fletcher Avenue, the channel is vegetated with grasses and other herbaceous vegetation. Between Fletcher and Highway 6, the channel appears meta-stable and more closely resembles a “natural channel” shape, with a wooded riparian corridor along both sides, albeit narrow and confined between cornfields. The channel bed is primarily gravel, overlaid with freshly deposited silt and sediment. Stream banks stand 4 feet from the channel bed, angled between 45 and 70 degrees, before meeting the first break in slope at an abandoned terrace. Steeper banks, near 70 degrees, are concave and scoured. Even these scoured banks appear stable, and show no signs of past mass failure. This is due, in part, to a relatively healthy riparian corridor that widens approaching the confluence with a smaller tributary, near Highway 6. Canopy cover is 100 percent, provided by cottonwoods and an understory of medium-sized mulberry trees.

Downstream of the double box culvert under Highway 6, the wooded corridor disappears, with a complete lack of woody vegetation. The channel bed is mainly unconsolidated silt.

Shown in Figure C-001, there is one location north of Highway 6 where a future channel meander adjustment in Stevens Creek could threaten the proposed pipeline. This active channel process can be mitigated using proven bio-engineering methods.

Impact on Potential Development - On the north side of Highway 6 all of the alignments are located at a safe distance from the creek while trying to minimize impacts to the development potential of the land. On the south side of Highway 6, the alignments for the most part are located in the floodway. All three of the alignments are located on the west side of Stevens Creek in a Tier 1 development area.

Traffic Disruption/Inconvenience to Public - Each of the alignments must cross the Highway 6 corridor with its associated utilities. This crossing will be installed using tunneling techniques. Alignments 1A and 1C include an additional tunneled crossings and are located nearer to existing roads which may increase the construction related inconvenience to the public.

Estimated Overall Project Costs - The probable opinions of estimated project costs have been prepared for each of these alternatives as shown in Table 2 below.

Table 2 Phase I Alignment Alternatives - Estimated Project Costs Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Alignment Alternative	Approximate Pipe Length (linear feet)	Total Projected Project Cost
Alignment 1A	6,000	\$9,039,000
Alignment 1B	5,900	\$8,937,000
Alignment 1C	6,000	\$7,739,000

3.3 Preferred Alignment

Alternative 1C is the preferred alignment. This alignment is not only the least costly but is favored primarily due to having fewer conflicts with existing utilities which will allow the Stevens Creek Trunk Sewer to be constructed in this Phase without a siphon.

4.0 PHASE II - ALTERNATIVE ALIGNMENTS

4.1 Phase II Alternative Alignments

The Phase II alignment starts immediately south of Fletcher Avenue at the 66-inch stubout which marked the end of Phase I. Three alternative alignments have been identified for this phase of the trunk sewer as shown in Drawings C-001 and C-002. All three alignments share the same location for southerly reaches. The primary differences are that Alignments 2A and 2B parallel the existing roadways while alignment 2C is located in the floodway paralleling the creek.

Immediately south of Fletcher Avenue Alignments 2A and 2B proceed west to 84th Street. At 84th street alignment 2A proceeds south on the west side of 84th street while alignment 2B proceeds south along the east side of 84th Street. At Havelock Avenue the two alignments proceed easterly to Stevens Creek where they merge with Alignment 2C. Meanwhile alignment 2C proceeds southeasterly from Junction Structure E-6/E11 generally following Stevens Creek. Near Havelock Avenue the three alignments share the same route and generally parallel Stevens Creek to just south of the Murdock Trail where they end at Junction Structure E-1. Locating the Junction Structure adjacent to the Murdock Trail was adopted to allow City Maintenance Crews access to the structure using the trail.

Junction Structure E-1 will have three stubouts for future connections. To the southeast will be a 54-inch stub and plug for Phase III connection of the Stevens Creek Trunk Sewer. Located to the south will be a 24-inch stub and plug for the future Subbasin E-1 connection. Also at this structure will be a 15-inch stub for the connection of the Regent Heights Sewer. It should be noted that the actual location of the Regent Heights Sewer connection to the Trunk Sewer and the physical location of the Junction Structure will be finalized during the final design phase.

4.2 Alternative Evaluation

Construction Issues - Of the three alignments, 2C provides the least construction difficulty as it traverses open ground for the most part. Alignments 2A and 2B not only parallel existing busy roads, but have increased excavation difficulties at the hill near the intersection of 84th Street and Havelock Avenue. In addition, alignment 2B parallels two major LES overhead power transmission lines which will require additional construction monitoring by both LES and the City. Alignment 2A although not adjacent to the LES easement will need to cross under these power lines at two different locations. All three alternatives will need to across the deep drainage ditch that sits approximately 300 feet south of Havelock Avenue.

Conflicts with Existing Utilities - Alignments 2A tunnels beneath 84th Street on two occasions, as well as a 115 KV and 35 KV power line. This will require special construction and coordination with LES.

Alignment 2B runs parallel to a 115 KV and 35 kV power lines which is of concern and will increase the construction costs. Additionally, alignment 2B also crosses a 7200 V power line near the corner of Havelock and 84th Street.

Environmental Factors - The alignments do not cross any identified environmentally sensitive areas through this phase. Additionally, they are located out of the riparian corridor along Stevens Creek.

Stream Geomorphology - The proposed alignments do not cross the main creek in this reach. Two processes are occurring along Stevens Creek in this reach. The channel has incised and is now widening with widespread bank slope instability and erosion, and the failure plane at the base of the slope failures appears to be between the loess and underlying glacial till. This failure mechanism is enhanced by seepage along this contact and lack of large woody vegetation to reinforce and dewater the soil mass. There is some local scour in the meanders and local slope failures. The critical bank height appears to be less than 12 feet at an angle of 60 degrees from the horizontal.

Between Murdock Trail and Havelock, wedge and circular bank failures are common along both banks. The failure surface appears to be the contact between the glacial till clay and overlying silty clay loess. Seepage from the banks often appeared at this interface. Residual bank failures are typical, and in some locations two to four steep failure scarps are not uncommon. Scarps and scour lines vary between 4 and 8 feet from the existing water surface.

The channel bed is roughly 10 feet wide and the banks are steep, with angles commonly exceeding 60 degrees and some standing near vertical. Bed materials range from consolidated clayey silt, gravel, and cobbles near the Murdock Trail, to unconsolidated silt approaching Havelock. Bank heights average 12 to 14 feet, and bank scouring and failures tend to alternate from one side of the channel to the other. A series of gravel and cobble riffles begins upstream from the Murdock Trail bridge. The cobbles are weathered riprap, introduced in the stream from previous bridge armoring. The riprap armoring has induced bank scouring along the right descending bank immediately upstream from the bridge and along the left descending bank nearly 100 feet downstream from the bridge.

Channel bars occur throughout this reach. The bars are geotechnical in origin and develop when failed bank material is scoured by the flows at the bed-bank interface leaving a vegetated center bar. Debris jams are also common throughout the reach and range from small debris accumulations to jams filling the entire channel. The bank height ranges from 12 to over 20 feet with the bank slopes ranging from 45 to 70 degrees. The riparian corridor is narrow, often only a tree wide. The bank vegetation is often limited to grasses and forbs.

The average scour height in the creek is about 12 feet. This translates to a horizontal failure distance of about 24 feet assuming a 2H:1V slope. The proposed alignments are located for the most part at a distance greater than 100 feet. This is adequate distance to avoid potential future landslip and erosion of the creek bank.

Impact on Potential Development - Alignments 2A and 2B are located for the most part out of the floodway which may impact the future use of the land. In addition Alignment 2A parallels 84th Street and Havelock Avenue past established setbacks which may impact future use of the property. Alignment 2B is located parallel to 84th Street next to an existing LES power easement well past established setbacks which will impact the development potential of the land. Alignment 2C is located entirely in the floodway and does not parallel any existing or proposed roads. All three alignments are located on the west side of Stevens Creek in Tier I development areas.

Traffic Disruption/Inconvenience to Public - Alignments 2A and 2B both parallel existing roads and require additional tunneling to cross under existing roads and utilities. This activity increase the potential for traffic disruption and inconvenience to the public.

Alignment 2C is located in open areas away from existing roads and utilities. This alignment provides the least inconvenience to the public.

Probable Opinion of Estimated Costs - Probable opinions of estimated project costs have been prepared for each of these alternatives as shown in Table 3 below.

Table 3 Phase II Alignment Alternatives - Estimated Project Costs Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Alignment Alternative	Approximate Pipe Length (linear feet)	Total Projected Project Cost (millions)
Alignment 2A	10,800	\$11,089,000
Alignment 2B	10,250	\$10,121,000
Alignment 2C	8,050	\$7,858,000

4.3 Preferred Alignment

Based on the above analysis Alternative 2C is the preferred alignment. This alignment is not only the least costly but is more favorable regarding the least impact Traffic Disruption, Inconvenience to the public, fewer conflicts with utilities and the least impact on future development.

5.0 PHASE III - ALTERNATIVE ALIGNMENTS

5.1 Phase III - Alternative Alignments

The Phase III alignment starts at the 54-inch stubout just upstream of Junction Structure E-1 and proceeds southeasterly to Junction Structure E-2 located near Holdrege Avenue. At Junction Structure E-2, flow from Subbasin E-2 will enter the trunk sewer through a 24-inch diameter pipe (Phase IV) for which a stubout will be provided until future use. A 54-inch diameter stubout will be provided to the south of Junction Structure E-2 as a starting point for Phase V (continuation of the Trunk Sewer to the south).

Two alternative alignments have been evaluated for Phase III as shown on Drawings C-002 and C-003. Alignment 3A crosses to the east side of Stevens Creek near Murdock Trail just upstream from Junction Structure E-1. Once on the east side of the Creek the alignment generally follows the creek southeasterly until a point where it changes direction and goes south. At this location the alignment crosses the creek for a second time where it runs with Alignment 3B. At this point the two alignments parallel a wooded area until terminating at Junction Structure E-2.

