

查勘陝西涇渠水利報告書

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序

關中八水涇遜於渭自秦始皇時鄭國疏濬後年湮代久遂多淤塞壬戌夏龍溪吳君南凱來陝勘測閱時三月乃成是編於渠之歷史沿革及其流域出產細大不遺可謂詳且盡矣陝省自清季以來疊經喪亂小民迫於飢寒流爲盜賊馴成今日民窮匪盛之局目下圖治之策非興地利勸墾植不爲功計是渠可溉之田共五千八十頃今所溉者不過二十餘分之一苟得有成爲利豈淺鮮哉是則所望於三秦父老有以玉成其美亦敝人所日夜馨香默祝者也是爲叙

民國十一年中秋日青浦董健吾

!! 利之人驚！災救本根!!

用款八十萬元

溉旱田五百萬畝

達五縣之地計方積千里

每年可增糧食五十萬担

暫時每畝費銀一元六角

二年間即可收回本息

後來決無難民

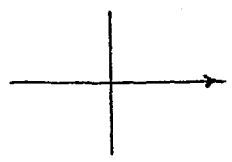


涇渠九龍灣攝影
Chiu Lung Wan.



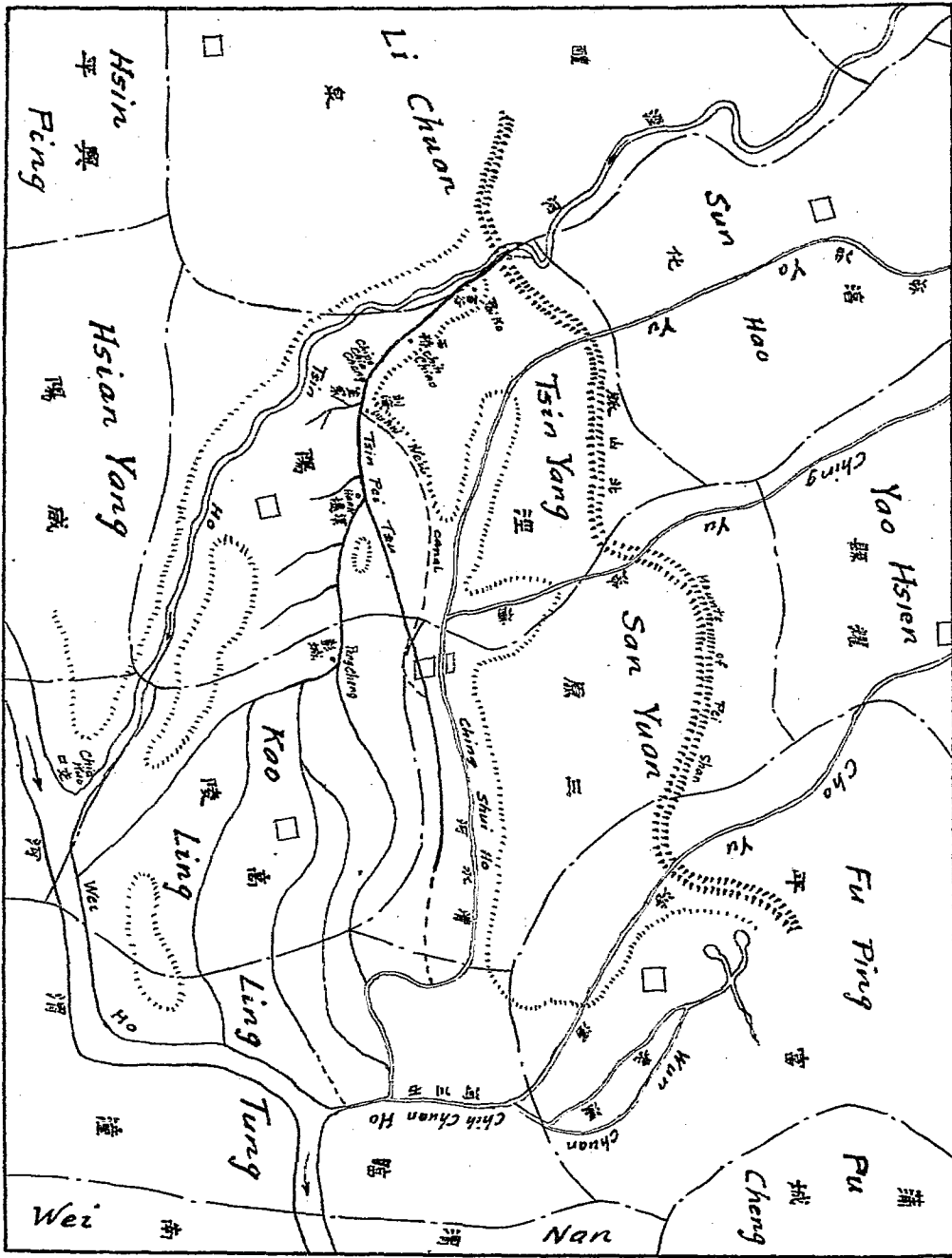
涇渠龍洞渠攝影
Entrance of Tzin Canal.

圖 域 流 渠 經



里十二
20 li scale

圖例 Legend	
	District boundary
	River
	Old canal
	Proposed canal
	Plateau
	Mountains Chain
	City
	Town
	Village

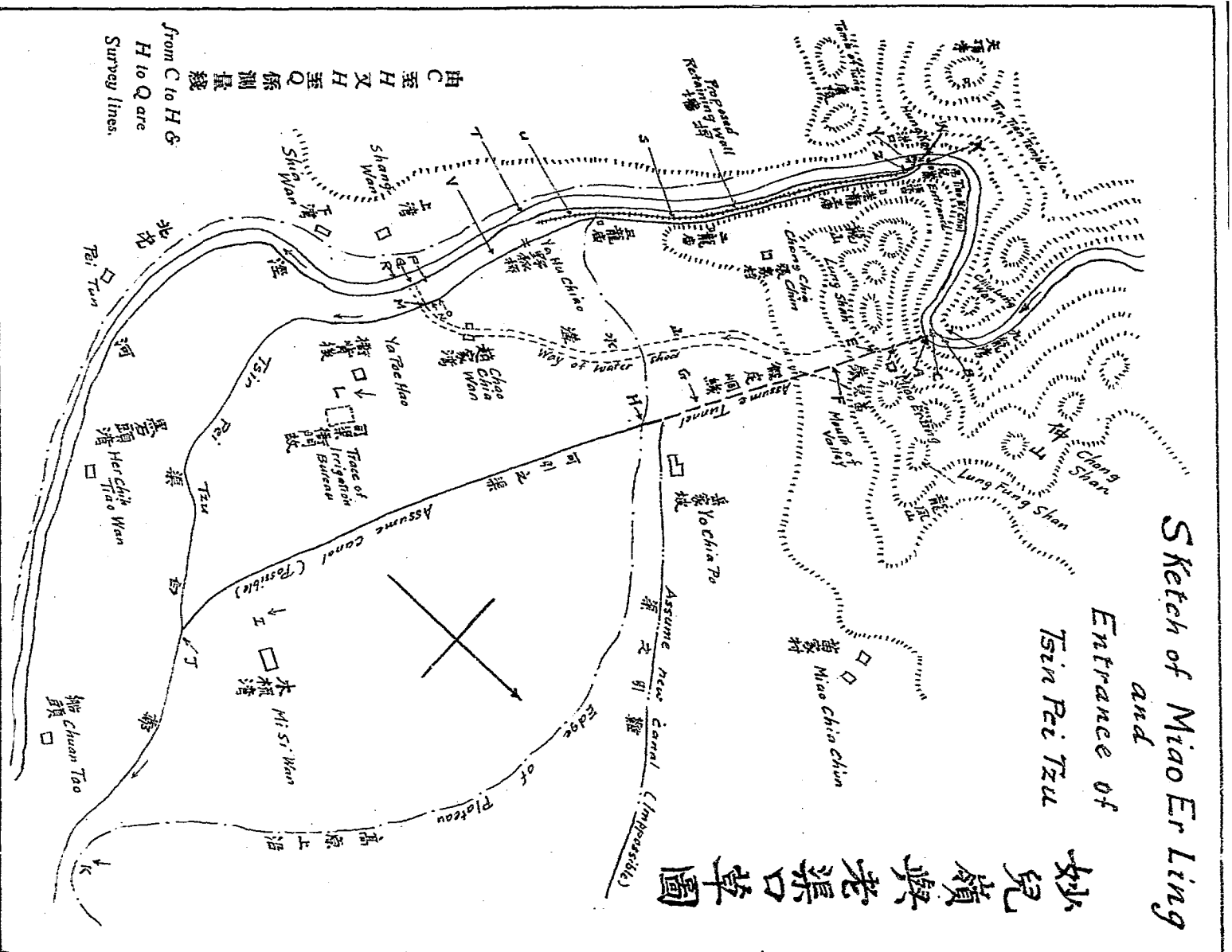


Sketch of Districts showing Irrigable Area under Tsin Canal.

Sketch of Miao Er Ling

and Entrance of Tsin Pei Tzu

妙兒嶺與老渠口草圖



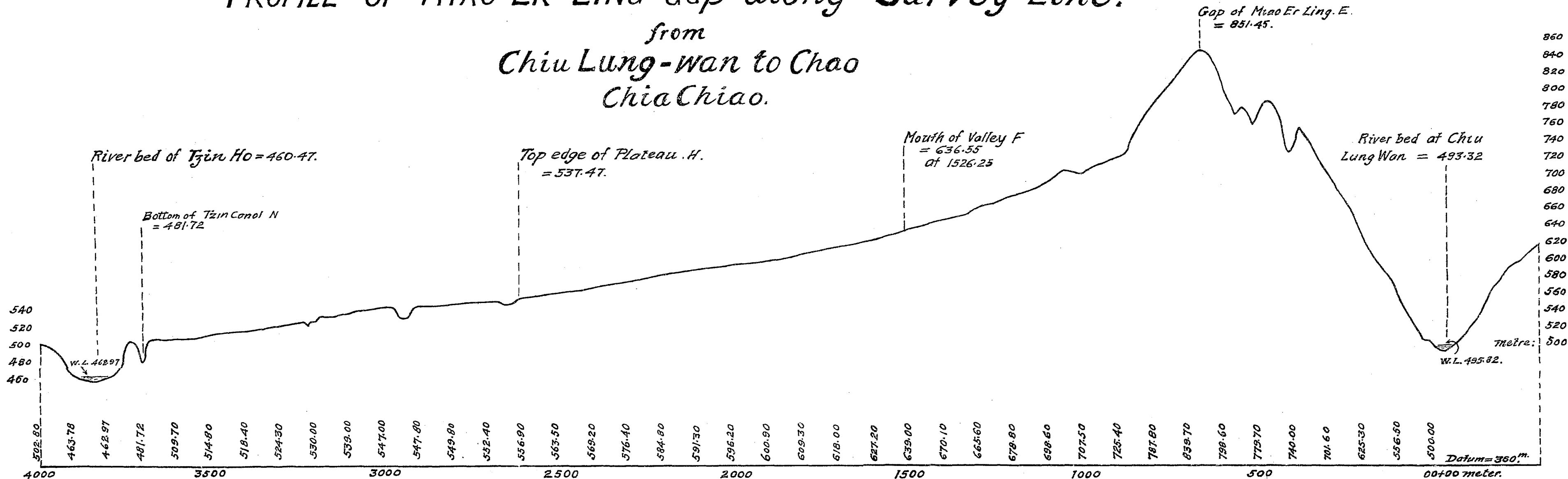
由 C 至 H 又 H 至 Q 係測量綫
 from C to H &
 H to Q are
 Survey lines.

