Examination of Selected Assertions by U.S. EPA in the Proposed Plan San Jacinto River Waste Pits Superfund Site

F. Douglas Shields, Jr.

Doug Shields, Jr., Ph.D., P.E., D.WRE

www.friendofrivers.com

Shields Engineering, LLC
Suite 134

850 Insight Park

University, MS 38677

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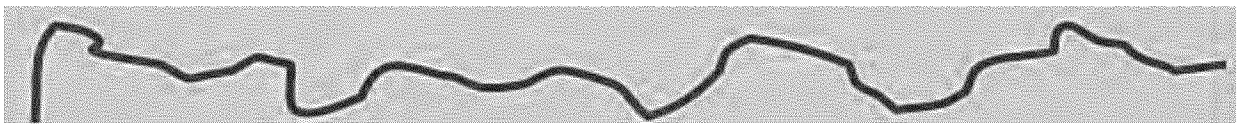

1 Introduction

I have been engaged to provide comments on selected assertions within the Proposed Remedial Action Plan (PRAP, U.S. EPA 2016a) for the San Jacinto Waste Pits Superfund Site (Site). Site characteristics and history are described elsewhere (U.S. EPA 2016a, 2016b and Hayter et al. 2016). The PRAP assertions examined here deal with fluvial and coastal erosion processes along the reach of the San Jacinto River, in particular, the area containing the impoundments located north of Interstate 10 (Northern Impoundments) and the impoundment located on the peninsula south of Interstate 10 (South Impoundment). Figures are provided at the end of this document, and my resume of my qualifications is included as an appendix. Each of the selected assertions from the PRAP is set out below, followed by an evaluation of that assertion.

2 EPA Assertion #1. The San Jacinto River is a very dynamic system..... A series of aerial photographs illustrate this variability[1].

The photo sequence cited to support this assertion is presented without quantitative analysis. No mention is made of rectification or registration, and no allowance is made for varying water levels[2]. Standard techniques for analyzing aerial and satellite imagery involve georeferencing the images to obtain consistent frames of reference and remove distortions so that errors in measuring distances (and thus errors in measuring morphologic changes) are reduced. In a water body such as that surrounding the Site, water level variation can produce large changes in water surface area because of the extremely flat topography along some parts of the channel. Furthermore,there is no attempt made by Region 6 to disaggregate the effects of subsidence, erosion and dredging (which are discussed below)on channel morphology.

By definition, the expression, "very dynamic," suggests that the river is "characterized by

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[1] Text of the PRAP continues, "An aerial photograph taken in 1956 (Figure 3), before the waste pits were established, shows I-10 crossing the river and extensive islands and land to the north. The next photograph, from 1966 (Figure 4), shows the northern pits located just west of the I-10 Bridge (the pits were built and in operation in the mid–1960s); significant changes to the north can be seen compared to the 1956 photograph. Land erosion and subsidence is evident in the next photograph from 1973 (Figure 5); there is a new passage to the west of the Northern Impoundments since the 1966 photograph. Photographs in the 1990's and later (Figure 6) show continued loss of land."

[2] Normal tidal variation at the Site is about 1 to 2 feet (ft); stage changes associated with high flows are much greater. The range of stages observed over the last 20 years for the San Jacinto River at Sheldon (several miles upstream) is about 7 ft. Record stage at the Sheldon gage is about 33 ft above low stage.

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constant change or activity." My review of the aerial photo record and available topographic survey maps, summarized below, suggests that the main channel of the river channel is stable with respect to the fluvial processes[3] of lateral migration and avulsion and therefore cannot be characterized as "very dynamic."

Lateral migration refers to the movement of meanders across a floodplain. This process usually involves erosion of the outside (concave bankline) of bends and deposition on the inside or opposite banks. Avulsion, an entirely different process, refers to the diversion of the entire river or a large fraction of the river through a newly eroded channel across the floodplain. Frequently, avulsions occur across the necks of meander bends. During a high flow, floodwaters follow a more direct route straight down the river valley than passing around a bend, triggering erosion of a new channel that captures flow and becomes the new river channel even after the flood recedes.

Lateral migration may be rapid or gradual, while avulsions are normally rapid, occurring during a single flood event. Meandering rivers may be classified as stable or actively meandering based on the rate and magnitude of change (Lagasse et al. 2004). Stable meandering channels do not migrate appreciably over many decades because they have insufficient stream power to erode their banks. These kinds of channels are also referred to as "moribund" (Thorne et al. 1996). An actively meandering channel has sufficient energy to deform its channel boundaries through bed scour, bank erosion and point bar growth. It is important to note that the term, "meandering," as used here refers only to the river planform and not its dynamism, stability, rate of lateral migration or to the process of meander formation and migration. Rivers may be classified based on their planform as straight, meandering, braided or anastomosing (Thorne et al. 1997). Typically, any river with a single thread channel and a sinuosity greater than about 1.5 is classified as meandering, although some writers set the threshold as low as 1.25.

Lagasse et al. (2004) present a classification scheme for rivers partially based on earlier work by Brice (1975), which is based on planform, width variation, and sandbar patterns. Meandering channels may be classified based on sinuosity, planform (single thread, braided, or anastomosed) and other morphologic characteristics. The Lagasse scheme was developed to assist engineers in evaluating the stability of river channels and assessing the risk posed to transportation infrastructure (roadways, railroads, bridges, etc.) by channel erosion processes such as lateral migration, avulsion and bank erosion.

In order to allow for the preliminary study of the San Jacinto River morphology and related processes required to prepare this report, a web-based GIS was produced using historical maps and aerial photographs as layers. All layers were georeferenced to a common coordinate system, and all aerial photo coverages were orthorectified. More in-depth analysis of this

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[3] The term "fluvial processes" used herein refers to the transport of water and sediment by river currents, waves and tides. These processes have the potential to modify beds and banks of channels and estuaries. Fluvial processes are distinct from impacts of human activities such as mining, channel dredging and regional or global sea level rise.

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information would include assessing effects of water level variation, major hydrologic events and cultural activities between coverages, and quantitative measurement of areas and distances comprising key morphologic features.

Lake Houston was impounded in 1953, and major effects of subsidence and dredging were manifest at the Site after about 1960. Basedon pre-1960 maps and aerial photographs, the San Jacinto River between the Lake Houston dam site and the Buffalo Bayou confluence (located about 2.3 miles down river from the I-10 crossing) may be classified using the Lagasse et al. (2004) scheme as a type B1, single-phase meandering equiwidth channel (sinuosity = 1.54, width nearly constant, bars almost absent, minimal braiding). This type of meandering channel is characterized by static or stable conditions and low rates of lateral migration in contrast to actively meandering channels. Figure 1 graphically depicts the stability of the entire reach, with almost no variation in channelplanform, width or position between 1916 and 1955 (The 1920 USGS topographic map was based on 1916 survey data). The static position of concave banklines (outsides of bends) is particularly striking. Both maps show that floodplain land bordering the convex (insides of bends) are nearly level and low-lying. Aerial photos of the reach from 1944 and 1953 (Figure 2) and of the Site itself from 1953, 1964 and 1966 (Figure 3) suggest that these areas were lightly vegetated wetlands or tidal flats. The 1920 topographic map has contour intervals of 1 ft and shows the top of the bluff at Lynchburg on the Crosby Road has an elevation of 35-40 ft above mean sea level (MSL). The water surface elevation depicted on this map in the same vicinity appears to be about 2 ft above MSL. Although the datum for these two early maps is uncertain, it is worth noting that land surface elevations on the 1955 map are similar to the 1920 map.

By the mid-1960s, change is apparent in the water surface area of the reach of the San Jacinto River between Banana Bend Oxbow and the Northern Impoundments (Figure 4). At the Northern Impoundments themselves, the concave (eastern) side of the bend, normally the location of bank erosion in an actively migrating meander, remained in the same location as in 1916. However, the water area on the opposite (western) side of the channel expanded. The main channel position remained stable, but water area expanded due to dredging and subsidence. Although the overall natural form of the channel was masked by the effects of human activities (dredging and subsidence), the channel remained stable with respect to fluvial processes. The main channel has not changed course. The observed morphologic changes in the reach of the river containing the Northern Impoundments and Southern Impoundment were apparently not due to dynamic fluvial processes but to dredging and subsidence. For example, the location of the channel thalweg [4] and the relatively high elevation (shallow water) along the convex (western) side of the channel (point bar) are still obvious despite expansion of water width (Figure 5).

Despite the effects of land subsidence, in-channel and floodplain sand mining and other anthropogenic impacts, the overall stability of the San Jacinto River alignment over the last century is remarkable. The 1920 USGS map, based on a 1916 survey, is shown along the 2014

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[4] Thalweg is defined as a curve connecting the lowest points of successive cross-sections along the course of a river.