5.2 Alternative Evaluation

Construction Issues - One of the main reason for crossing to the east side of Stevens Creek is to avoid a very steep and hilly area that is located adjacent to the west bank of the creek. As shown in Drawings C-002 and C-003, Alignment 3A crosses Stevens Creek twice which will present construction issues that will need to be considered. For the purpose of this analysis it was assumed that these crossing will be constructed using trenchless methods. The actual method will need to be determined after the field survey during final design. Close coordination will be required during the design and construction phases with the City and LPSNRD staff. Alignment 3B is located very near the banks of Stevens Creek to avoid the construction issues associated with locating the trunk sewer under the large hill. This will present construction issues relating to slope stability, extremely deep trenching, and stream degradation issues may will present themselves.

Conflicts with Existing Utilities - The biggest concern with this Phase is avoiding the future 98th Street improvements. At the time of this study several alternatives roadway alignments have been developed as shown on Drawings C-002 and C-003. Based on the information available at this time alignment both of the alignments shown avoid the future 98th Street improvements. This issue will need to be closely monitored and coordination will be required as the projects continue.

Both of the alternative alignments will require tunneling to cross Adams Street. This tunnel will also allow the alignment to pass under a 12 KV power line that parallels Adams Street.

Another crossing of a 115KV overhead power line will be required for both alternatives. This power line is located approximately half way between Adams Street and Holdrege Street.

Environmental Factors - Located primarily on the south side of Adams Street between 120th Street and Stevens Creek is an area of significant environmental and cultural value. Both of the alignments evaluated are located to avoid these areas. Alignment 3B crosses through an area that is listed on the National Wetlands Inventory. Construction through this area will require close coordination with interested parties and special permitting may be required. Additionally remediation requirements may be required as part of the construction process. Furthermore, areas of alignment 3B are located very near or encroaching the riparian corridor of Stevens Creek south of Adams Street.

At the southerly end of this reach both alignments cross an area that is identified as being on the National Wetlands Inventory. Construction through this area will require close coordination with interested parties and special permitting may be required. Additionally remediation requirements may be required as part of the construction process.

Stream Geomorphology - Along this reach there are several knickpoints and knick zones between Adams and Murdock Trail. In this area, the channel bed alternates between a scoured bottom and several feet of unconsolidated sediment. Some scouring is observed in this reach. Pool and riffle sequence is not well developed throughout this reach. The riparian corridor is narrow, often only a single tree wide.

Between Holdrege and Adams, the creek meanders, characterized by alternating wedge failures along the banks and a silty channel bed with recurring woody debris jams. Much of the reach can be classified as incising or recently incised and now widening. The debris jams encountered along this reach act as *de facto* grade controls, slowing or halting the upstream advance of headcuts. Based on aerial photograph interpretation, the average sinuosity of this reach is approximately 1.4.

As shown in Figures C-002 and C-003, there are two locations where Alignment 3A crosses under Stevens Creek. It is envisioned that these crossings will be constructed using trenchless methods. The information provided from the watershed study did not indicate that crossing areas posed no threat. Therefore, no special restoration efforts are planned at this time. During final design this assumption should be confirmed.

Where alignment 3A crosses Tributary 20, the stream is incised and this could lead to future bank failure. To minimize any impacts that this will have on the trunk sewer the pipe should be protected and the tributary restored using bio-engineering or other approved engineered solutions. During final design this issue should be confirmed.

Impact on Potential Development - A segment of Alignment 3A is located on the east side of Stevens Creek in a Tier III area. Although the alignment is located on the east side of the creek provisions are not being provided for east side connections as part of this project. This alignment is located entirely in the floodway which will minimize the impact on future development. This alignment may have an impact on costs of developing the west side of the creek. These costs, if any are associated with providing additional sewer to convey the wastewater to a junction structure.

Alignment 3B is entirely located on the west side of Stevens Creek in a Tier I area. Portions of this alignment are located outside of the both the floodway and floodplain due to very hilly terrain.

Traffic Disruption/Inconvenience to Public - Both of the alignments will have to cross under Adams Street. Other than that crossing neither of the two alignments should pose any other traffic disruption of inconvenience to the public.

Probable Opinion of Estimated Costs - Probable opinions of estimated project costs have been prepared for each of these alternatives as shown in Table 4 below.

Table 4 Phase III Alignment Alternatives - Estimated Project Costs Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Alignment Alternative	Approximate Pipe Length (linear feet)	Total Projected Project Cost
Alignment 3A	10,800	\$8,445,000
Alignment 3B	10,500	\$8,711,000

5.3 Preferred Alignment

Alignments 3A provides the least impact on future development since it is located entirely within the floodway. Additionally, due to the geographic features on the west side of Stevens Creek, Alignment 3A is anticipated to be less expense to construct. Finally, from an environmental and geomorphology view Alignment 3A is preferred.

6.0 PHASE IV – ALTERNATIVE ALIGNMENTS

6.1 Phase IV Alignments

There is only one subbasin sewer included within the Scope of Work for this project which serves Subbasin E-2. The two alignments for this subbasin sewer start at the 24-inch stubout provided at Junction Structure E-2 and runs southwesterly through the middle of the subbasin as generally shown in the Drawings C-003 and C-009. Additionally, a dam and impoundment are planned to be constructed on this drainage tributary as shown on the above mentioned drawings. Alignment 4A goes around the dam and impoundment on the north side, while Alignment 4B goes around the dam and impoundment on the south side. Flow from each sub-subbasin within the boundary of Subbasin E-2, will drain into the 24-inch sewer through branch sewers ranging in size from 12- to 15-inches.

6.2 Alternative Evaluation

Construction Issues - Both alignments are constructed in open areas. No existing utilities or other improvements have been identified which will cause construction related issues. The location of the sewer as it related to the planned dam and impoundment will need special

coordination as both projects continue. Neither alignment presents a construction advantage over the other.

Accessibility for Maintenance - There are currently plans to begin residential development along the proposed water impoundment previously discussed. As the development plans proceed adjustments to the subbasin sewer alignment may be required to allow for access to the junction structures and manholes for maintenance

Both of the alignments provide the same access to the junction structures and critical manholes. As the design of this subbasin sewer progresses it is recommended that the actual location of junction structures and manholes be located to provide the needed access.

Conflicts with Existing Utilities - At the time of this study no existing utilities were identified that would conflict with the proposed alignments.

Environmental Factors - Both of the alignments travel through an area listed on the National Wetlands Inventory. Construction through this area will require close coordination with interested parties and special permitting may be required. Additionally remediation requirements may be required as part of the construction process.

Stream Geomorphology - This alignment is just upstream of Holdredge and "O" Street. Tributary 30 flows northeast from "O" Street, passing under Holdredge Street before emptying into the Main Stem. Tributary 30 is located west of Steven's Creek Main Stem. The average channel slope is roughly 0.46%.

Downstream of Holdredge Street, the bed width is approximately 14 feet and bank height ranges from 3 to 7 feet. The riparian corridor is approximately 90 feet wide with 100 percent canopy made up of honeylocust and hawthorn trees. The streambed is unconsolidated silt and the banks are primarily clayey silt. There is scour on the left and right descending banks and exposed roots barked over on the right descending bank. Approximately 200 feet downstream of Holdredge Street, the low flow channel narrows to 3 feet just downstream of a debris jam.

As the tributary approaches the confluence with the main stem, the riparian corridor widens, but many of the mature trees have been cut down and woody debris has been dumped in the channel. Large debris jams are prevalent and occur every 300 feet. Bed material is unconsolidated silt. Bed width ranges from 3.5 to 5 feet and bank height is about 6 feet. Overhanging trees and exposed roots are common along this reach. Scour lines on the left bank are typically 5 feet above the channel bed, and up to 8 feet on the outside of meander bends.

Alignment 4A crosses tributary 30 in one location, while Alignment 4B crosses the tributary in two locations. Most of the reach is fairly stable and the proposed alignments are not currently threatened. To prevent future threat to the pipeline the areas crossed should be restored using bioremediation or other engineered solutions. This recommendation should be confirmed during final design.

Impact on Potential Development - Both alignments are located outside of the permanent pool of the stormwater impoundment, and for the most part out of the flood pool. Manholes and junction structures are not located in the reaches located in the flood pool.

Alignment 4B located on the south side of the impoundment is better located to serve the potential commercial area located along "O" street. Both alignments are located outside of the Stevens Creek Floodway and 100 year floodplain in Tier I areas.

There are current plans to begin residential development along the proposed water impoundment previously discussed. As the development plans proceed adjustments to the subbasin sewer alignment may be required. It is recommended that close coordination between the dam project, proposed development, and subbasin sewer project take place.

Traffic Disruption/Inconvenience to Public - Neither alignment presents any advantage related to traffic disruption or inconvenience to the public.

Probable Opinion of Estimated Project Costs - Probable opinions of estimated project costs have been prepared for the two alternatives are shown in Table 5 below.

Table 5 Phase IV Alignment Alternatives - Estimated Project Costs Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Alignment Alternative	Approximate Pipe Length (linear feet)	Total Projected Project Cost (millions)
Alignment 4A	8,750	\$3,083,000
Alignment 4B	9,100	\$3,211,000

6.3 Preferred Alignment

Alignment 4B is the preferred alignment for this Phase, primarily due to the proximity of potential commercial development and avoiding the majority of potential housing developments. However, it is recommended that the design and construction of this phase be closely coordinated with the construction of the proposed dam and impoundment and development.

7.0 PHASE V - ALTERNATIVE ALIGNMENTS

7.1 Phase V Alternative Alignments

This phase starts at the 54-inch stubout just upstream from Junction Structure E-2 and proceeds generally southeasterly to Junction Structure E-3B located near Stevens Creek and "O" Street. At this junction structure, the flow from Subbasin E3-B will enter the system through an 18-inch diameter sewer. The 54-inch diameter trunk sewer will continue from Junction Structure E-3B southeasterly to Junction Structure E-3A. At Junction Structure E-3A the flows from Subbasin E-3A will enter the trunk sewer through a 36-inch diameter

sewer. A 48-inch stub and plug to the southeast will be provided as a starting point for the Phase VI of the trunk sewer.

7.2 Alternative Evaluation

Construction Issues - South of "O" street along 120th Street the construction activity may encroach on the existing road due to the close proximity between the creek and the road. Other than that one area the construction will be in relatively flat and open ground and no construction differences between the two alignments are anticipated.