圖面剖腰山嶺兒妣

橋家趙至洩龍九由綫測

PROFILE OF MIAO ER LING gap along Survey Line.

from
Chiu Lung-wan to Chao
Chia Chiao.



圖

切 橫 均 平 河 涇

Average Cross Section of Iziu River.

Scales: Hor: one div. = 5 m.
Ver: one div. = 2 m.

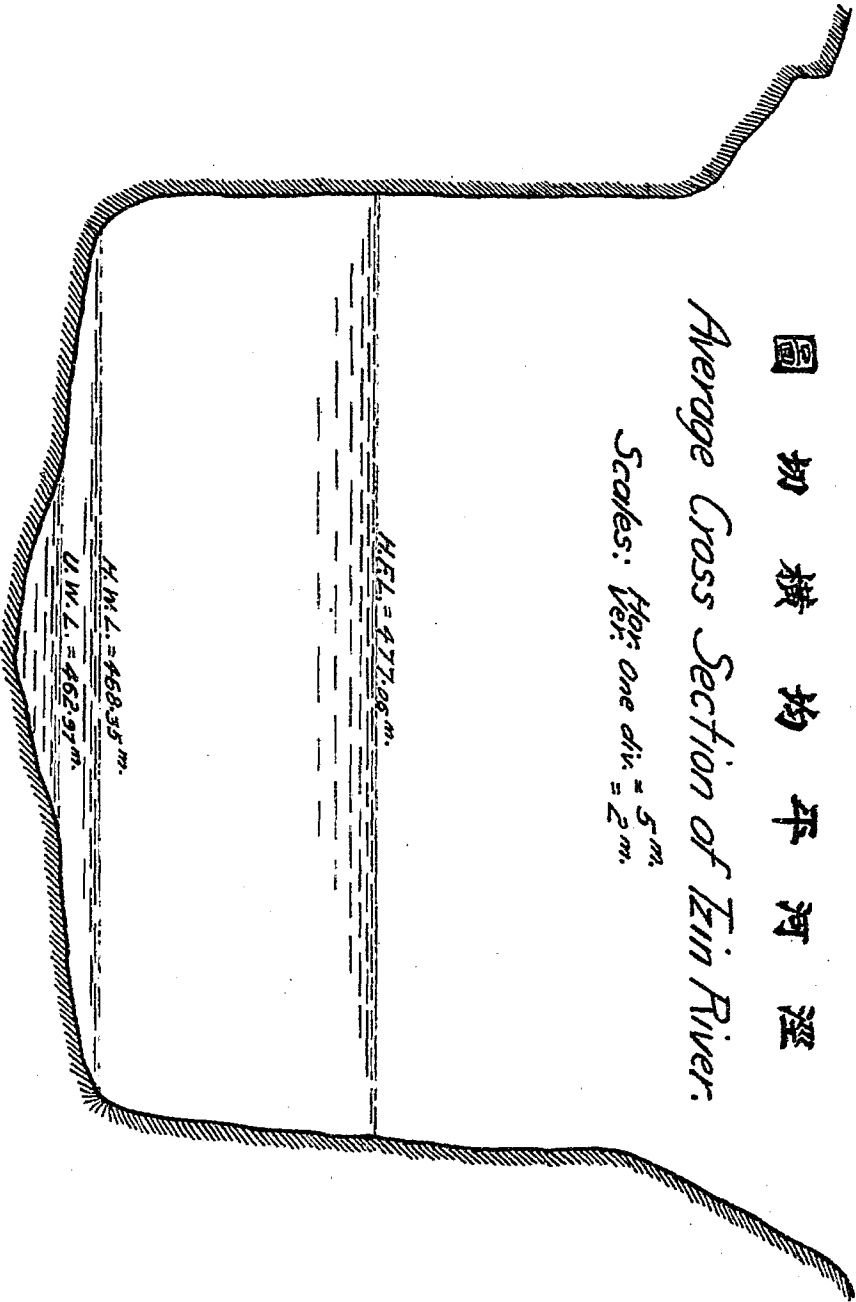
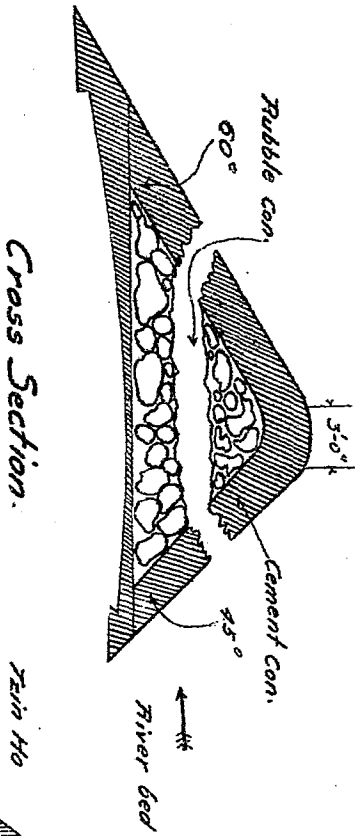


圖 畧 壩 塔

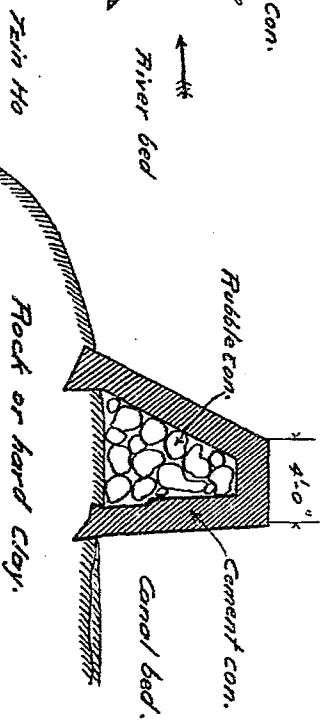
Show of River Cross Dam.
for raising the water level.



Cross Section.

圖 畧 壩 牆 樺

Show of Cement & rubble Mas.
to be one side of Canal.



Aver. Cross Section.
Scale. one in. = 2ft.

弁言

竊醫者之治病也。必先審其體質之強弱。年齡之老稚。然後切脈問症。對症投藥。而厥疾瘳。若鹵莽決裂。妄施方劑。未有不促人於死者也。研究水利之道亦若是。凱此次測勘涇渠。計畫之先。不厭瑣碎。力求精詳。因歷史而察古今地勢之變遷。就水道而究先後治渠之得失。復上窮河源。以測水量之大小。隨驗土質以別原隰之肥磽。舉凡山川之形勢。物植之蕃衍。皆足以證水利之得失者。無不悉心考慮。以求利導。惟氣度與雨量。非一時所能詳紀。姑缺而不書。然以吾國地土之大。水源之多。似亦因勢利導爲用已宏。亦不必拘於滴水不漏者也。茲就現在能資其研究者。筆之於書。參以管見所及。分爲二說。曰鑿開山峒。曰改良渠口。前者爲賓。後者爲主。蓋涇渠西始龍山。東迄交口。北界清河。南盡涇水。其間可耕之地。縱橫千里。果能改良渠口。已足操縱其經緯。又何須開峒。枝枝節節而爲之乎。戰國策載范雎說秦王曰。大王之國。北有甘泉谷口。名論不磨。顧用之者何如耳。凱以工賑餘暇。拉雜成篇。冀質之高明。以匡其謬。

吳南凱謹識



緣起

秦始皇元年。即西歷紀元前二百四十六年。世界大事年表特書曰。(秦鑿涇水爲渠)是年大事。僅此與埃及戰克叙利亞二者而已。是足見涇渠非尋常之功業矣。故曰支那工程。禦侮則有長城。轉輸則有運河。交通則有洛陽等橋。若水利者。當首屈涇渠。皆驚人之構造也。夫水利之道。我國知之最早。周季魏西門豹奉命治鄴。相度地勢。鑿渠十二。引用漳水灌田數百里。臨漳一帶。賴以富庶。韓惠王惡秦之強。陰使水工鄭國遊說始皇鑿涇爲渠以疲之。始皇察其奸。欲殺之。曰。臣始爲間。然關中早乾之地。勞民一時。而獲千古之利。以此富秦。何負於大王哉。始皇悅而納其說。遂自仲山鑿渠引涇。北連三浴二泉。東聯洛河。南達渭水。甘澤披於十邑。溉田四百萬餘畝。斥鹵礪礪。胥成神皋。秀野資給。都會益用富強。河渠之利。何其溥也。迄今二千餘年。三浴陷而落水淤。桑滄易世。北山南趨。五河不理。六渠不修。以故河流漸張。高原日廣。清河以北之水。不復古昔之狀。僅區區百里之所謂鄭白者。亦同諸廢渠耳。萬歷中。三原人王思印上書請開吊兒嘴。重引涇水爲關中利。知縣袁化中辯曰。渠口由漢至元。漸改漸高。山勢益狹。水流益急。至明項忠鑿龍山之麓。穿峒爲渠。余公阮公繼之。歷十有七年而工始成。官累民

困。河雖引而淤塞之患日甚矣。且其利不及秦之百一。涇水已無益於渠。若再開吊兒嘴。恐亦虛靡等諸廣惠耳。議遂不決。年來兵燹瀕仍。渭北一帶。田園荒蕪。人民散徙。赤野千里。滿目蕭條。熱心之士。抱負救窮振國之義。重倡吊兒嘴之議。庶幾僥倖獲生機之一綫。伊取袁公云（倘開吊兒嘴。而能另導一渠。避涇水之鋒。則勞一時而利萬世）之一語乎。或曰。妙兒嶺易於吊兒嘴。且山薄而河高。由該處鑿峒。則可引涇水暢流於高原之上。其利必駕於秦漢時矣。議論紛紛。莫宗一是。今春北京青年會總幹事格林先生爲賑來陝。聞是議深以爲救災之本。極力贊成。回京時以此事實之於我政府。河海顧問方維因先生。當日即電招凱到部。討論其大略。并推凱擔任測勘之職。中國華洋義賑會總幹事艾德敷先生亦勉凱即日回陝。以竟其功。凱以學識疎淺。何當此託。旋又得陝省人士敦促。義無可辭。遂毅然西行。至西安北詣涇原。測勘與調查。凡費三十餘天。實測方四千里。踏查略及五縣之地。又考諸書史。證及誌錄。依次造報。以略備參攷之資焉。