National Agriculture Imagery Program coverage in Figure 6. A trace of the water's edge from the 2014 image is superimposed on the 1920 map in Figure 7. Although low-lying bar and tidal flat surfaces have been flooded due to land subsidence, the coincidence of the higher banklines is noteworthy. Similar overlay of banklines from 1953 aerial photography on the 2014 image is presented in Figure 8, and high banklines again coincide.

Dredging. Dredge cuts in this area are apparent in aerial photographs from the mid-1960s as arcuate shorelines (e.g., Figure 3). US EPA (2016b) notes, "Dredging and sand mining by others within the river and marsh to the west andnorthwest of the waste pits through the 1990s and early 2000s ….. Historical documents indicate that dredging actions also occurred in the river in the vicinity of the upland sand separation area located to the west of the Northern Impoundments (sand separation area)….."

Subsidence. A region of major subsidence is centered on the Site. Historical subsidence of up to 10 ft between 1906 and 1979 in the vicinity of the Site has been reported by the Harris Galveston Subsidence District, Bawden et al. (2012), Dellapenna (2016) and Al Mukaimi et al. (in preparation). Maps provided by the Harris Galveston Subsidence District show that both the Northern and Southern Impoundment areas subsided 8 to 9 ft between 1906 and 2000 (Figure 9). Subsidence at the Site is evident when the 1920 and 1967 topographic maps are compared, assuming the datums (given as MSL for both maps) are compatible. Examination of the 1920 and 1955 topographic survey maps indicate that the low lying lands that were submerged prior to the 1967 survey and the 1977 photo shown in Figure 2 were less than 10 ft above MSL, and thus subject to inundation due to this much subsidence. Data describing recent subsidence in the vicinity of the Site (e.g., Harris Galveston Subsidence District) show little subsidence since 2007, and about a foot of subsidence since 1973. Kearns et al. (2015) found that subsidence in the southeastern region of the Houston metropolitan area has nearly ceased, with rates < 3 mm/yr for 2005-2012. In fact, slight land rebound has been observed at some sites along the Houston Ship Channel since 2005. Subsidence has been arrested by institutional controls on groundwater extraction are in place at the regional scale and that are entirely independent of decisions or actions related to the Site. Typical charts of subsidence data for monitoring instruments in the vicinity of the Site are presented in Figure 10 and additional data are available at http://hgsubsidence.org/subsidence-data/.

In conclusion, the assertion that the aerial photograph record indicates that the river is "very dynamic" is flawed because it makes no distinction between morphologic effects due to land subsidence processes (which have virtually ceased), dredging and sand mining (now restricted in the river reach containing the Northern and Southern Impoundments (Coleman (2009)), and the effects of fluvial processes. With respect to fluvial processes, the evidence from maps and aerial photographs suggests a very stable type of river, and the historical behavior of the channel over the last century is consistent with the hypothesis that the San Jacinto River behaves in a very stable, near-static fashion as do other rivers with similar morphology.

3 EPA Assertion #2. The San Jacinto River is a very dynamic system, subject to changes in size

and flow paths as experienced during the 1994 storm[5].

Please note that the above response to Assertion # 1 addressed the comment that the aerial photograph record shows that the river is "very dynamic." Below we address the assertion that the river in the vicinity of the Site is susceptible to changes such as those observed during the 1994 flood event. Assessment of river behavior for sites such as this one should be done using standard protocols and tools (e.g., Thorne et al. 1997, Hayter et al. 2014). The PRAP (EPA 2016a) extrapolation of rates of channel change from upstream reaches (i.e., Banana Bend and Banana Bend oxbow as described by National Transportation Safety Board (1996)) to the reach immediately adjacent to the Northern Impoundments is not supported by evidence or logic, as outlined below.

San Jacinto River reaches upstream from the Site are more fluvial and less subject to hydraulic control by sea level than the reach extending downstream from the Site to Galveston Bay. In general, the channel upstream from the Site is narrower and more sinuous than for the reach extending downstream from the Northern and Southern Impoundments. These upstream areas also have experienced different levels of impact due to operation of Lake Houston, floodplain sand mining, and subsidence. Downstream morphologic effects of dams and the reservoirs they create diminish with distance below the dam (Graf 2006). Floodplain sand mining impacts at the upstream sites were significant enough to produce erosion of high flow channels across meander necks, but similar channel activity did not occur in the meander bend adjacent to the Northern and Southern Impoundments. Observed historical subsidence also diminishes as one moves upstream from the Site (Figure 9). In short, the channel changes upstream from the Site during the 1994 flood that were described in the PRAP and by NTSB (1996) reflected different conditions than those at the Site. In the absence of these conditions (narrower, more sinuous channel; more fluvial conditions; less subsidence; more floodplain sand mining; closer to Lake Houston dam), we should not expect similar channel behavior in the river reach adjacent to the Northern and Southern Impoundments as was observed upstream in 1994.

The observed 1994 flood behavior at Banana Bend Oxbow and Banana Bend may be regarded as an avulsion in distinction to the more gradual process of lateral channel migration associated with erosion of the outsides of meander bends. However, it is more properly termed, "floodplain erosion," or "erosion of high flow channels," since the floodplain erosion was not extensive enough to capture river flow at stages lower than flood stage. The location of the Banana Bend

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[5] The text of the PRAP continues, "The 1994 flooding caused major soil erosion and created water channels outside of the San Jacinto River bed. This flooding caused…….new channels created in the flood plain outside of the San Jacinto River boundaries. The largest new channel was cut through the Banana Bend oxbow just west of the Rio Villa Park subdivision, about 2½ miles northwest of the Site. This new channel was approximately 510-feet wide and 15-feet deep. A second major channel cut through Banana Bend just north of the channel through the Oxbow. Both of these new channels were cut through areas where sand mining had been done before, as is the case in the vicinity of the Site."

Oxbow floodplain erosion that occurred in the 1994 flood event (Figure 11) was coincident with the location of sand mining on a meander neck. The location of the sand mine was highly conducive to floodplain erosion during a flood because it presented floodwaters with a slope advantage of 8.8 (= 19,086 ft/2,168 ft = length of flow path around bend divided by distance across meander neck). Almost the entire path taken by the eroding floodwaters had been excavated prior to the flood. The area disturbed by sand mining on the 1989 Google Earth coverage of this site occupies 1,938 ft of the 2,168 ft-long-path eroded across the meander neck in 1994. In the case of Banana Bend (Figure 12), the location of the high flow channel that eroded through the floodplain just east of the River channel during the 1994 flood was also coincident with extensive floodplain sand mining. Institutional controls are available to restrict activities such as floodplain sand mining (US EPA 2016b). For example, the USACE 403(b) permitting process can be used to limit sand mining in the San Jacinto River,[6] and additional restrictions have been placed on permitted activities in the reach containing the Northern and Southern Impoundments under Clean Water Act Section 404 and Rivers and Harbors Act Section 10 (Coleman 2009).

Logically, fluvial erosion that might impact the Northern or Southern Impoundments or any specific area along any river could occur in three locations: distant from the area, adjacent to the area, and through the area.

- Erosion distant from the area (e.g., erosion of a high flow path or avulsion of the main channel that created an alternate route for the channel) would reduce hydraulic loading and erosion potential at the Site itself.
- Erosion alongside the area (e.g., river erosion immediately adjacent to one of the Impoundments) might pose a hazard of undermining protection structures such as an armored cap (Northern Impoundments) or existing industrial structures and soil overburden (Southern Impoundment). In the case of the Northern Impoundments this risk could be quantified using simulation models and addressed by cap design features such as more gradual side slopes or reinforced toe sections sized with appropriate factors of safety as proposed by Alternative 3aN of the PRAP. In the case of the Southern Impoundment, undermining of the Impoundment due to local scour along its margins would require realignment of river flow under the I-10 bridges and then removal by erosion of much of the peninsula containing the Southern Impoundment and structures now on the peninsula. This type of major flow realignment is unlikely in light of the fact that the channel alignment has been stable for the past century. Furthermore, undermining scour along the margins of the Southern Impoundment would undermine the considerable volume of soil overlying

[6] Hayter et al. (2016), notes: "A TxDOT Agreement was put into place during TCRA construction in which TxDOT is required to receive a three-day notice before commencement of construction activities, and requires TxDOT to be provided notice should any future construction disturb sediments in the San Jacinto River…"

the Southern Impoundment[7] and this material would then slump into the scour, retarding its progress.

- The risk of erosion through the Site has been asessed by simulation models (Hayter et al. 2016, AQEA 2012) and, in the case of the Northern Impoundments, may be addressed by protective measures (armored cap) sized with appropriate safety factors also as proposed by Alternative 3aN. The risk of erosion through the Southern Impoundment could be assessed by the same simulation studies.