Conflicts with Existing Utilities - Between Junction Structures E-2 and E-3B, each of the alternative alignments must tunnel beneath 112th and "O" Streets, as well as avoid any interference with the 3 Phase overhead power line that runs parallel to both 112th and "O" Streets. Likewise, both alternatives cross under the 115 and 35 KV overhead power near Stevens Creek and "A" Street.

Environmental Factors - Alignment 5B just north of "O" street travels through an area of established woods including oaks. It is desirable that this area be avoided if possible. Also in this same area the alignment is very near to or encroaching upon the riparian border of Stevens Creek.

Stream Geomorphology - This reach of Steven's Creek is incised with frequent wedge failures and woody debris jams at several knickpoints, variably spaced throughout the reach. Approaching 112th Street and continuing downstream to Holdredge Street, the channel appears stable. Streambanks are densely vegetated with grasses down to the water surface.

Stream banks along this reach are generally steep, between 45 and 90 degrees. Scour indicators range in height from 3 feet to 6 feet. Bed width gradually increases downstream from O Street, doubling in width from 6 feet to 12 feet. The top of bank width fluctuates between 40 and 70 feet. Bank material is primarily clayey silt and unconsolidated silt. Downstream of O Street there are some areas with gravel and cobble bed.

Like much of the lower main stem of Steven's Creek, the riparian corridor is comprised mainly of hickories and cottonwood, with the occasional silver maple, and mulberry understory. Canopy cover over the channel is sparse, ranging from 0 to 25 percent. However, while canopy cover and tree species remain consistent, the corridor width is highly variable. Immediately downstream of O Street the corridor is narrow; less than 50ft. A little over 100ft downstream, the corridor width nearly triples. But, once again, much of the wooded corridor disappears no more than 400ft downstream, with a total corridor width of only 40 feet.

Much of the reach is stable. However, the channel is widening at the confluence with Tributary 45. This poses a potential future threat to the proposed pipeline. To minimize this future threat bio-engineering should be included in a future project in this area. The pipeline crossing of tributary 45 in a relatively stable location. If the crossing is open trenched the

steam should be restored using bio-engineering and pipe protection techniques. These recommendations should be confirmed during final design.

Impact on Potential Development - Both alignments for the most part are located within not only the 100 year floodplain, but in the floodway and should not impact future development. In areas where the alignment is outside of the floodway it parallels existing roads which should minimize any impacts to future development potential of the land.

Both alignments are located on the west side of Stevens Creek in Tier I areas.

Traffic Disruption/Inconvenience to Public - Neither alignment presents any advantage related to traffic disruption or inconvenience to the public.

Probable Opinion of Estimated Costs - Probable opinions of estimated project costs have been prepared for each of these alternatives as shown in Table 6 below.

Table 6 Phase V Alignment Alternatives - Estimated Project Costs Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Alignment Alternative	Approximate Pipe Length (linear feet)	Total Projected Project Cost
Alignment 5A	13,700	\$10,383,000
Alignment 5B	14,650	\$10,924,000

7.3 Preferred Alignment

The preferred alignment based on estimated costs, geomorphology, and environmental concerns is 5A.

8.0 PHASE VI - ALTERNATIVE ALIGNMENTS

8.1 Phase Alternative Alignments

This phase of the project starts at the 48-inch stubout just upstream from Junction Structure E-3A and proceeds southeasterly to Junction Structure E-4 which is located north of Van Dorn. At this junction structure the flow from Subbasin E-4 will enter the trunk sewer through a 36-inch diameter pipe. A 36-inch stubout to the southeast will be provided as a starting point for Phase VII of the project.

After field reviews and working meetings with City and other involved parties only one viable alternative has been identified for this alignment as shown in Drawings C-004 and C-005. There are some minor variations to this alignment which are shown in Drawing C-005. However, they were so similar to alternative 6A that they were not treated as separate alignments.

Construction Issues - The alignment is generally in relatively flat and open ground and no construction differences are anticipated.

Conflicts with Existing Utilities - For the majority of the alignment the sewer parallels two high voltage overhead power lines which will required special attention during construction. At this time no other existing utilities have been identified.

Environmental Factors - The alignments generally are located at a distance to avoid the riparian corridor of Stevens Creek and avoid other identified areas of concern.

Stream Geomorphology - This reach is characterized by Nodaway silt loam. The average channel slope is approximately 0.1% with a sinuosity of about 1.3. A few areas of localized scouring have been observed. The majority of the reach is fairly stable and the proposed alignment is not threatened by stream channel processes.

The pipeline crossing of tributary 60 is in a relatively stable location. If the crossing is open trenched the steam should be restored using bio-remediation and pipe protection techniques. These recommendations should confirmed during final design.

Impact on Potential Development - The alignments are located in a Tier I area. The alignments are located for the most part within the 100 year floodplain with a few reaches within the floodway. For the majority of the alignments the sewer parallels two high voltage overhead power lines. The overhead power transmission lines currently limits development. Paralleling these overhead power lines will minimize the impact future development potential. The alignments from near "A" Street to Van Dorn Street that are located in an area that no-development area as defined in the Comprehensive Plan.

Traffic Disruption/Inconvenience to Public - The alignment should not present any traffic related problems or undue inconvenience to the public.

Probable Opinion of Estimated Costs - Probable opinions of estimated construction costs have been prepared for the alternative as shown in Table 7 below.

Table 7 Phase VI Alignment Alternatives - Estimated Project Costs Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Alignment Alternative	Approximate Pipe Length (linear feet)	Total Projected Project Cost
Alignment 6A	6,500	\$3,151,000

8.2 Preferred Alignment

The preferred alignment is 6A for primarily geomorphology reasons.

9.0 PHASE VII - ALTERNATIVE ALIGNMENTS

9.1 Phase VII Alternative Alignments

Phase VII starts at the 36-inch stubout just south of Junction Structure E-4 Junction and continue southerly to Junction Structure E-5H. At this Junction Structure the flow from Subbasin E-5H will enter the system through a 12-inch diameter sewer, The 36-inch diameter trunk sewer will continue south to Junction Structure E-5G. At this junction structure the flow from Subbasin E-5G will enter the trunk sewer through a 12-inch diameter pipe near Pioneers Blvd. A 36-inch diameter stubout will be provided to the south of Junction Structure E-5G as a starting point for Phase VIII. Two alternative alignments have been identified for Phase VII construction, and are shown in Drawings C-005 and C-006.

Alignment 7A runs parallel to the west side of Stevens Creek from Junction Structure E-4, until it reaches Junction Structure E-5H. At this location the alignment crosses Stevens Creek to the east side of the creek to avoid several hills that will require additional excavation to install the sewer. Once on the east side of Stevens Creek the trunk sewer will generally parallel the creek to the south to junction structure E-5G.

Alignment 7B runs parallel to the west side of the creek through the hilly terrain from Junction Structure E-4 to E-5G. This alignment is located very close to Stevens Creek in an effort to avoid the hilly terrain adjacent to the west side of Stevens Creek. This will result in the potential for geomorphology issues and increased construction costs due to the terrain.

9.2 Alternative Evaluations

Construction Issues - Construction of Alignment 7A on the east side of the creek will generally be easier and less costly than Alignment on the west side of the creek. This is due to the steep hilly terrain immediately adjacent to the west side of the creek and the very narrow associated floodway and floodplain. It was assumed that the creek crossing for alignment 7A will be performed using tunneling methods which are reflected in the estimated project costs shown above.

Alignment 7B is located on the west side of the creek. The terrain adjacent to the creek is steep and very hilly. Due to this the construction difficulty and associated costs will be higher.

Conflicts with Existing Utilities - At the time of this study no existing utilities have been identified that pose a conflict with the proposed alignments.

Environmental Factors - Both alignments 7A and 7B just south of Van Dorn Street cross an area identified as a grasslands and very close to an area listed on the National Wetlands Inventory. Construction through this area will requires close coordination with interested parties and special permitting may be required. Additionally remediation requirements may be required as part of the construction process.

Alignment 7B located on the west side of the creek is very close to the riparian corridor and special attention will be required to maintain proper setback distance and restoration requirements.

Stream Geomorphology - This reach is located between Pioneers Blvd and Van Dorn Street. The channel bed is approximately Nodaway silt loam. With the exception of few reaches of localized erosion, much of the reach is fairly stable. There is the occurrence of headcut and channel widening at two locations in the reach. The headcut is just downstream of the channel widening which is threatening the streambank. If the headcut moves through widening will get worse. This situation threatens the proposed alignment and needs to be arrested using cost-effective bio-engineering techniques.

Alignment 7A crosses Stevens Creek and Tributary 75 as shown in Drawings C-005 and C-006. Both of these crossings are in areas of headcut. The trunk sewer can be installed using open cut or trenchless construction techniques. However, the steam crossing should be restored using approved methods.

Alignment 7B is located very close to the west bank of the creek to avoid a large hill. The average bank scour height in this area is 12 feet. This translate to a horizontal failure distance of about 24 feet assuming a 2H to 1V slope. The alignment is located for the most part is located more than 100 feet from the bank. This results in no special bank stability requirements.

Impact on Potential Development - The construction for both of these alignments is planned several years in the future. At that time the actual location of the trunk sewer may be adjusted as necessary to more closely follow development patterns and the creek.

Alignment 7A is located on the east side of Stevens Creek in a Tier III area. Although the sewer is located on the east side of the creek provisions are not being provided for any east side service provisions as part of this project. This alignment may have an impact on costs of developing the west side of the creek. These costs, if any are associated with providing additional sewer to convey the wastewater to a junction structure.

Alignment 7B is located on the west side of the creek in a Tier II area. This phase of the project is located outside of the known floodplain, as close to the creek as possible while still maintaining a safe separation from the stream banks to minimize bank stability issues. This alignment is located in very steep and hilly area adjacent to the creek.

Traffic Disruption/Inconvenience to Public - Neither alignment should not present any traffic related problems or undue inconvenience to the public since they are located in open undeveloped areas.

Probable Opinion of Estimated Costs - Probable opinions of estimated project costs have been prepared for each of these alternatives as shown in Table 8 below. Estimated costs for special construction have been included.

Table 8 Phase VII Alignment Alternatives - Estimated Project Costs Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Alignment Alternative	Approximate Pipe Length (linear feet)	Total Projected Project Cost
Alignment 7A	5,750	\$2,926,000
Alignment 7B	5,500	\$3,018,000

9.3 Preferred Alignment

Based on the estimated project costs, construction issues, and environmental factors the preferred alignment is 7A.