涇渠沿革之歷史

涇渠自七國時。秦始皇納韓使鄭國之說。遣興水利。國至北山。視涇河巨石磷磷三四里。水流其中。堪以作堰。於是立石園以壅水。每行一百餘園。凡百二十行。皆借天生衆石。灌鐵雜灰爲之堰。數里散石星散作勢。遂引涇入渠。一瀉百里。聯合洽浴清浴濁浴溫泉。經富平蒲城而達於同州朝邑。經緯千里。灌田四萬餘頃。命名鄭國渠。史記河渠書至漢武帝使息夫躬領護三輔都。漢書息夫躬傳是涇流怒激。衝突激滌日下。而河中石漸摧落。困因無著。勢已難引涇入渠矣。元鼎六年。內史倪寬奏請於鄭渠上游更開小渠六道。以溉高仰之田。漢書倪寬傳注名爲六輔渠。太始二年。趙中大夫白公。又於鄭渠之上挖渠引涇。首始谷口。尾入櫟陽注渭水。長二百里。溉田四千五百頃。漢書溝洫志地得其饒。民困略蘇。衆稱白渠。又曰鄭白渠。謂北水利。鄭渠重興。祇此保存。其他不復得舊跡矣。苻秦依鄭白成法。發其王侯以下豪望富室僮隸三萬人。通渠引瀆。以沃岡鹵之田。晉書其後渠又通闕不常。唐以京兆尹一人。督視涇渭白渠。唐百官志弊端叢生。富商納款。競造碾磑。堰遏流梗。引渠遂有虛名耳。永徽六年。雍州長史長孫祥。奏准修渠毀碾。至大中水田纔得六千二百餘頃。此數恐記載不實寶歷光啓屢事踵修。然鄭渠故道猶未盡涇。洎宋至道中。從皇甫

選河亮等上言。別開渠口。重增墾墾。以復水道。淳化二年。縣民杜思淵請調丁修治。卒以工大

而止。後代木堰。凡用稍椿萬一千三百餘。皆出於沿渠之民。計田出丁。凡役萬三千人。載經陽志法

民可憐勞費。景德三年。復詔博士尙賓經度。以鄭渠不可復。乃自介公廟迴白渠洪口。直東西合舊

渠。宋河志自唐以來。人民只知用水。紛爭先後。竟不知水自何處。置渠口而不顧。由是日益壅闕。

雖經康定。天聖景祐諸代。歷修無干也。徽宗大觀二年。帝命趙佶總浚渠事。開石爲渠者三千

一百四十一尺。最深者三十八尺。人工四十九萬八千六百六十六名。土渠北自石渠口。東南與故

渠接者三千九百七十八尺。最深七十五尺。工二十六萬七千九百八十四名。歷兩年告竣。蔡

修渠題名記設有迴流之洞。瀉水之閘。及透槽石欄。頗費匠心。涇水引入。深有四尺。下傾三白。灌田

約二萬頃。失實賜名豐利。金宣宗定興五年。三渠設官。金食貨志然不數年渠又高。石堰日壞。水不能

入。至大元年。西台御史王琚。建言更於其上開石渠五十一丈。延祐元年興役。至元五年工成。

引水入於故道。名王御史渠口。第渠口漸改漸高。山勢漸狹。流浪愈激。水利日微。明太祖成祖

宣宗繼修之。董暹於附近撥軍民相參修治。役丁夫萬四千四百人。軍萬五千名。天順中又圯。

西安府志巡撫項忠穿鑿龍山石坡。下接五御史渠口。勞役十有七載。寬僅四尺。似此一渠組成。何

當大川之衝。是速泥沙閉塞而已。項氏自謂功比鄭白。名渠廣惠。俗名龍洞何其謬也。正德十一年。復於王御史與豐利二渠間。鑿山取直四十二丈。萬曆中三原人王思印上書請開吊兒嘴。知事袁化中辯之。并建議利用泉水。照行。然修東補西。均未得根本之計畫。順治九年知縣金漢鼎重修廣惠。削石鑿岩。泉流灑出。刊碑自訟。稱泉之利過於涇水云云。豈噶者之得飲。以止爲海乎。雍正五年。總督岳鍾琦請帑修堤決淤。七年移西安府通判駐經陽之百谷鎮。專司渠事。是時建閘啓閉。猶未盡絕涇水。乾隆二年增修龍洞渠堤。始斷涇水。疎泉溉田。十六年涇水漲溢。決堤淤渠。邑人孟輯出銀五千兩。獨力捐修。至嘉慶道光同治修不勝修。八年內閣學士袁保垣擬復廣惠故渠。改良則可。復又何用。載椿灌鐵。砌石築壩。捍涇入渠。經營十年。迄無成效。涇陽縣志而民間爲水聚訟。交馳於道。十九年知縣涂官俊。議勻水杜弊。終未有成。二十四年巡撫魏志燾。派隊修築石土各渠。并疎鳴玉之泉。未幾冲決如故。二十七年六月暴雨壞堰。知縣雷天裕復修土石計一千九百六十五丈。時英教士敦崇禮擬分其國賑款之半。作築堤引涇入渠之費。不果。宣統二年秋霖。涇漲溢滿。渠又壅塞。知縣劉懋官籌修之。亦不過敷衍而已。飾珠洞以東渠身起伏。水難趨下。石堤散裂。卮滿尤多。四出如噴池。民國六年三原人高君明德聰穎之士也。

度渠腹有湧眼最大者。以爲別是泉源。勢必自高處傾下。以鐵管倒接引之入渠。後察知是水。係由渠中滲出。竟未收效。此自有渠以來歷代沿革之大略也。

涇水河源與自身之現象

涇水爲關中八河之一。其大次於渭河。發源自甘肅平涼縣之筭頭山。及隆德之武山。流趨東南。經涇州。由長武入陝。出仲嶺兩山之間。南流復拆而東。至高陵入渭。計約六百里。由龍山渠口至櫟陽交口約百二十里。永樂上流河在兩原之間。岸距河底三四丈。故一帶田園未嘗受涇水一滴之施。均賴諸雨水也。寬百尺至三百尺之間。平常水流深不過五六尺。雖旱不涸。但塊石星羅棋布。態如醉翁。立足無定。水急流迅。激湍之聲。可達里許。以故不利於行舟。水渾如丹。質略帶礫。用於植物者。若稍施改良亦甘澤也。河身下流漸東漸寬。因每值秋水。汎濫茫茫。南崩北塌。永樂以東。竟有寬至里許者。沙灘起伏無定。深淺不勻。故旅渡爲艱。行人苦之。吁。我國雖無科學之可言。但古哲立法設教。小如織機。大如建築。遺模千古。深悉中國西人。莫不佩服。奈後不知考求增進。以致淪沒。三秦水利。除鄭白外。竟無其人。地自受荒。水自入海。不亦惜乎。今渠道已取利涇水。不可不言其大略。測其流量。蓋凡作器者。必先量其材。水利之道。亦不外此軌。余曾於老龍王廟上下游各三里。數試流量。及各種基要。平均於左。以備識者參攷。

一 河身坡度每千尺下一尺

- 二 河寬七十五尺
- 三 水深六尺
- 四 河身橫切四百五十平方尺
- 五 流水速率(用浮木法)每秒四尺(用葛達氏算法)每秒三尺九寸六分
- 六 橫濕綫長一百二十尺
- 七 水徑點三尺七寸五分
- 八 每秒流量一千八百立方尺
- 九 永內含蓄渣泥每百分由二十至三十
- 十 水重於華氏六十度約六十五磅
- 十一 洪水面比常水約高五十一尺
- 十二 洪水濕綫長三百零九尺
- 十三 洪水橫切一萬一千零十二平方尺
- 十四 洪水流率每秒鐘行十九尺二寸八分

涇渠流域

涇渠口始於老龍王廟西百五十尺。老龍王廟下即名龍洞。今已閉塞不通。東九百餘尺爲篩珠泉。又東百尺滙瓊珠泉。涇渠賴以溉田。則此二泉最大之孔徑約六寸。餘十餘處均參差小泉。合量約相等。又東過水磨。又東至大小梯子崖。又東卽王御史渠口。又東至火燒橋。又東過小退水槽。會天澇池并碧玉噴玉鳴玉調琴諸泉。又東退水槽下爲分水嶺。卽大退槽。經大王橋。小王橋至野狐橋。計七百三十丈爲石渠。或依岩開石。或近水砌堤。上下厚薄均未得法。寬狹不齊。坡度又無準繩。其禦水力且不論。是徒使水流不暢。沙泥易積之一大弊也。由野狐橋至趙家橋約四里。係砂礫渠。寬約丈二尺。不但渠之兩邊未留坡度。間且有下寬而上狹者。故歷年崩塌。修不勝修矣。轉東南伸出之樊坑渠。今廢。又東至馬道橋。凡一千八百六十三丈。此一段爲挖深土渠。由馬道橋出原口始開支渠。溉田者首爲王屋一斗。以下歸民自修。俗呼爲民渠。實官渠也。自百谷鎮渠依高原逶迤順勢而下。至石橋鎮三十里。渠與涇河相距四五里。勢則平行。由石橋鎮迴交家前村。包圍劉海渠。又與高原分離。漸東漸遠。循平原上層之邊而行。取其易於灑沃下原也。然渠北之原高不過六尺。渠綫水面若再提高此數。則能流行於渠

北之地。自劉海至三原界。可多灌田數百頃。此亦以渠源關係。涇水今不能入渠者。亦爲泉眼位置所限耳。又二十里至漢堤鎮。今存老堤數段。或云卽漢時堵水爲潢。訓練水師之處。或云爲鄭渠故道。以勢度之二說皆是。鄙意以漢時築潢。必近鄭渠。以利用其水。否則此地距渠離治皆遠。決不築潢於是間。以故可知當時渠水利之富矣。鎮之西北設有三限石閘。支分三路。南支直達涇陽縣治。長十里。中支間胼一股南下。止於永樂鎮。再南則地勢巒高成原。水難流及矣。中幹東入高陵縣界二十里至彭鎮。又東白渠已淤毀無用。唐穆宗長慶三年。高陵令劉仁師請更水利。高陵縣志以杜私竇。涇陽人賂術士上言。白渠下高祖故墅在焉。不宜以畚插近阡陌。上聞。命京兆立止之。仁師馳詣相府控告。具發其賂。請以頰血汚車茵。丞相彭原公歛容謝曰。明府眞愛民。即入言。翌日果有詔許修新渠。工成名堰。劉公名渠。彭城。劉彭城人彭城闢出口四渠。間增一渠。凡五渠。曰中白。曰中南。曰高望。曰禡南。曰昌運。中白渠東流經仁村至櫟陽鎮北入清河。長二十里。其南七里爲中南渠。自磨子橋經坳下村東過高橋孝義坊入清河。長五十五里。高望渠自磨子橋經魏村及李趙村之間。東過阿石橋陳楊村。越臨潼境入渭。長五十五里。禡南渠自磨子橋西南流折東。經里沙鎮原趙村。又東南過渭橋貫臨境入渭。昌運渠自縣