4 EPA Assertion #3. Sonar tests in a 130-foot section south of the I-10 Bridge located adjacent to the Site found about 10 to 12-feet of erosion from the bottom of the river bed.

Channel scour downstream from bridges (such as that observed downstream of the I-10 bridge as a result of the 1994 flood) or other hard structures is not indicative of scour processes that will be operative at the Northern impoundments in the future, unless a bridge is built immediately upstream. Sonar examinations of the riverbed in the vicinity of the Interstate 10 crossing after the 1994 flood are described by NTSB (1996): "The Texas Department of Transportation evaluated the extent of scour around the substructure of critical sections of the two Interstate 10 bridges (east- and west-bound). The results of the sonar tests performed on October 21–22, 1994, documented 12 locations in the main channel for distances up to 130 feet south of the east-bound Interstate 10 bridge."

During this extreme event, scour was limited to a region in the main channel 130 ft south (downstream) from the east-bound bridge. Scour was not reported upstream from the crossing, between the bridges or outside the main channel. The Northern and Southern Impoundments were not scoured during the 1994 flood, despite the 10-12 ft of scour in the main channel downstream from the bridge and the fact that the Northern Impoundments were not capped at the time.

The peninsula containing the Southern Impoundment is immediately downstream from the Interstate 10 crossing, but it would be impacted by bridge scour only in the event of a major realignment of the San Jacinto River main channel. As noted above, that channel has been stable and nearly static for a century and exhibits characteristics similar to stable rivers found elsewhere. Such a major realignment would be highly unlikely.

5 EPA Assertion #4. These changes (i.e., loss of land at the waste pits site due to erosion and subsidence) will likely continue in the future.

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[7] Soil borings into the Southern Impoundment indicate dioxin and furans associated with paper mill wastes are buried by a layer of soils about 4 to 5 ft thick. One boring found TEQ above background within 1 ft of the surface. In other cases, the overburden had TEQ at or below background.

As noted above, the major driver of historical land loss at the Site was subsidence, which has been arrested by institutional controls such as those on groundwater extraction. Additional historical land loss was due to sand mining and in-channel dredging, which are now also restricted or banned in this area. It follows that land loss due to these factors should not continue in the future unless the driving factors are re-activated. At any rate, scientific data and tools are available to quantify risk regarding future morphologic changes impacting the Site (Hayter et al. 2014).

6 EPA Assertion #5. Corps (Hayter et al. 2016) models (and any existing sediment transport model) cannot simulate river channel changes due to bank erosion, shoreline breaches, etc. during a high flow event caused by a major flood or hurricane. Therefore, the model predictions should be considered as having a very limited long-term reliability.

Models are developed to evaluate specific situations or answer specific questions. Models themselves do not represent predictions; however, interpretations of model output can be used to predict future outcomes. Models can also be used to simulate a hypothetical scenario in order to evaluate a possible future state. Model uncertainty can be evaluated and quantified.

As noted in the PRAP, the Corps' hydrodynamic simulation model (Hayter et al. 2016) does not predict lateral movement or avulsion of the channel. Accordingly, the 2D hydrodynamic models (Hayter et al. 2016, AQEA 2012) have not been used to evaluate potential larger scale river processes such as localized bank erosion, channel migration, or avulsion. To date, the models have been used to answer specific questions related to conditions directly adjacent to the cap.

However, notwithstanding their limitations,these and similar models can quantify shear stresses impinging on the Northern and Southern Impoundments under "worst-case" extreme events (or more frequent) events. Evaluation of these stresses in light of critical stresses needed to erode the channel boundaries and floodplains can give an indication of the potential for channel migration or avulsion to initiate. Such an evaluation should consider reaches up- and downstream from the Site. In fact, models developed by Hayter et al. (2016) in support of the PRAP might have been used to perform such an analysis if they captured stresses on the floodplain during overbank flow conditions. However, the work plan presented by Hayter et al. (2016), requested by the EPA, did not include this task.

The current version of HEC RAS 5.0 includes the USDA-ARS Bank Stability and Toe Erosion Model (BSTEM). Although it cannot simulate large-scale channel change, it can simulate bank erosion. This model could have been used to examine bank erosion rates and erosion potential under various scenarios. Recently-developed, "morphodynamic" simulation models (e.g., Langendoen et al. 2015 and 2016) simulate lateral channel migration and predict future channel alignments. Thus, contrary to EPA's assertion, simulation of avulsions (cutoffs) and subsequent channel response would have been possible.

7 EPA Assertion #6. Future storm intensity and flooding may be even more intense due to climate change, sea level rise, and continued urban development.

Greater submergence due to sea level rise may further reduce hydraulic loads during the most extreme events. The Northern Impoundments' location just upstream of the I- 10 crossing and rising sea level will place it under backwater conditions and in a depositional rather than erosional environment for the most extreme events. In fact, considering a wide range of events, the Site is already depositional. Hayter et al. (2016) found that net average long-term sedimentation rate averaged over the area of the existing cap is 1.3 cm/yr. ± 0.8 cm/yr. Similar findings were reported by AQEA (2012).

It is assumed that as additional information becomes available about storm intensity and hydraulic loadings under future climate and sea level scenarios, these data could provide a basis for quantitative analysis. If appropriate engineering analyses indicate potential for unacceptable hydraulic loading on the Impoundments or river channel movement over the period of interest, there are structural measures (river training structures such as groins, spurs, jetties, revetments or bank protection structures) that could be designed, in accordance with standard guidance and with appropriate factors of safety, to address such conditions.

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Figure 1. Side-by-side comparison of 1916 and 1955 topography surrounding San Jacinto River, Texas.

1916 USGS Survey (1920 Map)

1955 USGS Survey (1955 Map)

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Figure 2. Side-by-side comparison of Google Earth aerial photo coverage of San Jacinto River, Texas between Lake Houston Dam site and Burnett Bay (a) dated December 31, 1943 (listed as 1944), and (b) December 31, 1952 (listed as 1953). Red curve on photos is channel centerline from 1995 USGS topographic map.

Figure 3. Aerial photograph of waste pits site dated (a)dated October 10-28, 1953, (b) October 7-15, 1964, and (c) October 16, 1966. Photos a and b from National Environmental Title Research, historicaerials.com. Photo c from Figure 4 of PRAP (US EPA 2016a).

a

b

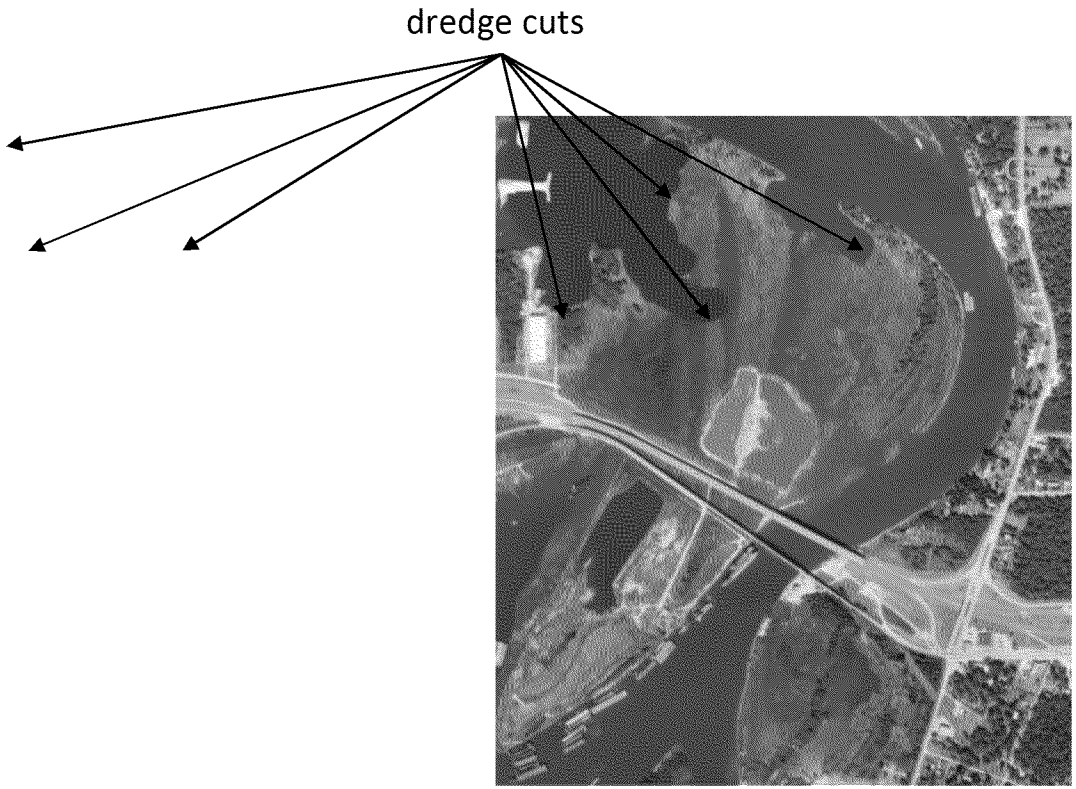

Figure 4. Side-by-side comparison of 1967 map and 1977 aerial photography of San Jacinto River, Texas.