10.0 PHASE VIII - ALTERNATIVE ALIGNMENTS

10.1 Phase VIII Alternative Alignments

This phase of the project starts at the 36-inch diameter stubout just south of Junction Structure E-5G and continues generally south to Junction Structure E-5F. At this structure the flow from Subbasin E-5F will enter the system sewer through a 12-inch diameter sewer. The 36-inch diameter trunk sewer continues south to Junction Structure E-5E. At this junction structure the flow from Subbasin E-5E will enter the system through a 15-inch diameter sewer. Continuing south from this Junction Structure the trunk sewer will reduce to a 30-inch diameter sewer and continue to Junction Structure E-5D, near Pine Lake Rd. At this Junction Structure the flow from Subbasin E-5D will enter the trunk sewer through a 12-inch diameter pipe. The 30-inch diameter trunk sewer will be plugged for the Phase IX continuation.

Two alternative alignments have been identified for Phase VIII as discussed below and shown in Drawings C-006 and C-007. Alignment 8A is a continuation of Alignment 7A, and maintains a parallel course to Stevens Creek along its east side until a location approximately half way between Old Cheney Road and Pine Lake Road. At this location Alignment 7A crosses to the west side of Stevens Creek and continues southerly to Junction Structure E-5D. This alignment avoids several hills that will require extra excavation to install the sewer.

Alignment 8B is a continuation of Alignment 7B, and maintains a parallel course to Stevens Creek along its west side to Junction Structure E-5D. This alignment is located very close to Stevens Creek in an effort to avoid the hilly terrain adjacent to the west side of Stevens Creek. This will result in the potential for geomorphology issues and increased construction costs due to the terrain. The general features of these two alignments are shown in the following table.

10.2 Alternative Evaluations

Construction Issues - Construction of Alignment 8A on the east side of the creek will generally be easier and less costly than the west side. This is due to the hilly terrain and very narrow floodplain and floodway located on the west side of the creek. It was assumed that the creek crossing for alignment 8A will be performed using tunneling methods which are reflected in the estimated project costs shown above.

The construction of Alignment 8B will be more difficult due to the very steep and hilly terrain located immediately adjacent to the creek.

Conflicts with Existing Utilities - At the time of this study no existing utilities have been identified that pose a conflict with the proposed alignments.

Environmental Factors - Alignments 8B located on the west side of the creek is very close to the riparian corridor and special attention will be required to maintain proper setback distance and restoration requirements.

Stream Geomorphology - The reach is characterized by fairly steep slopes is between Pine Lake Road and Pioneers Blvd. The average slope in this reach is roughly 0.28% and is characterized by silt loam. This reach is stable. Localized scouring has been observed. The maximum scour height is approximately 10 feet. Two locations exist in the reach where the creek is incised and the potential for bank failure is great. These locations are shown in Drawing C-007. The headcut could migrate upstream and if not arrested could threaten the proposed pipeline. To prevent this future condition the pipe should be protected and any construction activities associated with these crossings would require stream bank restoration.

Impact on Potential Development - The construction for both of these alignments is planned several years in the future. At that time the actual location of the trunk sewer may be adjusted as necessary to more closely follow development patterns and the creek.

Alignment 8A is located on the east side of Stevens Creek in a Tier III area. Although the sewer is located on the east side of the creek provisions are not being provided for any east side service provisions as part of this project. This alignment is located as close as possible to the creek to minimize slope stability issues. This alignment may have an impact on costs of developing the west side of the creek. These costs, if any are associated with providing additional sewer to convey the wastewater to a junction structure.

Alignment 8B is located on the west side of the creek in a Tier II area. This phase of the project is located outside of the known floodplain, as close to the creek as possible while still maintaining a safe separation from the stream banks to minimize bank stability issues. This alignment is located in very steep and hilly area adjacent to the creek.

Traffic Disruption/Inconvenience to Public - Neither alignment should not present any traffic related problems or undue inconvenience to the public since they are located in open undeveloped areas.

Probable Opinion of Estimated Costs - Probable opinions of estimated project costs have been prepared for each of these alternatives as shown in Table 9 below.

Table 9 Phase VIII Alignment Alternatives - Estimated Project Costs Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Alignment Alternative	Approximate Pipe Length (linear feet)	Total Projected Project Cost (millions)
Alignment 8A	11,800	\$5,499,000
Alignment 8B	10,850	\$5,239,000

10.3 Preferred Alignment

Based on the estimated project costs, construction issues, and the riparian corridor protection the preferred alignment is 8A.

11.0 PHASE IX - ALTERNATIVE ALIGNMENTS

11.1 Phase IX Alternative Alignments

The final phase of the project starts at the 30-inch diameter stubout just south of Junction Structure E-5D and continues uphill to Junction Structure E-5C. At this junction structure the flow from Subbasin E-5C enters the trunk sewer system through a 24-inch diameter sewer. Additionally, the trunk sewer changes size at this Structure from 30-inch to 24-inch. The trunk sewer continues generally south from this structure to Junction Structure E-5B. At this location the flow from Subbasin E-5B enters the system through a 15-inch diameter sewer. Also at this location the trunk sewer changes size to 18-inches in diameter. The trunk sewer continues south to Junction Box E-5A. At this location a 15-inch stub and plug will be provided to the west and a 12-inch stubs and plugs will be provided to the north and south for future connection.

There was only one alignment identified for this construction phase. Alignment 9A runs parallel to Stevens Creek along its west side, southward to Junction Structure E-5A as shown on Drawings C-007 and C-008.

11.2 Evaluation of Alternatives

Construction Issues - Construction on the west side of the creek should not present any extraneous construction issues.

Conflicts with Existing Utilities - Careful planning and coordination must also be made in an effort to avoid interfering with the 115 KV and 345 KV overhead power lines.

Environmental Factors - The alignment does not cross any identified environmentally sensitive areas.

Stream Geomorphology - This headwater reach is characterized by fairly steep slopes and is between Yankee Hill Road and Pine Lake Road. The average slope in this reach is approximately 0.3% and is dominated by silt loam soils. The sinuosity of the main channel is about 1.97. Some localized scoring has been observed in this reach. The average scour depth is about 4 feet and the potential for wedge failure is minimal. Even though the potential for wedge failure is minimal, the proposed pipe alignment is more than 100 feet from the stream bank to avoid any failures associated with scouring.

Attention, however, must be drawn to the occurrence of headcut and channel widening just south of Yankee Hill Road. The headcut is just downstream of the channel widening which is threatening the streambank. If the headcut moves through widening will get worse. This situation threatens the proposed alignment and needs to be arrested using bio-engineering techniques. To prevent future threat to the trunk sewer this area of the creek should be restored using approved methods.

The proposed alignment crosses Tributary 96. The side slopes of Tributary 96 are greater than 3H to 1V. Due to the flat slopes in this reach the potential for bank erosion is minimal.

Impact on Potential Development - The construction for both of these alignments is planned several years in the future. At that time the actual location of the trunk sewer may be adjusted as necessary to more closely follow development patterns and the creek.

This phase of the project is located as close to the creek as possible while still maintaining a safe separation from the stream banks to minimize bank stability issues. It should be noted that as the stream continues uphill the floodway and floodplain become narrower and harder to define. There are stretches of these alignments that are not located within the identified floodway. As the project continues to this point it may be beneficial to make minor changes to the alignment to avoid conflicts with planned or existing development.

Traffic Disruption/Inconvenience to Public - This alignment should not present any traffic related problems or undue inconvenience to the public since it is located in relatively open undeveloped areas.

Probable Opinion of Estimated Costs - Probable opinions of estimated construction costs have been prepared for the alignment as shown in Table 10 below.

Table 10 Phase IX Alignment Alternatives - Estimated Project Costs Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska		
Alignment Alternative	Approximate Pipe Length (linear feet)	Total Projected Project Cost
Alignment 9A	7,250	\$2,567,000