西張市里分中南渠。東過通遠門。經郭橋至臨潼境。入清河。五渠均係就民役挑挖。其深視水暢流爲度。并無一定規法。故民以築成工省爲本。顧一時之得。而未計及久遠。雖年年疎淘。不覺其困。無非將淘起之土。堆於渠邊。一經雨洗。則又刷落於渠。如是循環。至今已現淤滿廢弛之象矣。倘不及時補救。將來必或夷爲平地。或變爲流水河道。實有負劉公愛民之遺意也。北渠廻漢堤西北。轉東與冶河相距六七里。作八字形。漸東漸近。東南經白楊西丁漫劉南魚諸村入三原境。東向與清河作平行。清河即冶清合并直抵縣城二十里。入西出東。中穿鐘樓之下。出城數里。渠已漸沒。無入渭之尾閘矣。計由龍洞渠口至三限閘。幹渠五十六里。三分渠約二百五十里。凡流域三百餘里。斗門如蜈足草根。未計其數。五縣田畝受漑有差。約如下表。

今昔水利比較表

縣	涇	醴	三	高	臨	總
名	陽	泉	原	陵	潼	數

以上爲涇渠流域。白公重復鄭國之故道也。若渠身之現狀。可供改良之基要者；茲就趙家石橋。觀察測算。紀其平均如左。

一 渠身橫切十六平方尺

田之溉未	田之溉現	田之溉可
頃〇〇一二	頃〇〇二	頃〇〇五二
頃〇二	頃〇一	頃〇三
頃〇八四一	頃〇二	頃〇〇五一
頃〇八一	頃〇二	頃〇〇二一
頃五四	頃五	頃〇五
頃〇二八四	頃五四二	頃〇八〇五

二 橫濕綫長九尺

三 水經點一尺八寸

四 渠身坡度每千尺下三尺七寸

五 流水速率每秒一尺四寸

六 流量每秒二十二尺四寸立方

每日流量壹百九十三萬五千三百六十尺立方

設每畝田地需用水量二千立尺。現渠之水。每日祇能灌田十頃。每月最多不過三百頃以外。

渭北地位之狀況

渭北地處北山之南。原多平少。桑滄遞嬗。泥土趨下。高原大勢日低。而面積日廣。漸與平野混合。故富平地形較昔增高。觀現土人挖出古時渠身及橋梁。可以知矣。涇陽志載。秦時渠水溉田四萬餘頃。王太岳云。係制度不同。古時以百步爲畝。漢時則以二百四十步爲畝。當時所謂四萬頃者。止得漢之一萬六千餘頃耳。或疑爲記錄以畝爲頃之誤。均係推測之論。鄙意以爲鄭國修渠不僅一渠。引水亦非只涇河一源。以地勢斷之。當時引涇爲渠。其南者入於渭。北者

流於冶。冶與清合。接於溫泉。下游折而東。滙洛。注於黃河。其冶清溫洛一帶之下游。必築壩堵水入渠。法與涇同。總名曰鄭國渠。溉田四萬頃。亦理之至也。後人以爲昔時水利。灌沃十邑。祇賴涇水一源。不亦謬乎。鄭渠至漢時。溫淤洛陷。清冶分裂。各不聯絡。除清冶略有數綫微利。餘已無水利之可言矣。夫渭北諸邑。爲省城之屏衛。北道之要衝。秦漢以下。事涉干戈者。史不絕書。以故兵燹爲多。若早涼風。苞蝗疫。狼鼠奇災異患。誌不勝紀。其最慘者。莫如同治間回禍之毒。婦女幼童。幾無遺類。男丁未及逃亡者。亦均慘遭填壑。鄉村焚如。田野蹂踏成墟。事後亡者無資歸里。客死於外。留者無具耕作。恐徵錢糧。多甘委棄田園。而不顧。縣吏問舍求田。無敢應者。其慘可知。光緒初。雖農業漸復。亦均由山東山西河南客籍。以賤價收買。勤力經營。反客爲主。至今渭北各村。未有純全土民者。論商務。首推三原涇陽二縣。每年批販隴蜀皮貨藥材。本地則麥棉爲大宗。出口年以數百萬計。其餘諸縣。鎮亦均可觀。洎乎民國。兵匪割據。禍患不亞於回亂。今日匪去。明日兵來。物無大小。搜括再四。燒毀殆盡。村民一夜數驚。或藏山穴。或伏溝壑。雖值淫雨。狀似鷓鴣。淋漓擊縮。一堆於汙泥間。苟全其性命。而未敢回家者。日則鷓鴣面鳩形。盈於道路。老者呻吟愁歎。壯者四顧徬徨。此親聞之父老者。又見哀鴻遍野。村戶鎮店。十室

九空。蒿目之下。扼腕徒磋爲之傷心者再矣。邑侯余公有巡鄉詩曰。（連村遞入步徘徊。滿目淒涼盡劫灰。暮靄庭堦堆瓦礫。塞風院落舞蒿萊。絕無鷄犬緣牆走。祇有狐狼嘯野哀。那怪流備歸里少。棲身難覓怎歸來。）足可爲渭北狀況寫真矣。

渭北土地與出產

我國以農業立國。蓋以天體氣候佔優勝之勢也。夫屬於農務之最有關係者。即溫度水分風力土質是也。渭北土地背山帶河。形勢崎嶇。凸凹無序。氣候參差。降水氣壓又因之變常未定。故欲研究水利與農業之進步。須有數年之觀測。記份列表。無微不至。庶幾於水利經濟。兩得其全。斷非等諸兒戲。數月可以問津。識者當以吾言不妄。查北原一帶。土地在原下者。多黃土。粒細如粉。質黏似膠。頗不便於水分空氣之疏通。實有礙植物根部之蔓延。過於乾燥。則又凝結成塊。或至裂縫。肥料分解既緩。生活成熟亦遲。雖經歷年播化。稍就佳况。究竟不免此弊。倘若酌加砂土少許。時獲水利均勻之澤。則農田當可列上上矣。凡在原之上。山之麓者。地多砂土。但粒不大。鬆疎易耕。雖雜有礦質。若以渾水混渥之。其收成亦不亞原下。土質最佳者。爲涇陽沿渠一帶。因得水利之運融。土砂含量均極適宜。故對生活關係。結果甚佳。沿原數處。雖有

發現礫硝。露於地面。如得水力之淘汰。亦易滌淨變沃壤也。鄙意以為現陝省欲辦水利振興農務者。急宜從記錄氣候。溫度水分觀測水量。河水流量與水查驗土質。抄土分量與考究。試驗種植糧草入手。庶幾以無用之水為有用。變貧瘠之地為沃野。關係豈只區區渭北一隅哉。現就五縣之地。東起仲山。西止交口。北界清河。南盡涇水。計約二千四百里。半為高原。城鎮鄉村等。其可耕之地能受流水之灌注者。五千餘頃。細究下表五穀之生活。則可得需水分量之梗概矣。

五穀生活表

時	種	名	穀
旬下月三		梁	高
旬下日三		豆	綠
旬下月四		米	大
旬上月五		米	小
旬中月四		等豆	黃
旬月中五		谷	苞
旬中月六		麥	蕎
旬中月八		麥	大
旬中月八		麥	小
旬下月三		花	棉
旬下月八		藍	大
旬下月四		藍	小
旬中月六		子	菜
旬上月七		蒜	大
旬中月九		豆	豌豆
旬中月三		麻	芝
旬上月三		麻	線
旬中月三		薯	番
旬上月五		米	菽

查米蒜小藍需水最多。不可以爲準繩。茲取其適中如高粱者。其生活時間一百五十天。需水八畝尺。即日需水半畝寸。（每畝田水深一尺者爲一畝尺。）或半畝尺。供用十天。此爲穀中平均數。由是可計算每畝田地。應需水量三千立方尺。按地畝五千頃計算。則需水十五萬立

期	時	水	需	時	收
天十五百一		尺	八	旬下	月八
天十五百一		尺	八	至旬初	月七
天十五百一		水積需天每	三	旬下	月八
天百一		尺	七	旬下	月八
天四百一		尺	七	旬上	月九
天百一		尺	八	旬下	月八
天十九		尺	五	旬中	月九
天十五百二		尺	五	旬下	月四
天十六百二		尺	五	旬上	月五
天十九百一		尺	八	至旬初	月七
天十五百二		尺	五	旬上	月五
天十九		尺五丈一		旬下	月六
天百三		尺	五	旬中	月四
天百三		尺六丈一		旬上	月五
天十三百二		尺	五	旬上	月五
天十三百一		尺	八	旬上	月八
天十二百一		尺四丈一		旬中	月七
天十四百一		尺	八	旬下	月八
天十二百一		尺	五	旬中	月八

方尺。足供十天之用。其放水面積須一百方尺。流率則每秒鐘二尺半。

假定涇渠進口表

一〇〇	二·五	二二六、〇〇〇、〇〇〇	百分之三十	一五二、九〇〇、〇〇〇
切面積	流率	每天流量	水分消耗	每天水利

就右列水量分配。溝渠之里數及容積則可推算其幹支與分流如下。

水利與地畝分配表

容積	五七、六〇〇、〇〇〇立尺	六四、八〇〇、〇〇〇立尺	七二、〇〇〇、〇〇〇立尺
橫切	三六、〇〇〇×一六〇足	三、六〇〇、〇〇〇×一八尺	七二、〇〇〇、〇〇〇×一尺
里數	二〇〇	二、〇〇〇	四、〇〇〇
渠別	幹	支	分
	渠	渠	渠

計 共

一九四、四〇〇、〇〇〇立方尺

此數比水量加大四百萬餘立方尺。約五分之一。作爲雨水或防患之設備。

研究涇渠進口之計畫

涇北地畝約分三等。山之下爲高原。次中原。與平原是也。考古渠遺跡。就涇水一支言之。渠綫當在高中兩原之間。其流域可以分漑中原及於下之平原。若今之水道則處於中原之外沿。受水利者祇平原之地而已。或曰涇河上游。近九龍灣之水面。實高於高原。若開吊兒嘴。或鑿洞。妙兒嶺。上自嶺口引涇入渠。取道苗家村。東南沿仲山之麓。直趨浴谷。與清河携手而行。爲幹渠。然後自西徂東。挖闢支渠。由高瀉下。一日千里。果如所言。則水利實可驚人也。但以目力察之。似未必然。均是推測之論。非證實未足以決猜疑也。余初抵仲山。登其巔。瞻望觀測。亂山重疊。涇河逶迤其間。水聲咤叱。漩浪交飛。後由淳化界越嶺攀岩。順流追察山腰最薄者。實爲九龍灣對角之妙兒嶺一處而已。若吊兒嘴則爲龍山脈之轉角。山笨原遙。誠無研究之價值。故水平實測則自九龍灣涇側盤石上始。山腰三重。兩面峭立。又滿披野棗。銳利如針。頗難駐