1966-67 USGS Survey (1967 Map)

1977 Aerial photography (Google Earth)

Figure 5. (a) Transparency of October 16, 2014 aerial photo (NAIP) of Site overlaying 1920 USGS topographic map. Note tow moving downstream along 1916 thalweg in 2014 photo while just to the south barges are parked in shallows above the 1916 bar (black box).(b) Interpolated surface map of combined 2009 and 2010 bathymetric surveys inside the USEPA Preliminary Site Perimeter (from AQEA 2012).

a

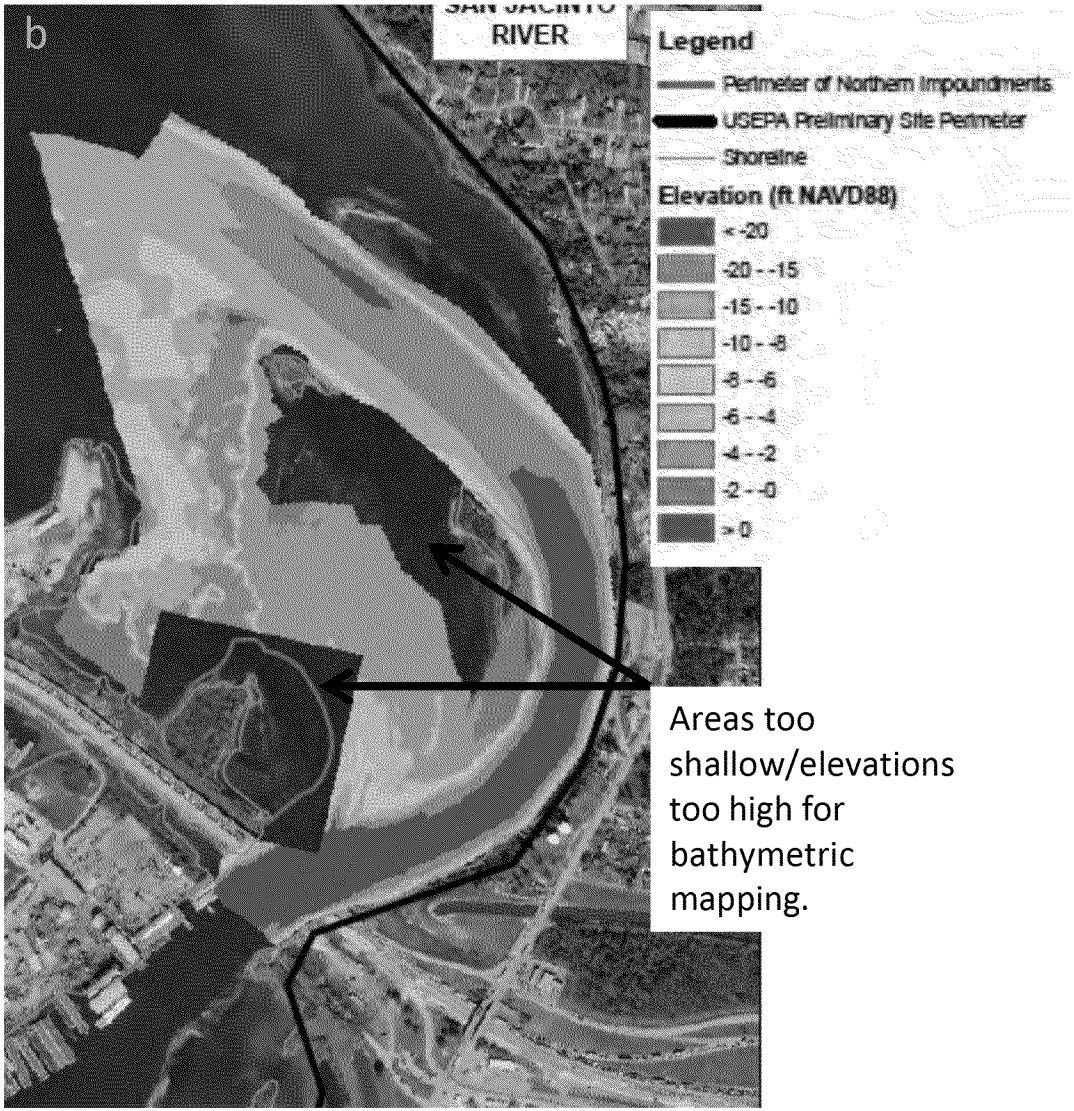

Figure 6. Side-by-side comparison of 1916 topography and 2014 aerial photo of lower San Jacinto River, Texas.

1916 USGS Survey (1920 Map)

2014 NAIP

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Figure 7. USGS 1920 topographic map based on 1916 survey with overlay of water boundary from 2014 NAIP aerial photo coverage. Although low lying areas flanking the 1916 channel have been flooded due to land subsidence by 2014, note the stability of the higher banks (arrows).

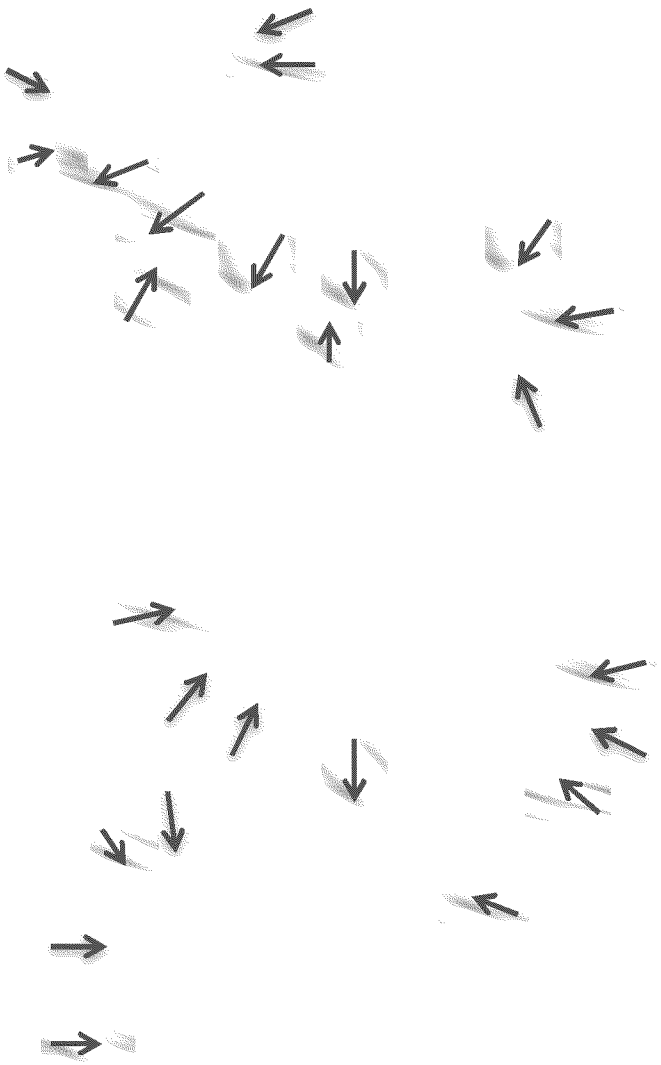

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Figure 8. 2014 NAIP aerial photo coverage with overlays of water boundaries from 1953 aerial photo coverage (red) and 2014 NAIP aerial photo coverage (magenta). Although low lying areas flanking the 1953 channel have been flooded due to land subsidence by 2014, note the stability of the higherbanks as in Figure 7 (arrows).

Figure 9. Subsidence map of region surrounding Site. Inset is enlargement of area around I -10 crossing (yellow curve) of the San Jacinto River. From Harris Galveston SubsidenceDistrict (http://hgsubsidence.org/).