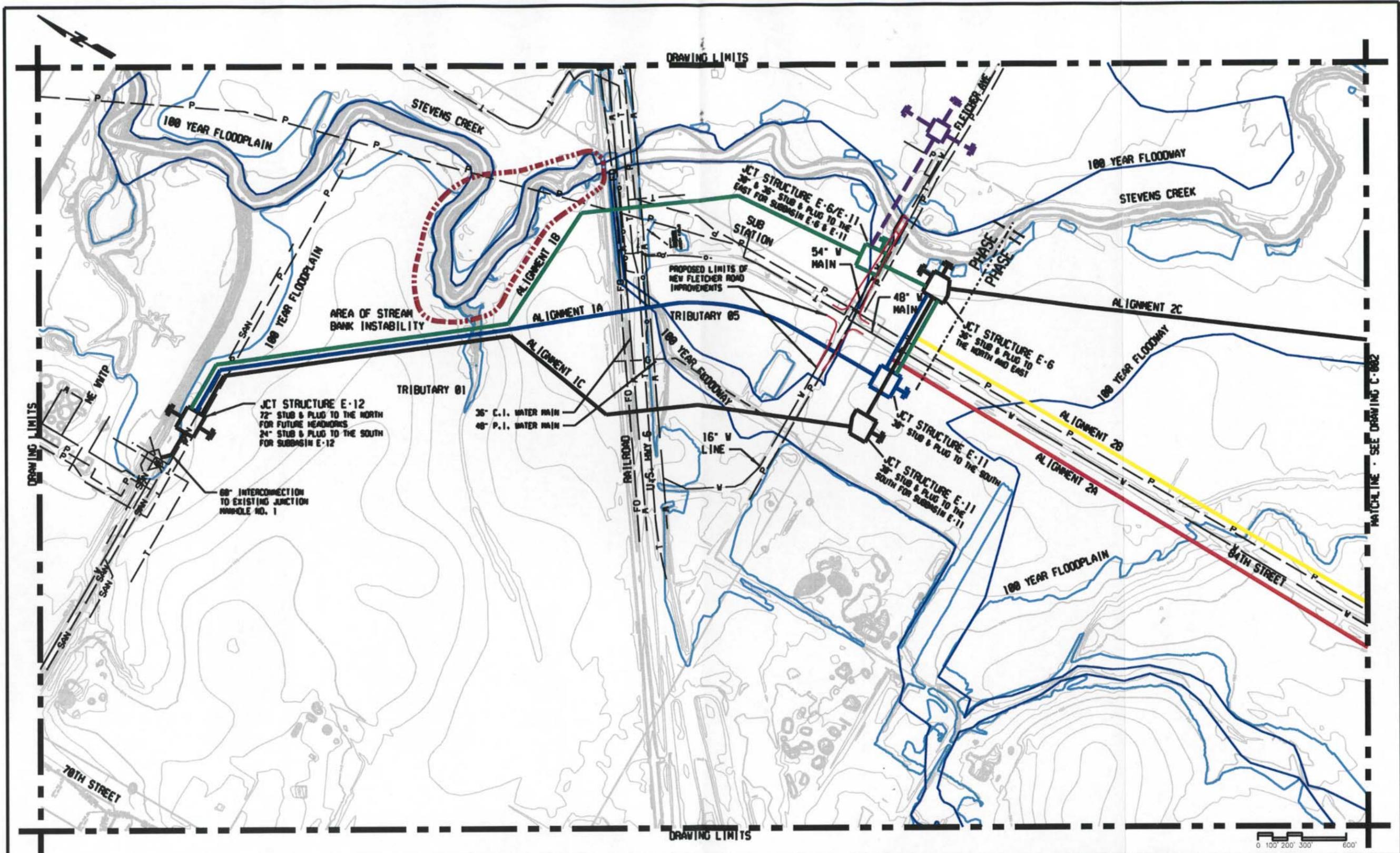
11.3 Preferred Alignment

Based on the above criteria the preferred alignment is 9A.

12.0 SUMMARY OF PREFERRED ALIGNMENT

The preferred Stevens Creek Trunk Sewer alignment, that is designed to convey the wastewater from the Tier I and Tier II areas is generally located on the west side of Stevens Creek. The trunk sewer has been divided into phases as previously discussed. The preferred alignment is summarized in the following Table.

Table 11 Summary of the Preferred Alignment Stevens Creek Basin Trunk Sewer City of Lincoln, Nebraska				
Phase	Alignment	Approximate Length (ft)	Pipe Size (inches)	Estimated Project Costs
1	C	6,000	72" Ø	\$7,739,000
2	C	8,050	66" Ø	\$7,858,000
3	A	10,800	54" Ø	\$8,445,000
4	B	9,100	24" Ø	\$3,211,000
5	A	13,700	54" Ø	\$10,383,000
6	A	6,500	48" Ø	\$3,155,000
7	A	5,750	36" Ø	\$2,926,000
8	A	11,800	36 and 30" Ø	\$5,499,000
9	A	7,250	30, 24, and 18" Ø	\$2,567,000
Totals	-	78,950	-	\$51,783,000



REV	DATE	BY	DESCRIPTION

DESTONED
 MJS
 DRAWN
 CVW
 CHECKED
 BOC
 DATE
 11-11-04

PRELIMINARY
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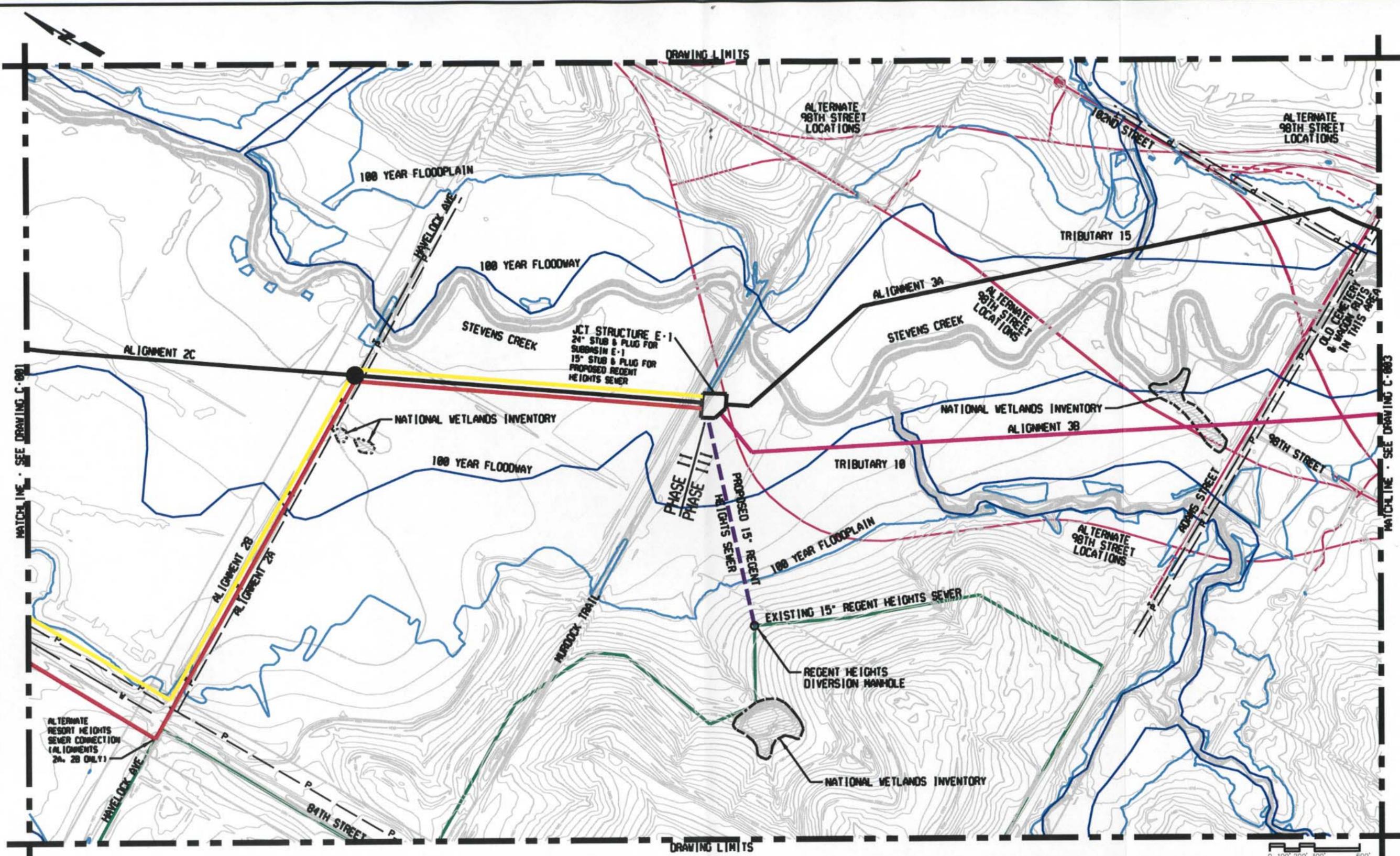


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CITY OF LINCOLN, NEBRASKA
STEVENS CREEK BASIN TRUNK SEWER
 CIVIL
ALTERNATIVE ALIGNMENT ANALYSIS
PHASES I & II

VERIFY SCALES
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JOB NO.
 6983A.18 (TM4)
 DRAWING NO.
C-001
 SHEET NO.
 SHT 1 OF 9



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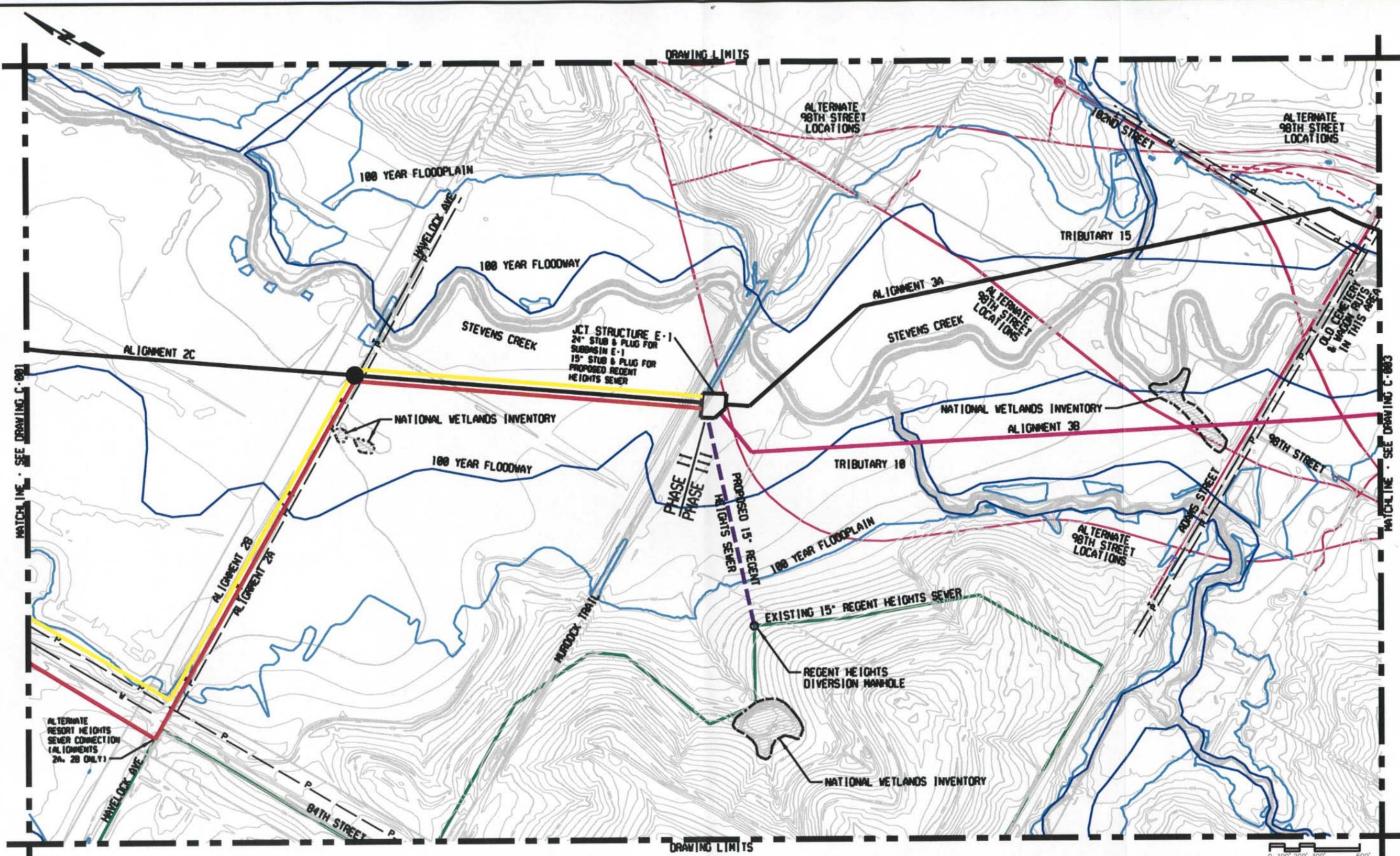