足。一日只測數十丈。第一綫至嶺口五千零六尺。竟高於河底一百七十一尺七寸九分。第二綫至岳家坡。尙高河底四十五尺有奇。水流灣之中原地面。正與涇河水面平高。較之現渠則加高七十三尺。如是則引涇之水。用於高原則不足。施於中原則有餘。但高原與中原高度相差太鉅。(百尺)設於九龍灣建壩截堵。提高水面。非第靡費無益。且欲積水高至百尺者。遼遠來源。兩傍河岸高下參差。堅弱不一。勢必中途決裂。四生枝節。此引涇上漑高原不能辦到之理由也。若就中原地勢求利。祇需水面加高現渠十尺。則綽綽有餘裕矣。今因圖面太小。山綫地形假定數未能繪明。特將要點登記於下。以備查考。

假定地形高低要點表

低高 (達米)	點要
500.00	A
493.32	B
495.82	C
758.79	D
851.46	E
636.55	F
607.09	G
537.47	H
496.69	I
420.50	J
511.69	K
498.69	L
484.87	M
481.72	N
483.17	O
464.95	P
460.47	Q
462.97	R
488.46	S
506.48	T
477.06	U
468.35	V
479.63	W
477.34	X
479.64	Y
487.30	Z

研究上列水平及三原地勢。誠無開洞之必要。蓋以大工小用。非經濟之設施也。今姑將妙兒嶺概算列表。作為他種計畫比較之用可耳。茲假定由A處鑿洞至B處。計長八千尺。石峒約佔三分之一。餘均砂礫土峒。論石質對於工程與時期。雖難進行。用費又大。但工竣則屬天然之峒。修面費甚微。至砂礫雖然易挖。則易於傾陷。必須架木立牆。作拱式峒頂種種耐久之考慮。於是截長補短。石峒與土洞之價值。實不差上下。然後由峒口B開渠接老渠之丁處。蓋此處老渠已據高原下層最高之地位。而涇水又不得上原。只此一途提其水面。高其渠堰。足可分流劉海東北一帶。計溉田不過五千頃之數。限於涇渭二河之間。不能越雷庭一步矣。此種計畫可與重修老渠口之計算參酌。何為適當。不難迎刃而解也。

位	地
	上石盤測河涇
	底河涇
	面水
	腰山一第
	腰山二第
	口嶺
	上原高
	邊原高
	面地原
	底渠現
	沿下之原
	地平
	上橋石家趙
	底渠
	面水之渠
	邊河涇
	底河
	面水
	上堤石之渠
	岸渠
	綫水洪
	綫水時平
	口渠
	底涇之口渠近
	面水
	上石父分涇與口渠

妙兒嶺山响估價概算表

器具	購地	水壩	捍牆	蓄池	新渠	山峒	名目	橫切方尺	長 (尺)	用材	每尺價值	共	洋
	一百五十畝	八〇	一二〇	一〇〇〇	七〇〇	一〇〇							
	每畝	二〇〇	三〇〇	深四十尺	八、五〇〇	八、〇〇〇							
	中等田	西門塊石三合土	西門雜石三合土	石灰石工	土工	西門三合土及磚木							
	四十元	一百五十元	二百元	二百元	六元	一百一十元							
五〇、〇〇〇元	六、〇〇〇元	三〇、〇〇〇元	六〇、〇〇〇元	一六、〇〇〇元	五一、〇〇〇元	八八〇、〇〇〇元							

改築老渠口之計畫

薪費	三年	用度	工程人員	他機關不在此內
				六〇,〇〇〇元
工程作三井八處開工總計洋				
				一、一五三,〇〇〇元

昔渠口始自瓠口。卽古之寒門也。以歷代更移上游之數目。段段計之。當在今日衙背後東北。秦時河身必高。大石散布其中者。勢分立隱。水或流其間。或越其上。凡有小石則填留凹處。細沙則隨流而下。不知積極幾千百年。方成此天然之局。故河底堅實。每遇洪水則兩無干犯。洎乎鄭國爲壩。上阻急流。下受傾注。淤渦如輪。勢若淘井。深或難測。於是壩前已無捍拒之力。壩後時有狂暴之水。基礎稍有不勝其衝。壩必決裂。萬流爭前。大石小石彼此移動。立身無着。愈推愈遠。語云。破壞易建設難。此河身欲再定桑滄之現象。復天然之勢。豈朝夕哉。此河底所以漸上漸低之理由也。今上自龍洞。下抵野狐橋。爲涇水入口之關鍵。昔依山削坡。鑿石爲渠。形如喂馬水槽。大小不一。深淺不均。計每天水量進渠不過二百萬立方尺。僅可供給三百餘頃。

地畝之需。比之漢時不啻天壤乎。故現涇渠流域各縣水利祇此一綫。農人賴以爲命。因此用水分日計時。自下而上。除涇陽西北一帶略得飽沃外。餘若二原高陵一曝十寒。臨潼一隅。與涇陽東北。則未敢希其涓滴也。此等石渠。已小不能大容。又易淤塞。初誤於王琚。再誤於項忠。後人遂拒涇納泉。棄河源而用泉流。則其利益之相差可想而知矣。細察河形水勢。龍洞渠側之涇底。竟低於老龍王廟西之涇底二十餘尺。鄙意以爲引涇當就現之舊渠口。至於野狐橋計畫入手。計長三里許。凡爲石渠以及石砌之渠岸者。一概拆去。或以炸藥毀平之。北靠山坡。則削直爲渠之一岸。南近涇河則築西門混合捍牆爲渠之他岸。下連於三龍王廟前之土股。渠床遇坡度不配者。以西門混砂填補之。試將廢棄此段之渠身。另建新渠。其一切工程節略於後。

渠身

渠口寬定二十尺。深六尺。作燕翅形。渠身坡度分爲三段。頭二段每千尺下一尺。末一段則每萬尺下一尺。後此土渠則依地勢與尾閘之水平定之。渠床須比例均勻。平滑無阻。入渠河泥必聚於二段之末端。水流由此略作休息。祇從水平綫上挨泳而東。如是則其水內泥量。當可

大減。不但於全渠有關，亦將有益於植物作用也。

捍牆

捍牆建築始自堵壩，上距渠底平均高八尺，向河方面則不等，因以沿河蠻石參差不齊，故須視形勢定之。牆頂寬四尺，向渠牆面以高十二尺橫伸一尺之斜坡，向河牆面則尚須計河之流水再詳定之。製法則外包西門混合土尺許，內均實以塊石與西門砂之構合（如前圖）至於他之依山作牆，倘有不整或不固之處者，亦以西門砂抹平之。庶幾內無決裂之弊，外無崩敗之慮。此學術之理，經驗之法，非平空杜撰可以妄論也。

堵壩

堵壩築近渠口，橫截於河中，長約三百尺，上高與牆齊，下深則視河基定之，頂寬三尺，作圓弧形，內坡傾斜伸四十五度，外坡則六十度，然後再延長作平面式，十餘尺，製法混合料，則與捍牆同。此種工程，上下坡腳最爲緊要，腳根須釘入河中之結實處，遇有蠻石與之連合者最隱。此壩可提高水面六尺，足供五千頃田畝之用，餘水則越壩而過（視前圖）。壩下之水力倘欲利用之，亦可作一種小機之主動力，其進款未必無裨於渠，但其外坡建築有不同耳。

山水槽

龍山小岩甚多。每值雨水暴流時。夾砂石漫坡而下。現渠身已循山麓而行。須就山脇出處。酌築山水槽計四座。建於渠岸之上。形如平橋。兩邊砌牆高二尺。上承山口。下作斜坡抵於河濱。如是旱則可以當橋。雨則可以洩水。渠身庶無砂石淤積之患矣。

洩水閘

洩水閘築於渠口下游百尺。則就捍牆留孔約六尺。兩頭作橋壩式。設閘口二重。門框下處。作糞斗形。順坡直抵於河邊。閘門則特製一種鱗魚骨之門簾式。祇須轉壩頭之輪軸。則能自由開閉。凡值洪水之時。則開此閘洩放之。如是則渠身庶免受波力及淤泥之患也。

淘泥閘

淘泥閘則設於二段之末端。即渠口下坡之盡處。暫名U點。法於捍牆間作一內閘。外則築儲泥塘一處。形式就地勢定之。又在U處預造凹槽。橫截渠身。北端略高。南端則接連於儲泥塘。塘近河邊。則設放泥閘一座。平時開渠閘而閉塘閘。凡欲淘泥之時。則閉渠閘而開塘閘。此法設若於流量泥分細加研究。則渠水不難得澄清之果也。

改築老渠口之概算表

名目	橫切(尺)	長(尺)	用	料	每尺價值	共	洋
捍堵	一四〇	六、〇〇〇		西門土塊石工	七〇元	四二〇、〇〇〇元	
堵壩	八〇	三〇〇		西門土塊石土	一五〇元	四五、〇〇〇元	
山水槽	四處	視形勢定之		西門土與石條	每座八百元	三、二〇〇元	
洩水閘	二四〇	三〇		石鐵木工	一五〇元	四、五〇〇元	
淘泥塘	形式	未定		石灰西門碎石	價約閘之四倍	一八、〇〇〇元	
炸鑿費	一〇〇	四、〇〇〇		火藥或炸彈	一〇元	四〇、〇〇〇元	
渠床	一〇	六、〇〇〇		西門砂混合	八元	四八、〇〇〇元	

器具	凡屬於起重一切工程器具	五〇、〇〇〇元
薪費	工程人員以六個月計算他種機關在外	一〇、〇〇〇元
總共	工料備齊同時與工需用約洋六十三萬八千七百元正	

竊以改築渠口計畫與開峒比較費用相差甚鉅。但其利則不減絲毫。况渠之流域最廣者。亦不過限於清涇二河之間。前已言之。高原則分立如伏波。間瀉山水。寬至數十丈。深少亦達百尺。壟斷已屬天然。浮渠飛槽雖可辦到。而水能上高原與否。暫置不問。恐靡費之奢。未必有補於受利之數也。敢以此質諸高明。

開峒與改築渠口之比較

類別	價值	時期	耐久	修補	水面	查驗	養費
開峒	一、一五三、〇〇〇元	三年	十	二	一、六二六尺	難	三

改良渠綫之研究

相 差	五、一四、三〇〇元	二年半	百分之三十	三分之一	五、三、尺	三分之一
改築渠口	六三八、七〇〇元	六個月	七	三	一、五七、三尺	易
						二

涇渠綫道已於流域篇中言之。其流行雖未失地勢之分配。然均係注重於山形之傾斜。以故
 流水偏向一面。如現時之支渠皆趨渠之南。若北流者則百未得一。鄙意以為渠綫宜擇原脊。
 引渠於上。倘間有壟斷之處。則於渠之兩邊增修土堰接連之。設將來水面提高五尺以上。渠
 身必然能暢流自如。凡流於最高之原脊者為幹渠。次則為支渠。順民之便。挖引漑田。何患無
 微不至乎。此事宜由經驗之工程師預先相度地勢。詳細窮測。方能定其經緯。庶幾無得此失
 彼之弊。此流域之宜審慎者一也。夫治水者慮其患。引水者希其利。慮患則喜其速去。希利則
 樂其逗遛。此則修河與引渠不同之點。故渠之傾斜以愈小為佳。否則度大流急。不但渠身有
 冲陷之患。則水量入不敷出。豈為水利乎。倘地形相差太鉅。勢非速度不可。宜設法增半萬字