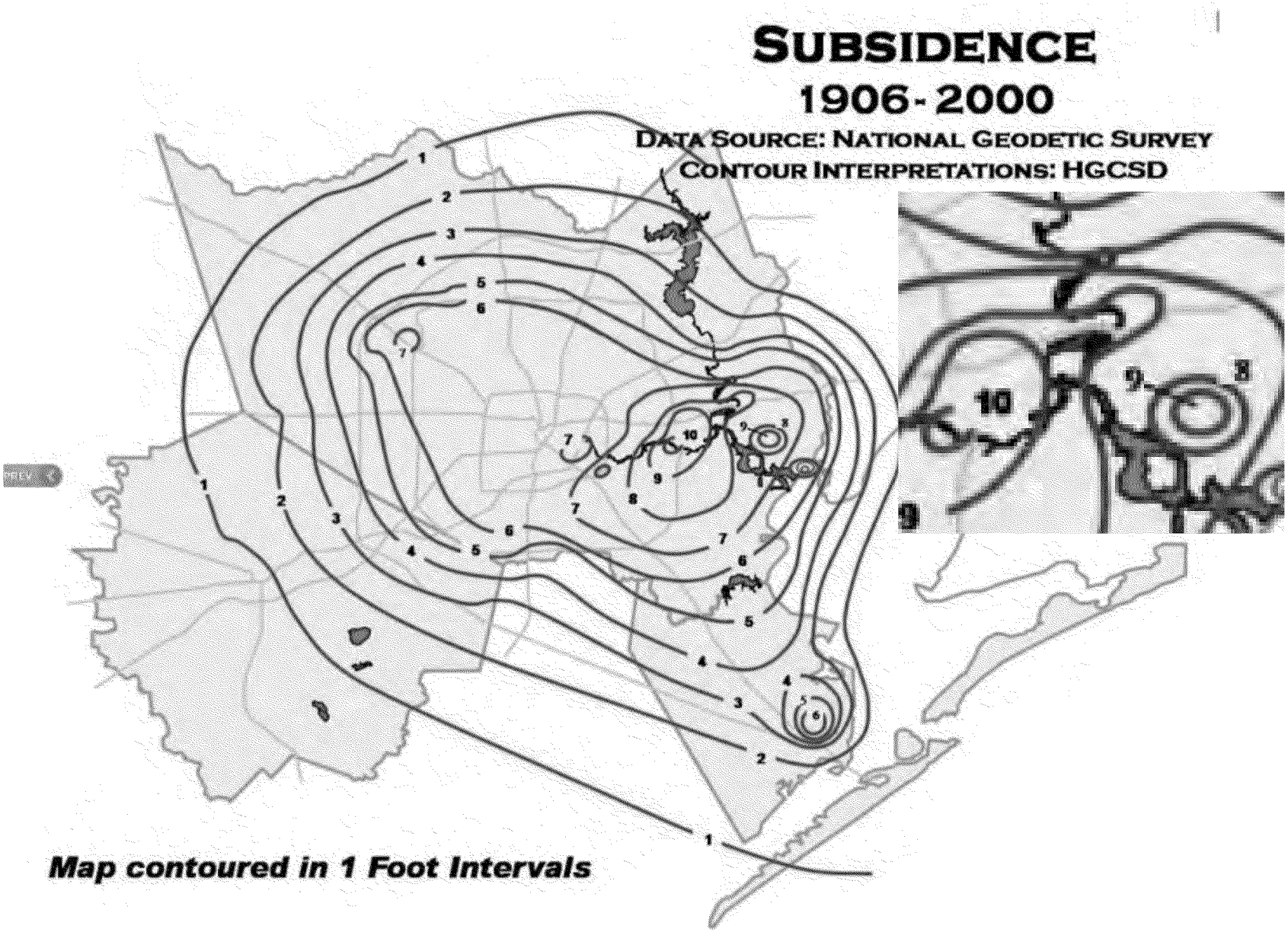


Figure 10. Typical subsidence data for instruments in vicinity of Site (yellow rectangle). From Harris Galveston Subsidence District. http://hgsubsidence.org/subsidence -data/

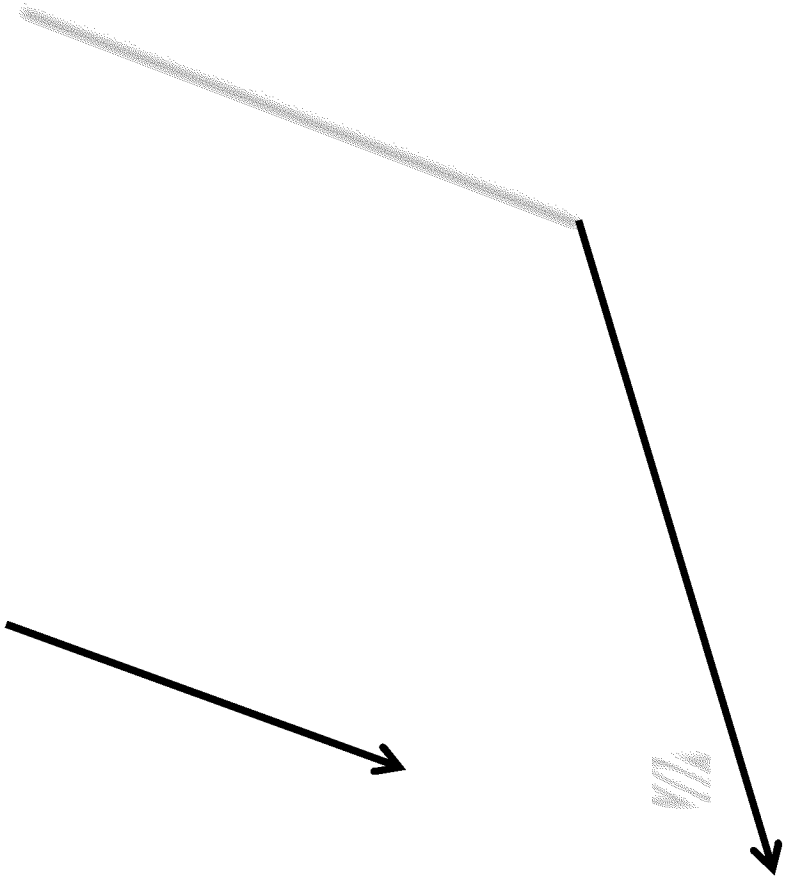
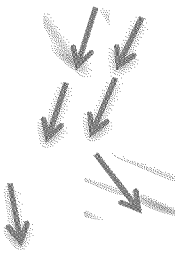


Figure 11. Aerial photographs of Banana Bend Oxbow before and after 1994 flood.

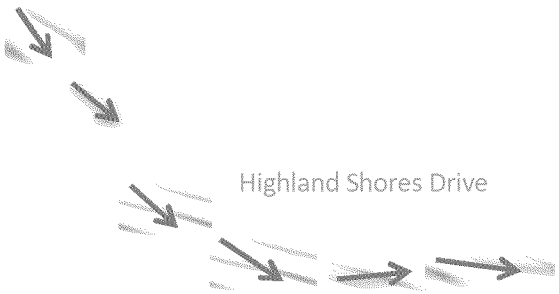


Banana Bend Oxbow in 1978 before 1994 flood. Note sand mines on left side of photo. From Google Earth.

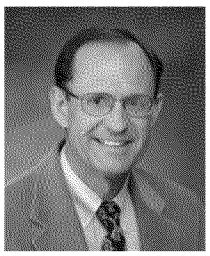
Banana Bend Oxbow in 1995 after 1994 flood. Erosion during overbank flow created a high flow channel across neck coincident with sand mines. From Google Earth.

Figure 12. Aerial photographs of Banana Bend before and after 1994 flood.

Banana Bend in 1989 before erosion of high flow channel in 1994 flood. Note sand mines in center of photo. From Google Earth.



Banana Bend in 1995 after 1994 floodplain erosion. Evidently the flooded mine complex to the north of Highland Shores Dr connected with the channel to the south to provide a path for high flows across the floodplain. From Google Earth.



F. Douglas Shields, Jr., Ph.D., P. E., D.WRE
CONSULTING HYDRAULIC ENGINEER
SHIELDS ENGINEERING, LLC

850 INSIGHT PARK
UNIVERSITY, MS 38677
www.friendofrivers.com

662.380.3944
662.236.1926
doug2shields@gmail.com

Doug Shields has 40 years of experience in water resources and environmental engineering, including 12 years for the U.S. Army Corps of Engineers and 22 years as a Research Hydraulic Engineer at the National Sedimentation Laboratory in Oxford, Mississippi. Dr. Shields' research focuses on response of fluvial systems to human influences and development of environmental design criteria for all types of channel stabilization and modification projects, including stream bank erosion controls and management of riverine backwaters. He is a leading authority on stream and river restoration. Doug has authored or co-authored more than 300 technical publications and has completed consulting projects dealing with stream restoration, erosion protection of riparian cultural resources sites, stream bank erosion, geomorphic assessment, and local flooding.

Current position

Principal and Hydraulic Engineer, Shields Engineering, LLC

Hydraulic Engineer, cbec eco engineering, Sacramento, California (part time)

Education

1983-87 Colorado State University; Hydraulics; Ph.D. 1987, 4.0/4.0

1975-77 Vanderbilt University; Environmental and Water Resources Engineering; M.S., 1977, 4.0/4.0

1971-75 Harding University; major, mathematics, minor, physics; B.S summa cum laude, 1975 3.9/4.0

Certification

Registered professional engineer in the State of Mississippi since 1981, number 08360.