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PHASES II & III**

VERIFY SCALES
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JOB NO.
6983A.10 (TM4)
DRAWING NO.
C-002
SHEET NO.
SHT 2 OF 9



REV	DATE	BY	DESCRIPTION

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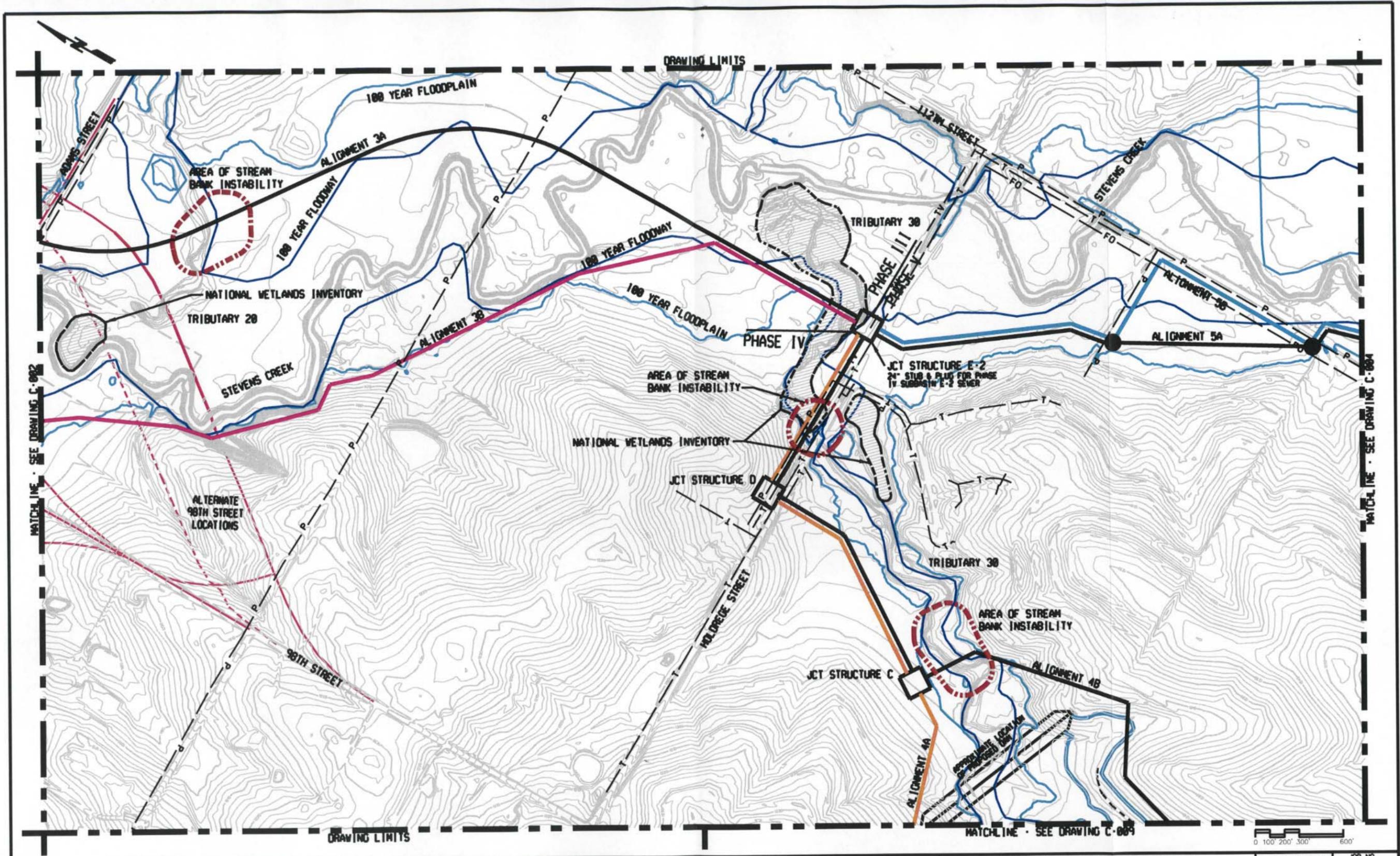
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STEVENS CREEK BASIN TRUNK SEWER
CIVIL
**ALTERNATIVE ALIGNMENT ANALYSIS
PHASES II & III**

VERIFY SCALES
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JOB NO.
6983A.1B (TM4)
DRAWING NO.
C-002
SHEET NO.
SHT 2 OF 9

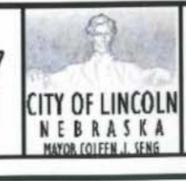




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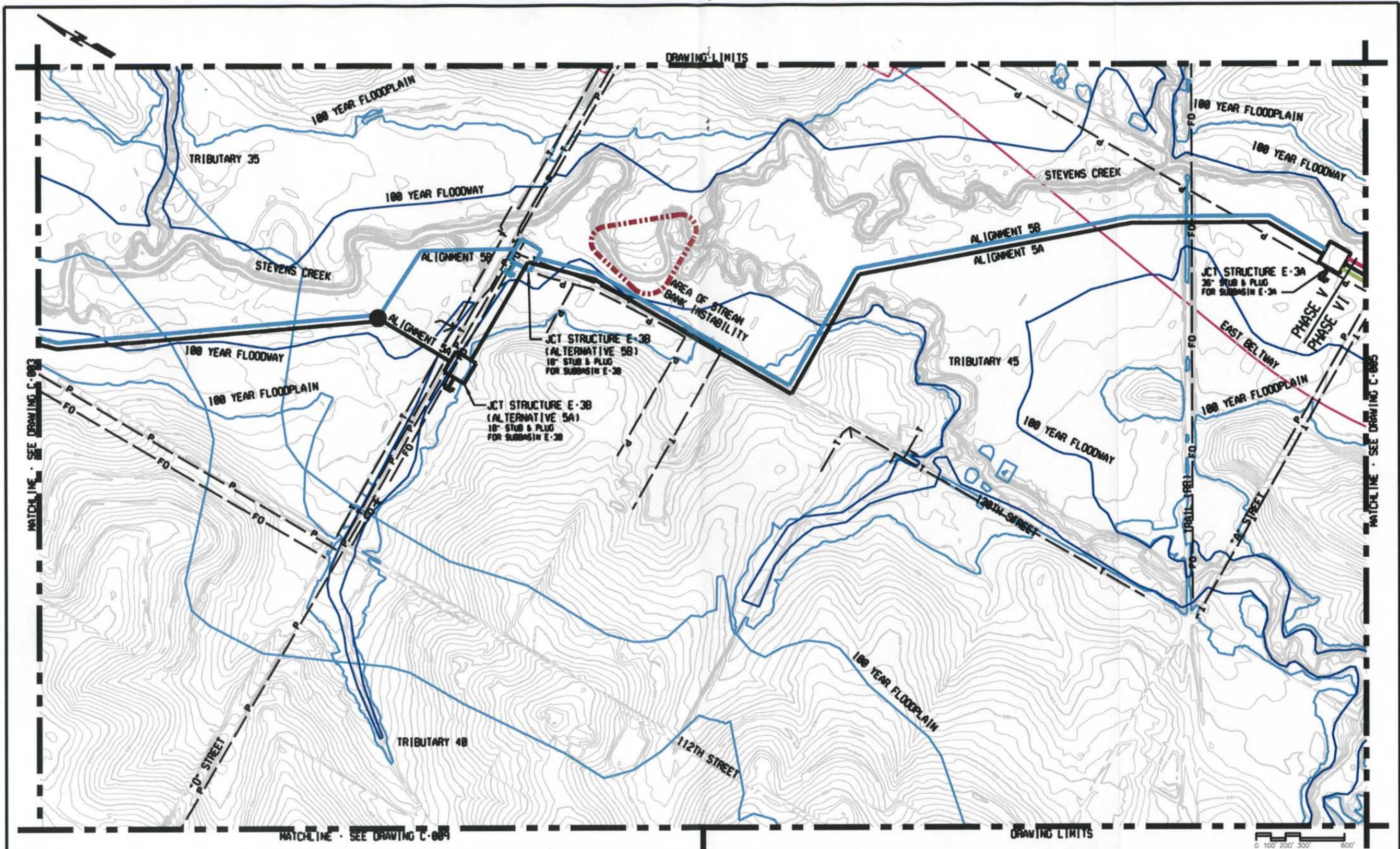


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 CIVIL
 ALTERNATIVE ALIGNMENT ANALYSIS
 PHASES III, IV & V

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JOB NO.
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 DRAWING NO.
C-003
 SHEET NO.
 SHT 3 OF 9