形(乙)之籬壩以節減之。然渠身亦不得太於平坦。須有傾斜之勢。一則可以利流通。一則可以汰污穢。尤有進者。上流傾斜須小於下流。此無他。防其阻力之關係耳。再者渠身須以淺爲便。(視水量爲度)邊坡則以大爲固。(視土質分配)蓋渠深則有用水之困。無異取水於井。運水於塘。坡小則有崩塌之患。是同於水中立牆。沙中挖溝。使水量有不足者。渠可加寬。地畝有不足者。則須築牆代坡。或以灰土。或以磚石。英美各國因有水量不足。與地畝貴重之故。甚至有以西門土作渠邊者。現我國交通不便。實業未興。水多而地賤。可無此困難。因地制宜可矣。此渠身之宜審慎者又一也。普通以渠岸多種樹木爲佳。究其理未必盡然。蓋渠邊若得工程上之整齊。其堅否與樹木無干。且其害有三。則分吸水量。浮動渠身。與擾亂就近生植之作用是也。若水量充足者。種樹祇爲取材。得根可以實土。(對於坡小與土鬆者言之)惟須擇木而樹。凡有盤根與遲長者。宜舍用之。至於分渠設閘。當道建橋。孔位之大小處置。尤爲全渠關鍵。現就經濟論之。渠身宜從老渠改良入手。不善者修整之。未達者增補之可也。劉海東北。永樂東南。最宜注意之處。三原舊支應改從城外爲宜。城內作爲分流可矣。又各尾閘入清入渭。不防多滋轉折。藉此臨潼一隅。亦可倍受其益耶。若幹支由公共改修。分流由民戶自理。合橋閘

種種建造。費不過十萬金以內。則可以收全功矣。

涇渠之利益

夫古時關中富庶甲於天下。齊晉糧食仰給於秦者屢矣。今則西安磽赤。稍有旱乾。則榆林棄子。漢中食人。高原以無水爲災。平野則以多水爲患。二千年間何桑滄之速。使人不可思議。抑亦天工遞嬗。人力廢墮。有以致之。不然何至六渠無遺。八水改流者乎。吁。亡羊補牢。識者以爲倡辦水利。爲今日三秦之要政。救困之原料也。舍此則糧食缺乏。（客有自陝來者云。旅行數十里。雖有金錢。亦無從得食。後迂道三五村。始以二百文交換一塊堅硬如鐵之黑饅頭。糧食之窮可知矣。）雖賑無及。現如各界仁人之爲陝賑施者。亦不過維其善之百一耳。何曾起死回生。根本救濟乎。此良心上之發言。非造謠也。然昔關中所以富者。究賴何產。無他。五穀耳。穀以麥爲大宗。而麥又因地爲本。賴水爲生。有地無水。麥何以長。且人以食爲天。無糧則何以度活。貴爲王侯。寶藏盈室。如趙武者亦不免缺糧以死。况貧困如牛馬之黎民乎。夫視今日田畝近於水渠者。則禾美而收豐。每畝地價值至百金。若遠離水渠之旱田者。雖值賤數金亦無人問價矣。蓋貧農力耕。惰者荒廢。每每中途遇旱。或他種災異。率多無成。倘百能獲十。則屬僥倖。

下列之五穀產價表爲最富之田。最豐之時。沿途查詢。記之於書。如有未實之處。閱者諒之。

五穀產價表

每斗價元	每畝產數	穀名
五角四	斗十	高粱
角五	斗六	豆綠
角二元一	斗廿	米大
角六	斗六	米小
五角四	斗五	等豆黃
角六	斗七	谷苞
角五	斗五	麥蕎
五角四	斗十	麥大
角七	斗七	麥小
五角二	斤十四	棉花
五角一	斤十五百	藍大
角二	斤百二	藍小
角七	斗五	子菜
厘二枚每	枚千二萬二	蒜大
角五	斗四	豆豌豆
角六	斗六	麻芝
角二	斤百	麻線
五分一	斤餘千	薯紅
角二	斗六	米穀

今如改修涇渠。總費不過八十萬金。則可利五縣方千里之地。溉五十萬畝之田。平均每畝價一元六角。每畝最少年可增收三元。現祇以每畝每年加利一元計之。則每年計可增利五十萬元。於二年中。即可收回本息八十餘萬金。世間營業未有如是之薄也。考南北美洲。坎那大。南歐。埃及。波斯。印度。與澳大利亞諸地。近之對於農務莫不精求進步。均以科學資本為決算基礎。創厚利之業。雖預費數百萬。而目前未獲一利不顧也。據一九一零年美洲水利報告云。美洲農務在進行中之人力水利者。達三百二十萬英畝。(每英畝合華七畝)其已收效溉田者。計一千五百萬英畝。今之進行中三千二百萬畝。預算須美金四萬四千三百萬元。平均計之。每英畝值美金約十四元。即每華畝價洋四元。此數與涇渠所費相差若何。知而不為。又何怪西人之

每畝得利			
四	元	五	角
三	元		正
二	十	元	四
三	元	六	角
二	元	二	角
四	元	二	角
二	元	五	角
四	元	五	角
四	元	九	角
十	元		正
三	元	二	角
四	元	十	正
三	元	五	角
四	元	四	正
二	元		正
三	元	六	角
二	元	十	正
約	元	十	元
一	元	二	角

笑我華人今日處退化之級階。只役於人而無自馭能力。可恥孰甚。萬望三秦父老昆仲。於清夜自思。諒不以吾言爲謬也。至渠成之善後。修養之保全。又非斯時可得盡論之也。

etc. during the year. Because no annual records have been taken for the above either in the River Conservancy or Bureau of Irrigation in Shensi.

Well, may I say in conclusion that I believe that more experienced engineer will offer a far better plan and project regarding the problem, and I shall be glad to hear in future.

It will not only be able to increase the amount of income but will convert the soils into more fertile ones or even change dry places into paddy-fields.

After the reopening of the canal and the distribution of irrigation I dare say, twice as much will be produced as the income now yielded.

Now assume that each Mu of land is able to produce an increased of one dollar, then the annual extra income is equal to $5,000 \times 100 = \$ 500,000.00$ According to the figures for the cost of canal construction and the irrigation scheme it would cost about \$1,60 per Mu. The project will pay for itself within two years, and every succeeding year yields an interest of 100 per cent. How big an income it is! Many things like this Chinese do not undertake.

In foreign countries, people are always trying to get an increased benefit out of nature, such as irrigation brings, and are always seeking improvements. They value the land and water. Many earth canals are lined with cement mortar so as to prevent loss by seepage.

Land in China is so cheap, existing silent in desert condition! Water is so abundant pouring steadily into the sea! what a contrast between their present and potential values! As an illustration the fact that the irrigation for 5,000 Ching of land from Tzin Ho, mentioned above would use only $1/15$ of the water of the river will verify that statement.

This is my brief report and proposal for the Tzin Canal. But there is still much data which I can not find out, such as, temperature, rainfall, wind force, water level of the Tzin Ho,

Advantages of Tsin Canal.

At present all the fields are dependent upon the rainfall, most of them are bare turned into desert owing to the lack of water. Thus the land beyond the reach of the laterals of the canal, costs no more than \$10 dollars per Mu, whereas that nearly costs about \$100.00 per Mu. But now there are only small portions of such valuable land.

Name of crops.	Yield tou per Mu (tou 10.350 Liters)	Cost per unit dollars.	Income per Mu. dollars.
Millet.	10	0.45	4.50
Green bean	6	0.50	3.00
Rice.	20	1.20	24.00
Canary seed	6	0.60	3.60
Yellow bean etc.	5	0.45	2.26
Pearl Barley.	7	0.60	4.20
Buckwheat	5	0.50	2.50
Barley	10	0.45	4.50
Rye	7	0.70	4.90
Cotton	40 catties.	0.20	10.00
Tall Indigo	155 catties.	0.15	23.25
Small indigo	200 catties.	0.20	40.00
Vegetable seed.	5 tou.	0.70	3.50
Garden pea.	4 tou.	0.50	2.00
Garlic 2	22.000 bulbs	0.20 per hundred.	44.00

The above table shows the yield and cost of crops in good seasons any person will believe that a better result can be obtained if the irrigation provides them a continuous saturation.

them all through the year, I propose to make the side slope at 1 1/2 to one at least, and the grade at 1 in 10,000 at most.

There is a piece of land about 600 Ching between Ya Yu Ho and Tzin Pei Tzu from Liu Hai village 劉海村 to San Yuan city, 4 ft. higher than the edge of the canal.

If the source of water can be made 6 ft. higher, then a new canal about 50 li from the northeast of Liu Hai to southeast of San Yuan city can be dug on the ridge of the field (shown on sketch), and some other canals may be lengthened as far as the gravity water can reach.

The estimates for the new canals and improving the present ones are now computed approximately as follows:—

Name of work.	Average Cross Sec.	Length.	Kind of work	Cost per Lin. foot	Total Cost.
Improving Canals.	21 Sq'.	360,000'	Earth work excavation to form levees.	11 cents.	\$39,600.00
New canals.	114 Sq'.	180,000'	—do—	57 cents.	\$102,600.00
2 5 ft.-Span Stone Arch Bridge.	30 places.		½ used old materials.	\$1,200 each.	36,000.00
6 locks.....			Stone Masonary	\$3,000 each.	18,000.00
			Total cost		<u>\$186,200.00</u>

The total length of the laterals which I have calculated as to be dug by the natives themselves according to their need would amount to 40,000 li. when the water is well distributed the field will become so thoroughly saturated that many of them will be turned into paddies. In that the income of each Mu will, I dare say, be 5 or 6 times as much as before.

Since 2 problems have been studied, their different advantages will be evident from the following tables:—

Comparison of 2 Inlets from Tzin Ho

	Tunnel Inlet	Pening Inlet.	Difference
Cost.	\$1,153,000.00	\$620,500.00	\$532,500.00
Time.	2 years.	6 months.	2 $\frac{1}{3}$ Years.
Duration	10	7	30 %
Annual Repairing.	2	3	1/3 less.
Elevation of Water	1,626,291'	1,573,12'	53.17
Examination	Hard	Easy	Tunnel is even higher but unuseful & take trouble to examine its way.
Expenditure of Annual repairing	3	2	1/3 less expensive.