Career

1977-78 Instructor and Research Associate, Department of Civil Engineering, Tennessee State University, Nashville, Tennessee.

1978-80 Hydraulic Engineer, Nashville District, U.S. Corps of Engineers

1980-90 Research Civil Engineer, U.S. Army Engineer Waterways Experiment Station (WES).

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1986-87	Supervisory Research Civil Engineer, Acting Chief, Water Resources Engineering Group, WES
1990-2012	Research Hydraulic Engineer, USDA, ARS, National Sedimentation Laboratory, Oxford, Miss.
1994-pres	Adjunct professor, Department of Civil Engineering, University of Mississippi
2012-pres	Principal, Shields Engineering, LLC, Oxford, MS
2012-pres	Hydraulic Engineer, cbec eco-engineering (part time)

Stream and River Restoration Experience

1991-1993	Responsible for site selection, real estate, planning, design and direction of construction for three stream restoration projects in incised channels in northwestern Mississippi. Treatments included instream weirs, riprap toe protection, spur (wing) dikes, and willow planting on a total 10,000 linear ft of channels. Monitoring continued for up to 11 years, including collections from degraded and pristine reference sites. All research findings have been published in refereed literature.
1998-2006	Responsible for site selection, real estate, planning, design and direction of construction for a 6000 ft stream restoration project in central Mississippi. Channel treatments were limited to plant materials (large wood, willow cuttings, switchgrass plantings). Monitoring continued through 2004. Research was interdisciplinary and involved scientists from several universities and government agencies. Research findings have been published in refereed literature.
2000-2001	Identification of environmental enhancement opportunities for an urban river corridor, Menominee River Watershed Assessment, Milwaukee, WI. Subconsultant to Interfluve, Inc.
2001-2003	Developed software to advise users on selecting appropriate environmentally sensitive channel- and bank protection measures for a given site. Subconsultant to Salix Applied Earthcare on contract with National Cooperative Highway Research Program.
2004-2005	Development of channel stabilization plan for Kinishba Wash at Kinishba Ruins, Arizona, Subconsultant to Nickens and Associates.
2006	Assessment of performance of biotechnical stabilization of Hasotino cultural resources site, Snake River, Washington. Subconsultant to Nickens and Associates.

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2006	Design of Miller Creek restoration project, Mobile, Alabama. Subconsultant to Volkert and Associates. Project intended to rehabilitate stream from damages produced by illegal modifications and featured extensive use of large wood.
2007-2008	Geomorphic analysis to support planning for Amite River restoration project, Louisiana. Subconsultant to Taylor Engineering. Lead author on literature review and field assessment of geomorphic status of major river system.
2008-pres	Expert review panel, Sacramento Area Flood Control Agency and California Levee Vegetation Science Team. Review of comprehensive effort to assess effects of trees and tree removal on earthen flood control levees.
2009	Headwaters Corporation, Kearney, Nebraska. Expert review of Platte River Recovery Implementation Program Monitoring Protocol for Channel Geomorphology and In-Channel Vegetation.
2011 – 2012	Subconsultant to cbec, inc. eco engineers, West Sacramento, California. Swift Slough restoration feasibility and design alternative analysis. Assist team with development of design alternatives to enhance the hydrologic connectivity of Swift Slough, a major backwater on the Apalachicola River, Florida.
2012-2015	Subconsultant to ICF International. Preparation of national guidelines for placement of large wood in streams. Team project.
2012-2016	Member of Russian River Independent Science Review Panel, California Land Stewardship Institute. Holistic assessment of water use and ecological impacts in Russian River watershed, northern California.
2012-pres	Hydraulic engineer, cbec, inc. eco engineers, West Sacramento, California. (part time). Senior level review and advisory activities on Southport Early Implementation Project levee setback, development of guidance for Rapid Stream Stability Assessment for use by Caltrans, and other projects.
2013-pres	Subconsultant to Ayres and Associates, Fort Collins, Colorado. Evaluation and Assessment of Environmentally Sensitive Stream Bank Protection Measures. Project funded by Transportation Research Board, National Cooperative Highway Research Program (NCHRP Project 24-39). Work with interdisciplinary team to develop quantitative design guidance for biotechnical bank protection measures.

Experience as an Expert Witness

1993	Retained as expert witness by Mr. Dana Swan, partner, Chapman, Lewis & Swan, Clarksdale, MS. Case involved erosion of a stream channel bank and attendant damage to client's property following work on the channel by a real estate developer. Following my deposition, developer settled outside of court.

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2006 Consultant to Village of Taylor, MS. Provided an examination of runoff, storm drainage, erosion and sedimentation issues surrounding design of the Main Street Taylor Development. Acted as consultant at request of Freeland and Freeland law firm, Oxford, MS.

2008 Retained as an expert consultant and potential expert witness by Orrick, Herrington & Sutcliffe LLP Sacramento, California, counsel to Robert Mori and Robert Mori II in the case of Mori II v. Baroni, et al. I was never called upon to serve.

2010 Retained as an expert witness by Daniel, Coker, Horton & Bell, Oxford, MS. Case (Crockett et al. v. City of Saltillo, MS) involved flooding of a subdivision. I prepared a preliminary report and a work plan for more detailed analysis. Case was settled out of court.

2013 Retained as an expert witness by Daniel, Coker, Horton & Bell, P. A, Oxford, MS. Case (Kmart Corporation v. City of Corinth, MS. et al.) involved flooding of a retail shopping center. I assessed the evidence in the case and critiqued analysis and report by plaintiff's expert. Case was settled out of court.

2014 Retained as an expert by Wheeler and Howorth, landowners adjacent to Shaw Place, an antebellum home surrounded by 5 acres inside the City of Oxford, MS. Provided a written report and testimony before the City Planning Commission regarding effects of development on runoff and erosion. Case settled prior to litigation.

2015 Retained as an expert by Lafayette Civic Center in pre-litigation examination of erosion and sedimentation impacts on small lake related to adjacent earthmoving activities. Matter is pending.

2015 Retained as an expert by Willoughby and Hoefer, P. A., Columbia, SC. Case (Snyder et al. v. SCE&G) involves assignment of responsibility for extensive flooding of residential areas during high flow events associated with Hurricane Joaquin in October 2015. Matter is pending.

2017 Retained as an expert by Baker Hostetler, LLP Los Angeles, CA. Addressed concerns raised by USEPA regarding a riparian Superfund site by performing a qualitative geomorphic assessment of lateral channel stability of San Jacinto River, Texas. Matter is pending.

Direction of Graduate Research

1997. Martin W. Doyle. Bed material size trends in incised channels. M.S. Thesis, University of Mississippi.

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2001. Nathalie Morin. Specific gravity of naturally occurring large woody debris in the river environment. Internship report, L'INRS-Eau, Terre et Environment (in French).

2005. John M. Stofleth. Hyporheic and Total Storage Exchange in Small Sand-Bed Streams. M.S. Thesis, University of Mississippi.

2012. Mary A. McCaskill. Bacterial and sediment transport in an artificial sand bed stream during unsteady flow. M. S. Thesis, University of Mississippi.

Membership in Professional Societies

- Fellow, American Society of Civil Engineers
- Fellow, Environmental and Water Resources Institute
- Diplomate, American Academy of Water Resources Engineers
- Order of the Engineer
- American Geophysical Union

Awards

2008	Diplomate, American Academy of Water Resources Engineers
1999	Bronze Award, U.S. Environmental Protection Agency Office of Water
1997	American Society of Civil Engineers Hydraulic Engineering Achievement Award, Mississippi Section
1984	American Society of Civil Engineers (ASCE) Zone II Young Government Civil Engineer of the Year
1983-1984	U.S. Army Corps of Engineers Civil Works Fellowship
1975-1976	Energy Research and Development Agency trainee fellowship, Vanderbilt University

Offices and Committee Assignments Held in Professional and Honorary Societies

1986 –1990	Control member of American Society of Civil Engineers Task Committee on Aquatic Habitat and Sedimentation
1991-1995	Corresponding member of American Society of Civil Engineers Task Committee to update *Sedimentation Engineering* Manual and Report on Engineering Practice No. 54
1994 –2005	Board of Governors, Order of the Engineer, The University of Mississippi, Link No. 149

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1996-2007	Control member of American Society of Civil Engineers Task Committee on Sedimentation Engineering for River Restoration
2007-2009	Chair of American Society of Civil Engineers Hydraulics and Waterways Committee
2012-2013	Vice Chair, American Society of Civil Engineers River Restoration Technical Committee
2013	Chair, American Society of Civil Engineers River Restoration Technical Committee
2016	Chair, American Society of Civil Engineers Task Committee on Representation of Vegetation in Two-Dimensional Hydrodynamic Models

Selected Invitations

Invited to present, "Evaluating Impacts of Channel Stabilization Structures on Riverine Habitats," to the meeting of the Environmental Advisory Board of the Chief of Engineers, U.S. Army Corps of Engineers, Denver, Colorado, October 7, 1987.