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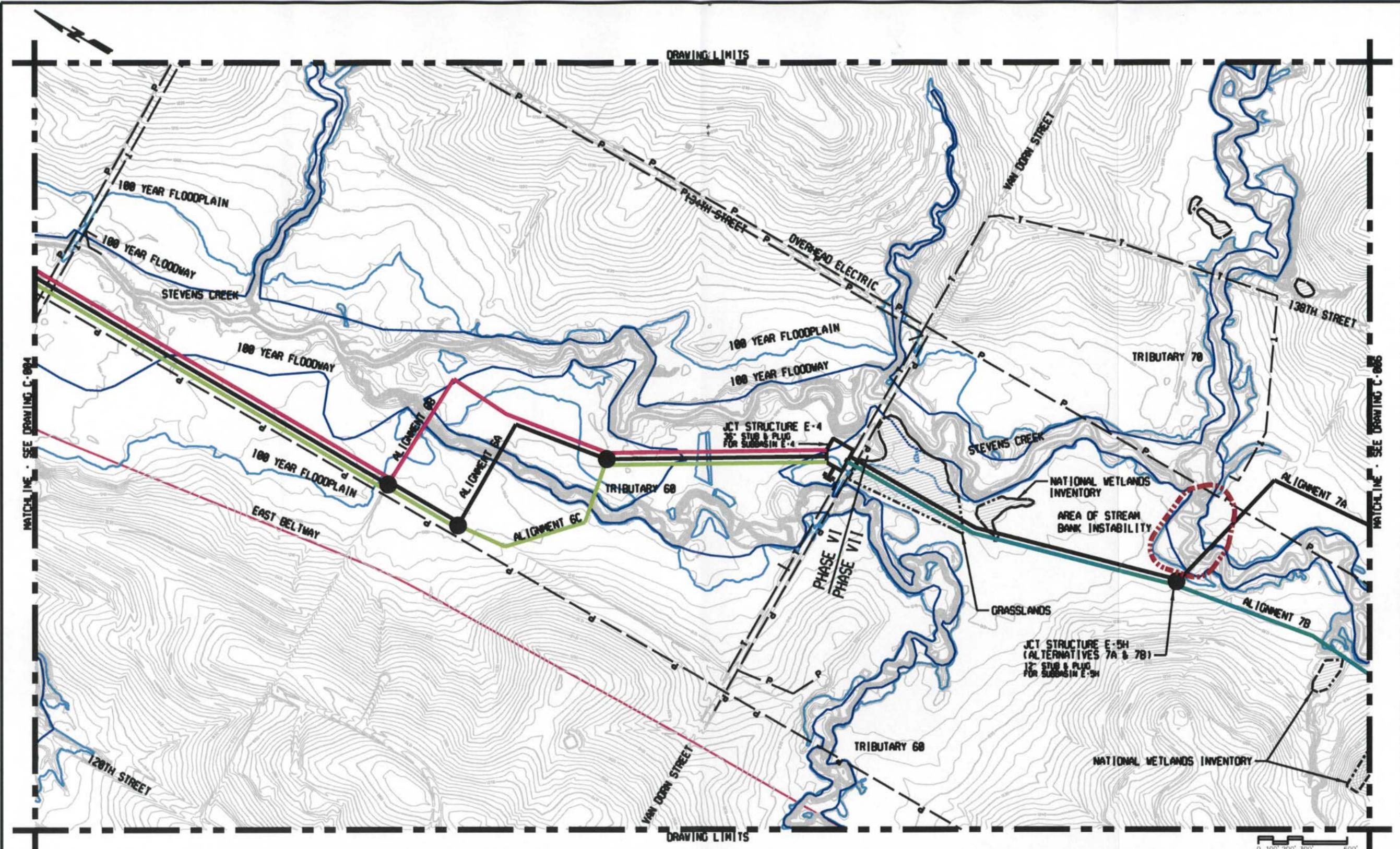


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PHASES V & VI**

VERIFY SCALES
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IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

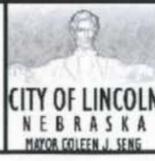
JOB NO.
6983A.1B (1/4)
DRAWING NO.
C-004
SHEET NO.
SHT 4 OF 9



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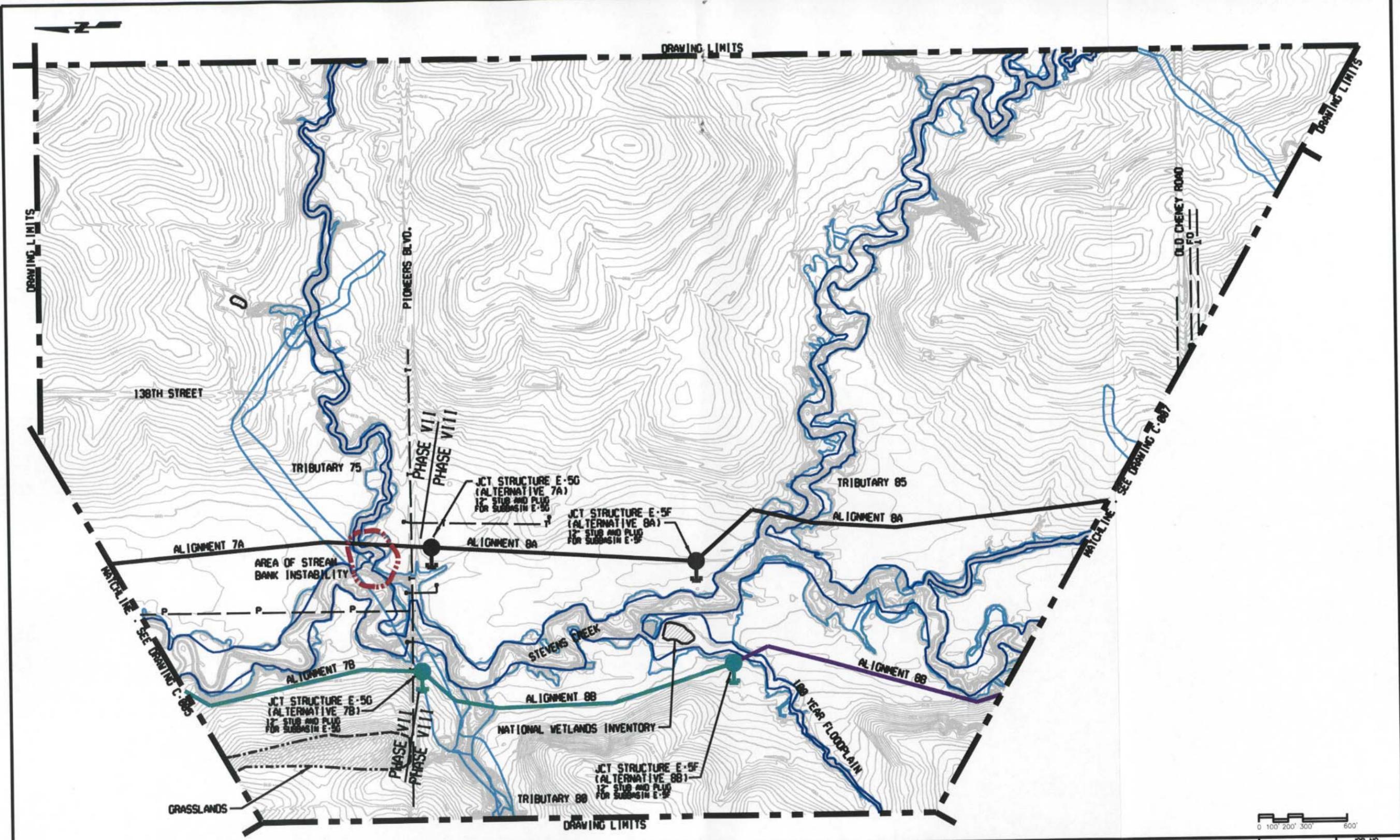


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STEVENS CREEK BASIN TRUNK SEWER
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ALTERNATIVE ALIGNMENT ANALYSIS
PHASES VI & VII

VERIFY SCALES
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 0 1" 1'
 IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

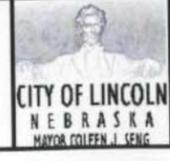
JOB NO.
 6983A.1B (TM4)
 DRAWING NO.
C-005
 SHEET NO.
 SH1 5 OF 9



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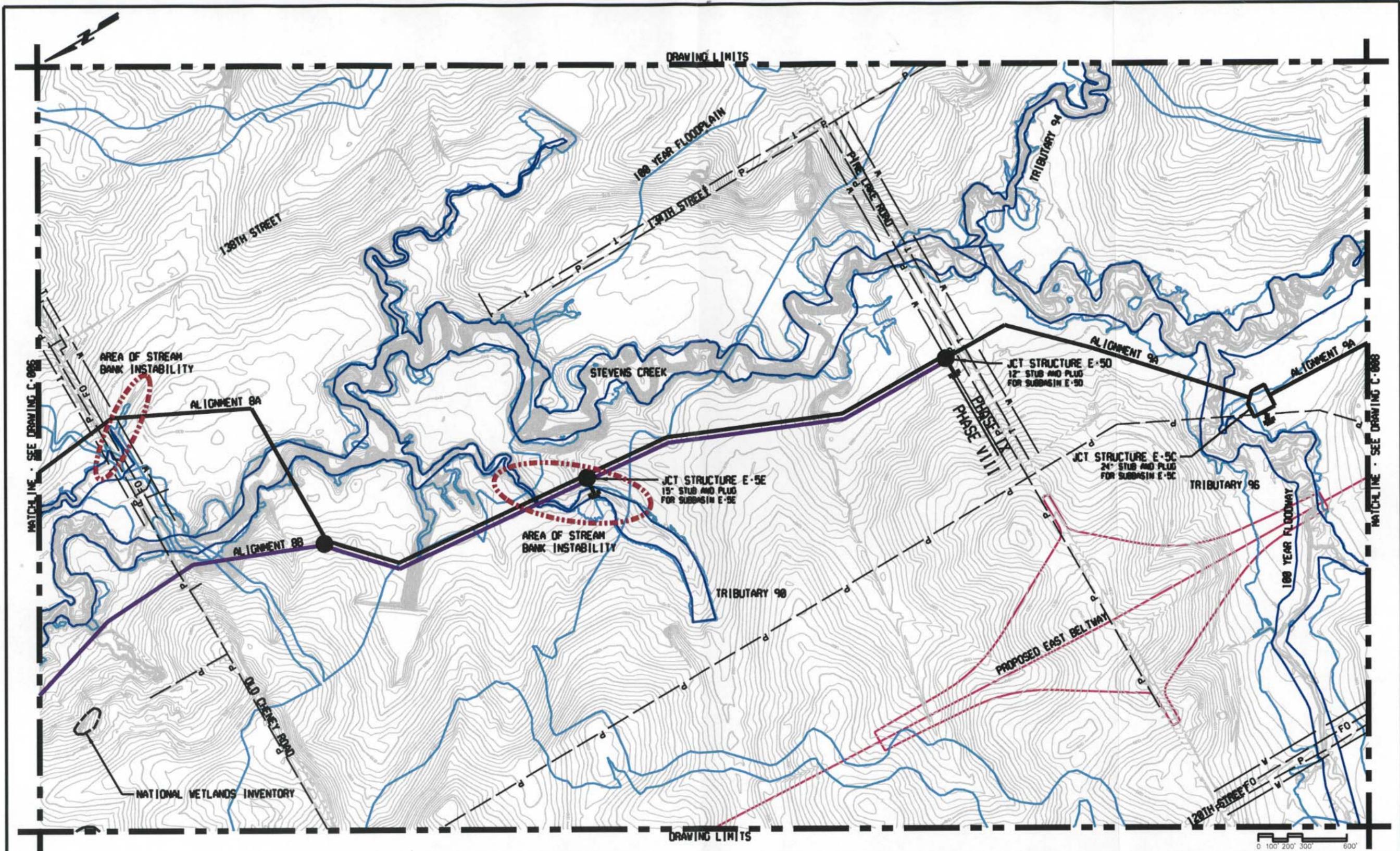
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STEVENS CREEK BASIN TRUNK SEWER
CIVIL
**ALTERNATIVE ALIGNMENT ANALYSIS
PHASES VII & VIII**