Although each has its own benefit, the opening of a canal inlet is cheaper and easier to be carried on. So I recommend this way. It will be permanent if there is a Bureau of Canal Maintenance and irrigation Management established as soon as it is constructed.

After the inlet for Tzin Canal has been made in good order, all the canals, main and branches ought to be widened and improved with better side slope and grade of their beds. Because for the construction of the irrigation canal, the need of the bigger side-slope and smaller bottom grade, is most important.

At present, the sides of old canals are steep and the grades are irregular. * The people have to take time and trouble to repair

it. This would mean doing away with the old canal and building up a new one.

A dam for raising up the water level must be built across Tzin Ho at the entrance, also a lock below the entrance and a sluice near Ya Hu Chiao are required, to serve either to discharge the water when a flood comes or to clear the silt from the bottom at particular times. After the canal has been so improved I venture to say that the benefit of irrigation for the land is just as much as a tunnel could accomplish.

For reference I make the following Rough estimate of the cost.

Estimate for the Improvement of Canal Entrance.

Name of work.	Gross Sec.	Length.	Kind of Material used	Cost per Lin. foot.	Total Cost.
Retaining wall.	140 Sq'	6,000'	Cement Con. & rubble Masonary	\$70.00	\$420,000.00
Themes	4 places for discharging mountain water.		Stone & cement.	At \$800.00	3,200.00
Dam	80 Sq'	300'	Cement Con. Stone Machinery	\$150.00	45,000.00
Lock.	241 Sq'	30'	Stone Machinery	\$150.00	4,500.00
Cleaning pit	Shape according to land.		Lime, and cement Con.	4 Times locks.	18,000.00
Explosives & rock cut.	100 Sq'	4,000'	By gun powder & Rand work.	\$10.00	40,000.00
Canal Bed.	10 Sq'	6,000'	Cement concrete.	8.00	48,000.00
Simple Machines & Equipments.....					50,000.00
Engineering Organization for 5 months					10,000.00
Total cost.					\$628,700.00

Name of work.	Cross Sec.	Length.	Kind of Material used	Cost per Lin. foot.	Total cost.
New canal,	700 Sq.	8,500'	Earth Excavation	6.00	\$ 51,000.00
2 Reservoirs	1000 Sq'	40' deep	Lime mortar stone masonry	200.00	16,000.00
Retaining Wall for entrance.	120 Sq'	300'	Cement Concrete.	200.00	60,000.00
Dam for entrance.	80 Sq'.	200'	Cement & Ruble masonry.	150.00	30,000.00
Right of Lands.	150 Mu.		At \$40.00	6,000.00
Simple Machines and Equipments.....					50,000.00
Engineering organization for 3 years.....					60,000.00
			Total cost		<u>\$1,154,000.00</u>

2. After studying the history of Tzin canal, it is well known that the canal had been altered and improved year by year. Now the canal from the entrance to Ya Hu Chiao is about 6,600 ft. long; its average width is 6 ft. its bottom is uneven, in many cases the lower parts being actually higher than places further up the canal giving a wave-like formation. In such condition it is not only insufficient to contain a bigger amount of water, but it easily catches the silt as the ancient people said. The formation along the side of the mountain consists largely of blocks of granite and ignite rocks. This was why a 3-li stretch of small canal cut by hand tools occupied a period of 17 years.

Improving the entrance and building a new and larger canal instead of the old one, I propose, a part of old stone canal from the entrance to Ya Hu Chiao ought to be blasted and levelled into a so good grade for the new bottom; then the rock on the mountain side cut as to be one side of the new canal and a retaining wall built on the side toward to the river to be side of

Point.	Elevation in Metre.	Situation.
T.	506.48	Bank of Tzin Ho.
U.	477.06	H. F. water level.
V.	468.35	Annual flood. level.
W.	479.63	Centre of entrance.
X.	477.34	Bed of T-zin Ho.
Y.	476.64	Water level.
Z.	487.30	Top of rock between river and canal.

If it is desired to open tunnel, it can be regarded as a method of creasing the area of irrigation but simply would be changing to a different entrance for the canal instead of the old one. Because the old canal goes almost along the edge of the plateau at the highest situation possible so that no new canal could be located higher unless one could be made on the top of the plateau.

This discussion leads to conclusion that either Tiao Er Chui or Miao Er Ling for the new canal is of no advantage. So the consideration and study may be commenced for improving the entrance of the canal.

How let me try to estimate how much is the cost of a tunnel, if it was made from A to H. and a cutting from H to J. connecting to the old course of canal at the routh of Mu Si Wan. I calculate as follows.

Estimate of Miao Er Ling Tunneling

Name of work.	Cross Sec.	Length.	Kind of Material used	Cost per Lin. foot.	Total cost.
Tunnel.	100 Sq.	8,000'	Cement concrete bricks & woods.	\$110.00	\$880,000.00

a careful comparison of from A. to G and G. to P. It is found that the point F is 141.79 ft. higher than point B and 96.63 ft. higher than G; the elevation of A is nearly on the same level with that of Mu Si Wan Village. Therefore, the canal could not possibly be opened on the top of plateau, even near the edge of it.

Herewith a list of elevation shown below for reference, (the datum=500 Metre, or 1640 ft.)

Point.	Elevation in Metre.	Situation.
A.	500.00	Side of Tzin Ho.
B.	493.32	River bed.
C.	495.82	Water level.
D.	758.79	Cap of Mountain.
E.	851.46	Cap of Mountain.
F.	636.55	Mouth of valley.
G.	607.09	Top of plateau.
H.	537.47	Near edge of plateau.
I.	496.69	Flat field.
J.	420.50	Bed of earth canal.
K.	511.69	Lower edge of plateau.
L.	498.69	Ground level.
M.	484.87	Top of Chao Chia bridge.
N.	481.72	Bottom of canal.
O.	483.17	Water level. of canal.
P.	464.95	Side of Tzin Ho.
Q.	460.47	River bed.
R.	462.97	Water level.
S.	488.46	Top of stone level.

1. In the-time of Wan Li (1581 A.D.) Mi-ng Dynasty, the Sen Yuan Magistrate Wang Si Yin 王思印 Proposed to cut thru Tiao Er Chui, (the south of Lung Shan) for another entrance into the canal in order to let in the water of Tzin Ho, and also collect the water from the springs.

It was discussed and objected to by Mr. Yuan Hwa Chung 袁化中 the Magistrate of Tzin Yang Hsien. On the ground that the stone canal was too small. Its capacity is not sufficient for the spring water be said. How can it spare additional space for the water of Tzin Ho? Its result will be the same as that of "Kuang Fui Tzu" which was of no advantage but resulted in silt and damage. He added that it might be better, if Tiao-er-choi cut using another route separated from the upper part of the old canal so as to avoid the gurgling of Tzin Ho which would be a constant trouble. This idea is quite right.

During the present years the people have suffered from famine. Thinking of no way to help the farmers, the San Yuan ge-ntry repeat the proposal and loudly declaim for the Miao-er-ling tunnel, instead of Tiao Er Chui; as the the Miao-er-ling is a gap of Lung Shan, about 31 li above Tiao Er Chui. It is at a sharp turn of Tzin Ho, narrower than Tiao Er Chui. Many people assumed that point F is lower than point B, and some said that anyhow point B is higher than point G (see sketch). It would be necessary to cut a stretch of tunnel A to F. Then, from the tunnel there would be new canal to be made on the top of plateau, from which an extraordinary area of land might be brought within the circle of irrigation. But is it possible? I have surveyed about 40 square li, including all the important related places near the entrance of the canal. and made

Area of land	Cub. ft. of water needed.	Water supply sufficient for.
5,000 Ching	1,500,000,000.	10 days.

To meet the requirement for this quantity of water there must be an inlet with a cross section of 100 square ft. and an available velocity of $2\frac{1}{2}$ ft. per Sec. So I tabulate as follows,

Gross Section	Velocity per Sec.	Water discharged Cub. ft. per day.	Allowance for seepage & Evaporation %	Actual water for Irrigation Cub. ft. per day.
100 Sq. ft.	$2\frac{1}{2}$ ft.	216,000,000.	30 %	151,900,000

To give the length and capacity of the canal best suited for the uniform irrigation of the above mentioned area, the main and branches are now adjusted as follows;

	Length.	Cross Section.	Cubic Contents.
Main.	200 li.	360,000 × 160'	57,600,000'
Branches.	2000 li.	3,600,000' × 18'	64,800,000'
Laterals.	4000 li.	72,000,000' × 1'	<u>72,000,000'</u>
		Total volume	194,400,000 Cub. ft

There is an amount of water 43,200,000 Cub. ft. or $1/5$ of the whole volume allowed for the factor of safety in the rainy season.

Study of Inlet from Tzin Ho for Irrigation Purposes.

There are two problems to be studied for the irrigation from Tzin Ho as follows:—

1. Building Mia Er Ling tunnel.
2. Improving the entrance of the old canal.

Name of crops.	Time of seeding	Time of Harvest.	Length of Growing period.	Water requirements.
Canary seed	5th Moon	8th Moon	100 days.	7 Mu ft.
Yellow bean etc.	4th Moon	9th Moon	140 days.	7 Mu ft.
Pearl Barley	5th Moon	8th Moon	100 days.	8 Mu ft.
Buekwheat.	6th Moon	9th Moon	90 days.	5 Mu ft.
Barley	8th Moon	4th Moon	250 days.	5 Mu ft.
Rye.	8th Moon	5th Moon	260 days.	5 Mu ft.
Cotton	3rd Moon	7th to 9th	190 days.	8 Mu ft.
Tall indigo	8th Moon	5th Moon	250 days.	5 Mu ft.
Small indigo.	4th Moon	6th Moon	90 days.	15 Mu ft.
Vegetable seed	6th Moon	4th Moon	300 days.	5 Mu ft.
Garlic.	7th Moon	5th Moon	300 days.	16 Mu ft.
Garden Pea.	9th Moon	5th Moon	230 days.	5 Mu ft.

With the exception of rice, garlic, and small indigo which need a big amount of water during the growing period: I take millet as the base, as its growing period is about 150 days and it requires a capacity of 8 Mu-ft. of water, i. e. every day wants a 1/2 Mu-inch water supply or 5 Mu-ft. (1 Mu-ft.-one Mu of land covered with one foot depth of water) for every ten days. This is an average of different crops.

Such being the case I figure that one Mu of land needs 3000 Cub. ft. of water or 1/2 Mu-ft. every 10 days, according to the irrigable area. This shows a net quantity of 1, 944,000,000 Cub. ft. of water supply required. This practically means using not more than one fifteenth of the water of the water of Tzin Ho.