Invited by the Southern Division, American Fisheries Society to co-author chapter, "Dikes and levees," for book, Impacts on Warmwater Streams: Guidelines for Evaluation, with C. H. Pennington, 1989.

Invited to present, "Engineering Constraints on Riverine Habitat Restoration," Missouri River Mitigation Workshop, Desoto National Wildlife Refuge, Iowa, June 27-28, 1990, U. S. Fish and Wildlife Service. Interagency workshop laid foundation for major mitigation project.

Invited by the Korean Institute of Construction Technology to visit South Korea and present seminar, "Instream Flow Methods to Meet Recreational and Aesthetic Objectives," and discuss current research activities. In concert with this invitation, also invited to deliver keynote address, "Rehabilitation of Watersheds with Incising Channels in Mississippi, USA," to the annual meeting of the Korean Society of Civil Engineers, October 17-23, 1994.

Invited by USDA-Natural Resources Conservation Service to chair interagency team of experts requested to visit North River Watershed in Missouri and to provide transfer of technology developed by the Demonstration Erosion Control Program to landowners, US Fish and Wildlife Service, and State agencies, October 23-25, 1995.

Invited by a consortium of the Environmental Defense Fund, the Bay Institute, and Philip Williams and Associates, all of San Francisco, to serve on an expert review panel for a study preparing a framework Restoration of the San Francisco Bay-Delta-River ecosystem, October 30, 1995—October 1997.

Invited by Ontario Ministry of Ministry of Natural Resources (Canada) to participate in the Temperate Wetland Restoration Workshop in Barrie, Ontario and present, "Physical perturbations on temperate riverine wetlands." The workshop was sponsored by Environment Canada, Ontario Ministry of Ministry of Natural Resources, Ontario Ministry of Environment and Energy, Trent University, and Ducks Unlimited Canada, November 27 - December 1, 1995.

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By invitation of the USDA-NRCS International Conservation Division, worked as part of an interdisciplinary, interagency team to review forested riparian buffer strip research and management practices in Taiwan. The assignment included presenting a lecture on the state of science and ongoing research, touring field research sites on Taiwan with Taiwanese scientists and officials, and co-authoring a memorandum detailing recommendations, June 14-21, 1996.

Invited by the Comite Intergubernamental de la Hidrovia Parana-Paraguay (CIH), Buenos Aires, Argentina to serve on a five-person expert panel to review hydrologic studies conducted to assess technical and economic feasibility and environmental impacts of construction of the Hidrovia project—a collaborative effort among five South American countries to improve navigation conditions along 3,442 km of river using dredging and other channel modifications. The project holds potential for impacting the Patanal, the world's largest freshwater wetland. Due to recommendations of the incumbent and other panelists, governments of the countries involved initiated reconsideration of the project's impacts, November 19-21, 1996.

Invited to serve as a convenor for five technical sessions on stream habitat restoration for the XXVII Congress of the International Association of Hydraulic Research, August 10 15, 1997.

Invited to present keynote address in May 1998 at the International Symposium on River Restoration, Technology Research Center for Riverfront Development, Tokyo, Japan, July 15, 1997.

Invited to serve as examiner for PhD dissertation, "On the role of woody vegetation in riverbank stability," by Bruce Abernethy. Ph.D. thesis submitted to Department of Civil Engineering, Monash University, Clayton, Victoria, Australia, March 1999.

Invited to present lecture, "Ecological engineering in research and practice," to annual meeting of the American Ecological Engineering Society, University of Georgia, Athens, May 1, 2001.

Invited to make presentation "Interactions of riparian zones with aquatic restoration," to American Water Resources Association Summer Specialty Conference on Riparian Ecosystems, June, 2004.

Invited to make presentation on river restoration monitoring to meeting of National River Restoration Synthesis Project, Santa Barbara, California, August 20, 2005. (declined)

Invited to join the National Center for Earth Dynamics Stream Restoration Partners Group, University of Minnesota, February 9, 2005. Later invited to participate in expert panel workshop on training for stream restoration practitioners sponsored by the NCED, April 2-4, 2006.

Invited to chair session and make presentation on large wood in streams at the Sixth Annual Stream Restoration Design Symposium, Skamania Lodge, WA, February 7, 2007

Invited to make presentation, "Stream Restoration Design," and serve on panel for discussion of new ASCE Manual of Practice: Manual 110 Sedimentation Engineering at the Environmental and Water Resources Institute World Water Congress 2007, Tampa, Florida, May 17, 2007.

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Invited to make presentation, "Role of vegetation in bank stability & revetments" and participate in a panel discussion, "Applying the engineering and science to solutions," as part of the Levee Vegetation Symposium organized by Sacramento Area Flood Control Agency (SAFCA). This symposium was sponsored by the Corps, State of California Reclamation Board, California Department of Water Resources and SAFCA to explore science, real-world experience, challenges, and policy solutions related to levee vegetation. The Corps proposed tighter vegetation regulations for earthen levees in the wake of the Katrina disaster, triggering a crisis for local sponsors of levee projects. Registration numbers revealed over 511 people from 21 states nationwide registered for the symposium, representing over 151 agencies from federal, state and local flood management, resource agencies, academic institutions and consulting engineering and environmental firms. August 28-29, 2007.

Invited by the National Oceanic and Atmospheric Administration National Marine Fisheries Service to serve on an expert panel on setting up a process for reviewing proposed stream habitat restoration projects, December 11-12, 2007.

Invited by Natonal Marine Fisheries Service to serve as expert reviewer for River Restoration Analysis Tool, http://www.restorationreview.com/, 2010.

Interviewed by the U.S. Government Accountability Office to provide input to a comprehensive review of the hydrologic and environmental effects of river training structures on the Mississippi River, http://www.gao.gov/products/GAO12-41, 2011.

Invited by Bureau of Reclamation to participate in a Technical Workshop on Large Wood Applications and Research Needs in River Restoration, 2012.

Invited to present a series of lectures on river restoration research and challenges, US Bureau of Reclamation, Denver, CO, 2014.

Invited to present webinars on Stream Restoration by ASCE/EWRI Distinguished Member Webinar Series, 2014.

Advisory activities

Between 1985 and 1990, served as in-house expert for U. S. Corps of Engineers field offices for environmental issues related to stream channel modifications, dredging, and dredged material disposal (nationwide). Consultations (3 to 6 per year) sometimes were limited to telephone conversations, but usually involved face to face meetings, seminar presentations, site visits, literature review, and preparation of letter reports. Typical examples include preparation of a monitoring plan for sediment deposition in cutoff meander bends along the Tombigbee River portion of the Tennessee-Tombigbee Waterway (Mobile District, 1985); field consultation with the New England Division (1986) regarding impacts of gravel mining in Naugatuck River, Connnecticut; seminar for interagency group at Memphis District (1987) regarding application of stream obstruction removal guidelines to the Cache River, Arkansas; field and office consultations regarding habitat restoration within Anacostia River Basin, MD (Baltimore District, 1990).

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Similar short-term consultations were also provided to personnel of other government agencies one to three times per year. Examples included work with the George D. Aiken Resource, Conservation, and Development Area of Randolph, Vermont regarding engineering design criteria for aquatic habitat improvement structures for the Ottauquechee River, Vermont (1984); the Minnesota Department of Natural Resources, regarding selective removal of large woody debris from streams for flood stage reduction (1984);U.S. Fish and Wildlife Service, Bloomington, Indiana regarding incorporation of artificial wetlands in an enlarged channel, (1987); and staff of the New Jersey legislature regarding construction of dredged material containment islands, (1988).

Participated in periodic coordination meetings for the Demonstration Erosion Control Project with technical experts from Corps, NRCS, USGS, and universities. Presented stream restoration research plans and results. Contributed to discussions regarding morphologic evolution of incised channels and attendant impacts on habitat and downstream sediment yield. Meetings included: Stream restoration sites (October 28-29, 1991), Greenwood, MS (August 20, 1992), Hotophia Creek restoration site (January 14, 1992), Waterways Experiment Station Hydraulics Laboratory (September 8, 1992, January 12-13, 1993, February 25, 1993), NSL (October 21, 1993 and April 22, 1993)

Organized briefings and field trips for interagency groups and foreign visitors to incumbent's stream restoration and stabilization research sites for technology transfer, including fellows of the Food and Agriculture Organization of the United Nations (1991), twelve engineers and scientists from the Corps of Engineers, NRCS, U.S. Fish and Wildlife Service, ARS, and the State of Mississippi (1992), Eight engineers and scientists from U.S. Corps of Engineers. Mobile District (1993), two engineers from m Korean Institute of Construction Technology (1993), five engineers and biologists from Baltimore District, U.S. Corps of Engineers working on Passaic River, New Jersey, flood control project (1994), the Options Appraisal Manager, National Centre for Risk Analysis and Options Appraisal, the Environment Agency, England and Wales (1997), six engineers and scientists from Missouri Department of Conservation (1999).