VERIFY SCALES
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0 1" 1'
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO.
6983A.1B (TM4)
DRAWING NO.
C-006
SHEET NO.
SHT 6 OF 9

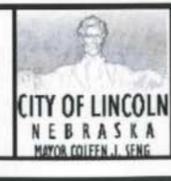




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 DATE
 11-11-04

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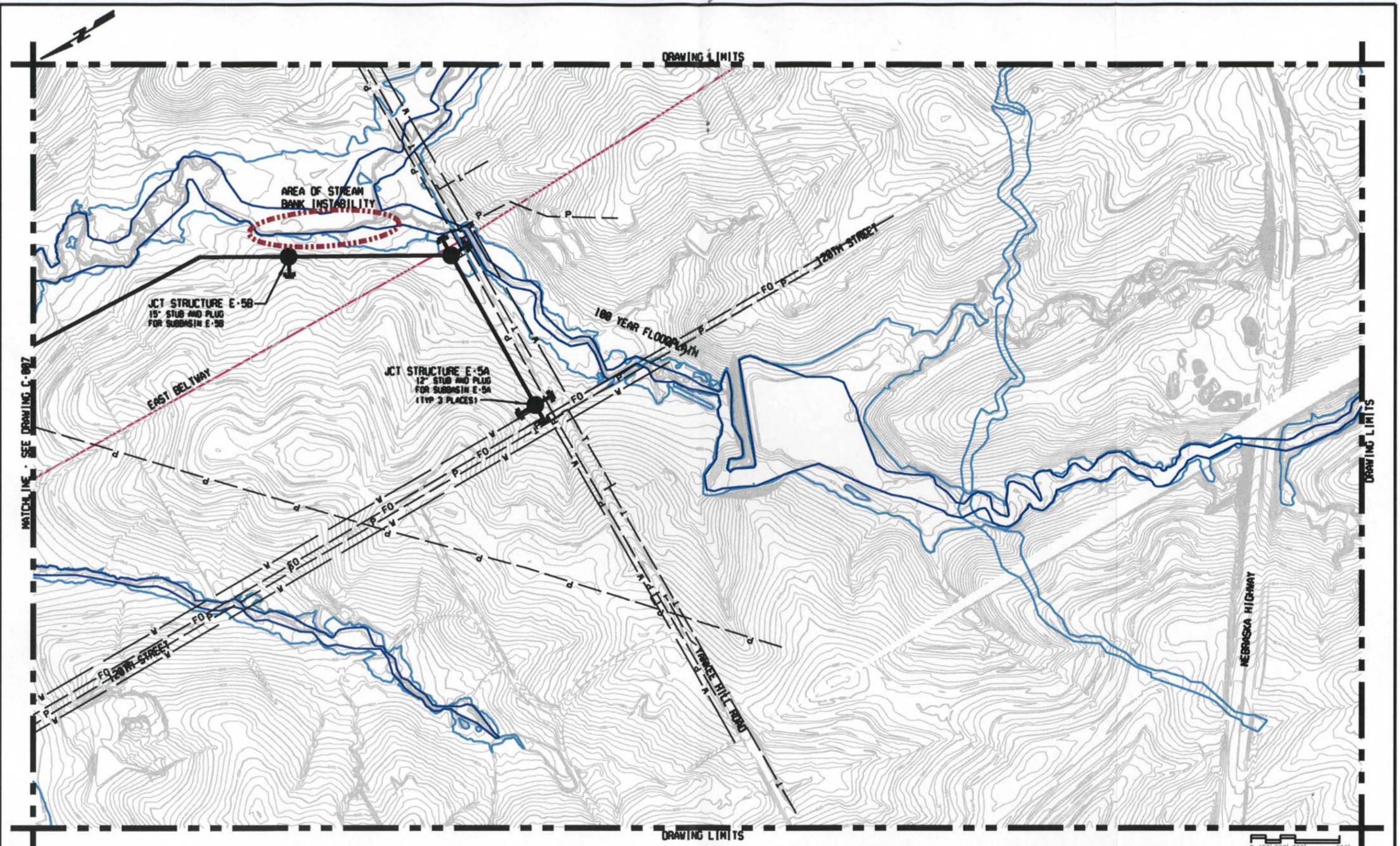


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CITY OF LINCOLN, NEBRASKA
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ALTERNATIVE ALIGNMENT ANALYSIS
PHASES VIII & IX

VERIFY SCALES
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 0" = 1"
 IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

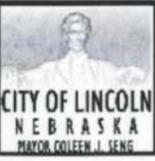
JOB NO.
 6983A.1B (TM4)
 DRAWING NO.
C-007
 SHEET NO.
 SH 7 OF 9



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11-11-04

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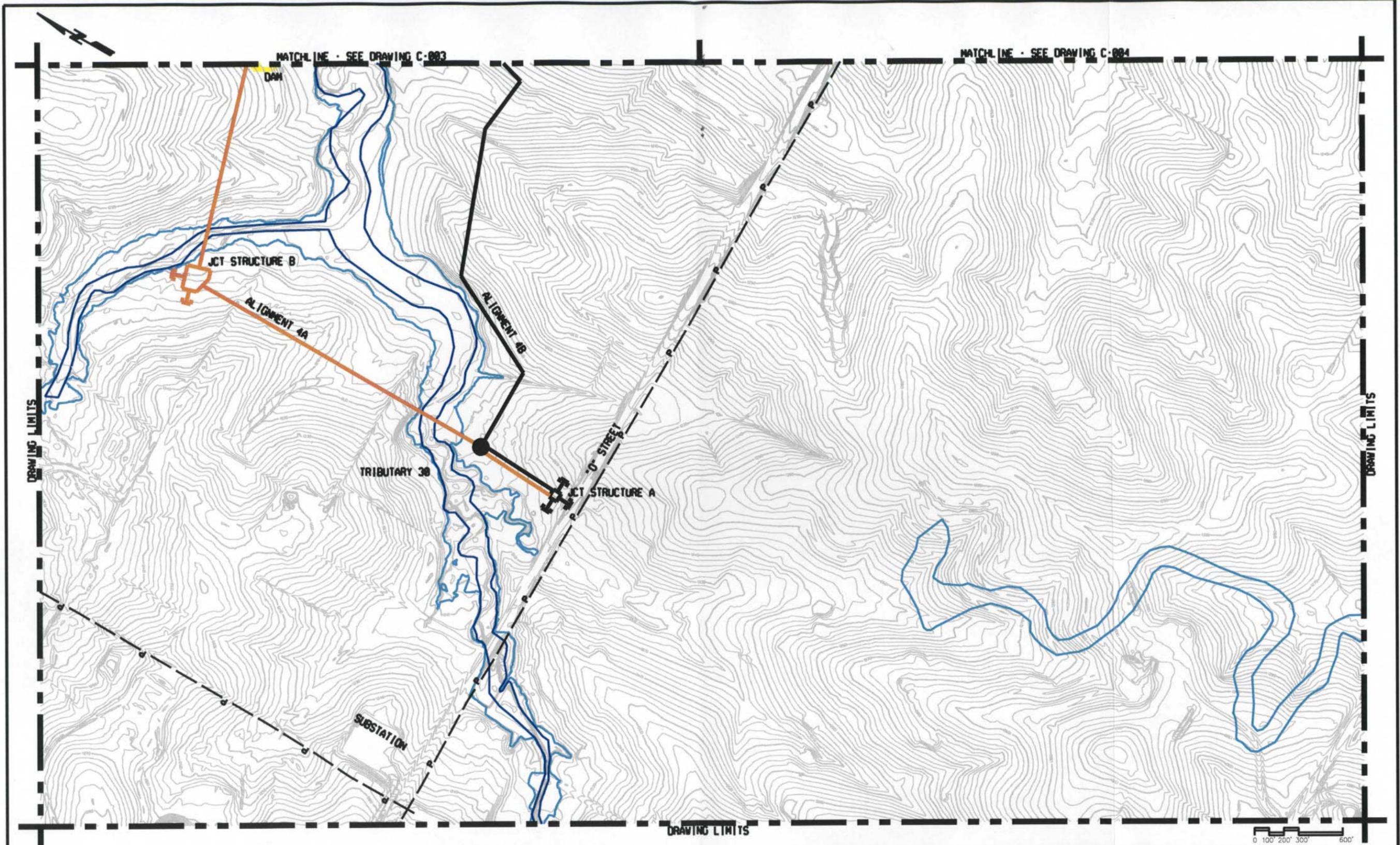


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**ALTERNATIVE ALIGNMENT ANALYSIS
PHASE IX**

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

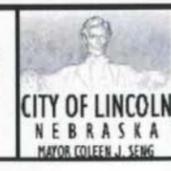
JOB NO.
6983A.1B (TM4)
DRAWING NO.
C-008
SHEET NO.
SHT 8 OF 9



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CITY OF LINCOLN, NEBRASKA
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CIVIL
ALTERNATIVE ALIGNMENT ANALYSIS
PHASE IV

VERIFY SCALES
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0 1" 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY

JOB NO.
6903A.1B (TM4)
DRAWING NO.
C-009
SHEET NO.
SHT 9 OF 9