Now I develop the project for an area of 5,000 Ching according to preceding schem of the land that may be brought under irrigation, as follows:

The average grade and data of the old canal is as follows:—

1. Gross section.....	16 Sq. ft.
2. W. P.....	9 ft.
3. H. R.....	1.8 ft.
4. Slope.....	0037 ft.
5. Mean V....	1.4' per Sec
6. Water discharged.....	22.4 Cub. ft.
	per Sec. equals 1,935,360 Cub. ft. per day,

As each Ching requires a capacity of 2,000 Cub. ft. of water, the old canal can irrigate atmost an area of 10 Ching per day or 300 Ching per month.

Water Supply

The area of the 5 districts which are north of Tzin, Ho, south of Ching Shui Ho (Ching Yu and Ya Yu Contained) east of Chung Shan and west of Wei Ho is about 2,400 equare li. Half of this area consists of plateaus cities, towns, villages etc. So there remains about 500,000 Mu or 5,000 Ching of flat field which is irigable by gravity flowing. The soil there is mostly fine yellow clay. These fields will become more fertile if they have uniform moisture content through out the year.

By a careful study of the following table showing the relations of crops, an idea of the water supply can be gained.

Relations of Crops

Name of crops.	Time of seeding	Time of Harvest.	Lenhth of Growing period.	Water requirements.
Millet.	3rd Moon	8th Moon	150 days.	5 Mu ft.
Green bean	3rd Moon	7th to 8th	150 days.	8 Mu ft.
Rice.	4th Moon	8th Moon	150 days.	3 Mu-inches daily.

漢堤鎮 where the canal is divided into 3 branches, called San Pei Tzu. The length of canal from Houng Kow to the junction of San Pei Tzu is 56 li in all.

The south branch flows directly southwards to the city of Tzin Yang Hsien 涇陽縣 having a length of 20 li. The middle branch separates eastwards 20 li to Peng Chen Cha 彭城關 in the district of Kao Ling Hsien 高陵縣.

In the time of the Tang Dynasty 唐朝 3rd year of Chang Ch'eng 長慶 (823 A.D.), Magistrate Liu Jen Soo 劉仁師 opened 5 sub-branches from Peng Chen Cha, three of them are at the north of city connected with Ching Shiu Ho 清水河 and the other two at the south of city discharging to the Wei Ho. The total length of the five sub-branches is 205 li.

The north branch, 20 li from Han Ti Chen makes a "V" with Ya Yu Ho until they are very close to each other and pass thru the city of San Yuan running parallel. Beyond the city on east, the canal runs only 20 li, But in ancient time it entered the territory of Fu Ping Hsien 富平縣 where at present the land becomes higher.

The total length of the canal now remaining is 320 li altogether with its branches and sub-branches.

List of Irrigable Lands.

Name of District.	Irrigable lands.	Now irrigated	to be Irrigated.
Tzin Yang	2,500 Ching.	200 Ching.	2,100 Ching.
Li Chuan	30 Ching.	10 Ching.	20 Ching.
San Yuan	1,500 Ching.	20 Ching.	1,480 Ching.
Kao Ling	1,200 Ching.	20 Ching.	1,180 Ching.
Ling Tung	50 Ching.	5 Ching.	45 Ching.
Total.	5,080 Ching,	245 Ching.	4,825 Ching.

5. By Rutter's method3967 ft. per Sec
5. Mean wetted peremitor.....120 ft.
6. Mean Hydraulic radius.....375 ft.
7. Quantity discharged.....1800 Cub ft. per Sce.
8. Gravity water Contains Silf and
Clay.....10 to per cent.
9. Weight of water in 60°
F.....65 lb. approx per cub. ft.
10. H. F. W. L. is 51 ft. higher than usual.
11. W. P. of H. F. W. L.....309 ft.
12. C. S. of.....do.....11,912 Sq. ft.
13. Velocity of H. flood.....1928 ft. per Sec.

Irrigation Area and Course of old Canal.

The conal beginning from Hung Kow 洪口 to Ya Hu Chiao 野狐橋 is rock cutting, 3 li long, from Ya Hu Chiao to Chao Chia Chiao 趙家橋 gravel and cutting one li long. and from Chao Chia Chiao to Ma Tao Chiao clay cutting 4li long. These stretches are along the mountain side and all are deep cuttings unable to supply and irrigating benefit on either side.

Beyond Ma Tao Chiao the irrigation commences from Wong Yi Tao (the first lateral of the canal). The canal goes down eastward, nearly parallel with the course of Tzin Ho and along the side of the plateau.

After a length of 20 li, at the east of Shen Chiao-chen 石橋鎮 where the elevation is gradually reduced from high land to flat, the canal turns to the north and skirting around the village of Chiao Chia Chien 交家村 swings back up to the village of Liu Hai 劉海 for a length of 16 li. The direction of canal is again toward the east till it reaches Han Ti Chen

cleared and its entrance connecting with Tzin Ho was intentionally blocked up. This was a plan to have the benefit of the spring water for irrigation from the canal rather than that of Tzin Ho which will take trouble all the times. In the 27th year of Kung Shu 光緒 (1901 A.D.) Rev. Miur Duncan intended to distributed half of the famine relief fund from England to cover the expense of clearing the canal and rebuilding a strong dam & permanent dike for the canal in order to recover the original benefit of the Tsin Pai Tsu section. But this was still not successful (All important rivers, canals, etc. are shown on the sketches).

The Condition of Tzin Ho

The course of Tzin Ho runs down from Peng Tao Shan 屏頭山 and Wu Shan 武山, Lung-tek Hsien 隆德縣 of Kansu province 甘肅 and it flows down southeast via Pen-liang 平涼 and Tzin Chow 涇州 until it enters into the Wei Ho 渭河 at the south of Kao Ling Hsien. 高陵縣, Shensi.

Its whole length is about 600 li, and the part between Hung Kow 洪口 (Tiao-er-chui) and the junction of Wei Ho is about 120 li.

The river bed is very uneven and rough being composed of rocks and gravels mixed with clay. The grade both at one mile a-bove and one mile below Houng Kow is 0.006 ft. Other data is as follows,—

1. Mean width of river.....75 ft.
2. Mean depth of river.....6 ft.
3. Mean Cross Section.....450 Sq. ft.
4. Mean Velocity by floating.....4 ft. per sec.

unreliable as the cultivated lands of these districts do not constitute so vast an area as that. This section is called Feng Lee Tzu 豐利渠, in 5th year of Hsiang Ting, Tsin Dynasty 金朝 (1218 A.D.), there was an irrigation Bureau specially established in charge of this canal. In the Dynasty of Yuan 元, first year of Chi Ta 至大 (1308 A.D.), a Censor named Wong Tzu 王弼 was ordered to repair the whole canal and cut another entrance as the water at that time could not be collected as before. The dimension of new section which was called Wong Yu Szu Tzu 王御史渠 is 510' × 10' × 5'. It was so located that still very little water flowing in to the canal.

The canal decade after decade shifted up higher and higher till it was being closed at the narrowest part of the valley where Tzin Ho rushes out from the mountains. During floods the force of current became very strong against the junction of the canal. For this reason in the time of the T'ian Sun, Ming Dynasty 明朝 (1459 A.D.) Vicery Shiang Chung, 項忠 reopened 2,000 ft. of 8' × 20' stone ditches and 4 × 4'-tunnels which lasted for a period of 17 years. The dimensions were too small to contain the water of the Tzin Ho. This construction proved to be easily silted up or destroyed. The cost of its dredging and repairing annually was more than the irrigating income that could be obtained. In the 9th year of Sun Tzi 順治, Ching Dynasty 清朝 (1652 A.D.), Magistrate Tsin Han Ting 金漢鼎 made a few openings for water to flow from springs on the mountain side. It was thought that the amount of spring water gathered in the canal, would be not less than that of Tzin Ho which would flow in. Therefore, in the 2nd year of Chin Lung 乾隆 (1737 A.D.) the stone canal was

land irrigated at that time. Though it had tired out a part of people for the time being, but it made Kuang Chung 關 中 very rich for a long period. Therefore the canal is named "Tsin Kuo Tzu".

During a long period of the past, the canal was not taken care of or repaired, so that it had become nearly useless by the time of the Hann 漢 Dynasty (95 B.C.) as the entrance of the canal was getting higher than the river bed of Tzin Ho, and no water could be let in to it. So his Honor Chao Pei Kung 趙 白 公 dug another stretch of canal above Tsin Kuo-tzu 鄭 國 渠 and using various kinds of mixed materials as well as rocks constructed a dam to raise the water level of Tzin Ho. Meantime the canal only went as far as the Chih Chuan Ho 石 川 河 (one of the Wei Ho branches). The land of districts (4500 Ching) was irrigated, but the advantage was greatly reduced, compared with that of Chin Dynasty. This section of canal is hereafter called "Tsin Pie Tzu".

Afterwards this had to be repaired year by year, as the dam did not last.

In the Sung Dynasty 宋 朝 2nd year of Ta Kuan 大 觀 (208 A.D.) the Emperor Hui Chung 徽 宗 ordered the minister Chao Chuan 趙 佶 to cut the rock at the base of Lung Shan 龍 山 to make a water way to form another inlet into the old one. The new stretch of canal was 3,141 ft. in length, and 34 ft. in depth with 4 ft. of water. Also there were two locks on the side towards the river were built for discharging when the canal was flooded. This work had taken two years. In that time the irrigation was distributed over 20,000 Ching of land according to the records, but they have been proved

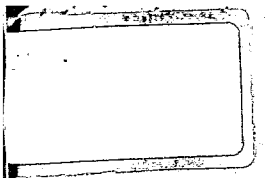
Shensi International Famine Relief Commission, Sian
Brief Report and Data for the Irrigation Problems
of
Tzin Canal Near Tiao Er Chui

Gentlemen:—

Before I report to you gentlemen the irrigation and survey of Tzin Canal 涇 渠 near Tiao-er-chui 吊 兒 嘴 (Tiao-er-chui is the mouth of Hun Kow 洪 口 valley): it is necessary for me first to state its geographical history, then relate its present circumstances, and give the data connected therewith. This is translated from Chinese Report from which, if reference, a more detail explanation can be informed.

History

In the time of the seven powers 七 國, (246 B.C.) the king of Hann 韓 feared the strong power of Chin 秦 and sent the irrigation Engineer Tsin Kuo 鄭 國 to Chin Shih Hwang 秦 始 皇 proposing to open some canals from Tzin Ho 涇 河 and other rivers for irrigation. It was a hard work needing a large number of labourers and a great deal of money to complete. This was a method that Hann 韓 devised to make Chin 秦 weak. The Chin Emperor accepted the proposal and ordered Tsin Kuo to carry on his projects. The canal from Tzin Ho is the biggest, connecting on its way with Ya Yu 洽 洛, Ching Yu 清 洛, Cho Yu 濁 洛, and Wun Chuan 溫 泉 rivers and finally with Lo Ho 洛 河. It passed through the lands of ten districts. There was an area of 40,000 Ching of



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REPORT OF TZIN CANAL

THROUGH

FIVE DISTRICTS.

SHENSI PROVINCE.

BY

N. K. Woo. C. E.

MAR. 1923.