Provided consultation and literature to Executive Director, Golden State Wildlife Federation, Sacramento, CA, regarding effects of levees on riverine and floodplain ecosystems, October 21, 1993.

At the request of the St. Louis District of the Corps of Engineers, worked as part of an interdisciplinary team to provide recommendations regarding aquatic and wetland habitat restoration opportunities associated with repair of levees damaged by the 1993 Midwest flood. Concepts were used by Corps personnel in a report to district managers, November 30-December 2, 1993.

Technology transfer to Stream Program Coordinator, Missouri Department of Conservation, including in-depth discussions, inspection of field research sites, and provision of literature to support programs of stream rehabilitation technology demonstration and transfer to riparian landowners, April 4-5, 1995 and January 21-23, 2003.

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Provided field consultation to hydraulic engineer of the U. S. Corps Engineers Mobile District and research hydraulic engineer of the U. S. Army Engineer Waterways Experiment Station regarding stream restoration design for a 2.5-mile long, $1 million project on Twentymile Creek, Mississippi. (May 22, 1995). Summarized observations in a letter report. Provided additional consultation to hydraulic engineers and biologists of the Mobile District regarding planning and design for restoration structures and plantings for this project, August 31, 1995 and May 14, 1996.

Provided information to Chief of River Engineering Division, Coastal and Hydraulic Engineering Laboratory, U.S. Army Engineer Waterways Experiment Station regarding status and probable environmental impacts of Hidrovia Parana-Paraguay Waterway Project, September 3, 1997.

At the invitation of the U.S. Forest Service, provided on-site consultation and a letter report regarding stabilization and restoration of stream corridors threatened with incision in the Homochitto National Forest, November 2001.

At the invitation of the Corps of Engineers, provided on-site advice and consultation regarding planning and design for restoration of the Salmon River near Challis, Idaho, July 30-August 1, 2002.

Assisted in hosting delegations from Korean Institute of Construction Technology and National Center for Computational Hydroscience and Engineering, University of Mississippi for briefings on river restoration research and tours of NSL, May 29, 2002 and October 15, 2002.

At the invitation of the Michigan Sea Grant Program, provided invited lecture and participated in panel discussion for a workshop on environmentally sensitive streambank and shoreline erosion control, ~100 participants, October 29, 2003.

Provided invited review of research plans for Center for Bottomland Hardwoods Research, Southern Research Station, US Forest Service, May 26, 2004.

Organized workshop on stream restoration research for 25 participants from three states, October 24-25, 2006. Presentations by 8 NSL scientists and tour of restoration research field sites.

National Center for Earth Dynamics Stream Restoration Partners Group, University of Minnesota, invited panel and workshop participation on stream restoration research (2005) and training stream restoration practitioners (2006).

Invited presentation and panel discussion, Levee Vegetation Symposium, Sacramento, California, 500 participants, August 28-29, 2007.

Reviewer for Journal of Environmental Quality, AI Applications in Natural Resource Management, Environmental Management, Soil Science Society of America Journal, Journal of Environmental Engineering, Transactions of the American Society of Agricultural Engineers, Regulated Rivers: Research and Management, Geomorphology, Journal of Hydraulic Engineering, North American Journal of Fisheries Management, Fisheries, Aquatic Conservation, Water Resources Bulletin, Journal of the American Water Resources Association, and Journal of Hydrologic Engineering. Editorial board, Environmental Management, 1999-2003.

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Special assignments

1982-87 Environmental Manual Advisory Group, U.S. Army Engineer Waterways Experiment Station. Responsible for production of a series of manuals to incorporate environmental criteria into standard procedures for design, operation, and maintenance of reservoir, waterway, and flood control channel projects.

1985 Environmental Water Quality and Operational Studies overview briefing team, U.S. Army Corps of Engineers. Team visited Corps field offices and presented seminars summarizing findings of 5-year, $30 million research program. These presentations laid groundwork for ensuing transfer of technology to field offices.

1982-93 Regular lecturer on environmental design considerations for the following annual short courses conducted at the U.S. Army Engineer Waterways Experiment Station:

Streambank Protection

Hydraulic Design of Flood Control Channels

Environmental Aspects of Local Flood Protection Projects

Hydraulic Design for Project Engineers and Planners

1996 Chaired meeting involving scientists from University of Middlesex, U.K. engaged in study of engineering uses of willows, USDA-NRCS plant materials center personnel, active and retired NSL scientists, and visiting scientists. Meeting included briefing on findings of current and recently completed research and visits to field sites. Data and findings were used by visitors in their study, August 23, 1996.

1996 Co-hosted of tour of Demonstration Erosion Control Project watersheds for a group composed of NRCS state conservationists from ten southeastern states, Soil and Water Conservation Commissioners, and other officials.

1997 Served as technical program co-chair and co-editor of Proceedings of the international conference, Management of Landscapes Disturbed by Channel Incision. Conference drew 250 participants from 25 states and 26 foreign countries. (#161)

1999-2004 Served as director of the Little Topashaw Creek Stream Corridor Rehabilitation Project, coordinating work among NSL scientists, cooperators, and landowners. This project provided a setting for interdisciplinary research involving three universities and three federal agencies in areas relating to erosion control, ecosystem rehabilitation, and water quality within an agricultural watershed. To date, this project has provided a basis for 18 proceedings papers, 3 poster presentations, two technical sessions at a national conference, and 11 refereed journal papers. Project hosted field tours by U.S. Corps of Engineers Advanced Streambank Protection Short Course (Twice), scientists and engineers from USDA-NRCS, Mississippi offices, students and professor from Oklahoma State University, and eight scientists from Northeast Forest University, China. Developed website to facilitate technology transfer. (http://ars.usda.gov/Research/docs.htm?docid=5526)

1999 Directed the technical watershed tour for about 35 participants in the US-China Bilateral Workshop: Sediment management in agricultural watersheds.

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2004 Directed the technical watershed tour for the Third International Conference on Gully Erosion (GEC III).

2004-2010. Served as coordinator of Coldwater River Watershed Rehabilitation project. This project is an investigation of riverine backwater management to yield ecological services in the agricultural landscape. Developed website to transfer initial findings. (http://www.ars.usda.gov/Research/docs.htm?docid=12773)

2007-2008 Served as the technical publications co-chair for the conference, "The National Sedimentation Laboratory: 50 Years of Soil and Water Research in a Changing Agricultural Environment."

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Peer-Reviewed Publications

Shields, F. D., Jr. 1982. Environmental features for flood control channels. Water Resources Bulletin. 18 (5):779-784.

Schroeder, P. R. and Shields, F. D., Jr. 1983. Chemical clarification of dredged material. Journal of Environmental Engineering. 109 (2):414-427.

Shields, F. D., Jr. 1983. Design of habitat structures for open channels. Journal of Water Resources Planning and Management. 109 (4):331-344.

Shields, F. D., Jr. and Nunnally, N. R. 1984. Environmental aspects of clearing and snagging. Journal of Environmental Engineering. 110 (1):152-165.

Shields, F. D., Jr. and Sanders, T. G. 1986. Water quality effects of excavation and diversion. Journal of Environmental Engineering. 112 (2):211-228.

Nunnally, N. R., Hynson, J. R. and Shields, F. D., Jr. Environmental considerations for levees and floodwalls. Environmental Management. 11 (2):183-191. 1987.

Thackston, E. L., Shields, F. D., Jr. and Schroeder, P. R. 1987. Residence time distributions of shallow basins. Journal of Environmental Engineering. 113 (6):1319-1332.

Shields, F. D., Jr. and Abt, S. R. 1989. Sediment deposition in cutoff meander bends and implications for effective management. Regulated Rivers: Research and Management. 4:381-396.

Shields, F. D., Jr. 1990. ENDOW--Selecting environmental features for stream alteration projects. AI Applications in Natural Resource Management. 4 (3):62-63.

Shields, F. D., Jr. 1991.Woody vegetation and riprap stability along the Sacramento river mile 84.5 to 119. Water Resources Bulletin. 27 (3):527-536.

Shields, F. D., Jr. and Hoover, J. J. 1991.Effects of channel restabilization on habitat diversity, Twentymile Creek, Mississippi. Regulated Rivers: Research and Management. 6 (3):163-181.

Shields, F. D., Jr. and Thackston, E. L. 1991.Designing treatment basin dimensions to reduce cost. Journal of Environmental Engineering. 117 (3):381-386.

Shields, F. D., Jr. and Aziz, N. 1992.Knowledge -based system for environmental design of stream modifications. Applied Engineering in Agriculture. 8 (4):553-562.

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